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1947-2022

CELEBRATING PLATINUM JUBILEE YEAR

Platinum Jubilee Celebration

8th International Conference
(Hybrid Mode)

Plant Pathology: Retrospect and Prospects

March 23-26, 2022

Venue:
Sri Karan Narendra Agriculture University
Jobner-Jaipur, Rajasthan, India

ABSTRACTS & SOUVENIR

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MICROBES IN PLANT HEALTH & DISEASE

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"The financial assistance received from Research and Development Fund of National Bank for Agriculture and Rural Development (NABARD) towards publication of journal/ printing of proceedings of the Conference is gratefully acknowledged".

FOREWORD

Indian Phytopathological Society (IPS) has entered into the 75th year of its establishment and service to the science & Society both at national and international level. The Society is organizing Platinum Jubilee Celebration and International Conference (hybrid mode) on “Plant Pathology: Retrospect and Prospects” at SKN Agriculture University, Jobner-Jaipur, Rajasthan, India during March 23-26, 2022.

The science of “Plant Pathology” has evolved over the years since its inception and played pivotal role on plant health & human health as well. Plant pathologists, worldwide, engage themselves in mitigating challenges encountered in food production due to plant pathogens. Healthy food is the prime requirement to ensure nutritional security and to boost immunity. With the advent of modern scientific tools/approaches, the science of plant pathology has got transformed to a greater extent resulting into the ease of handling the subject in a more focused manner. Now, to commemorate the completion of seventy-five years by the Indian Phytopathological Society (IPS), a globally recognized scientific society, we must retrospect upon plant pathology to acquire detailed insight into the progress made in achieving the global food security. In this context, IPS intends to organize a four days International Conference on “Plant Pathology: Retrospect & Prospect”. Primary aim of the conference is to have a flashback of the journey of Plant Pathology in India till the platinum jubilee year and to look forward to its future in global perspective. The conference would provide a platform to retrospect upon the milestones achieved and to explore the future scope of tackling diseases in crop plants. The four days long deliberations will cover the evolution and advancements in teaching, research and extension activities amidst researchers, academia, entrepreneurs, farmers, and policy makers. The detailed deliberations on four major themes of plant pathology would certainly pave the way to ensure better plant health vis-a-vis human health and food security.

The present conference would serve to address major important issues like taxonomy, fungal, viral, bacterial and nematode diseases of agricultural crops and their management, fungicides/ bactericides- a global perspective from industries, plant-microbe interactions, impact of climate change on plant diseases, disease complex/IDM approaches and policy issues, industrial linkages/extension plant pathology, to achieve sustainability in food production in India. Special satellite symposium on “Ameliorate Resilience of Arid Crops” is planning to organize theme wise mini symposium sponsored by collaborating scientific organization and Indian Society of Arid Legume for enhancing resilience in arid land crops. The satellite workshop on *Trichoderma* and *Gliocladium* is intended to bring together leading academic scientists and researchers across the globe and the private entrepreneurs engaged in commercialization of their technologies. During the conference delegates from forty-one different countries are attending through virtual mode. About 400 participants have registered for both online and offline from different institutes across the world. I hope that the delegates in the eighth international conference will deliberate upon the important issues relating to plant pathological problems of the country and will come out with suitable recommendations.

I would like to congratulate and compliment my colleagues from SKN College of Agriculture (SKNAU, Jobner) and members of Indian Phytopathological Society who have made the efforts in celebrating the 75th year for both the college and Indian Phytopathological Society (IPS).

P.Sh

(PRATIBHA SHARMA)

PREFACE

Robin Gogoi

Kalyan K. Mondal

Malkhan S. Gurjar

Agro based commodities and food production have been remaining at higher demand to feed the ever increasing global population. To meet the requirement of high crop production, cultivable fertile areas are needed. Unfortunately, agricultural land is shrinking due to rapid industrialization and urbanization. Further, to feed the growing population we need to reduce the crop losses caused by biotic and abiotic threats. Most of the abiotic threats like flood, draught is very uncertain and difficult to manage. However, crop losses caused by biotic threats including plant diseases, pests are manageable with timely adoption of appropriate control measures. Thus, the required food production can only be achieved to a greater extent through minimising the losses due to biotic factors. To address these challenges, the plant protectionist, globally, engage to devise novel low-input management options for biotic threats. **Indian Phytopathological Society** since time memorial has addressed several issues and updates on these fronts of plant protection. The 8th International Conference (In dual mode) on **"Plant Pathology: Retrospect and Prospects**" at SKN Agriculture University, Jobner-Jaipur, Rajasthan, India is one of that kind that primarily focused to discuss and deliberate on education, research & development in Plant protection as a whole and to formulate the roadmap for future towards meeting the food security. The proceeding of the abstracts to be presented in this conference (w.e.f 23-26 March, 2022) is compiled as **"Proceedings Book"**. We tried our best to bring this compilation errorless and timely. However, we apologise for any inadvertent mistakes/ typo errors which was unavoidable considering the volume of the contents. Our heartfelt thanks to the dedicated team of Publication committee for this compilation. Our thanks to the EC members, IPS for their time-to-time input and valuable suggestions.

We wish that this compilation would serve as a valuable reference for Scientists working on Plant Protection.

Robin Gogoi
(Convener, International Conference & Secretary, IPS)

Kalyan K Mondal
(Co-Convener, International Conference & Joint Secretary, IPS)

Malkhan Singh Gurjar
(Co-Convener, International Conference & Treasurer, IPS)

Dated: 19.3.2022
New Delhi

सत्यमेव जयते
त्रिलोचन महापात्र, पीएच.डी.
सचिव एवं महानिदेशक
TRILOCHAN MOHAPATRA, Ph.D.
SECRETARY & DIRECTOR GENERAL

भारत सरकार
कृषि अनुसंधान और शिक्षा विभाग एवं
भारतीय कृषि अनुसंधान परिषद
कृषि एवं किसान कल्याण मंत्रालय, कृषि भवन, नई दिल्ली 110 001

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MESSAGE

I am delighted to know that Sri Karan Narendra Agriculture University, Jobner- Jaipur and Indian Phytopathological Society (IPS) is organizing Platinum Jubilee and 8th International Conference (hybrid mode) on "**Plant Pathology: Retrospect and Prospects**" at SKN Agriculture University, Jobner-Jaipur, Rajasthan, India during March 23-26, 2022 to mark 75 years of service to the science & Society at India and also at international level.

Globally plant pathogens have adverse impact on the security of food, fibre and biofuel crops, and on the economy of the country. To minimize this sharp impact, plant pathologists across the globe have been working relentlessly and to mitigate the problems created by the biotic agents like fungi, bacteria, virus and phytoplasmas. The crop losses inflicted by different plant pathogens are one of the major key constraints in achieving the global food and nutritional security. Changing climatic conditions not only influence the phenology of insect-pests and diseases but also their time of appearance/ emergence consequently favoring their increased spread and damage potential of the disease.

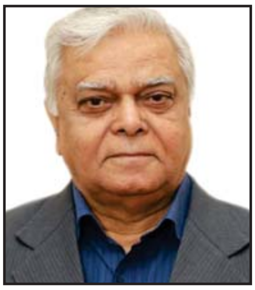
The conference being organized is the need of hour to address the major challenges. I hope and wish that the conference will serve as an outstanding platform for researchers and different stakeholders to communicate and imbibe novel ideas and information pertaining to the trending issues related to crop diseases and their management. I believe the outcomes of the conference will surely be helpful to enhance crop yield by reducing the crop loss incurred by plant diseases under Indian condition.

I extend my warm greetings and felicitations to the participants and the organizers and wish the conference a grand success.

T. Mohapatra
ICAR

Dr. C. D. MAYEE
Ph.D (IARI) New Delhi, D.Sc.
AvH Fellow (Germany), NAAS Fellow,
Chairman: Agriculture Finance Corporation (Mumbai)
Agrovision Advisory Committee (Nagpur)
President: ISCI (Mumbai), SABC (New Delhi)
Board Member: African Biosafety Network (Uganda)
Dr. PDKV Akola, ISAAA (USA), SKAUST, Srinagar, (J & K)

Former :
Chairman, ASRB (ICAR), New Delhi
Agri Commissioner, GOI, New Delhi
Director, CICR, Nagpur
Vice Chancellor, MAU Parbhani



MESSAGE

I am very happy to know that Indian Phyto pathology Society, one of the oldest scientific societies in the country, has decided to celebrate Platinum Jubilee as the 8^{th} International Conference on Plant Pathology at SKN Agriculture University, Jobner-Jaipur during March 23-26, 2022. The science and the art of plant pathology has undergone several alterations and now the scientists are looking into new areas of science research to explore and understand the nitty gritty of plant disease systems and also the way we manage them in field. The latest tools of CRYAPER/Cas 9 and other gene editing techniques are being used by plant pathologists all over the world to incorporate resistant traits in crops that can become resistant to array of pests and pathogens. The technology is being improved continuously with discovery of better enzymes and engineering-inducible gene editing system as well as improved methods of delivery of gene editing machinery to become more precise. I am sure Indian Plant Pathologists will take advantage of such tools and techniques to develop sustainable resistant cultivars in future when the theme of the conference is look in retrospect and prospects and examine what we have achieved in the last 75 years and what is yet to be achieved in the next 75 years.

I wish the conference a grand success and congratulate the organizers for the most appropriate way to celebrate the platinum jubilee of the IPS

(Dr C.D.Mayee) **Date: January 05, 2022**

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डॉ. पी. के. चक्रबर्ती

सदस्य (पौध विज्ञान)

Dr. P.K. Chakrabarty ARS, *FNAAS*

Member (Plant sciences)

March 12, 2022

Message

I am pleased to learn that the Indian Phytopathological Society is organizing the Platinum Jubilee Celebration and International Conference to mark 75 years of its institution and services to the cause of plant protection Science. I am equally pleased that on this occasion the Society is organizing the 8th international conference on "**Plant Pathology: Retrospect and Prospects"** at SKN Agricultural University, Jobner, in Jaipur, Rajasthan, India during March 23-26, 2022. FAO estimates global losses of food crops due to weeds, diseases and insect pests between 20-40%. The objective of Plant pathology, which deals with the study of cause, etiology, resulting losses and control of disease, since the inception of the Society in 1947 remains the same as today. However, advancement in cutting edge Science and technologies in Plant pathology 75 years hence, provides humongous **prospects** in plant disease management. Nevertheless, the responsibility of protecting crops from diseases in the challenging environment has increased with increase in human population, globalization, climate change and trade. It is in this regard we need to address increasing challenges effectively and strategically using the prospects of advances in plant protection sciences. Thus the theme of the symposium is apt in today's context.

Protection of losses from pests and pathogens is paramount to food and nutritional security and national prosperity. Future research may target novel and innovative methods contrived after deciphering molecular mechanism of host-pathogen/insect interactions. Coupling artificial intelligence for pest/disease monitoring and diagnosis can result in greater precision on pest survey/surveillance. The next generation of products in the field of crop protection should focus more on use of tools and techniques such as antimicrobial peptides, recombinant antibodies, gene silencing, genome editing using CRISPR-CAS 9, etc. Host Induced Gene Silencing (HIGS) and Spray Induced Gene Silencing (SIGS) through application of miRNA and sRNA offer best alternatives to minimizing use of ecologically hostile chemotherapeutants for management of biotic stresses in agricultural crops.

Involving concerns of various stakeholders of agriculture in decision making and leveraging potential of Scientists, Industries, Government can improve the efficiency of management manifolds. Lack of enabling policies for effective implementation of management strategies often paralyze the innovative interventions. A basic tenet for effective management lies in understanding various limitations by the policy makers so that rational ways and means can be developed with enabling policies for deployment of such technologies.

I am sure the symposium will discuss not only the scientific advancements in the field of Plant Pathology Research, but also discuss the farmer's concerns and industrial perspectives, so that the losses due to diseases can be strategically kept below the economic threshold limits. I laud the efforts of the IPS towards this endeavour and wish organizers and the symposium a grand success.

P. K. Chakrabarty

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MESSAGE

I am pleased to know that the Indian Phytopathological Society, New Delhi is organizing Platinum Jubilee and 8th International Conference (hybrid mode) on "**Plant Pathology: Retrospect and Prospects**" at SKN Agriculture University, Jobner-Jaipur, Rajasthan, India during March 23-26, 2022 to mark 75 years of service to the science & Society at India and also at international level.

Maintaining Plant health is as important as human health since 80% of the food we eat comes from plants, and to emphasise this, UN had declared 2020 as International Year of Plant Health amid COVID-19 pandemic. More than 800 million people do not have adequate food and many malnourished as well auguring bio-fortification for attaining nutritional security and Hon'ble Prime Minister had dedicated 17 bio-fortified crop varieties to cater this demand. At least 10% of global food production is lost to plant diseasestarting from the Irish famine due to late leaf blight in potato and Bengal famine due to leaf spot disease in rice. Developing effective environmentally safe crop protection technologies is essential for sustainable agricultureand attaining an environmentally responsible world. Several pathogens like fungi, bacteria, viruses, viroids and phytoplasmas cause major losses in horticultural crops as well leading to perennial setbacks in production potential as well.

The present conference would serve to address major important issues like plant-microbe interactions, fungal, viral, bacterial and nematode diseases of agricultural crops and their management, fungicides/ bactericides- a global perspective from industries, impact of climate change on plant diseases, disease complex/IDM approaches and policy issues, industrial linkages/extension plant pathology, to achieve sustainability in food production in India.

I hope that the delegates in the 8th International conference will deliberate upon the important issues relating to plant pathological problems of the country and will come out with suitable recommendations.

I congratulate and wish all success to the organizers and participants of the international conference.

AKUS

Date: 17th March, 2022

Dr. A K Singh

VICE-CHANCELLOR SECRETARIAT
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Jobner, District - Jaipur (Rajasthan) Pin-303329
Phone: 01425-254039, 254555, Email : vc@sknau. ac.in

Prof. J.S. Sandhu
Vice-Chancellor
Ex-DDG (Crop Science), ICAR &
Agriculture Commissioner, Govt. of India

Message

I am glad to know that Indian Phytopathological Society, New Delhi is organising 8th International Conference on Plant Pathology: Retrospect and Prospects on March 23-26, 2022, with the aim of the conference is to have a flashback of the journey of Plant Pathology in India till the platinum jubilee year and to look forward to its future in global perspective.

Plant Pathology is challenging and important science of disease development and ability of managing diseases. Society, consumers and growers will able to continue to benefit from Plant Pathology if this science comes out with findings for significant plant protection measures.

I hope this conference will provide a platform for students, teachers, researchers, agro-industries and growers from all over the nation to discuss various issues for resolving major plant protection issues.

I extend my warm greetings to all the delegates of the conference and hope the deliberations will pave the way for amelioration plant protection challenges. I wish the International conference all success.

(J. S. Sandhu)
Vice-Chancellor

डॉ. नरेन्द्र सिंह राठौड़
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महाराणा प्रताप कृषि एवं प्रौद्योगिकी विश्वविद्यालय
विश्वविद्यालय परिसर, उदयपुर–313001 (राजस्थान), भारत

No. PS/VC/MPUAT/2022/२१
Date: 7th January, 2022

Message

I am pleased to know that Indian Phytopathology Society is organizing an International Conference entitled 'Plant Pathology: Retrospect and Prospects' along with Platinum Jubilee celebrations of the society during 23-26 March 2022 at SKN Agriculture University, Jobner. I congratulate all the members of the society on the instance of Platinum Jubilee celebrations. India has come a long way to the production status of 308 MT food grain and 331 MT of horticultural production in 2021. The contribution of Plant Pathologists in this expedition of steady increase has been of high order. We know that crop pathogens cause substantial yield and economic losses and reduce food security at household, national and global levels. Therefore, control of plant diseases is crucial to the unswerving and sustainable food security. Hitherto, disease control has been reasonably successful for most crops with the given tools and techniques. However, there have been selection pressures for the pathogen's adaptation and evolution due to intensive input use. Climate change also threatens to alters stages and rates of development of the pathogen, mutate host resistance and result in changes in the physiology of host-pathogen interactions. Therefore, with the understanding of the dynamic nature of the plant diseases, the management approach must be in line with the environmental-acceptability and circumstances prevailing in the agriculture field as well as markets. The conventional plant pathology will have to make way for technology driven pathogen detection and management systems to combat the fast changing scenario. The modern molecular biology methods utilizing essential bio-molecules have modernized detection of plant diseases. Further, the plant disease management practices such as development of transgenic plants, generation of plant resistance through molecular breeding including marker-assisted selection and quantitative trait locus and bio-control of plant diseases using beneficial microbes will have to make way for conventional methods. Looking to the multifaceted and complexity of the issue of sustainability in agricultural production, a trans-disciplinary approach and multi-sectoral actions, integrating agriculture, environment, economy, and socio-cultural issues has become inevitable. I hope that discussions on novel approaches of plant disease management shall be pondered upon during the conference. I congratulate the organizers for hosting the conference in the Platinum Jubilee year and desire that fruitful presentations and discussions are made and the recommendations are documented for the policy makers and the stakeholders so as to show the exact worth of the event. I wish the conference a grand success.

(Dr. Narenda Singh Rathore)

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उत्तमा वृत्तिस्तु कृषिकर्मैव

प्रो. आर.पी. सिंह
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January 10, 2022

Message

I am pleased to learn about the Platinum Jubilee Celebration of the Indian Phytopathological Society (IPS), New Delhi and congratulate the President and the officials of the society for this achievement. I also extend my good wishes for the 8th International Conference on "Plant Pathology: Retrospect and Prospects" to be held at SKN Agricultural University, Jobner, Jaipur, Rajasthan during March 23-26, 2022.

Plant diseases not only threatens the economical balance of the farmers but of the country and to be wider the whole world. There are so many examples of epidemic appearance by virulent pathogens in different regions of the world from time and again. Sustainability in agricultural growth is largely dependent upon health of the crop. These need to be addressed by the plant pathologists and develop simple, practical and economically viable strategies for successful plant disease management. Now a day, so many new technologies are available which can be used to tackle these problems.

I am sure the International Conference will provide a great opportunity to the Plant pathologists from across the continents to interact extensively on the current and emerging issues to plant pathogens, crop health and plant disease management and come up with certain workable recommendations.

I strongly recommend use of applications of biotechnology in plant pathology and once again convey my best wishes for the International conference as well for the publication of a useful souvenir on this occasion.

R.P. Singh

(R.P. Singh)

Prof. DC Joshi
Vice-Chancellor

AGRICULTURE UNIVERSITY, KOTA
Borkhera, Baran Road, Kota 324 001 (Raj.)

MESSAGE

I feel very much delighted that the Indian Phytopathological Society is entering 75th year of its establishment and service to the science & society in India and also at International level. I am happy to know that the Society is organizing Platinum Jubilee Celebration and International Conference on "Plant Pathology: Retrospect and Prospects" at SKN Agricultural University, Jobner during March 23-26, 2022.

I extend my warm greetings to organizers and participants and wish the Conference a grand success alongwith the grand celebration of the Platinum Jubilee.

(D. C. JOSHI)

Dr. P. Chowdappa
Vice- Chancellor
Bharatiya Engineering Science and
Technology Innovation University
Anantapur, AP

MESSAGE

I am happy to learn that Indian Phytopathological Society, New Delhi is organizing International Conference on **"Plant Pathology: Retrospect and Prospects**" during March 23-26, 2022 at SKN Agricultural University, Jobner-Jaipur, Rajasthan to mark 75 years of its service for the cause of science of Plant Pathology, farmers, industry and other stakeholders.

An estimated 20-40% of crop yield is lost to pests and diseases every year. Plant disease epidemics were responsible for several historic famines, most notoriously the Irish potato famine of the 1840s and the Bengal famine of 1943. Most recently, 13-A2 clonal population of *Phytophthora infestans* migrated from Europe triggered devastating epidemics on tomato in India. Losses of staple cereal crops directly affect food security while losses in horticultural crops and forest plants have major impacts on nutrition, livelihood security, economy and ecosystem.

The management of plant diseases is very important in improving food security to overcome the challenge of feeding the current and future population. As a result of Green Revolution, there was three- four fold increases in cereal production over the period of 1960-2000. Plant pathology played its role in ushering green revolution; indeed, Dr Norman Borlaug, Father of Green Revolution, was a plant pathologist. Dr Borlaug did not practice plant pathology but worked across disciplines to bring Green Revolution. Multidisciplinary approach is need of the hour in tackling plant pathogens as plant pathology shares an interface with all disciplines in agricultural, horticultural, chemical, engineering, environmental and social sciences in meeting the challenges of food security and environmental stewardship in the twenty-first century.

The curriculum of Plant Pathology has to be redefined to address the issues of industry and farming community in view of emerging plant pathogens, fungicide resistance, breakdown of host plant resistance, and climate changes. Various skills in artificial intelligence and machine learning, robotics, drone technologies and social sciences have to be imparted to students of Plant pathology to make them ready to tackle issues.

I congratulate organizers for timely holding of such an important international symposium and my best wishes for grand success of symposium.

(P. Chowdappa)
Former Director
ICAR-Central Plantation Crops Research Institute Kasaragod, Kerala
and
Former President, Indian Phytopathological Society, New Delhi

PANJAB UNIVERSITY
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Dr. S. S. Chahal
Honorary Emeritus Professor
(Former Vice Chancellor, MPUAT (Raj),
DBU and Khalsa University (Pb.)

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MESSAGE

The Indian Phytopathological Society (IPS) has completed seventy four years of its magnificent existence and played a central role in development and dissemination of knowledge of plant pathology. It has immensely contributed towards food grains production in India which has touched 308 million tonnes (MT) alongwith 331 MT of horticultural production. The country is now in surplus position but due to shortage of modern storage capacity and limitations of cold chain facilities at various levels of marketing, there is colossal loss of food grains, fruits and vegetables. Under such a situation, it is obvious to explore avenues for export rather than allowing the produce to go waste. It is however, noteworthy that our export of agriculture and allied products is not consistent in its growth. To promote it, there is need to improve quality to meet international standards. However, rejection of export consignments due to certain Sanitary and Phytosanitary (SPS) issues in recent years still is the major barriers in promotion of export from India. For solving SPS issues, foremost important is to ensure conformity to the standards of importing countries. Following good agricultural practices such as reducing the use of pesticides, particularly those banned in importing countries, global best practices necessary to maintain food hygiene, refining testing procedures and undertaking corrective measures regularly are important to remain relevant in competitive global market. Establishing reliable product traceability system supported by proactive measures with adequate forecasting system for the expected problems and undertaking corrective measure is the most successful way of resolving a number of SPS issues. There is continuous urgency for improving export infrastructure including mechanisation and mechanising the methods for various processes, appropriate packing as well as storage and shipping conditions to maintain good quality of export material.

It is heartening that to mark the 75th year of establishment the Society is organizing Platinum Jubilee Celebrations and 8th International Conference (hybrid mode) on "Plant Pathology: Retrospect and Prospects" at SKN Agricultural University, Jobner-Jaipur (Rajasthan) India during March 23-26, 2022. The deliberations are meticulously planned covering almost all the aspects related to plant pathology. It is expected that all such issues, including such as mentioned above, will be deliberated and the conference will provide an excellent forum for sharing latest information and catalysing opening of new vistas in plant pathology.

I extend all my good wishes for the success of this mega event of the Society.

S.S. Chahal

(S. S. Chahal)
Honorary Fellow IPS

INDIAN AGRICULTURAL RESEARCH INSTITUTE

Anupam Varma
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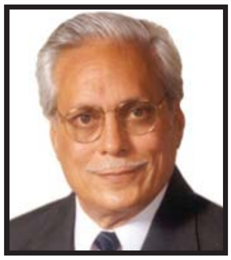

Advanced Centre for Plant Virology
Division of Plant Pathology
New Delhi - 110 012, India

MESSAGE

I am very happy, indeed, that the **Indian Phytopathological Society is celebrating the Platinum Jubilee this year.**

The fraternity of plant pathologists will always remain indebted to Dr. B.B. Mundkur for his vision is in establishing the Society in 1947 to promote the science of Plant Pathology in the country and for a wider role of Plant Pathology for societal development. Since then the society has grown from strength to strength. It is heartening to know it is the third largest Society of Plant Pathology with a membership of over 2000 plant pathologists representing about 50 countries. On this special occasion, we must also thank the stalwarts like Dr S.R. Bose, Dr J.F. Dastur, Dr R.S. Vasudeva, Dr R. N. Tandon, Dr T. S. Sadasivan, Dr Thirumalachar, Dr R.K. Saksena, Dr K.S. Thind, Dr K.S. Bhargava, Dr S.P. Raychauduri, and others, for their leadership, valuable guidance and untiring efforts in promoting the cause of Plant Pathology and the Society.

The 1st International Conference of Plant Pathology was organized by the Society in 1966, which was precursor for the establishment of the International Society of Plant Pathology. The Society also organised International Conferences to celebrate the Silver and Golden Jubilees. All these conferences were very well attended and motivating with the participation of prominent national and international plant pathologists. I am sure the International Conference on “Plant Pathology: Retrospect and Prospect”, which is being organised at the SKN Agricultural University, Jobner, Rajasthan, during March 23-26, 2022, to celebrate the Platinum Jubilee of the Society, will be another important landmark of the Society.

I warmly congratulate you and your colleagues for developing a very nice programme for the Platinum Jubilee Celebrations and the International Conference.

Wishing the Coference at Jobner grand success.

With best wishes

Anupam Varma

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MESSAGE

It gives me an immense pleasure to note that the Indian Phytopathological Society has completed 74 years and entering 75th year. IPS is also celebrating Platinum Jubilee and conducting an international conference at SKNAU, Jobner, Rajasthan from March 23-26, 2022 on an important topic entitled" Plant Pathology: Retrospect and Prospects". I convey my hearty congratulations to Prof. Prathiba Sharma, IPS President, Dr. Robin Gogoi, Secretary, all other executive members, organizers, life members, general members, delegates, and eminent plant pathologists.

Agriculture is the backbone for every country as it supplies food, feed and confers nutritional security of global population, which may reach 10.5 billion by 2050. Around 8.9% global population suffers from hunger. In this regard it is the duty of plant pathologists to save the crop loss and help the farming community. Around 30-40% of losses are incurred due to pests and diseases on crop plants. The host pathogen interaction under favorable environmental variables result in disease production. Excellent work has been done in this regard besides controlling the diseases using IDM. However, identification of plant pathogens using morphotaxonomy and molecular tools, though gaining importance, needs much more skills and HRD. This will enable the extension workers to identify the symptoms and the pathogen besides proposing control measures. The efforts by eminent plant pathologists in our country are enormous and creditable works have been done in genomics of plant pathogens and need to be congratulated for their concerted efforts. The production of disease resistant varieties and manipulation of environmental variables besides using biocontrol agents envisaged suitable disease control technologies. However, there is a necessity to strengthen the modern aspects of plant pathology, plant disease epidemiology, early detection of disease under field conditions, proper disease diagnosis, application of nanotechnology, development of disease resistant varieties in crops, application of remote sensing, drone technology, nanotechnology and other technologies so as to save the farm produce. Emphasis be laid on the unearthing hidden microbial and fungal diversity existing in our country. The conference topic selected by the IPS and organizers is of topical interest and applied value. I congratulate all the concerned in this regard and wish a grand success of the proposed conference with indepth deliberations.

11/1/2022

C. Manoharachary

R.K. Jain, FNAAS
Emeritus Scientist (ICAR) &
Former Dean (IARI)

Division of Plant Pathology
New Delhi-110012
1

MESSAGE

I am pleased to learn that the Indian Phytopathological Society (IPS) is organizing 8th International Conference on **Plant Pathology : Retrospect and Prospects** during March 23-26, 2022. The Society has a rich history of more than seven decades and has undoubtedly played crucial role in addressing issues concerning food security in general and save the harvest in particular by organizing National and International meetings and publishing the journal **Indian Phytopathology**.

The theme of the forthcoming international conference is very **apt.** It will be highly appropriate to do SWOT analysis during the conference in the backdrop of a recent review entitled **" Global challenge facing plant pathology : Multidisciplinary approaches to meet the food security and environmental challenges in the mid-twenty-first century"** by Jeger et al. published in CABI Agric Biosci (2021). I am confident that the conference will not only bring out success stories **(TOP TEN)** in plant pathology but also identify researchable areas for the next few decades such as Exotic and re-emerging pathogens, Easy to use diagnostics, New approaches to exploit genetic diversity, Development and use of novel plant protection molecules etc.

I sincerely wish good participation and science during the forthcoming conference.

R K JAIN

Punjab Agricultural University
Ludhiana, India

Dr. T.S. Thind
Ph.D., PDF (France), Fulbright Fellow
Honorary Adjunct Professor

MESSAGE

It is a great pleasure to know that Indian Phytopathological Society is organizing an International Conference on 'Plant Pathology: Retrospect and Prospects' at SKN Agricultural University, Jobner, Rajasthan during March 23-26, 2022 to mark 75 years of its establishment. The Society has contributed immensely in furthering the science of Plant Pathology and related disciplines and has addressed diverse plant health issues all through its glorious journey. The conference theme is aptly chosen to introspect the progress made in various sub-disciplines of Plant Pathology in ameliorating plant health and address present challenges and future needs.

Research in understanding the causes and nature of plant diseases and finding appropriate solutions for their management has traversed a long way from conventional observation-centric investigations to technology-driven, inter-disciplinary approaches involving modern technologies such as molecular biology (including CRISPR, RNAi, recombinant DNA technology), information technology, nanotechnology, remote sensing, etc. Undoubtedly, these technologies have greatly helped in advancing our knowledge about host-pathogen-environment interactions and have led to better control of some difficult diseases through target-based approach. Nevertheless, it needs to be seen that future plant pathologist does not get too much alienated from the actual field situations.

I am sure that this international conference will provide an ideal platform for plant pathologists from various geographical regions to interact and exchange new research findings on disease problems impacting crop health and will come up with new ideas for future research.

I extend my warm greetings and compliments to the organizers and participating scientists and wish them a great success for fruitful deliberations.

TSThind

Dated: 06.01.2022 (T.S. Thind)

Dr. A.K. Misra, ARS, FPSI, FISMPP, FINSOPP, FSDSH, FCHAI, FUPAAS
Former Project Coordinator AICRP (STF) &
Head, Division of Crop Protection,
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MESSAGE

I am happy that Indian Phytopathological Society is organising International Conference on "Plant Pathology: Retrospect and Prospects" on March 23-26, 2022, at Sri Karan Narendra Agriculture University, Jobner, Jaipur, Rajasthan. Since its inception, Indian Phytopathological Society has already successfully organised 7 international conferences and this is 8th in the series, which is part of platinum jubilee celebration. The conference theme is rightly selected as "Plant Pathology: Retrospect and Prospects". Really in a platinum jubilee year it is time to look back our achievements and find out our strength and weakness and prepare ourselves for the future challenges. Last time we gained experience by successfully organizing e- conference (during covid period), which was a successful unique experience. Activities went well by organizing lectures/ presentations in virtual mode. During the last 75 years plant pathologists have seen the various changes and it has changed from traditional and fundamental plant pathology to now molecular, diagnostic, genomic, commercial and smart plant pathology. The dedicated team of plant pathologists in the world has great responsibility to fight against hunger and malnutrition by protecting our crop with devastating diseases and ensure food security and health to the growing population. It is the duty of plant pathologists to boost production by protecting our crops from various diseases and minimize losses of pre and post harvest stages. In the era of climate change, the pathological problems are also changing and hence plant pathologists have greater role to see plant health in changing climate. Eco-friendly approach is essential without compromising food production. Hence, growing healthy crop with minimum diseases and post-harvest losses is the priority of plant pathologists. Indian Phytopathological Society is spread in more than 50 countries with over 2000 members. Definitely, it will be a great opportunity for the members to share their experience and fix future priorities. The conference is designed with four Thematic Sessions with International Workshop on Trichoderma which will be very informative, useful and interesting for the delegates of the conference.

I am sure the conference will focus on important areas and come out with practical implementable suggestions and recommendations.

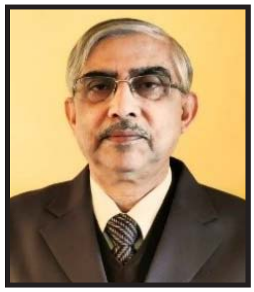
I wish the mega event a grand success.

A.K. Misra

Lucknow

Dated : 05.01.2022

Professor B.N. Chakraborty
FNAAS, FNBS, FRSC (London), FAScT,
FPSI, FISMPP, FISPC, FMSI, FIMS
Former President, IPS



MESSAGE

It gives me great pleasure to be associated with Platinum Jubilee Celebration of Indian Phytopathological Society (IPS) and International conference (hybrid mode) on "**Plant Pathology: Retrospect and Prospect**" during March 23-26, 2022 at Sri Karan Narendra Agriculture University, Jobner-Jaipur, Rajasthan, India. This Society (IPS) has successfully completed its journey of 75 years of its establishment with keen involvement of past presidents, secretaries, zonal presidents and councilors, executive council members, editorial board members as well as contributions made by each member to achieve an International status linking with American Phytopathological Society (APS). One of the key achievements has been the upgrading of the journal "***Indian Phytopathology***" by linking with Springer publication since 2018.

Sustainable plant health management is the key issue of global development with regard to food safety, food security and environmental preservation as well as protection. The dynamics of plant diseases and pest influx are changing rapidly mainly due to changing climate. Managing them has, therefore, become a huge challenge. Due to the climate change, the area under protected cultivation is gaining momentum. However, there is resource constraint to meet the needs of growing population with declining land and water with increased pressure of biotic and abiotic stress. Though several technologies are available in the omics era to detect plant pathogens, still the technologies towards the management of plant viruses, bacterial and fungal pathogens have to be addressed well. Intensified research on related issues could result in improved understanding and management of plant health in the face of different current and future extremes.

I wish the grand success of this event and believe that this would provide a useful platform for deliberation by learned delegates, fruitful discussions and interactions among scientists, research scholars and students as well as valuable recommendations for the benefit of farmers.

B.N. Chakraborty

(B.N.Chakraborty)

Prof. (Dr.) R. N. Pandey

Former President, IPS, New Delhi &
Professor & Head (Retd.)
E-mail: pande56@gmail.com Cell: 099259 52458

MESSAGE

It is a matter of immense pleasure that our society with glorious history is entering in 75th year of establishment and organizing "Platinum Jubilee Celebration and International Conference on "Plant Pathology: Retrospect and Prospects" and "Satellite Sympsium" on "Ameliorate Resilience of Arid Crops" at SKN Agricultural University, Jobner-Jaipur, India during March 23-26, 2022.

The Conference is planned to hold the Technical sessions on themes:1.Teaching in plant pathology, i.e. a. Evolving aspects of plant pathology teaching in India, b. New education policies (NEP) and impact on plant Pathology, etc.; 2. Basic research in plant pathology i.e. a. Taxonomy and systematics of plant pathogens, b. Genetics and ecology of plant pathogens, c. Genomics of plant pathogens, d. Mechanism of disease development, e. Host plant resistance, f. Epidemiology and crop loss assessment; 3. Applied research in plant pathology, i. e.

a. Diagnosis of plant pathogens, b. Resistant cultivar development, c. Success stories in plant diseases management; 4: Commercial plant pathology i.e. a.

Entrepreneurship, industry and business incubation in plant pathology, b. Smart agriculture with precision plant protection and fnally the much required International

Workshop on Trichoderma, etc. Plant Pathology in general and researches on Plant Health management in particular in our country has advanced very well. There has been tremendous progress in;

Characterisation and identif cation of plant pathogens and useful microbes with molecular markers; Microbial genomics; PGPR and bio-agents as bio-fertilizers and bio pesticides; Management of plant diseases, etc. The advances in microbial diversity, genomics, bio- informatics, etc. have brought into focus several applications of microbes viz. PGPR, bioagents, etc. Technologies for management of crop diseases and plant health through different approaches have been evolved by the scientists for the use of farmers.

The planning of the conference is meticulous, appropriate and timely and hope that the conference will provide a common platform to scientists, academicians, government agencies, students, farmers and industry personnel to meet and discuss their common interests in academics, research, innovations with dedicated objective of popularising the technologies of plant health management for eco-friendly and sustainable agriculture and to draw a road map for future course of action for policy makers. During the current year the EC has worked well to organise a series of lectures delivered by Eminent Scientists.

I take this opportunity to express gratitude with thanks to Dr Trilochan Mohapatra, Secretary, DARE and DG, ICAR, New Delhi & Dr. J.S. Sandhu, Vice Chancellor, SKNAU, all the Patrons & Heads of different institutions for their guidance and encouragement.

I also thank profusely to the members of Organizing Committee, Dr. Pratibha Sharma, President IPS, and Chairperson, Dr. Rakesh Pandey, President-elect, IPS, and Co-Chairperson; Dr. M.L. Jakhar, Director Research & Organising Secretary; Dr. Mahabeer Singh, Head (Plant Pathology) and Dr. Rajesh Bagri, RARI, Co organising Secretary, for their whole hearted effects to successfully organise the Conference.

I take this opportunity to congratulate and thanks profusely to Dr. Robin Gogoi, Secretary & Convener; Dr. Kalyan K. Mondal, Jt. Secretary, Dr. Malkhan Singh Gurjar, Treasurer and Dr. Ritu Mawar, Principle Scientist & Co Convenors, all the EC members of IPS, Advisory Committee and members of different Committees, and all those who have put their untiring efforts to organise the Conference and wish the conference a grand success.

12 th February, 2022

(R.N. Pandey)

DEAN, FACULTY OF AGRICULTURE
अधिष्ठाता, कृषि संकाय
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डॉ. एम.पी. ठाकुर
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पूर्व अध्यक्ष, अखिल भारतीय पादप रोग विज्ञान समिति, नई दिल्ली

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MESSAGE

I am very happy to learn that Indian Phytopathological Society, ICAR-Division of Plant Pathology, IARI, New Delhi is organizing an **8th International Conference** on "Plant Pathology: Retrospects and Prospects" during IPS Platinum Jubilee Celebration of the society from March 23-26th, 2022 at Sri Karan Narendra Agriculture University, Jobner-Jaipur (Rajasthan), India. If we see the progress made by this society in Plant Pathology in the last 75 years, then one has to feel happy and satisfied that the purpose for which the society was established by the founders is fulfilled. The society has organized seven International and National Conferences on various topics to address the emerging issues and problems in Plant Pathology faced by the farming community in timely diagnosis of the diseases, characterization of the disease causing agents, understanding the mechanisms of host parasitic relationship and finding suitable solutions using advanced biotechnological tools and IT interventions leading to overall combat plant diseases in a integrated manner. The society has collaborated with dozens of like minded academic societies engaged in solving the problems of Plant Protection. IPS has joined hands with American Phytopathological Society, USA few years back and has widened its base to reach to the wider plant protection community from several countries of the world in order to exchange of their ideas, thoughts, innovations in addressing problems related to the field of Plant Pathology.

I think the objectives framed by the founders of plant pathology in establishing the society to debate on plant pathological issues and come out with suitable solutions have been very well addressed in the last 75 years. The society has now about 2500 life or annual members in >45 countries and become the third largest society of Plant Pathology in the world. There are dozens of awards/recognitions instituted by the society to recognize the talents in solving the plant pathological problems within and across the field. The society has published different books, publishing one of the renowned quarterly journal '*Indian Phytopathology*" with Springer Nature, Annual Reports, quarterly IPS News letter for the benefit of the students, researchers, extension personnels and different stakeholders.

I wish the 8th International Conference of the society a grand success.

(M.P.Thakur)

INDIAN PHYTOPATHOLOGICAL SOCIETY

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

Dr. Pratibha Sharma
President, IPS

MESSAGE

It is matter of great happiness to know that Indian Phytopathological Society, New Delhi is organizing Platinum Jubilee and International Conference (hybrid mode) on "**Plant Pathology: Retrospect and Prospects**" at SKN Agriculture University, Jobner-Jaipur, Rajasthan, India during March 23-26, 2022 to mark 75 years of service to the science & Society at India and also at international level.

Plant diseases have always been a major constraint in the production and productivity of agri-horticultural crops. The vast diversity of different cropping patterns, prevailing environmental conditions and evolving virulent pathotypes leads to the occurrence of devastating diseases in different parts of India. Characterization of pathogens is very important in order to design the durable management strategies. These situations demand for the collaborative and systematic approaches for characterization and management of prevalent pathogens. The topic and different themes of conference are very pertinent and it is hoped that fruitful deliberations will be made which will lead to the concrete recommendations in management of emerging and re-emerging plant pathogens for achieving sustainability in food security.

I foresee there will be comprehensive interactions and discussions in all the technical sessions under the specified themes in the conference. The final outcome of the international conference will make possible to bring out a document with respect to the basic and applied researches which will hold up agricultural sciences and sustain food security.

I wish my best and hearty congratulations to my team members and the co-organizers and their team members for coming forward to organize the conference in hybrid mode, and also taking opportunity to wish the researchers, students and extension workers for their ventures extended to the greater cause.

I further wish the international conference to be the most prolific and grand success.

(Pratibha Sharma)

Dated: 14th March, 2022

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Dr. M. L. Jakhar
Director Research

Azadi Ka Amrit Mahotsav

Message

Over the next decades, global issues relating to climate change and international biosecurity associated with increasing trade and air travel will lead to new challenges in all areas of agriculture and the environment, including the management of plant diseases and their societal impact. Hence, a forum for communication of research findings related to these global issues, from the molecular and ecological interactions among plants, pathogens, other microbiota, and vectors, to aetiology and epidemiology of disease in field populations and diverse landscapes, is essential if these challenges are to be met.

I am happy to learn that the Indian Phytopathological Society, New Delhi is organising an International Conference on theme "Plant Pathology: Retrospect and Prospects on March 23-26, 2022 at Jobner. It is hoped that the discussion on various themes of the conference will pave way for evolving future strategies on improving Phytopathological strategies for food security in the world.

I congratulate the organisers for this initiative and wish the event a grand success.

(M. L. Jakhar)
Director Research

Indian Phytopathological Society

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RAKESH PANDEY
Ph.D., DAAD Fellow, FNAAS
Professor Emeritus AcSIR & CSIR- Emeritus Scientist
President-Elect, Indian Phytopathological Society

MESSAGE

Indian Phytopathological Society will be conducting the Platinum Jubilee Celebration and International Conference on "Plant Pathology: retrospect and Prospects" at SKN Agriculture University, Jobner, Jaipur (Rajasthan) during March 23-26, 2022. The present international conference would serve to address major important issues related to teaching, commercial aspects of plant pathology, basic and applied research related to plant pathology with major emphasis on *Trichoderma* workshop which has direct impact on plant health, environment and food security.

The present conference will provide a good platform for the plant health specialists, extension researchers and molecular plant pathologists from both academia and industry to come together, discuss, deliberate and to devise strategies to contain the threats posed by variety of plant pathogens on various agri crops including medicinal and aromatic crops to ensure food security, environmental and human health.

On the occasion of the completion of 74 years of IPS dedicated service to the nation, this platinum jubilee conference is an attempt to provide highlights of major Phytopathological works towards promoting Indian Agriculture. I convey my best wishes to the organizers and participants and hoping for the event to be a grand success.

Thanking you

(Rakesh Pandey)

January 10, 2022

To: The Indian Phytopathological Society
Date: January 28, 2022

The International Society for Plant Pathology extends warm congratulations to the **Indian Phytopathological Society** as the IPS begins Platinum Jubilee Celebrations marking 75 years since its establishment. We wish you a joyous and intellectually stimulating celebration during the ***8th International Conference on Plant Pathology: Retrospect and Prospects,*** to be held March 23-26, 2022 at SKN Agricultural University, Jobner-Jaipur, Rajasthan, India.

ISPP looks forward to future collaborations with IPS!

Best regards,

Jan E Leach

Jan E. Leach
ISPP President

Indian Phytopathological Society

(Regn. No. S399 of 1949-50 under Societies Registration Act XXI of 1860)

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Dr. Robin Gogoi
Secretary

MESSAGE

Crop Protection is one of the major dimensions in Agriculture, and Plant Pathology is the major area in it. On an average, crop diseases pose about 19-22 per cent yield loss annually which has been remaining a major concern for the plant pathologists. The science of plant pathology in the educational institutions of India has got tremendous momentum since its beginning from 1905. This agricultural science has ably shown positive impact in the research fields and every corner of the farmers' fields and contributing to the country's higher productivity. It is the happiest moment for all of us that the Indian Phytopathological Society (IPS) has successfully completed 75 years after its foundation in 1947 laid by the visionary person B. B. Mundkur. Under the umbrella of this Society, our pledge is to continue relentless services to the Indian Agriculture and to support the farmers' livelihood. Henceforth, the Society is going to celebrate its **Platinum Jubilee and 8th International Conference in Hybrid mode on the theme "Plant Pathology: Retrospect and Prospects" during March 23-26, 2022** at Sri Karan Narendra Agriculture University, Jobner-Jaipur, Rajasthan, India. A large number of plant pathologists and crop protection scientists from India and abroad, research scholars and post graduate students will take part in this conference by attending physically and online as well. They will place various findings and ideas in four major technical sessions, namely, Teaching, Basic and Applied Research in Plant Pathology, and Commercial Plant Pathology. In addition, the Conference has covered a satellite programme of "International Workshop on *Trichoderma* and *Gliocladium*" keeping in view of the organic cum natural farming in India. I am convinced, there will be close interactions and thorough discussions in every technical session and the final outcome of the conference will facilitate to bring out a functional document with respect to the basic and applied research.

I am pleased to welcome you all to the 8th International Conference of the IPS convening in the beautiful campus of SKN Agriculture University, Jobner. I am, and the Society is highly indebted to the Vice Chancellor of the University for hosting the grand programme of the plant pathologists. I wish my best and hearty congratulation to the organizers and their team members for coming forward to convene the conference. I further hope, all the participants will enjoy openly in this get-together happening first time after the confinement of serious Covid-19 period.

In advance, I wish the International Conference to be a grand success.

Dated: 15th March, 2022

(**Robin Gogoi**)

New Delhi

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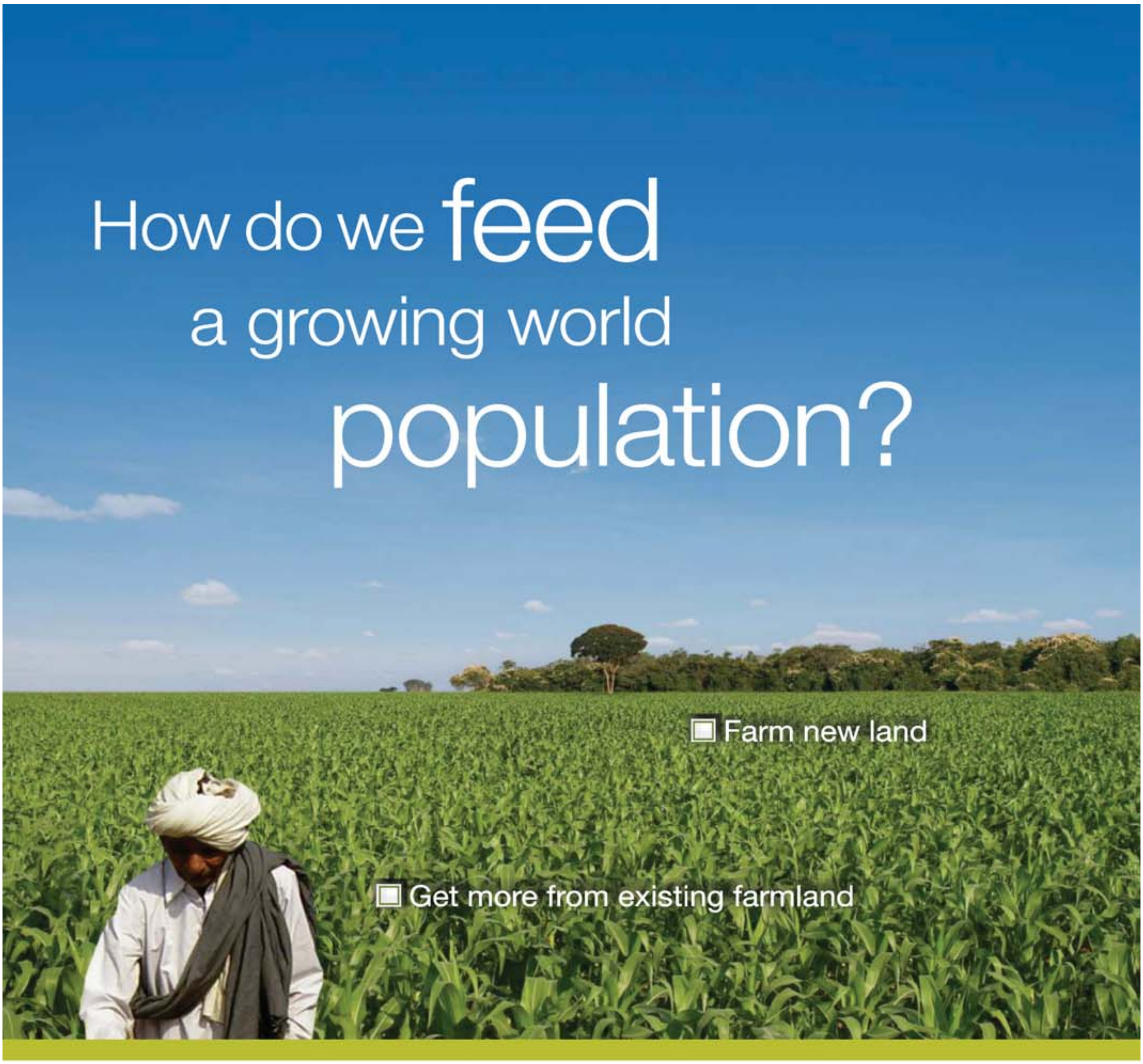
भारत गाँवों में बसता है
- महात्मा गांधी


How do we feed
a growing world
population?
Farm new land
Get more from existing farmland

Award Lectures/
Plenary Lectures

Presidential Lecture

AL(01):Biocontrol Strategies- Retrospect and Prospects

Pratibha Sharma*
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Tubeuf (1914) coined the term 'Biological control' in relation to the plant pathogens, while Hartley (1921) first attempted to control root diseases of plant with introduced microbes. Cook and Baker (1983) defined biological control as the reductions of the amount of inoculums or disease-producing activity of a pathogen accomplished by one or more organisms other than man. Harman (2000) defined biological control as a critically needed component of plant disease management. Important genera used as biocontrol agents include *Trichoderma, Gliocladium, Aspergillus, Penicillium, Neurospora, Chaetomium, Dactylella, Arthrobotys*, *Glomus*, *Pseudomonas fluoresens*, *Bacillus subtilis* and *Streptomyces* species. The term "biological control" or "Biocontrol" have been used in different fields of biology, most notably entomology and plant pathology. The organism that suppresses the pest or pathogen is referred to as the Biological control agents (BCAs) which are used now-a-days instead of Biopesticides. Among the agents some also have the ability to increase plant growth, so these should be considered as plant growth promoting agents. Since the current day emphasis is on sustainable agriculture therefore, possibility of seed/planting material treatment and biopriming of nurseries with biopesticides/ BCAs should be given priority at all levels. Different microbial consortia can also be used for better control of plant diseases. Mukhopadhyay (1987) highlighted that "Biological control of soil borne plant pathogens by *Trichoderma* spp. and other bioagents as a vital area of plant pathological research all over the world these days". Biological plant protection is too important component in the eco-friendly management of plant diseases all over the globe. It is now widely accepted that biological control of crop diseases is a distinct possibility for the future and can be exploited within the framework of Integrated Pest/ Disease Management System. The idea of a well-developed biological system management through the manipulation of agroecosystems is an urgent requirement to do away pesticidal hazards. Research on the release of naturally occurring antagonists and enhancement of resident antagonist are definitely a part of the recommendation combo of a plant protection manager, but the mechanism part is totally missed out. The study on the introduction of microorganisms, promotion of root health, shift in microbial diversity, influence of soil nutrients and organic amendments are the specific features associated to the inundative approaches and biodiversity. The studies on the genetic binding of a microorganism to a plant system are also important feature which highlight the rhizosphere specific microbial communities. The role of crop cultivars is still unknown and studies in this area will help to understand the plants ability to attract and support Rhizosphere specific microbial communities. The importance of entophytes needs attention which has remained a neglected area, since this could make us understand rhizosphere specific microbial community structure for root health. Improved techniques should allow analysis of the biological system management through estimation of natural biological activity in soils in absence of soil suppressiveness. Endophytes and plant growth promoting bacteria help in rhizosphere to control the growth of many soilborne pathogens. In nature, due to the interaction of several populations of microorganisms, soil suppressiveness usually limits disease incidence efficiently and consistently. But in absence of this phenomenon, we are bound to use the introduced antagonists, which are target specific limiting the crop protection and therefore multitargeted biological control strategy is required. The interaction

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between plant pathogens is not only affected by the density or microbial spectrum of the community, but also by the function or activity of the individual components in that community. Our lack of knowledge of how these interrelationships works are driven along with the fact that a vast number of soil microbial species are still unknown which require more research. We really need to clearly understand how the natural soil populations, microbial diversity and community are influenced by different agro ecosystems and environment. The trend towards a Biological System Management is to develop an integrated relationship between the biological system of the agroecosystem with the crop production system. The interrelationships between biological entities –plant, pathogen, pest and microbial community with a particular ecosystem play an important role in developing management strategies. Today research on biocontrol is a buzz word and vogue of every lab not knowing its fate. Large number of experiments are being designed for sake of a publication. Reviews are available on this subject which allows us to understand that how antagonists have established their role in the management of pests. To prioritize biocontrol research and application definitely is an utmost requirement of all plant protection managers since, biocontrol directly or indirectly has become an important component. Some excellent field researches conducted are not of academic interest, and it leaves you alone but the technological transfer would greatly aid in reducing the amount of confusion among growers for whom the technologies are developed. Role of industry needs to be emphasized and they should also come out with their viewpoints We really also need to develop a second generation of BCAs besides the most promising and common tested BCAs. Commercial use and application of biological disease control have been slow mainly due to their variable performances under different environmental conditions in the field. This problem can be solved by better understanding of the environmental parameters that affect the biocontrol agents. In addition to this problem, there has also been relatively little investment in the development and production of commercial formulation of biocontrol active microorganisms probably due to the cost of developing, testing, registering, and marketing of these products. Biological control agents are generally formulated as wettable powders, dusts, granules and aqueous or oil-based liquid products using mineral and organic carriers. Many companies with more diverse product lines including a variety of agrochemical and biotechnological products have played a significant role in the development and marketing of the products for the control of plant pathogens. To improve commercial use and application of biological disease control it is extremely important to emphasize and concentrate on several factors including training of growers, formulation of biocontrol microorganisms and studying the role of environmental factors. Biocontrol products are either marketed as standalone product or formulated as mixture with other microbial. Some products with biocontrol properties may not be registered but sold instead as plant strengthens or growth promoters without any specific claims regarding disease control. To help improve the global market perception of biopesticides as effective products, the biopesticide industry alliance is establishing a certification process to ensure industry standards for efficacy, quality, and consistency.

S.P. Raychaudhuri Memorial Award Lecture

AL(02): Dr. T. Mohapatra

Secretary (DARE) & Director General (ICAR), Krishi Bhavan, New Delhi, India

Mundkur Memorial Award Lecture

AL(03):Advances in Plant Pathology Research: Challenges and Opportunities

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The discipline of Plant Pathology is expanding requiring a multi-faceted interdisciplinary approach to understand the complexity of interactions for any given disease, disease complex or syndrome. Many recent developments in research has identified some key issues which need to be addressed to meet the global food security and to address the environmental challenges. A major concern in front of plant pathologists is to respond to challenges by contributing to a wider forum for multidisciplinary research, recognizing the impact that is going to be generated at national and international level. Linkages between plant pathology and other areas like precision agriculture; plant growth and development; decision analysis and disease risk; development and use of new and novel plant protection chemicals; new ways of exploiting host genetic diversity including host resistance deployment; new perspectives on biological control and microbial interactions; advances in surveillance and detection technologies; invasion of exotic and re-emerging plant pathogens; and the consequences of climate change affecting all aspects of agriculture, the environment, and their interactions are needed to be addressed taking a system biology approach. Climate change and international biosecurity associated with trade and air travel are the global challenges impacting society. Fungal pathogens are emerging and/or remerging in this scenario. In era of molecular biology, there is a need to understand pathogen evolution, biology, lifestyle, novel disease management strategies using molecular approaches besides understanding ecological interactions among plants, pathogens, and other microbiota keeping in view etiology and epidemiology, in order to meet these emerging challenges. During the last three decades, significant advances have been made in our understanding of plant pathogens and their interactions with the host through genomics led studies. The genomes of more than 1100 fungal species are available in the public domain. Plant pathogenic fungi comprised the largest category (35.5 %) in which plant pathogens are predominant. 191 genomes of pathogenic fungi are available in which 61.3 % cause diseases on food crops. In genomics era, genome sequence led diagnosis and management strategies have major role to curtail losses due to diseases. Concerted efforts have been made in the areas of host pathogen interactions, molecular characterization of pathogens/biocontrol agents, developing diagnostics for Karnal bunt pathogen (*Tilletia indica*), spot blotch (*Bipolaris sorokiniana*), rusts (*Puccinia triticina* and *P. striiformis tritici*) and *Chaetomium globosum* (biocontrol agent). This has helped in developing resistant varieties and integrated management of diseases. A novel toxin 'Bipolaroxin' was identified and characterized using NMR and GCMS in *B. sorokiniana* having role in pathogenesis. *B. sorokiniana*-wheat interactions at cellular and molecular level confirmed hemibiotrophism and led to the identification of significant upregulated defense genes. In genomics era, genome sequence led diagnosis and management strategies have played a major role to curtail losses due to diseases. Genomics and transcriptomics studies of fungal pathogens of national importance has generated a gamut of information which has helped in better understanding of pathogenesis, population dynamics of rapidly evolving pathotypes/races, their diagnosis and developing management strategies for minimizing losses caused by diseases. In this direction, high quality draft genome sequences of *Puccinia striiformis tritici* race I (38S102) (Accession No. MKXH00000000), *Tilletia*. *indica* isolate RAKB_UP_1 (Accession no. MBSW00000000), *Bipolaris sorokiniana* BS-112 (Accession No. RCTM00000000), *Fusarium fujikuroi* isolate F250 (Accession No. KM50526), *T. caries* and *B. oryzae* have been generated and published in NCBI database. Genomics and transcriptomics data generated on *Chaetomium globosum*, a biocontrol agent has led to the identification and expression analysis of significant genes involved in ISR and other mechanisms of antagonism. Studies have also led to the development of quick and reliable PCR/qPCR, LAMP and macroarray-based diagnostics for major pathogens. These advances will be discussed during the presentation along with challenges and opportunities.

Sharda Lele Memorial Award

AL(04):Phylogenetics, diagnostics, pathogenomics/ proteomics, functional genomics and potential target sites for the management of *Colletotrichum falcatum* causing sugarcane red rot

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Currently, red rot caused by *Colletotrichum falcatum* Went (Perfect state: *Glomerella tucumanensis* (Speg.) Arx and Muller) is the major limiting factor as it causes frequent breakdown of released resistant cultivars due to emerging new variants of the pathogen. Since knowledge on the genetic structure and evolutionary potential of pathogens are essential for breeding and management of plant resistance, population structure analysis of *C. falcatum* with large number of isolates was conducted using conserved gene sequences and molecular markers (ISSR, RAPD), which indicated major grouping of virulent isolates (95%) and minor grouping (5%) of least virulent isolates. Based on this, falcatum specific primers for PCR based diagnostics were identified, validated and being utilized. From phylogenetic studies, it had been inferred that the existence of high phenotypic variation is mainly due to adaptation of isolates to the newer cultivars resulting in breakdown of resistance. Hence further studies were conducted to characterize pathogenicity related genes/ proteins. For which, initially identified existence of pathogenicity gene homologs of other *Colletotrichum* spp in *C. falcatum* and then characterized pathogenicity related genes/ proteins under genomic and proteomic approaches. Further standardized functional analysis of genes by Knock-out and Knock-down (RNAi) approaches to confirm the identified gens in *C. falcatum* pathogenesis. Above all, a few potential target sites had been identified for fungicidal management under conventional approach for immediate application. Results of all these findings generated in relation to phylogenetics, its diagnostics, identification of pathogenicity related genes/ proteins, functional analysis of unique genes and characterization of candidate genes for disease management, deserve the credit on first kind of report with respect to *C. falcatum*.

Jeersannidhi Award Lecture

AL(05):Unravelling the enigmatic Sugarcane-fungal pathogen interactions from an "*Omics*" perspective

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Disease resistance in crop plants is an enigma to be unravelled, in spite of advances made in plant biology. The science of plant disease resistance has undergone a paradigm shift in understanding starting from the gene for gene concept to the rapidly evolving robust molecular biology platforms viz. Next Generation sequencing, Genome Editing, etc. An integration of the tools of "*Omics*" namely genomics, proteomics, metabolomics, etc. has strengthened in decoding plant-pathogen interactions at the molecular level. More specifically, genomics research with the phenomenal upsurge to the next generation sequencing platform and beyond has proven to be robust enough to decipher complete genetic information coding for useful traits of interest. Proteomics and Metabolomics are the complementary tools to genomics, which are gaining substantial progress in many crop plants like Rice, Maize, Sorghum, etc., besides having been well established in the model plant – *Arabidopsis*. There is an unprecedented acceleration in the pace, with which this tool of "*omics*" is carrying forward progressively to address many unresolved issues in Plant Pathology. It is quite evident that Proteomics and Metabolomics are powerful tools in the post-genomic era and plays a key role in empowering systems biology in plants. In sugarcane, the inadequate understanding on the contribution/distribution of multiple alleles to the complex traits such as disease resistance is strangling the breeding efforts, which could only be addressed by the development novel/new strategies that integrates various biotechnology tools. However, sugarcane genome sequencing is lagging a way behind, when compared to other related monocots like sorghum and maize, due to polyploidy, large size and complexity of sugarcane chromosomes. Considering the developments in sugarcane proteomics, in spite of absence of whole genome information of sugarcane, it is appropriate to state that the potential of proteomics has added enough leverage to decipher the interactome of disease resistance in sugarcane. With the accomplishments in elucidating sugarcane ESTs, which was ably supported to unlock the secrets of pathogenomics and pathoproteomics by exploiting the next generation sequencing platforms, it is now made possible to improve our understanding on the disease resistance in sugarcane. Hence, the integration of the tools of "*omics*" approaches would enable researchers to reconstruct the whole cascade of cellular events leading to rapid responses and adaptation to disease resistance in Sugarcane, the trait which accounts for considerable yield and quality loss.

A.N. Mukhopadhyay Oration Award Lecture

AL(06):Climate-Ready bioinoculants for sustainable crop productivity

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Crop plants and their microbiomes have co-evolved and microorganisms form an indispensable component of crop production systems across the world. With the rising concerns of climate change and climatic variability, occurrence of extreme weather events is on the rise in recent resulting in onslaught of biotic and abiotic stresses on the crops. Though, several microbial formulations have been developed and successfully commercialized, their performance is variable across agro-ecologies. One of the reasons could be that, despite endowed with excellent plant growth promoting traits, they are failing to withstand these stresses. In this backdrop, climate-ready microbial inoculants are a boon provided they deliver anticipated results. Thus, it is imperative to identify abiotic stress tolerant strains of beneficial microorganisms and understanding their mechanisms. By studying the impacts of elevated temperature and CO_2 on these microorganisms, suitable adaptation strategies could be developed. Isolates of *Trichoderma*, *Bacillus*, *Pseudomonas, Azospirillum* and *Azotobacter* were collected from different agro-ecological crop production systems of India and tested for their biocontrol ability, plant growth promotion and abiotc stress tolerance. Promising isolates possessing combinations of traits of biocontrol ability, plant growth promotion and abiotic stress tolerance were identified. Selected strains were field-evaluated. Functional genomics of abiotic stress tolerance was studied so that they could be transferred to otherwise efficient strains. Variations in PGPR traits, qualitative and quantitative aspects of EPS production, and ability of the isolates to solubilize zinc and phosphorus were studied to identify promising strains possessing desirable traits. Impact of elevated CO_2 over generations on these beneficial microorganisms was studied to understand possible implications of such impacts on crop production systems and develop suitable adaptation strategies. Further innovative research and development, awareness building programs and enabling policy environment coupled with investments and skill development are essential to develop farmer-friendly coping mechanisms to neutralize the impacts of climate change and climatic variability on crop health.

D.P. Misra & R.N. Pandey IPS Women Scientist Award Lecture

AL(07):Ganoderma basal rot mortality: An emerging threat for greening Indian desert

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Indian arid region in recent years witnessed large scale mortality in Indian mesquite {*Prosopis cineraria* (*L.*) Druce} or *Khejri* due to root rot caused by *Ganoderma lucidum* and *G. tsguae*. In addition a beetle *Acanthophorus*, which damages the roots made entry of the pathogen easy for infection. A series of studies were conducted to assess the bio-efficacy of biocontrol agents and in *in-vitro* and in the field against *Ganoderma species*. Three native biocontrol agents isolated from rhizospheric soil of healthy and diseased tree of *Khejri* were purified to study their morphological characters. These were identified as *Trichoderma longibrachiatum, T. harzianum* and *Aspergilus nidulans.* Studies revealed that *T.longibrachiatum* and *T. harzianum* significantly inhibited the mycelial growth of *G. lucidum* compared to control. Maximum mycelial growth inhibition (47.6%) of *Ganoderma* was recorded in 96 hrs. with *T. longibrachiatum*. The comparative efficacy of these bioagents was tested by amending soil with individual bioagents or with food substrates where *Ganoderma* infected cowpea bits were inoculated. All the treatments showed a significant reduction in viable infected root bits of *Ganoderma* after 60 days over the control. However, there were significant differences in the reduction of viable propagules of *Ganoderma* among all the treatments having bioagents. Maximum reduction (85.0%) of viable infection of *Ganoderma* was achieved in a treatment combination having all the three bioagents, *Prosopis juliflora,* and onion residue compost within 40 days. Laboratory experiments were also performed to ascertain the compatibility of these bioagents at different concentrations of insecticides in wet and dry soil conditions. Significant variations in the survival of all the three bioagents were estimated in both the conditions, time of incorporation, and at different concentrations of insecticides. On the basis of aforesaid results, field experiments cum demonstrations were conducted at three problematic sites of arid districts of Rajasthan for the last two years. Maximum reduction in the Ganoderma-induced root rot mortality and rejuvenation of affected *Khejri* trees was recorded in the treatment where chlorpyrifos (20g/ tree) was combined with *T. longibraciatum+ T. harzainum+ A. ninulans+ P .juliflora* and onion residue composts (500g/tree) supplemented with one irrigation. These combinations were also successful in establishing bioagents in nutrient deficient sandy soils of the region. This technology has been found more effective in rejuvenating partially infected trees. Integration of naturally available bio-resources of the region has been found successful in achieving our endeavor to manage this strategic problem.

A.K. Sarbhoy Memorial Award Lecture

AL(08):Current advances in the status of *Fusarium wilt* of banana in India

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In India, the Fusarium wilt disease, which is considered as most devastating in banana world-wide, is jeopardising not only the production, productivity and export of banana but also the livelihood and employment opportunities of millions of people especially small farmers and landless laborers. Although the presence of the disease caused by the fungus *Fusarium oxysporum* f. sp. *cubense* (*Foc*) was recorded in almost all the banana growing regions of India, the *Foc* strains infecting Cavendish group of bananas (VCGs 01213/16, 0125, 0124, 01220) are causing havoc in major Cavendish growing states like Tamil Nadu, Maharashtra, Gujarat, Madhya Pradesh, Uttar Pradesh, Bihar and West Bengal and the maximum of 90% incidence was recorded particularly in Bihar. The whole genome sequencing carried out for the abovesaid Cavendish infecting VCGs revealed that there is a variation in the organisation of genome assembly and virulence-associated genes, specifically secreted in xylem (SIX) genes when compared to the reference genome. These variations were exploited to design primers specific for *Foc* Race1, Race 4, Tropical Race 4 and Subtropical Race 4 and validated using other *Foc* races, VCGs or banana pathogens, *Fusarium* species and non-pathogenic *Fusarium oxysporum* isolates. This study demonstrated that the molecular markers developed for all the three *Foc* races of India could detect the pathogen in planta and up to 0.025 pg µL-1 DNA level. For the effective management of the disease, the identification of host resistance and development of effective consortia of bioagents were carried out. In these studies, the glass house and hot spot field screening of all the banana genotypes (215) resulted in the identification of about 55-60 genotypes belong to different genomic groups including Cavendish group (AAA) resistant to Fusarium wilt pathogen. Further studies on the micobiome of these *Foc* resistant and susceptible cultivars revealed a quality difference in the structure of microbiome. Besides, a total of five different consortia of endophytic and rhizospheric nature of bioagents and a cheaper and farmer friendly method of mass production and delivery system were also identified and found potential for the effective management of this lethal disease in banana. All these above said studies have given a hope that the Fusarium wilt disease can be controlled effectively in the future and thus can save the banana industry which worth more than 50, 000 crores of rupees in India.

M.K. Patel Memorial Young Scientist Award Lecture

AL(09):Development and field validation of robust riagnostics for emerging Virus and Virus-like Pathogens Infecting major horticultural crops in North East India

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Virus and virus-like pathogens have emerged as the major constraint in production and productivity of horticultural crops in North East region of India. Present study focused on development and validation of simplified and robust detection systems for major and emerging viruses and virus-like pathogens infecting diverse horticultural crops in the region. Simplified multiplex diagnostics were developed for the simultaneous detection of chilli veinal mottle virus and cucumber mosaic virus infecting chilli in North East India. A simplified template preparation using crude sap extract of plants in isothermal recombinase polymerase amplification (RPA) was developed for the detection of potyviruses infecting passion fruit and chilli. Similarly the robust RPA assay for detection of huanglongbing-associated *Candidatus* Liberibacter asiaticus and citrus tristeza virus were developed using crude sap of infected citrus plant as template. Crude sap from infected citrus leaves extracted in simple buffers was best suited for the simplified detection of these virus and virus-like pathogens. Developed RPA assay could detection the target pathogens up to 10^{-7} of crude sap dilution and was as sensitive as bench mark PCR. These assays were validated using large number of field samples and found highly robust. Developed detection assays will have applications in routine indexing and production of virus-free planting materials in the region.

PL(01): The Global Plant Health Assessment (GPHA): An early report of the results of an International Society for Plant Pathology initiative

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The impacts of plant pathogens on the functioning of ecosystems, be they natural or human-made, and their ability to generate services (provisioning, regulating, cultural) are poorly known. The ISPP therefore endorsed the conduct of an assessment of these impacts, which was undertaken by nearly 100 of its members. Addressing these impacts on all ecosystems and their services is impossible: the GPHA thus considered a set of key [PlantSystem x Ecoregion] in the world, where (1) the overall state of plant health and (2) the impacts of diseases on services were considered, each by a specific team of Experts. Twenty-seven standardized reports were generated by these teams on forests, urban vegetation, horticultural and home garden systems, perennial fruit crops, cereal crops, and roots and tubers across North and South America, Europe, sub-Saharan Africa, and South, South-East, and East Asia. The services considered are very diverse, including food, fibre, feed, raw materials, and fuel (provisioning); air, carbon, soil, water, and biodiversity (regulation); and beauty, recreation, and spiritual (cultural). A key feature of the GPHA is the use of standardised qualitative scales for Experts in different fields to express both systems status and trends, for a diversity of services, which then can be compared and analysed. This work will be reported soon in various forms and will provide milestones to discuss the consequences of climate change, global exchanges, globalisation, technology shifts, and human activities on the state of plant health in the Biosphere.

PL(02): Tripartite interactions among bacteria, aphids and wheat: Who is doing what?

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Phenotypic responses to biotic stresses are often studied as interactions between two species; however, in the phytobiome, these responses frequently result from complex interactions involving several organisms. Russian wheat aphid (RWA, *Diuraphisnoxia*) is a serious pest that impacts small grains globally. We demonstrated that RWA-induced chlorosis on wheat is partially determined by aphid-associated bacteria. The bacteria themselves are not virulent to wheat or barley, because inoculation of plants did not result in chlorosis, water-soaking or necrosis. Bacteria were not detected in high numbers in the aphid salivary glands or foreguts but were detected in aphid honeydew, suggesting stylets contaminated during feeding are an avenue for bacterial introduction into leaves. To understand the mechanisms by which bacteria are affecting RWA virulence, we are studying plant defense responses occurring during these tripartite interactions. Aphids with high titers of bacteria-induced gene expression and accumulation of salicylic acid (SA), a hormone involved in insect resistance, in wheat. High, sustained expression of SA biosynthetic genes was followed by downregulation of jasmonic acid (JA) biosynthetic

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genes; JA is associated with insect resistance. Our current hypothesis is that aphid-associated bacteria contribute to aphid virulence by modulating the plant's insect defense mechanisms.

PL(03): Strategic plant Pathology research and enabling policies-key to Agri sustainability and Food security

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PL(04): Robust broad spectrum bacterial blight resistance

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Bacterial blight causes major damage to rice production in Asia and Africa, and threatens in particular the food security and livelihood of small-scale producers, - the majority of rice farmers in both continents. Treatment with pesticides is problematic and often ineffective. Breeding genetic resistance is be the most effective and ecological solution. A major challenge is that the causative agent, *Xanthomonas oryzae pv. oryzae (Xoo)* is highly diverse and evolving rapidly, therefore new strains that break resistance emerge continuously. To be effective on the long run, strain diagnostics, surveillance and breeding approaches are required to provide new resistances at similar time scales as the emergence of new strains. India developed effective surveillance and a matrix approach in which known resistance genes are tested against a panel of strains. Since single R gene are ineffective, Indian breeders combine multiple resistances that cover the largest number of current strains. Our team took a different path: We found that the virulence of all known strains of Xoo depends on the ectopic induction of SWEET sugar transporters in the host. We have been able to generate elite rice lines that block induction of SWEETs, and as a result are resistant against all known Xoo strains. We also developed a diagnostic kit that enables rapid identification of the particular SWEET gene that is targeted by a newly emerging Xoo isolate, allowing for rapid generation of broad and robust resistance at a time scale similar to the spread of the new strain.

MJN(NEZ): Exploring plant disease antagonistic behavior of fungal entomopathogen *Beauveria bassiana* (Balsamo) Vuillemin against *Rhizoctonia solani* Kuhn causing sheath blight disease of rice

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Sheath blight is one of the major diseases of rice causing a greater yield loss up to 50% worldwide. Besides, immense use of synthetic chemicals resulted huge distress in environment and human health. Among biological alternative, only few biocontrol agents (BCAs) are currently laid up-frontline, therefore, there is need to explore already existing or new potentials of BCAs. *Beauveria bassiana,* traditionally used as fungal entomopathogen recently drawn attention worldwide as potential biocontrol agent against several plant pathogens. In the present study, antagonistic abilities of native *B. bassiana* isolates were evaluated against *Rhizoctonia solani* both under *in vitro* and field conditions. The results showed that *B. bassiana* exhibited efficient antagonistic abilities against *R. solani* with maximum per cent mycelial inhibition recorded up to 71.15%, and the underlying mechanisms were identified as production of cell wall degrading enzymes, siderophore and virulent genes. Indirect mechanism of plant growth promotion and endophytic abilities of *B. bassiana* was also explored. Under field condition, combined application of liquid based microbial consortium of *B. bassiana* isolates as seed treatment, seedling root dip and four foliar sprays with 10 ml in 1000 ml water at 60 days after transplanting at 15 days interval, resulted in reduced sheath blight disease severity by 65.80 % and enhanced yield attributes in treated plots as compared to control plots. From the present study, the hidden, diversified role of *B. bassiana* as plant disease antagonist and plant growth promoter were identified in addition to its exclusive insect pathogen behavior, which further adds new dimension in crop protection by introducing newer concept in Integrated plant disease management programmes along with overall health of plant.

MJN(DZ): Structural and functional analysis of rice phyllospheric bacteria for their antimicrobial properties and defense elicitation against blast disease

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Rice being most important staple, is affected by several biotic constraints among them blast disease caused by *Magnaporthe oryzae* is important one. Present blast management strategies including host-resistance and fungicide-spray are either non-durable or not compatible with environment and trade. Therefore, new management options are needed for sustainable rice production. With its adapted microbiota, the phyllosphere brings a unique microbiome with a potential for modulating plant traits. However, the ecological forces driving the phyllomicrobiome assemblage and functions are among the underestimated aspects of plant biology. In the present study, we combined the mNGS with microbiological methods to decipher the core-phyllomicrobiome of rice-genotypes differing for their reaction to blast disease grown in contrasting agroclimatic zones. Principal coordinate analysis indicated an influence of environmental factors rather than the genotype on phyllomicrobiome assembly. The predominance of phyla such as **Proteobacteria, Actinobacteria,** and **Firmicutes** encompassing the core-microbiome

consisting of 24-genera were observed on rice-phyllosphere. The microbiological validation of mNGS data confirmed *Acinetobacter, Aureimonas, Curtobacterium, Enterobacter, Exiguobacterium, Microbacterium, Pantoea, Pseudomonas,* and *Sphingomonas* on rice-phyllosphere. Images captured by SEM revealed the physical presence of bacterial-aggregates. All the cultured isolates were functionally characterized for antagonism against blast fungus. The isolates also showed induction of MAMP-triggered-immunity on rice seedlings. Further, blast suppression assay under artificial epiphytotic conditions culminated in identification of 17-isolates, which gave more than 50% disease suppression. Transcriptional profiles of rice innate-immunity marker-genes were up-regulated in bacterized seedlings. GC-MS analysis of the bacterial-volatiles indicated the presence of antifungal-volatile-compounds. Multi-pronged activities of phyllomicrobiome on *M. oryzae* (antifungal-activity), rice (defense-elicitation), and blast disease (blast-suppression) have been elaborated for management of blast by phyllomicrobiome re-engineering.

MJN(DZ): Evaluation of Resistance Behaviour of *Ty*-Gene(s) Containing Donor Lines of Tomato and Indexing of Naturally Occurring Begomoviruses Infecting Them

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Tomato leaf curl disease is caused by a number of begomoviruses. Resistance sources with different *Ty* genes have been identified in wild relatives of *Solanum lycopersicum*. In this study, seventeen *Ty*-gene donor tomato genotypes along with a susceptible check cv. Pusa Ruby were evaluated against tomato leaf curl disease under field condition using a newly developed scoring scale. Highly resistance response was observed in five genotypes containing both *Ty-2* and *Ty-3* genes. Further evaluation of three highly resistant genotypes under challenged viruliferous whitefly inoculation with tomato leaf curl New Delhi virus confirmed their resistance behaviour. Indexing of the begomoviruses in these genotypes through PCR using seven begomovirus species specific primers and one genus specific primer followed by sequencing of representative PCR amplicons revealed presence of a number of begomovirus species in these tomato genotypes indicating the probable mixed infection. Majority of the genotypes (thirteen) showed association of Croton yellow vein mosaic virus (CYVMV). Another genotype (ToLCD Tol-1) gave amplification only with genus specific primers indicating presence of other begomovirus(es) for which we did not have any primers. Complete genome of the begomovirus, from this sample and from another sample where only CYVMV infection was detected, were characterized. Sequence analysis of the CYVMV infected sample showed that the virus is actually a new species of begomovirus. The name *Tomato leaf curl Ty Pusa virus* (ToLCTyPV) was proposed for the new species, which was probably evolved due to an interspecific recombination between CYVMV and tobacco curly shoot virus (TbCSV). The begomovirus from the other sample was a strain of tomato leaf curl Karnataka virus. The study thus clearly showed the resistance response of the *Ty*-gene donor genotypes and the scenario of the begomoviruses infecting them.

MJN(NZ): Pathological and molecular variation in *Puccinia triticina* the incitant of leaf rust of wheat and host resistance

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Leaf rust of wheat caused by *Puccinia triticina* (*Pt*), is one of the most important diseases of wheat worldwide. To study the virulence pattern/ diversity of *Pt*, the surveys for leaf rust occurrence were conducted in Punjab during 2018-2021. SBS Nagar, Ludhiana west, Rupnagar and Gurdaspur were observed as hot spot areas. *Pt* pathotypes 77-5, 77-9, 77-13 (121R60-1,7) and 1R 31 were found by virulence profiling of the leaf rust infected samples collected from Punjab. The genetic diversity among *Pt* isolates was studied using SSR markers, demonstrated that the new pathotype (121R60-1, 7) is more closely related to the pathotype77-9. To know the effectiveness of *Lr* genes, the leaf rust differentials and known *Lr* gene lines were scored against *Pt* infection at four different locations of Punjab (Ludhiana, Gurdaspur, SBS Nagar & Abohar). The lines carrying *Lr* genes; *Lr 9, Lr 19, Lr 24, Lr 25, Lr 28, Lr 29, Lr 32, Lr 42, Lr 45, Lr 47, Lr 52, Lr 57, Lr 58, Lr 76* exhibited resistance against the most prevalent pathotypes of *Pt*. Based on the molecular data and race specific infection response at seedling as well as at adult plant stage; the gene postulation was done. The F_5 generation of four populations were evaluated against *Pt* from 2018-2021 under field conditions at PAU (Ludhiana). The genotypic ratio 1:1 of F_5 population fit significantly on the phenotypic data. For gene mapping the resistant and susceptible bulks along with the parents were genotyped with 90K SNP chip Ilumina array. The SNPs located on the chromosome 5A, 7B, 1B, 1D, 6A, 1A, 1D, 3B, 4B, 5A, 1A, 1B, 2B, 3B and 7A for 4 populations were selected for designing the KASP markers.

MJN(NZ): Early oxidative burst and anthocyanin-mediated antioxidant defense mechanism impart resistance against *Sclerotinia sclerotiorum* in Indian mustard

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The association between reactive oxygen species (ROS) regulation and Indian mustard resistance to *Sclerotinia sclerotiorum* is poorly understood. In this study, ROS generating and scavenging systems have been comparatively evaluated in two contrasting Indian mustard wild type genotypes [Sclerotinia stem rot-resistant RH 1222-28 (WR) and susceptible Varuna (WS)] as well as in two anthocyanin contrasting mutants [purple mutant (PM) with more anthocyanin and albino mutant (AM) with devoid anthocyanin]. The mean lesion length and rate of lesion expansion in the resistant WR and PM were significantly lower than that in WS and AM, irrespective of the inoculation time. Moreover, the biochemical results revealed that WS and AM activated defense responses at the later pathogen infection stages, resulting in higher concentrations of H_2O_2, O_2^-, and greater MDA content, with lower concentration and activity of non-enzymatic and enzymatic antioxidants. The necrotrophic phase (8 days after inoculation) accompanied these responses, leading to significantly higher stem lesion length and lesion expansion rate. In contrast, higher anthocyanins accumulation, an early peak in H_2O_2 and O_2^- concentration during the early infection phase, and a more efficient antioxidative system effectively restricted pathogen

colonization before the transition to the necrotrophic phase in the resistant WR and anthocyanin-more mutant PM. These results suggest that Sclerotinia stem rot resistance/susceptibility is regulated by well-coordinated ROS/antioxidants regulation system during different infection phases of *S. sclerotiorum*. Further, the anthocyanins accumulation near the pathogen infection site seems to play a key role in modulating ROS generating and scavenging machinery that contributes to resistance against *Sclerotinia sclerotiorum* in Indian mustard.

MJN(NZ): Prediction and validation of MYMV disease epidemic using a weekly infection model in mungbean (*Vigna radiata* (L.))

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A weekly infection model was used for a risk assessment of Mungbean Yellow Mosaic Virus (MYMV) disease transmitted by whitefly (*Bemisia tabaci* Genn) in persistent manner. The infection model included all the weather parameters and whitefly population response function. Weather parameters have no direct effect on the development of MYMV, but affect the whitefly population. Whiteflies activities have direct effect on disease development. A validation data of development of whitefly population and MYMV disease severity were recorded in mungbean crop at 7 days interval started from 20 days after sowing. The present study showed that whitefly population builds up started in month of July and reached to maximum at end of August to early September. There are various reason for build-up of whitefly population *viz.,* maximum temperature 36±2°C, minimum temperature 25±2°C, morning relative humidity more than 90 per cent, more sunshine hours and no rainfall prevailing during that period. Whitefly population had positive significant correlation with maximum temperature, bright sunshine hours while evening relative humidity and rainfall was recorded negatively significant. The slope of the regression line for logit y versus t was 0.12 logits/day for epidemic which indicates that population of whitefly provide an epidemiological tool in measuring the MYMV epidemic. A typical S-shaped disease progress curve was observed in MYMV disease. This model is helpful in guiding the farmers for timely and preventive spray of insecticide based on existing infection and population of whitefly in a season.

MJN(EZ): *In Silico* characterization of banana bunchy top virus in West Bengal with host-virus-vector interaction and global population structure analysis

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Banana bunchy top virus (BBTV) is one of the major disease threatening one quarter of the world's banana growing areas (Hooks et al., 2009) and is primarily transmitted by planting materials and secondly by an aphid vector, *Pentalonia nigronervosa*. Banana bunchy top virus (BBTV) isolates are either the Pacific Indian Ocean (PIO) or the South East Asian (SEA) group. However, there is only one or two completely sequenced isolates published from the northeastern part of India till date. Therefore during

2019-2020, diagnostic surveys were conducted in several regions of West Bengal (WB) and it was inferred that BBTD is widely prevalent in all parts of WB. Hence, we obtained and characterized the complete sequences of all the six genomic components of BBTV isolates from different regions of WB. Pairwise similarity of the isolates, evolutionary analysis, population dynamics and genetic diversity were conducted to obtain the generic relationship with the worldwide isolates. The clustering pattern and genetic diversity of BBTV population from West Bengal suggested monophyletic origin of majority of epresentative isolates from a common ancestor of PIO group and that the genetic diversity of the virus in the country is very low, but with expanding population growth. The virus shows the highest levels of sequence identity (About 99%) to BBTV isolates originating from Egypt, India, Australia and Democratic Republic of Congo. To better understand the host and virus interaction and biochemical responses (total chlorophyll, carbohydrates, phenols and enzyme activities) in banana cultivars viz., Champa, Grand Naine (G9), Kathali and Martaman, against the BBTV revealed that the virus infected samples of all cultivars showed a significant increase in the defense enzymes over the healthy samples. BBTV viral load was also estimated using SYBR green-based qPCR. The biochemical response and viral load was found high in G9 among the test cultivars. Investigation on the spatial distribution of viral load in infected plants showed be least in the rhizome and highest in the cigar leaf. A separate experiment on temperature susceptibility and expression of heat shock protein (hsp) in Non-Viruliferous (NVr) and Viruliferous (Vr) aphids were investigated. The lifespan of Vr aphids was shorter than NVr. Both cold and heat shock treatments stimulated higher expression of hsps genes (hsp40, hsp70, and hsp90) at various rates in Vr aphids than NVr ones. The significance of these results would bring prospects for obtaining virus free tissue culture plants and future epidemiological control system.

MJN(EZ): Weather based forewarning system of target leaf spot disease of tomato and its effective management through IDM approaches

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Tomato (*Solanum lycopersicum*) is an important vegetable consumed worldwide, rich in vitamins, minerals and antioxidants. Tomato crops suffer from different foliar diseases viz, target leaf spot (*Corynespora cassiicola*), early blight (*Alternaria solani*), Septoria leaf spot (*Septoria lycopersici*), late blight (*Phytophthora infestans*), bacterial leaf spot (*Xanthomonas campestris* pv. *vesicatoria*) and tomato leaf curl (ToLCV) that cause severe losses under favourable weather conditions. In order to obtain a clear idea about the influence of hanging weather parameters on pathogen biology and tomato diseases, retrospective and real-time site-specific investigation of foliar disease scenario of tomato was initiated in the Gangetic Alluvial plains of West Bengal for development of weather-based disease prediction model and its utilization in fungicidal scheduling for formulating appropriate Integrated Disease management strategies in managing the foliage disease (s) of tomato. The nine-year real-time surveillance disease data for tomatoes grown in the Gangetic Alluvial Region showed that target leaf spot and leaf curl were the two most important tomato diseases during the *rabi* season, while tomato leaf curl, early blight and late blight diseases were important in the summer season. Five different characteristic symptoms (Sym-1, 2, 3,4 & 5 types) of target leaf spot was recorded during the course of investigation. In the month of October, major dominated symptom was symptom type 1 (45%) followed by symptom type 2 (30%) and the lowest dominated symptom was symptom type 3 and 4 whereas the symptom type 5 was absent during the month of October. The present findings thus indicated that isolates of *C. cassiicola* from tomato have different optimum temperatures for their host-pathogen interaction and pathogenicity. It was observed that all the ITS sequences of the isolates from the current experiment grouped in a single clade with the various strains of *Corynespora cassiicola* from various countries. The highest conidial germination was noticed at the temperature of 25oC followed by 30oC with optimum leaf wetness hours was found to be at 8 hrs. MLR model was used to estimate the intensity of target leaf spot from 1991 -2050 based on PRECIS global climate model to compare its future trend. The model indicated that target leaf spot severity is on an increasing trend during decadal period of 2011-2020, but in declining trend during 2021-2030 as compared to 1991-2020 climatic period. However, increasing trend of target leaf spot disease severity was projected during the decadal periods of 2031-2040 and 2041-2050 in the tomato growing areas of West Bengal, India. Area Under Disease Progress Curve (AUDPC) due to target leaf spot disease was also found to be highest in October transplanted tomato plants (2641.37), followed by September (2342.69), November (2021.48), December (1611.55), August (852.06), January (820.73) transplanted tomato plants. No disease was observed in February transplanted crops. Among the different fungicides, Difenoconazole 25% EC was found to be the most effective and exhibited the highest toxicity index followed by Tebuconazole 50% + Trifloxystrobin 25% WG and Propiconazole 25% EC. The highest Incremental Cost Benefit Ratio (ICBR) was obtained in forecasting based applications as compared to calendar based applications of similar group of fungicides. The highest ICBR was found in forewarning based application of Difenoconazole 25% EC.

MJN(WZ): Bioefficacy of *Trichoderma* spp. Silver Nanoparticles Against Soilborne Pathogens of Chickpea (*Cicer arietinum*)

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A total of ten *Trichoderma* isolates were obtained from twenty rhizosphere samples collected from various places of Latur district. On the basis of cultural and morphological characters isolates were identified as *T. asperellum*, *T. harzianum* and *T. koningii.* Results from dual culture technique revealed that *T. asperellum* (CRT-4) was the best antagonist exhibiting highest per cent mycelial inhibition (66.18% and 89.44%) followed by *T. harzianum* (CRT-2) (59.81% and 60.33%) against *F.oxysporum* f. sp. *ciceri* and *S. rolfsii,* respectively. Biosynthesis of *T. asperellum* (CRT-4), *T. harzianum* (CRT-2) and *Trichoderma koningii* (CRT-9) AgNPs were done. Synthesized silver nanoparticles were characterized using UV-Vis spectrophotometry, TEM and FTIR. *T. asperellum* (CRT-4), *T. harzianum* (CRT-2) and *T. koningii* (CRT-9) AgNPs showed absorption peak at 422, 415, 386 nm, respectively. TEM studies revealed that particles were spherical in shape and the particle size of *T. asperellum* (CRT-4) AgNPs were found in the range of 21.29 to 30.42 nm, *T. harzianum* (CRT-2) AgNPs were found in the range of 14.74 to 41.01 nm and *T. koningii* (CRT-9) AgNPs were found in the range of 18.21 to 30.88 nm, respectively. FTIR analysis of the mycosynthesized AgNPs affirmed the role of mycelial cell free filtrates as a reducing and capping agent. The antifungal activity of AgNPs were evaluated against *F. oxysporum* f. sp *ciceri* and *S. rolfsii* by agar well diffusion method and poisoned food technique. In both method, *T. asperellum* AgNPs at 500 ppm concentration was proven most against test pathogens *F.oxysporum* f. sp. *ciceri* and *S. rolfsii*. *In vitro* evaluation of *Trichoderma* AgNPs against *F.oxysporum* f. sp. *ciceri* through sick soil method revealed that *T. asperellum* AgNPs at 500 ppm concentration was found most effective with highest seed germination(96.66%), highest shoot and root length (25.43 and 17 cm, respectively) and lowest wilt incidence (26.66%). Similarly, *in vitro* evaluation of *Trichoderma* AgNPs against *S. rolfsii revealed that T.*

asperellum AgNPs at 500 ppm concentration were proven most effective recording highest seed germination (83.33%), lowest PRESM and POESM (16.66 and 24.00%, respectively) and highest shoot, root length (26.63 and 18.21cm, respectively) and highest dry matter (18.45g).The evaluation of effect of *Trichoderma* AgNPs on growth parameter of chickpea through rolled towel paper method revealed that, *T. asperellum* AgNPs at 500 ppm concentration was the most effective recording highest seed germination (97%), highest shoot, root length (23.45 and 15.54cm, respectively), highest dry matter (16.07g) and the highest seed vigour index (3782.03).

MJN(WZ): Molecular characterization and evolution of Mungbean Yellow Mosaic Virus (MYMV) in Mung bean Spp. [*Vigna radiata* (L.) Wilczek]

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Mung bean (*Vigna radiata (L.) Wilczek*) is the third most significant short-duration legume crop in South and Southeastern Asia after chickpeas and pigeon pea. However, a major constraint in mung bean production is Yellow mosaic disease (YMD) caused by the *Mung bean Yellow Mosaic Virus* (MYMV). The *Mung bean Yellow Mosaic Virus* disease incidence and evolution of MYMV is studied in the present study based on the Coat protein (CP) gene analysis. The MYMV infection was confirmed among the symptomatic samples of the yellow mosaic virus of mungbean, soybean and cowpea collected from different regions of Maharashtra based on the gene-specific amplification of the CP gene (719 bp and 387 bp). The CP gene sequence of the MYMV infecting to cowpea collected from the Pune region showed 96.52 % similarity to the MYMV coat protein (AV1) gene sequence (Accession No JQ004982.1). This confirmed the identity of MYMV. The BLASTp analysis has shown 93.41% similarity to the coat protein [Mungbean yellow mosaic virus-Vigna]virus (Accession No. AAW50913.1. The MYMV strain infecting to cowpea collected from the Pune region was found closely similar (96.52 %) to MYMV and it has shown highest variation with Indian strain (MYMIV and HYMV) at 82.99 % of identity. Phylogenetic analysis based on the 19 sequences of CP gene of MYMV clustered all the sequences into three groups based on the nucleotide and protein sequences. Among 19 sequences studied four sequences (45%) including MYMV Pune isolate showed the highest pairwise identity (96-98 %) followed by approximately 30 % of the sequences showed 91-95 % identity. The lowest pairwise identities (84-87 %) were shown by approximately 25 % of the total sequences. In silico restriction, analysis using CisSERS tool has shown wide variation among the restriction sites between the selected CP gene sequences under study. From the present study it was observed that MYMV strain in Maharashtra is widespread, infecting to other legume crops and evolving concurrently along with Mungbean Yellow Mosaic India Virus (MYMIV) strain. The coat protein gene sequence is promising approach for correct identification of virus. The study will be helpful for early detection of the MYMV virus, so that better preventive measures can be taken to control MYMV.

MJN(MEZ): Screening of *Trichoderma* spp. for their volatile organic compounds as plant growth promoter and antifungal agent

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Plant diseases cause about 40 % crop losses worldwide. Biological control of several plant pathogens is promising alternative to chemical control measures. *Trichoderma* species have potential to manage plant diseases by producing volatile organic compounds (VOCs). VOCs from *Trichoderma* influence pathogen metabolism and its growth. Eleven *Trichoderma* strains from 7 different species were screened using double plate assay to identify the potential strain for the production of volatile compounds and their effects on the growth of *Sclerotium rolfsii*, *Rhizoctonia bataticola*, *Sclerotinia sclerotiorum*, *Fusarium oxysporum* f. sp. *lentis, Curvularia lunata, Colletotrichum gloeosporioides* and *Alternaria solani.* Among 11 strains, *T. asperellum* (BTas25) showed highest activity, *T. harzianum* (BThr12) was moderate and *T. brevicompactum* (BTbr14) was least effective. *Trichoderma* VOCs were extracted from the culture of *Trichoderma* by organic solvents and identified and detected through gas chromatography and mass spectrometry. In GC-MS analysis total 17 compounds were formed in GC-MS spectrum of methanolic extract of aforementioned 3 *Trichoderma* species. For *T. asperellum* (BTas25) 6 peaks, for *T. brevicompactum* (BTbr14) only 3 peaks and for *T. harzianum* (BThr12) 8 peaks of VOCs were observed. Overall five compounds *viz.* 2,4,6-Decatrienoic acid, 9-Desoxo-9x-hydroxy-7-ketoingol, 4H-Cyclopropazulenol, Hexadecanoic acid and ü-Pentamethylcyclopentadienyl- were identified that have antifungal and antimicrobial activity.

MJN(SZ): Exploring plants and microbes associated volatilomes against damping off caused by *Pythium aphanidermatum* in tomato

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Soil borne diseases are the major threat for many vegetable crops, especially in tomato cultivating areas. Damping off caused by *Pythium aphanidermatum* was known to cause severe crop losses. The volatilomes from several plants and microbial origin could produce novel volatile organic compounds (VOCs), which may have a great extent for exploration as antifungal agents against the plant pathogens. The volatilomes produced by the leaves of *Mentha spicata*, *Cymbopogon citratus*, *Vitex negundo*, *Coleus amboinicus*, *Vetiveria zizanioides*, *Ocimum tuniflorum*, *Azadirachta indica*; mycelia of *Auricularia auriculata, Coprinus cinereus, Ganoderma lucidum, Lentinus edodus, Trichoderma asperellum* and cell cultures of *Bacillus subtilis, Streptomyces rochei* were screened for their antifungal activities against *P. aphanidermatum* by sealed plate assay. Among them, the volatilomes produced by the leaves of *M. spicata* and *C. citratus showed* the maximum inhibitory effect of 45.56 and 24.70 per cent, respectively on the mycelial growth of *P. aphanidermatum.* The volatilomes produced by the mycelia of *T. asperellum* showed the maximum inhibitory effect of 69.26 per cent against *P. aphanidermatum.* In order to identify the nature of VOCs involved in the suppression of pathogens, carvone produced by the leaves of *M.*

spicata; citronellol and geraniol by *C. citratus*; isopentyl alcohol and limonene by *T. asperellum* with increased peak area percentage. Vaporous action of isopentyl alcohol completely suppressed the mycelial growth of *P. aphanidermatum,* while the compounds, carvone and citronellol showed the maximum inhibitory effect of 89.02 and 85.49 per cent, respectively when used at 500 ppm. The volatilomes produced by the leaves of *M. spicata, C. citratus* and mycelial cultures of *T. asperellum* were immobilized in vermiculite sample bound with castor oil in the ratio of 3:7 as the volatilomes immobilized vermiculite ball formulation and their efficacy were tested *in vitro* by olfactory chamber. The results revealed the volatilomes of *M. spicata* immobilized vermiculite balls could completely suppress the mycelial growth of *P. aphanidermatum*. Futher, the volatilomes formulation were tested based on the distance travelled by the diffused volatilomes using PVC chamber. The results revealed that the volatilomes of *M. spicata* traveled upto 20 cm distance from the centre of PVC chamber showed maximum reduction of colony growth of *P. aphanidermatum* (2 x 10-3 cfu) at 12th day after inoculation. Studies on the management of damping off in the volatile chamber under glass house conditions revealed that the volatilomes of *M. spicata* immobilized vermiculite balls significantly reduced the severity of damping off (with a per cent reduction of 90.91). Studies on defense genes expression revealed that pathogenesis related protein (PR1) (2.69 folds) and jasmonic acid signaling (LOX) (2.65 folds) genes were highly expressed after 48 h on exposure to the volatilomes of *M. spicata* immobilized vermiculite balls against *P. aphanidermatum* in tomato plants. The result of poly house trail revealed that the volatilomes of *M. spicata* immobilized vermiculite balls could significantly reduce the severity of damping off (with a per cent reduction of 85.71) and recorded higher germination (95.83 per cent), enhanced plant height (102.37 cm), more number of fruits/ plant (21.49), fruit weight (43.03 g) and more yield (989.69 g/ plant) due to the exposure of volatilomes of *M. spicata* in the tomato plants raised beds with relatively abundant control of *P. aphanidermatum.*

MJN(SZ): Identification, multi-genic and teleomorphic characterization of *Bipolaris setariae* causing browntop millet leaf blight in India

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Browntop millet (*Brachiaria ramosa* (L.) Stapf.) is one of the important climate resilient crop that recently introduced into millet system in India. In *Kharif* 2018, leaf blight was first time observed at ICAR-AICRP germplasm evaluation trails at Bangalore. Initially, spots were brown with yellow halo eventually turns to dark brown and leaves were blighted. Disease was observed to be maximum in southern Karnataka. Pathogen was isolated and pure cultured using standard isolation and single spore isolation techniques. Likewise, nine isolates were recovered on PDA from major millet growing regions of India and all isolates were found pathogenic on browntop millet in pathogenicity studies. Morphologically, the pathogen was identified as *Bipolaris* spp. by comparing with standard descriptions. Further, BLAST and combined phylogenetic analysis of ITS, GPDH and LSU regions revealed that *Bipolaris setariae* as the causal organism of browntop millet leaf blight in India. Whole genome sequencing of *B. setariae* revealed that genome is 32.56 Mb with 50.40 % of GC content. Gene annotation predicted that 447 genes belonging to CAZYmes classes, whereas, comparative protein analysis showed that 8322 proteins contributing to the core proteome of *Bipolaris* genus while 48 proteins are unique to *B. setariae*. BTMH5 isolate was identified as more virulent among all isolates. In vegetative compatibility studies, BTMH2 × BTMH6 showed compatible reaction where H-shaped hyphal anastomosis was observed. Barren pseudothecia are produced on Sach's agar medium. Amongst the 40 germplasm screened, only six were found moderately resistant and none of them showed resistant reaction.

MJN(SZ): Comprehending the complex rubber (Hevea brasiliensis) genome through linkage mapping and genome wide association studies to provide new insights on its disease tolerance mechanism

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

APS-IPS Travel Sponsorship Award Contest

APS(NEZ): Synthesis of green engineered copper nano-formulation and its use as a component of IDM for management of leaf blight of turmeric (*Curcuma longa* L.)

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Copper nanoparticles (CuNPs) were biogenically synthesized utilizing leaf extract of back turmeric (*Curcuma caesia*). Biosynthesized CuNPs were characterized using UV-Vis spectrophotometer, DLS, FTIR, NTA and SEM. *In vitro* toxicity assay of CuNPs against causal agent of leaf blight of turmeric *Colletotrichum capsici* showed significant mycelial growth inhibition at 500 ppm concentration followed by 300 and 200 ppm respectively. The compatibility of CuNP was tested against the constituent biological control agents of Umcomb *i.e*., *Trichoderma harzianum*, *Beauveria bassiana*, *Metarhizium anisopliae, Lecanicillium lecanii* and *Pseudomonas fluorescens* and were found to be compatible upto 200 ppm concentration. The toxicity of biosynthesized CuNPs were also evaluated against mammalian cell line (Vero cells). Results revealed that CuNPs poses weak cytotoxic (23.28%) effect at 200 ppm concentration. Thus, CuNPs at 100 ppm concentration was selected for further *in-planta* evaluation based on *in vitro* assay. Field trial was conducted to evaluate CuNPs (100 ppm) as a component of IDM along with Umcomb bioformulation against leaf blight of turmeric. The results revealed that rhizome treatment @ 10 ml of Umcomb + Foliar spray with CuNPs @ 100 ppm thrice at 21 DI (T_5) was most effective in management of leaf blight of turmeric. The minimum per cent disease index (16.67 %) was recorded for T5 along with higher plant growth parameters i.e., plant height (99.28 cm), number of leaves (9), yield (13.1 t/ha) and curcumin content.

APS(EZ): Characterization, epidemiology and management of chrysanthemum (*Chrysanthemum morifolium*) Leaf blotch disease in the gangetic plains of West Bengal

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Leaf blotch disease (C.O. *Septoria chrysanthemella*) of chrysanthemum (*Chrysanthemum morifolium*) is one of most wide-sprayed, severe and destructive diseases of chrysanthemum. Very meager information is available about morphological and cultural characteristics of the pathogen as well as epidemiology and management of the diseases. Initially six growth media and four different temperature regimes were tested for conidial germination. The highest conidial germination was recorded on carrot Czapek's Dox agar (CCDA) medium and 20p C temperature. Effect of leaf extracts, biotin and thiamine addition to Czapek's Dox agar (CDA) and CCDA media on the conidial germination of *S.chrysanthemella* at 20p C temperature. Revealed that the mean spore germination percentage under the CCDA medium treatment combinations was found higher than CDA medium treatment combinations and it was lowest in control and highest in leaf extract + biotin + thiamine added medium. Pathogenicity study was conducted at four temperatures and four inoculation techniques. It was found that pathogen required injury to cause damage;

optimum temperature for lesion area development ranges from 20 – 28 p C. Out of four agar media tested for radial growth, their broth media used for fungal biomass production under the said four temperature regimes indicated that CDA medium and 24p C temperature were the best for radial growth promotion of *S. chrysanthemella*. Czapek's Dox broth medium and the temperature regime of 16 - 24p C were considered best growth medium and temperature for mycelial dry biomass production. A field experiment was conducted considering four dates of planting; the third date of planting of chrysanthemum appeared to be a suitable date for planting. The loss of crop growth parameters and yield due to leaf blotch disease in untreated plot ranged from 37.3% to 291.7%. When 40 chrysanthemum cultivars were screened for three years, at the end of the experiment 5 cultivars were noted as resistant, 8 moderately resistant, 20 moderately susceptible, 6 susceptible and 1 cultivar as highly susceptible. When the 40 chrysanthemum F1 hybrid germplasm also screened against *S. chrysanthemella,* thirteen germplasm were found immune and 1 highly resistant, 12 resistant, 8 moderately resistant, 5 moderately susceptible, none under susceptible and 1 germplasm under highly susceptible groups. Out ten weather parameters considered for two consecutive years, the maximum temperature, minimum temperature and wind speed were identified as critical weather parameters for PDI increment; the wind speed was the only identified critical weather parameter, responsible for AUDPC increment and the maximum temperature, maximum relative humidity and rainfall were identified as three critical weather parameters responsible for the increment of ROS of leaf blotch disease. Effective concentrations of six different fungicides, two defense inducing chemicals and one botanical for 50% mycelia growth inhibition (EC 50) of *S. chrysanthemella* using six concentrations pointed out that the *in vitro* efficacy of these chemicals and botanical. Difenoconazole among systemic fungicides, Mancozeb among non-systemic fungicides and isonicotinic acid, a defense inducing chemical, appeared best performing. Field experiment was conducted with the same fungicides, it was found that Difenoconazole 25% EC and Mancozeb 75% WP were the best systemic and non-systemic fungicides.

APS(EZ): Biochemical responses and histopathological changes in chickpea-collar rot pathosystem

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The pathogen *Sclerotium rolfsii* (Sacc.) responsible for collar rot in chickpea identified as one of the major production constraints worldwide. The experiment was aimed to decode the relative changes of defense related enzymes and phenolics that take place in chickpea (both in resistant and susceptible genotypes) upon collar rot (CR) infection and the experiment was carried out at the Department of Plant Pathology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia in the year 2018-19 and 2019-20. Emphasis given to study the changes in total soluble proteins, peroxidase and total phenol content at 7, 14, and 21-days post inoculation (dpi) with CR pathogen in chickpea around its collar region. Scanning electron microscopy (SEM) was also done at the same dpi to compare the extend of mycelial network within the xylem vessel of inoculated resistant and susceptible cultivars along with the non-inoculated susceptible check. The results indicated that total phenol content was significantly 3 folds higher at 7 dpi then declined gradually upto 21 dpi. and, the total content is higher in moderately resistant (MR) cultivars than the moderately susceptible (MS) and the susceptible non-inoculated control. Total soluble protein content decreased with the days after post inoculation and this reduction is greater in the susceptible cultivar as compared to the resistant one. Total soluble protein content is relatively 3.41fold more in the inoculated cultivars than the non-inoculated control. Peroxidase (POD) activity also decreases from 7 dpi to 21 dpi and maximum POD activity recorded at 7 dpi in resistant cultivars than the susceptible one. This study was an effort to disclose the changes in the behaviour that took place inside the host upon pathogen infection along with the comparative biochemical changes that demarcate resistant and susceptible cultivars. Evidence of histopathological deviations had been documented through SEM revealed development of the pathogen was both inter and intra cellular in the susceptible host plant along with distorted xylem vessels. Step by step progression and colonization of the cells due to fungal invasion at definite time interval was clearly observed which ultimately led to the development of rigorous symptoms within 21 dpi whereas resistant genotype that do show the mycelial growth inside the host plant but at much lower rate. Thus, this study provides an overall comprehensive idea that contribute a step towards understanding of host pathogen interaction.

APS(NZ): Variability and management of maydis leaf blight of maize incited by *Bipolaris maydis* (Nisikado and Miyake) Shoemaker

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Maydis leaf blight (MLB) caused by *Bipolaris maydis* is one of the potential threat to global maize production. This disease has rapidly gained economic importance in several parts of north India and has potential to inflict economic loss in the tune of 25-80 per cent. Therefore, alternative and rapid means of restraining the disease are constantly being sought. Present investigation entitled "Variability and management of maydis leaf blight of maize incited by *Bipolaris maydis* (Nisikado and Miyake) Shoemaker" was conducted during *Kharif* 2020 at Regional Research Station, Karnal, Department of Plant Pathology and Department of Molecular Biology, Biotechnology and Bioinformatics, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Our study revealed that a noticeable difference was observed in disease incidence during survey in various maize growing districts, maydis leaf blight disease was noticed in all districts surveyed during *Kharif* 2020, however medium to high disease incidence was observed in Morni hills of Panchkula and low disease incidence was reported in Rohtak district. The isolates collected from different agro-climatic zones showed a considerable variation in cultural, morphological and pathogenic characters. A significant positive co-relation was found between conidia length, breadth and number of septa; latent period and incubation period; lesion length and lesion breadth. Similarly, significant negative co-relation was found between latent period, incubation period and disease score. Bm-7 isolate from Pantnagar-2 location was found to be most virulent, formed separate cluster in pathogenic clustering and also observed to be the most diverse in phylogenetic tree of ITS region. Out of 48 inbreds and 16 hybrids evaluated under artificial inoculation conditions, 7 inbreds and 5 hybrids showed resistant reaction to maydis leaf blight. Among different management modules, T3 (chemical module 2) seed treatment with salicylic acid @ 100 ppm/kg of seed, foliar spray of mancozeb 75 WP@2.5gm/L of water at 40 DAS, foliar spray of pyraclostrobin 133g/l + epoxiconazole 50g/l SE@ 1.5 ml/L of water at 60 DAS was found to be most effective and resulted in highest disease control of 67.4 per cent and 35.5 per cent increase in grain yield. The resistant inbreds and hybrids obtained could be used in

further breeding programme and variability among *Bipolaris maydis* isolates will contribute to identification of pathogenic races and their distribution in India. The study of different management modules will provide effective disease management strategy to maize growers.

Technical Session

Keynote Lectures/ Invited Lectures/ Oral Presentations

SESSION 1:
New Education Policies (NEP) and Impact on Plant Pathology

Keynote Lectures

KN01(1): Implications of National Education Policy-2020 in academic institutional governance and instructions in agriculture

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The new National Education Policy 2020 (NEP) is woven around the principles of development of individual interest by providing broad based, holistic, flexible, inclusive education by eliminating discipline insulated knowledge boundaries. Focused on providing high quality liberal education under more empowered governance, autonomy and transformation of regulatory system, it has highlighted providing professional education synchronizing and synergizing science, technology and social sciences through multidisciplinary instructional approach. The agricultural education too is bound for transformation on these lines since the Indian Council of Agricultural Research has adopted it and developed a strategy for speedy implantation in institutions engaged in imparting agricultural education. Discouraging fragmentation of State Agricultural Universities and eliminating affiliation system there is strategic planning to reorient course curriculum introducing multiple entry and exit provisions with options for certificate, diploma and general or research degree courses in all the subjects including plant pathology. The plant disease control education will now be more holistic by unity and integrity of wide array of knowledge, creativity and critical thinking with higher component of online delivery of instructions, virtual labs and expansion. For students of plant pathology there will be now wider availability for optional subjects under refined Choice Based Credit System. Through creation of Academic Banks of Credit, mobility of students will be facilitated equally well as the discipline transferability for promoting interest, innovation, quality and global acceptance of graduates in plant pathology. Availability of liberal financial support under the National Research Foundation (NRF) under NEP will expand the scope of qualitative, competitive and applied research on frontier areas as well as current issues and challenging aspects like plant disease management under fast changing climatic conditions, rational use of chemicals and devising maintenance mechanism of host pathogen equilibrium under natural farming. Involvement of social sciences aspects is also likely to act as key to understand the broad horizon of dissemination of plant pathological knowledge by extension specialists among farmers for producing healthy crops.

KN02(1): New education policies (NEP) and impact on plant pathology strategies for implementation of New Educational Policies in Plant Pathology

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New Educational Policy-2020 has been formulated to make India a global knowledge superpower adopting an education system rooted in Indian ethos. It has proposed several changes in the

higher education system, including agriculture education. The changes include transforming stand alone higher education institutions (HEIs) into multidisciplinary research-intensive organizations offering multidisciplinary programmes, multiple entry and exit, academic structure of certificate/ diploma/degrees/ and academic credit banking system. NEP-2020 envisions for universities, offering agricultural education must design the agricultural programmes towards developing professionals to understand and use local knowledge, traditional knowledge and emerging technologies to address critical issues of climate change, declining profitability, enhancing productivity to benefit the local communities directly. Providing right skills and knowledge is part of NEP-2020 for generating employment for 80 % of agricultural graduates, who are underemployment/misplaced employment/ no employment. ICAR ensures quality in higher agricultural education through its National Agricultural Education Accreditation Board by accrediting of Agricultural Universities/Colleges both in public and private sector. All HEIs either in public or in private shall be treated on par within this regulatory regime. The regulatory regime shall encourage private philanthropic efforts in education. The ICAR constituted NEP implementation strategy committee recommends the allotment of students to private institutions through AIEEA conducted by NTA/ICAR on the same lines of allotment to public institutions. As mentioned in the NEP-2020, multidisciplinary approach needs to be adopted in tackling plant pathogens as plant pathology shares an interface with all disciplines in agricultural, horticultural, chemical, engineering, environmental and social sciences in meeting the challenges of food security and environmental stewardship in the twenty-first century. The curriculum of Plant Pathology has to be formulated at various academic levels to address the issues of industry and farming community in view of emerging plant pathogens, fungicide resistance, breakdown of host plant resistance, and climate changes. Various skills in artificial intelligence and machine learning, robotics and drone technologies have to be imparted to students of Plant pathology to reduce crop losses . *Improving the availability and quality of learning materials. quality teaching, flexible and relevant national frameworks and increase of budget for plant pathology education are vital.* Plant pathologists should utilize the proposed National Research Foundation (NRF) in NEP 2020 to get more merit based and peer reviewed research funding. It has been estimated that more than 15% of food production is lost to plant diseases in developing countries including India. Historically, plant diseases have caused catastrophic impact on food production. Food security is threatened by an ongoing sequence of plant diseases and expertise is required to ensure food security for the 21st century. Thus, there is need to utilize NEP 2020 policies to revamp academic curriculum with multi disciplinary approach and to design new courses with multiple entry and exit in Plant Pathology to tackle emerging disease problems to feed ever growing population.

KN03(1): Plant Pathology Education: roblems and rospects in new education policy

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The fundamental principle of new education policy is to recognize, identify and fostering the unique capabilities of each student by sensitizing teachers as well as parents for holistic development of each student. The vision of this policy is to develop an education system rooted in Indian ethos that contributes directly to transforming India, by providing high quality education to students thereby making India a global knowledge superpower and students as global citizen. At present, plant pathological education has to be reoriented as per the fundamental principles and vision of new education policy. There are several problems, concepts and changes are going to take place to impart education and research in plant pathology for under graduate and post graduate students. Apart from challenges of implementing new education policy, climate change is predicted to results in reducing productivity and increased pesticide usage impact food safety. For the management of plant diseases in eco-friendly manner, plant pathologists are developing new and more efficient methods for sustainable crop production. To give adequate knowledge about plant pathology, the Agricultural universities have implemented student's READY programme to impart knowledge on practical agriculture and promote professional skills, entrepreneurship qualities and make students as Job creators rather than Job seekers. Therefore the challenges occurs in this sector faced by changing education policy in plant pathology by building fashioned plant pathologists. There are problems and prospects in implementing new education policy in plant pathology research and education.

SESSION 2:
Basic research in plant pathology

2A. Taxonomy and systematics of plant pathogens

Keynote Lectures

KN01(2A): Biodiversity, taxonomy and plant disease diagnostics of plant pathogenic fungi from India

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Host–Pathogen interaction under favourable environmental variables results in disease syndrome followed by symptom production. There are different symptoms produced by plant pathogenic fungi namely necrosis, hypertrophy and hyperplasia and also hypotrophy and hypoplasia. Identification of the fungal pathogen and their classification is an important aspect to be dealt. Most of the pathogenic fungi are either obligate parasites or biotrophs. Around 13 million of fungi have been estimated and of which only 1,40,000 fungal species have been identified world over. India has got a record of 29,000 fungal species. Since 1/3 of global fungal biodiversity occurs in India, hence there is a need to discover the fungi occurring in different ecological niches and also on crop plants. Around 30,000 plant pathogenic fungi have been reported in the world and of which 5000–7000 pathogenic fungi might have occurred on various crop plants and forest plants in India. Early detection of plant pathogenic fungi and diseases diagnosis are the important components that help in disease management. Morpho-taxonomy and molecular tools are employed in the identification of the plant pathogenic fungi. The establishment of relevant disease forecasting systems and models are important for early prediction of the outbreak of plant diseases. In India agriculture forms the backbone for the country's economy besides offering food security and nutritional security to the growing population. The aspects and prospects related to biodiversity, taxonomy and plant disease diagnostics of plant pathogenic fungi from India are discussed.

KN02(2A): Redefining *Fusarium*

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The *Nectriaceae* (*Hypocreales, Sordariomycetes*) includes saprobes, endophytes and numerous important plant and animal pathogens, several of which are used in commercial applications. Members of *Nectriaceae* are circumscribed by having yellow, orange-red to purple uniloculate ascomata, and phialidic asexual morphs. Due to the lack of DNA sequence data for many taxa in the family, species and generic concepts remain poorly defined. To address this issue, we performed a multi-gene phylogenetic analysis using partial nucleotide sequences of the *rpb1*, *rpb2*, and *tef1* and rDNA gene

regions for available type and authentic strains representing fusarium-like taxa. Using a polyphasic approach including morphology of the sexual and asexual morphs, these data resolved more than 20 genera in *Fusarium sensu lato*. Following the one fungus = one name initiative, *Fusarium* = *Gibberella*. This genus relates to the F3 clade *sensu* Geiser *et al*. (2013), and not the F1 node eventually chosen by the authors Geiser *et al*. (2021), including an assemblage of different biological genera such as *Albonectria, Bisifusarium, Cyanonectria, Geejayessia, Neocosmospora* and *Rectifusarium*. These genera do not only differ in their sexual morphs, but also in their asexual morphology and biology. The fusarium-like morphology, with hyaline, curved macroconidia with basal foot cells, is a synapomorphy that has been lost several times throughout the *Hypocreales*, and does not represent a character of generic value.

Invited Lecture

IL01(2A): Characterization of Ganoderma of Arecanut plant collected from Eastern and North Eastern India

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Ganoderma spp. associated with arecanut plant were collected through survey from West Bengal and Assam during 2019 and 2020. In the form of basidiocarp, samples were collected. From 12 isolates, the fungus of interest was isolated from basidiocarp on *Ganoderma* selective medium and one isolate of an unknown dicot flowering plant from IARI, PUSA, campus, New Delhi was included in the study. Isolates were studied for its morphological characters such as colour, length, breath, thickness of basidiocarp, presence or absence of stipe and basidiospore characters. Based on the stipe character, isolates JPG3WB19, JPG8WB19, KRG16AS20, KRG20AS20 and NDG1DL20 were grouped into stipitate group; isolates JPG2WB19, JPG5WB19, JPG6WB19, JPG9WB19, JPG10WB19, KRG14AS19, KRG17AS20 and KRG18AS20 were grouped into sessile group. Likewise, based on the basidiospore size, isolates JPG3WB19 and KRG17AS20 were categorised into larger spore group; isolates JPG2WB19, JPG5WB19, JPG6WB19, JPG8WB19, JPG9WB19, JPG10WB19, KRG14AS19, KRG16AS20, KRG18AS20, KRG20AS20 and NDG1DL20 were categorised into medium spore group. ITS sequence based molecular identification was also done for all 12 isolates using ITS 5/1 and ITS 4-primer pairs. Phylogenetic analysis using ITS sequence nucleotide data of different *Ganoderma* species were made and the study revealed that 7 isolates, JPG2WB19, JPG5WB19, JPG8WB19, JPG9WB19, KRG14AS19, KRG17AS20 and KRG20AS20 were found to be closer to *G. orbiforme* and 5 isolates JPG3WB19, JPG6WB19, JPG10WB19, KRG16AS20 and KRG18AS20 were found to be closer to *G. boninense*. Isolate NDG1DL20, collected from dicot flowering plant, was identified as *G. lucidum.* *G. orbiforme* and *G. boninense* were detected from the arecanut plants of both the state of West Bengal and Assam. *G. lucidum* was not found in any of the samples collected from Arecanut. *G. orbiforme* and *G. boninense* were found to be new on arecanut plant in India.

Oral Presentations

OP01(2A): Morpho-patho-genetic variability in *colletotrichum* species infecting chilli plants of Andaman and Nicobar Islands, India

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Chilli (*Capsicum annuum*) is one of the most important vegetable and cash crop and its is being cultivated for several hundred years as a sustainable form of agriculture in India and also in many other countries. India is the largest producer and consumer of chillies in the world with a contribution of about 25 percent. Anthracnose disease in chilli is one among the biotic factor in all chilli-growing areas of the world which may cause yield loss of up to 40%. The present study aimed to understand the basic pathogen nature of *Colletotrichum* species infecting chilli crop in the Andaman and Nicobar Islands, India before devising eco-friendly disease management practices. Twenty fungal isolates associated with chilli anthracnose disease from different chilli growing locations of Andaman Islands, India were characterized using multiple approaches. Morphological studies revealed, out of twenty isolates, fourteen isolates were found chromogenic and eleven showed concentric ring pattern of mycelial growth. Conidial morphology studies showed, the isolates were grouped in to two species (*C. capsici* and *C. gloesporioides*). However, the sequence analysis using internal transcriber spacer (ITS) region and housekeeping genes revealed the presence of two other species: *C. siamense* and *C. plurivorum,* in addition to *C. gloesporioides* and *C. capsici*. The pathogenicity tests upon three different chilli varieties revealed there is difference in the pathogenic potential among the collected isolates. The present study revealed the presence of high level of genetic and pathogenic variability among the *Colletotrichum* isolates infecting chilli in Andaman Islands.

OP02(2A): Molecular phylogenetic diversity and development of species specific molecular markers for plant pathogenic species within *Fusarium solani* species complex (FSSC)

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Seventy five isolates belonging to the *Fusarium solani* Species Complex (FSSC) were characterized based on Multilocus sequence analyses (MLSA) and morphological features. Internal transcribed spacer (ITS), translation elongation factor-1 (TEF-1±), RNA polymerase II subunit (RBP2), large subunit (LSU), Calmodulin, mitochondrial small subunit rRNA (mtSSU) and rRNA Intergenic spacer were used for molecular delineation. Based on phylogenetic analysis all the isolates were classified into eight described cryptic species viz., *Fusarium falciforme, F. striatum, F. metavorans, F. vanettenii, F. cyanescens, F. keratoplasticum, F. solani FSSC5* and *F. petroliphilum.* This study found that *Fusarium falciforme* is the most dominant cryptic species of *Fusarium solani* species complex present in India which contribute alone more than 58% with causing disease to diverse agricultural crops. *Fusarium falciforme*, *Fusarium metavorans* and *Fusarium striatum* was found predominantly plant pathogenic species. Furthermore, specific molecular markers for identification of these three predominantly present cryptic species were developed. The conserved sequences from multiple alignments of *tef* gene were used to design the primers for detection. *tef* gene sequence from 46 isolates of *Fusarium falciforme* and 33 sequences from 7 different cryptic species of *Fusarium solani* were aligned and 205 base pairs amplicon size species specific oligonucleotide primer were design. Similarly, *Fusarium metavorans* and *Fusarium striatum* specific oligonucleotide primers were design with amplicon size 365 base pairs and 207 base pairs respectively. The specificity of primers was validated against seven different cryptic species of FSSC. Sensitivity for detection of primers was analyzed. This finding will be helpful for researchers in rapid detection and identification of important plant pathogengenic cryptic species of FSSC.

OP03(2A): Identification and characterization of emerging bacterial boll rot of cotton in central India

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Upland Cotton (*Gossypium hirsutum* L.) is the most important natural fiber crop cultivated worldwide in the India, China, United States, Australia, Egypt, and African tropic regions. However, India covers largest acreage under cotton cultivation with highest cotton production in the world. An unusual emerging problem of internal seed and lint rot of developing green bolls of cotton in central India has been noticed symptoms with deformed bolls, reduced boll development, fiber quality and yield. The sampled green bolls that appears externally healthy but diagnosed disease when cross sectioned bolls observed symptoms with yellowish to pink-red discoloured lint, slimy appearance and rotting of immature seeds. These diseased boll rot samples upon isolation on nutrient agar, observed predominant bacteria with circular shape colonies, Gram negative, facultatively anaerobic, rod-shaped and translucent yellow colour colonies. On the basis of pathogenicity tests, confirmation of Koch's postulates and 16S rRNA gene sequencing, the phytopathogenic bacteria *Pantoea dispersa* was observed as causal organism of internal boll rot of upland cotton. The detailed polyphasic characterization of the bacteria on morphological, phenotypic, biochemical and molecular characterization confirm the taxonomic insights of the bacterial pathogen. Similarly, the bacterium, *Xanthomonas citri* pv. *malvacearum* was also observed causing water soaked, oily spot symptoms on green bolls of *G. hirsutum* (cv. HS-6) and HxB germplasm crosses in the experimental fields. The phylogenetic analysis using maximum-likelihood based on partial rpoB, gyrB and 16S rRNA genes was performed for further investigation on taxonomic classification of bacterial boll rot pathogens.

OP04(2A): Some important diseases of *Eucalyptus camaldulensis* and *E. tereticornis* from Telangana

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Eucalyptus is a large and important genus containing about 600 species. It is a commercial crop because of its wood, pulp and useful silvicultural properties. Eucalyptus species are used in papermaking. The two commonest species that are grown in Telangana are *Eucalyptus camaldulensis and E. tereticornis*. Many paper industries purchase wood-based pulp from Telangana and Andhra Pradesh region for paper production. In view of the above mycologists have started examining the diseases occurring on the above mentioned two species. The important diseases that occur on the above two dominant *Eucalyptus* species include leaf spot caused by *Alternaria alternata*. Another important disease being a damping off, seedling blight, stem infection, and leaf curling caused by *Cylindrocladium parvum.* Anthracnose disease caused by *Pestalotiopsis versicolor* has also been observed on *Eucalyptus* spp. followed by *Glomerella cingulata* which also causes anthracnose. The crown drying disease caused by *Phytopthora cinnamomi* has also been noticed in *Eucalyptus* plantations. Another important disease is a pink disease caused by *Corticium salmonicolor* has been noticed in the *Eucalyptus* plantations. Field collections are made, disease symptoms have been noted and respective pathogens have been isolated in pure culture. The fungal pathogens have been identified using standard manuals. Single spore cultures have been deposited at ITCC, Division of Plant Pathology, IARI. Pathogenicity tests have been conducted with respective pathogens on the host plants following Koch postulates. All the above diseases reported in this presentation form new additions to the Telangana state.

OP05(2A): Critical examination of diversity and distribution of rust fungi in Karnataka

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Rust fungi are an obligate biotrophic plant parasites belonging to the order Pucciniales. There are about 100 genera and more than 7,000 species. In the present study, diversity of rust fungi occurring in Karnataka region associated with agricultural crops as well as wild plants species have been investigated and critically evaluated. Identification of rust diseases were made by symptomatology, aetiology and also based on the morphology of teliospores, urediniospores and basidiospores. A total of 48 different species of rust fungi occurring on 56 hosts belonging to 18 plant families (Fabaceae-10, Poaceae-07, & Malvaceae-05) have been recorded. Among the 48 rust fungi, the genus Puccinia represented by 23 species. Three major rust fungal genera were critically examined which include *Puccorchidium* - sharing the features of *Puccinia* and *Diorchidium*; *Puccinia* – taxonomic reassessment based on selected species; and *Kernkampella* – a genus separated from *Ravenelia*. Briefly, two new rust species in *Puccinia* occurring on *Justicia wynaadensis* and *Aecidium* on *Dyospyros melanoxylon* were described. The typification for *Puccinia leiocarpum* found on *Ocimum adscendens* is proposed. The type description for *Puccorchidium polyalthiae* is modified based on the micro-morphological characteristics. The genus *Kernkampella* has been revisited based on its occurrence on *Breynia oblongifolia*, *B. patens* and *B. retusa*.

2B. Genetics and ecology of plant pathogens

Keynote Lectures

KN01(2B): Changing dimension of research approaches for characterization of viruses in plants

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The first plant virus causing mosaic disease in tobacco was characterized based on the infectious nature of sap that passed through bacteria proof filter obtained from diseased plants in the late 19th Century. It was followed by local lesion assay, crystallization of virus particles, shape- and size-based virion characterization through electron microscopy, transmission assays, type of nucleic acid and serological reaction-based characterization. It was the first-generation sequencing technologies that unveiled the first complete genome sequence of cauliflower mosaic virus in 1980. Since then, sequencing technologies became ultimate tool to characterize viruses. The advent of next generation sequencing (NGS) technologies has revolutionized the field of plant virology as many new viruses in different hosts, in different geographical locations were discovered and this facilitated us to better understand the virus evolution. Our recent analysis of public transcriptome data sets as well as sRNA or mRNA sequencing have shown the association of several known/unknown/novel viruses with various plant species. Using available mRNA and sRNA data sets of grapevine, complete or near complete genome of 19 viruses and viroids were reconstructed. Seven viral and 1 viroidal genome were recovered for the first time from any Indian grapevine cultivar. Metagenomics of grapevine cultivars also determined the seasonal dynamics of viruses. NGS of rRNA-depleted total RNA showed association of an unknown virus and viroid species in mosaic affected apple cultivars. However, there is a need of standardization of various steps involved in NGS and analysis of sequencing data for wider application.

KN02(2B): Race profiling and molecular diversity analysis of *Fusarium Oxysporum* f. sp. *lentis* causing wilt in lentil

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Wilt caused by *Fusarium oxysporum* f. sp. *lentis* is one of the important diseases of lentil worldwide including in India. Two hundred and thirty-five isolates of the pathogen collected from different parts of India showed substantial variations in respect to morphological features such as colony texture, pattern, pigmentation, and growth rate, etc. Based on the morphological features altogether the populations were grouped into 12 categories. A set of differential genotypes was identified for virulence analysis of the pathogen by evaluating 114 genotypes of lentil against an isolated FLDL1 of the pathogen. Based on the reactions, 10 genotypes with variable reactions and genetic background were selected as differentials for race profiling. The representative populations of *F. oxysporum* f. sp. *lentis* (70 isolates) were grouped into 7 races on the basis of virulence patterns obtained on 10 differential genotypes. The information on race profiling generated in the present study could be further utilized in the development of race specific resistant cultivars. Genetic diversity of the pathogen was analyzed using random amplified polymorphic DNA (RAPD), universal rice primers (URPs), inter simple sequence repeats (ISSR), and sequence-related amplified polymorphism (SRAP) molecular markers. URPs, ISSR, and SRAP gave 100% polymorphism, while RAPD gave 98.9% polymorphism and the isolates were grouped into seven clusters with genetic similarities ranging from 21-80%. The populations of northern and central regions of India clustered separately. The ITS and TEF-1*a* region of the representative isolates of the pathogen were amplified and sequences of these genes were analyzed. The phylogenetic analysis using these two genes grouped the isolates into two major clades representing various races. The molecular groups did not correspond to morphological features and geographical location of the pathogen whereas; it was partially corresponded to the lentil growing regions of the isolates and races of the pathogen.

KN03(2B): Virulence structure of *Blumeria graminis tritici*, the causal pathogen of wheat powdery, in Indian sub-continent

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Powdery mildew (PM) of wheat caused by *Blumeria graminis tritici* (*Bgt*) is one of the most devastating disease in areas with cool and maritime climate. It is a minor disease in Bangladesh, Bhutan and Myanmar and moderate in Pakistan and Nepal. In India, disease has emerged as a potential threat in North Hill Zone (NHZ) and North Western Plain Zone (NWPZ). Cultivation of resistant varieties is a practically feasible, economically viable, eco-and farmer friendly means to manage this disease. However, presence of viable teleomorph in temperate regions and high rate of mutation, followed by fast and enormous conidial production result into the evolution and fast spread of new and matching virulences, rendering the resistant varieties susceptible. It warrants continuous monitoring of *Bgt* virulences for effective and successful wheat breeding for PM resistance. In India, Arya (1962) was the pioneer to initiate work on virulence analysis of *Bgt*. Thereafter, investigations were undertaken using PM differential lines (*Pm* lines). The studies conducted in Himachal Pradesh and Punjab during 1980-2000 revealed no virulence on genes *Pm1a*, *Pm2, Pm4a* and *Pm2+6* whereas, virulence was quite high on *Pm3a, Pm3b, Pm3c* and *Pm8*. Isolates from Nilgiri hills showed virulence on genes *Pm1a, Pm3b*, *Pm4* and *Pm8*. Virulence analysis of 263 and 75 isolates from NHZ, during 1993-98 and 2015-2019, respectively revealed dynamism in virulence. Virulence on *Pm1a* increased from 6 (1993-1998) to 63% (2015-19) and it decreased on genes *Pm2*, *Pm3a* and *Pm3b* from 13, 75 and 22% during 1993-98 to 0, 33 and 1%, respectively, during 2015-19. Virulence on gene *Pm8* increased from 50% after a decade and >80% during 2015-2019. Genetically characterized pathotypes were used for speculation of race-specific PM resistance genes in advanced wheat breeding material following infection-type matching technique. Out of more than 30 *Pm* genes evaluated, *Pm2*, *Pm4a, Pm1+2+9+12* (Normandie), *Pm 2+Mld* (Maris Dove) and *Pm1c* (Weihestephan M1N) remained effective against the test isolates studied and these may be used as donors to develop PM resistant cultivars.

KN04(2B): Current Status of Phytoplasma Disease Research in Asian countries

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Phytoplasmas have been emerged as one the most serious constraints in the production of several agricultural crops all around the Asian countries during the last two decades. All-important agricultural crops which are largely cultivated in South and East Asian countries are reported to be infected with phytoplasmas with severe losses in yield and quality every year. A significant progress on identification and characterization of phytoplasmas, epidemiology, full genome sequencing and management of phytoplasma strains has been achieved in last two decades in Asia. Asian countries have a great genetic diversity of phytoplasma strains since several '*Candidatus* Phytoplasma' species have been identified. Over more than 250 plant species are known to be hosts of 26 ribosomal groups of phytoplasmas in Asian countries. Maximum reports are available from India, China and Iran. Currently, climate change, particularly global warming, affects not only the multiplication of phytoplasmas but also the fitness and population dynamics of insect vectors, which have a great impact on the geographical distribution and severity of phytoplasma diseases in Asian countries. As a whole, phytoplasmas belonging to the 16SrI, 16SrII, 16SrIII, 16SrV, 16SrVI, 16SrVIII, 16SrIX, 16SrX, 16SrXI, 16SrXII and 16SrXIV, 16SrXXX, 16SrXXXII groups have a range of plant hosts all over Asia. The most widespread phytoplasma groups resulted to be 16SrI, -II, -V, -VI, -IX, -XI and -XIV. Sugarcane, bamboo species, sesame, vegetables, legumes, brassicas, palms, stone fruits, seasonal ornamentals and tree species are the major crops infected by phytoplasmas in Asia. These phytoplasmas strains are known to be transmitted by several potential leafhoppers, plant hoppers and psyllid species, which have led to significant yield losses in valuable crops. As a result, phytoplasmas and their associated diseases have become an emerging threat to agriculture in Asia countries. In last two decades, significant advancement in full genome sequencing and draft genome of several phytoplasma strains has been completed in Japan, Taiwan, China and India, which has opened further possibilities for host metabolic interaction studies. Further efforts on epidemiology and to elucidate the molecular mechanisms of plant-insect vector-phytoplasma interactions, full genome sequencing of the emerging phytoplasma strains of Asia and management aspects will greatly contribute to a sustainable development of eco-friendly tools to control the phytoplasma-associated diseases in Asia.

Invited Lectures

IL01(2B): Present status of plant DNA virus in West Bengal, India: Genetic diversity, virus-vector interaction and prospects of virus control

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Emerging, re-emerging of plant virus diseases and changing and/or expanding host range became new threats to the food security. West Bengal is the leading rice and horticultural crops producing state in India. Intensification and diversification of crops instigate the infection of several pathogens and become pandemic of viruses having DNA genome likewise begomovrus, nanovirus, tungro virus in several crops. The begomovirus of ssDNA genome is predominantly ruling and causing serious diseases in plants including tomato, chilli, pepper, okra, tapioca, sweetpotato, papaya, ornamental and vegetable and grain legumes. Existence of different genetic group of white fly (Asia I, Asia II 5, Asia II 7 and China 3) in West Bengal becomes a new threat of transmitting begomoviruses and a critical relationship between vector -virus and host leads to emerge new species of virus and broaden the host range. Global dimension of ToLCV predicted showed significant variation. The extents of damage of banana orchard by Banana Bunchy Top Virus (BBTV) is increasing and whole genome sequencing of the isolates gave the evidence on the existence of Asia-Pacific strain across West Bengal. The effect of the BBTV on the physiology of *P. nigronervasa* also has been documented. Besides, this state is also reported as endemic of Rice Tungro disease and occasional incidence may cause epidemic in future. However, phylogenetic analysis of sufficient virus isolate sequences of Rice tungro Bacilliform dsDNA virus proved the continuation of infection with South-Asia strains specific. RNAi approaches may give stable transgene resistance to particular rice varieties. Multiple nucleotide sequence alignment of the isolates DNA plant and functional domains of the amino acids will help in evolutionary study of the viruses and relationship with the vector for better management of the viruses.

IL02(2B): Race distribution pattern of *Pyricularia oryzae* Cavara causing rice blast from north western Himalayan region of India

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The rice blast pathogen can rapidly change in virulence; such changes may overcome resistance in popular rice cultivars which results in severe outbreak of the disease. To understand virulence change in *Pyricularia oryzae* populations, 16 isolates were sampled from hills of Uttarakhand state of India and tested on 26 rice blast monogenic differentials (MDs) carrying 26 blast R-genes, namely, *Pia, Pib, Pii, Pik, Pik-h, Pik-m, Pik-p, Pik-s, Pish, Pit, Pita, Pita-CP1, Pita2-PI, Pita2-Re, Piz, Piz-t, Pi1, Piz-5, Pi3, Pi5(t), Pi7(t), Pi9, Pil2(t), Pi11(t), Pi19,* and *Pi20* in the genetic background of a Japonica rice type "Lijiangxintuanheigu" (LTH) along with a susceptible check, LTH and a resistant check, VL *Dhan* 154. The virulence frequency ranged from 23 to 92, and the least virulent isolate was Mo-nhz-09 collected from the Almora district whereas, a highly virulent isolate (Mo-nhz-04) was collected from the Nainital district. It was observed that R-genes, *Piz5, Pita2*-Re, *Pita2*-PI, *Pizt, Pi9,* and *Pita*-CP1 and resistant check, VL *Dhan* 154 showed low virulence frequency (<20%). In contrast R genes *Pi11*(t), *Pi12*(t), *Pi20*(t), *Pi3*(t), *Pi5*(t), *Pia*, *Pib*, *Pii*, *Pik*-s, *Pita*-K1, and *Piz* showed intermediate virulence frequency (20-60%) and *Pi1*, *Pi19*(t), *Pi7*(t), *Pik*, *Pik-h, Pik-m, Pik-p, Pish, Pit* and susceptible check, LTH showed high virulence frequency (>60%). A total of 16 races were classified out of these isolates. Highly virulent isolate, classified as U43-i7-k177-z17-ta733 race and most of the R-genes except *Pib* and *Pish* showed susceptible reaction to this race. An attempt was made to use the international MD set and classify races to know its distribution pattern in Uttarakhand hills of the northwestern Indian Himalayan region. The information might be helpful in deploying identified R-genes for the effective management of rice blast disease.

IL03(2B): Plant Influence on the ecology of soil pathogen and microbiome biofilms

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Soil microbial communities or microbiomes play a vital role during both health or diseased state of plants. Co-evolution of plants and soil microbiomes has resulted in mechanisms that allow assembly of beneficial microbiomes that protect against pathogen invasions. *In healthy states of plants*, in spite of the rich chemical diversity in the rhizosphere, fast growers do not overwhelm the microbial community and diverse members shift lifestyle from free-living to surface-attached biofilm mode of life. Biofilms not only provide stability in their ecological services to host plants but also protection against invasion against pathogens. *In diseased state of plants*, pathogens have evolved mechanisms to overcome the protective functions of biofilms. Their invasion leads to dysbiosis that involves creating an imbalance in evenness and diversity. This talk will introduce the ecological strategies that pathogens adopt to create a dysbiosis. Then, the speaker will introduce a novel chemical signalling paradigm that strongly influences the soil microbiomes to respond by switch in their lifestyles to form biofilms. This response is highly specific involving on a tenth of soil microbial taxa. Interestingly, the response is also dependent on the levels of chemical cues whereby microbiome members associated with healthy state of plants respond to lower levels of the novel class of chemical signals, whereas the soil pathogens respond to higher levels of the signals. The talk will end by sharing how our understanding these fundamentals of soil ecology and dysbiosis by pathogens is leading us to develop novel plant protection strategies for soil pathogens.

IL04(2B): Viruses transmitted by *Brevipalpus* (Acari: Tenuipalpidae) mites: overview and updates

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Brevipalpus-transmitted viruses (BTVs) cause economically important diseases such as citrus leprosis and coffee ringspot, which affect relevant crops mainly in the Americas. Additionally, at

least one of them, orchid fleck virus, naturally infects orchids worldwide and citrus in three American and African countries. Disease symptoms caused by BTVs are characterized by the presence of localized chlorotic, necrotic, or ringspot lesions on the aerial parts of the plants. There are no reports of BTVs invading their hosts systemically under natural conditions, and they are all transmitted by *Brevipalpus* spp. mites in a persistent manner. Taxonomically, they are classified into genera *Cilevirus* (family *Kitaviridae*) or *Dichorhavirus* (family *Rhabdoviridae*). Virions of cileviruses have short bacilliform morphology, with bisegmented ss(+)RNA genomes of ~9 and 5 kb, and typically six ORFs. The ICTV accepts three species of cileviruses, which are phylogenetically related to other kitaviruses and arthropod-infecting nelorpiviruses, sandewaviruses, and centiviruses. Dichorhaviruses virions present short bacilliform morphology with bisegmented ss(-)RNA genomes of ~ 6 kb each and six ORFs. So far, five species of dichorhaviruses are accepted by the ICTV, and they are phylogenetically closer to viruses belonging to the genus *Betanucleorhabdovirus*. Recently, five new cile-like kitaviruses were characterized in Hawaii, Iran, and Brazil. Four of them are transmitted by or have an association with, *Brevipalpus* mites. Three new tentative species of dichorhaviruses transmitted by *Brevipalpus* spp. are under characterization in Brazil. The increasing list of BTVs includes pathogens that infect a variety of plant hosts in expanding geographic regions and will be addressed in this talk.
Support: Fapesp.

IL05(2B): Experimenting with infectious clones of DNA viruses: recent experiences with viruses of okra and rice

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Infectious clones of viruses, which have been a powerful tool in the hands of plant virologists for quite some time now, are also, of late, benefitting plant pathologists, geneticists and molecular biologists. I will give two examples justifying the above statement based on the work done in my research group: one involving the begomovirus okra enation leaf curl virus (OELCuV) and its associated bhendi yellow vein mosaic betasatellite (BYVMB) and the other the tungrovirus rice tungro bacilliform virus (RTBV). Working with viral diseases of okra, it was realized that the etiology of okra enation leaf curl disease (OELCuD), an emerging disease of okra in the Indian subcontinent was unclear. To strengthen this point, a cloned DNA of OELCuV was converted into a partial dimer in a binary plasmid, suitable for agroinoculation, and various methods of inoculation were tried on okra plants, with and without BYVMB. Success in inducing symptoms of OELCuD was obtained when both OELCuV and BYVMB were agroinoculated in the shoot tip of okra plants. The cloned OELCuV DNA was demonstrated to exist in a replicative form in the symptomatic okra plants, as a proof of infection. These opened possibilities of testing okra lines for resistance against OELCuD, independent of the natural vector whiteflies and established Koch's postulates for this disease. In rice, using an infectious clone of RTBV, our group had developed a gene silencing system, using the principle of Virus Induced Gene Silencing (VIGS), a method to transiently silence genes in plants using modified infectious clones of viruses. Recently, we have used the RTBV-VIGS system for functionally characterizing a gene locus (*Xa38*) responsible for resistance against the Bacterial Blight disease (BB) of rice. Thus, the effort of developing infectious clones of plant viruses was rewarded by not only establishing the Koch's postulates for the OELCuD, but also by an enhanced understanding of the role of a resistance gene complex against an important bacterial disease, BB.

IL06(2B): An understanding of pathogen population diversity aids in the management of late blight diseases of potato and tomato

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Epiphytotic diseases are usually caused by plant pathogen populations rather than individual strains. Therefore, to '*know thy enemy'* pathogen populations need to be characterized with genetic and phenotypic/field attributes for meaningful disease management. Worldwide late blight (LB) is considered to be the single most limiting factor for potato cultivation and to a relatively lesser extent for tomato. The sudden and rapid LB disease onset not only causes crop loss but also socio-economic upheaval especially in the Indian context, for small farmers cultivating potato and tomato. The use of population diversity markers has been a major tool in discerning LB populations worldwide. Dedicated LB disease management networks like the EuroBlight (for Europe) and USABlight (for the USA) are utilizing these inputs for effective LB disease management and the endeavor is to replicate the success for the other newer networks like the AsiaBlight (for Asia). This talk will showcase the Indian baseline studies of the LB epidemic populations over the years (2008-09 to 2020-21) with respect to the clonal/sub-clonal lineages present, their relationship with SSR Multi Locus Genotypes (MLGs) worldwide as well as their phenotypic attributes like fungicide sensitivity, temperature adaptability, virulence, etc., with a focus on integrating these for effective management of LB in India.

Oral Presentations

OP01(2B): Detection, virulence and genetic diversity of Fusarium species infecting maize in India

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In addition to the *Fusarium verticillioides*, many other *Fusarium* species are known to cause extensive crop loss worldwide in maize. In this study, we surveyed and characterized *Fusarium* species associated with symptomatic maize affected with *Fusarium* stalk rot in India using morphological and molecular analyses. Evaluated pathogenicity of the collected isolates by inoculating in maize composite variety during *Kharif* and *Rabi* seasons. Pathogenicity tests revealed varying degrees of virulence with some *Fusarium* sp. causing severe disease symptoms whereas others displaying mild symptoms. Molecular identification based on *TEF-1±* gene sequencing classified all isolates into four major species with a majority belonging to *Fusarium verticillioides* followed by *Fusarium proliferatum*, 2 *Fusarium oxysporum* and 2 *Fusarium equiseti*. Among these highly virulent isolates of *Fusarium*, 5 isolates F1, F59, Chokla, Raichur and FUR11 were used to resistance evaluation against 40 inbred lines. The lesion length and disease severity were measured for each virulent strains in both seasons. Two inbred lines DML-1802 and NS-14 were found highly resistant against FUR11 and Raichur isolates. No inbreds were found resistant against F59 and F1 isolates. The resistant inbred lines can be used for future breeding program. High genetic variability suggests that these *Fusarium* species have the potential to become a major production constraint for maize growers. Findings in this report would greatly facilitate identification of *Fusarium* species in maize growing states and would provide groundwork for devising and implementing disease management measures for minimizing losses caused by *Fusarium* species in maize.

OP02(2B): Genome-based identification and validation of simple sequence repeat markers in *Tilletia indica* and compatibility assay of monosporidial lines

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Tilletia indica is a floret infecting fungal pathogen of wheat inciting Karnal bunt disease of wheat. Simple sequence repeats are widely used to uncover the population structures in fungi. In the present study, a total of 5,772 simple sequence repeat loci were identified in the *T. indica* genome. *In silico* analysis, forty microsatellite markers were used to the genotype of 20 *T. indica* isolates collected from north-western plains zone of India. Among SSRs, tri-nucleotide was most abundant (42%), followed by di-nucleotide (28%), mono-nucleotide (23%), tetra-nucleotide (3%), hexa-nucleotide (3%) and penta-nucleotide (1%). In PCR analysis, 130 alleles were amplified in 20 isolates of *T. indica* using 40 SSR markers. The polymorphic information value content (PIC) values ranged from 0.20 to 0.81 with an average of 0.51. The maximum PIC (0.81) was obtained for the TiSSR34 marker. 18 SSR markers were highly informative (PIC e” 0.5), 15 SSRs were moderately informative (0.5 > PIC < 0.25) and remaining 7 SSRs were less informative markers (PIC < 0.25). *T. indica* isolates did not cluster region-wise. Ten highly polymorphic SSR markers were also amplified in 60 monosporidial lines (ms) of *T. indica*. Highly polymorphic monosporidial lines were chosen for compatibility assay. 27 monosporidial crosses of *T. indica* were produced in Karnal bunt infection. TI7MS1XTI 8MS5 crosses produced the highest coefficient of infection (36) and TI7MS1XTI16MS1 gave 24.17 of coefficient of infection. The newly developed SSR markers will be useful for genetic and population studies.

OP03(2B): Understanding ecological diversity of sheath blight pathogen *Rhizoctonia solani* from various rice-ecosystem in India through phenotyping and whole genome sequencing (WGS)

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Rice sheath blight caused by *Rhizoctonia solani* (AG-I 1A) is a major disease occurs throughout the world and India and it causes yield losses up to 70% in the highly productive irrigated and rainfed lowland rice growing ecosystems. Scanty information is available about the genetic structure, evolution, ecology of polyphagous *R. solani* and this has made sheath blight resistance breeding and management challenging tasks. To understand the diversity in the Indian populations of sheath blight fungus, 32 isolates were collected from all six rice growing zones and analyzed their variations at cultural, morphological, virulence and genomic level i.e., whole genome sequencing (WGS). All 32 isolates showed radiated, round and elliptical colony shape. They produced 8 different colors, three textures, both surface and aerial mycelium, and varied number of zonation. Isolates (6) showed very fast (>2.5mm), fast(1.5-2mm) (9), medium (1.5-2mm) (9) and slow (1) growth rate. Initiation of sclerotia varied between 3rd and 6th day after culturing. Sclerotial characters differed among the isolates viz., number varied between 12 to 600, four different pattern, four varying of clump formation, aerial or surface production, smooth or/and rough texture and honey dew oozing (21). Fluorescence microscopic observations were showed ~5 to 9 nuclei count in single septum of *R. solani* mycelium among 32 isolates. Based on the virulence, 32 isolates were classified into four pathotypes. Virulence on rice *cv*. Tetep, showed moderately virulent (28), virulent (3) and less virulent (1), and on IR-64 shown highly virulent (7), moderately virulent (10) and virulent (15). All 32 isolates genome have been sequenced with 350 x throughput to produce 700.853 Gb sequence data. 5,046,121 SNPs were obtained by physically mapping the reads on the presently assembled BRS1 genome. A principal component analysis (PCA) based on the genomic distance divided the isolates into three different groups (North, South and East) and a subgroup of admixture between group I and group II, suggesting natural hybridization among the isolates. Present findings will helpful in finding the evolution, diversity of *R. solani* (AG1-IA) in India and formulating location specific target management strategy for sheath blight.

OP04(2B): Genetic DiveJrsity of Wheat Powdery Mildew (*Blumeria graminis* DC Speer f.sp. *tritici*) Population in India

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Wheat powdery mildew pathogen (*Bgt*) disseminates large number of conidia for recurrent infection and rust economic loss. Pathotypes / races of *Bgt* play vital roles in developing resistant varieties. Virulence patterns of *Bgt* were profiled in other countries, but limited efforts are made in India. Hence, we investigated genetic diversity at IARI, RS Wellington in Nilgiris, which is hot spot for PM, in collaboration with different ICAR institutes. We maintain 275 isolates of *Bgt* at Wellington. Out of these, 25 were selected based on their phenotypic data. Genomic DNA was extracted and genetic identity was ascertained initially by sequencing ITS region. Similar set of template DNA was used for amplifying 15 specific genes by using specific primers. The evolutionary history and genetic diversity of *Bgt* isolates were inferred based on the phylogeny derived from the consensus sequences of these isolates. For example, out of 25 *Bgt* isolates, the gene chitin synthase was amplified in 20 isolates. Some genes viz., chitin synthase was amplified in 20 isolates; ²-tubulin gene and Alpha-demethylase (cyp51) were amplified in four isolates; Elongation factor-1 (EFA) gene was amplified for nine isolates and other genes AOX and BEK were amplified for 21 isolates from different locations of India. These sequences were submitted in gen Bank (NCBI). Our salient results demonstrated a significant variation in genomic data of *Bgt* isolates from three agro-climatic and these important findings will help in identification

of virulent and avirueInt races among *Bgt* population and to indentify PM resistant wheat varieties in India.

OP05(2B): Phenotypic, multi-gene, and haplotype analysis of *Phytophthora* associated with areca nut

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Phytophthora, a ubiquitous filamentous oomycete, causes huge yield losses and is even fatal to areca nut palms. From 2014 to 2019, a severe fruit rot epidemic was recorded during the South-West monsoon season in major areca nut growing states of South India. We have assessed the diversity and investigated the population structure of geo-distant *Phytophthora* isolates infecting areca nut using a combination of morphological traits, multi-gene profiling, and haplotype analysis. A total of 101 *Phytophthora* isolates were obtained from infected samples collected from disease-endemic regions of Karnataka, Kerala, and Goa states. Morphological traits coupled with phylogenetic analysis, undertaken by utilizing *ITS*, *²-tub*, *TEF-1±,* and *Cox-II* loci, revealed the association of homothallic *P. heveae* (two isolates) along with the predominant species, *P. meadii*. All the *P. meadii* isolates were identified as A2 mating types. The study also demonstrated the existence of significant diversity in the collected geo-distant *Phytophthora* population. Totally, 128 haplotypes were identified across 40 isolates with the higher haplotype diversity and relatively varying haplotype frequency. Pathogenicity assays confirmed that both the species of *Phytophthora* were pathogenic to areca nut, while *P. meadii* isolates from Karnataka coastal region exhibited more virulence compared to other isolates. The information on population dynamics of the pathogen associated with fruit rot of areca nut would aid in formulating disease management strategies for effective management of disease and curtail further spread of this important phytopathogen in the areca nut ecosystem.

OP06(2B): Diversity of Streptomyces species associated with scab of potato in India

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Symptomatic scab infected tubers were obtained from various potato growing regions of Punjab, Madhya Pradesh, West Bengal, Chhattisgarh, Bihar and Meghalaya in India. The scab lesions on tubers were quite variable but generally appeared as rough, corky lesions, which ranged from a mere brownish roughening or abrasion of tuber skin (russet scab), proliferated lenticels with hard corky depositions leading to small raised dotted or circular lesions merging to form large irregular lesions, deep or shallow star shaped corky lesions to 3-4 mm pits surrounded by corky depositions. 41 isolates belong to Streptomyces spp. were confirmed, out of which thirty-four were confirmed as pathogenic. The phylogenetic analysis of 16s rRNA gene indicated that Indian Streptomyces isolates belonged to previously described pathogenic Streptomyces species i.e. S. scabies, S. europaeiscabies, Americam strain Streptomyces spp. Tx01-07D, S. bottropensis , S. griseus and non-pathogenic species viz., S. drozdowiczii, S. ciscaucasicus, S. galilaeus, S. variabilis and S. rochie. Sequence variability was confined to six regions namely the previously reported ±, ², ³, ´ and two regions (nucleotides 980-998 and 1099 to 1129) identified in this study. The ³ region was the most variable as reported earlier. Among the thirty-four pathogenic isolate, only six (all S. scabies) were positive for all the three marker genes for Streptomyces pathogenicity island (PAI) i.e. txtAB, tomA and nec1 genes; two (S. bottropensis) for txtAB and tomA genes; and four (two of S. bottropensis and two having similarity to Streptomyces spp. TX07-01D) for txtAB gene only. The remaining twenty-two pathogenic and seven non-pathogenic Streptomycetes were found negative for all the three marker genes for Streptomyces PAI.

OP07(2B): Ecology of soil borne fungal pathogens with special reference to *Sclerotinia scleortiorum* in NE India

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Attributes such as complex life cycle, long time survival ability, wide host range and lack of resistance source tag the soil borne fungi as menace. These fungi are important plant pathogens with broad ecological distribution and at times assume serious proportion as these are difficult to predict, detect, diagnose and manage. The sclerotial soil borne fungi, *Rhizoctonia solani, Sclerotium rolfsii*, and *Sclerotinia sclerotiorum* are mostly ubiquitous and more problematic. Diseases incited by these three soil borne fungi are recoded in the range of 3% to 20% in the region. *S. sclerotiorum* is a cosmopolitan necrotrophic host nonspecific fungi, reproducing asexually through sclerotia and sexually through ascospores, produced by self-fertilization. The crop production system in the country is known to be affected by *S. sclerotiorum* for several decades but the impact is felt much more in recent years especially in the subtropical zones during winters probably with the emergence of diverse virulent forms of the pathogen along with changes in climatic conditions towards more favourable proportions. Isolates obtained from different hosts and different agro-ecological zones of the north eastern region revealed considerable diversity for cultural and morphological characteristics. The average temperature was found to be the most important predictor and solely could able to explain 33 % variation in *Sclerotinia* disease incidence.

OP08(2B): Alteration in virulence pattern of *Puccinia striiformis* f. sp. *tritici* and pathotyping of yellow rust samples collected from North India between 2019 and 2021

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North-western plains zone (NWPZ) alone contributes nearly 45 percent of the total wheat production (49 million tons) from the 12.6 million-hectare area. However, this productive zone is vulnerable to yellow/stripe rust, caused by *Puccinia striiformis* Westend. f. sp. *tritici* Eriks. & Henn. (*Pst*). Annual surveys for monitoring the progress of a pathogen and detecting new pathotypes are pre-requisite to anticipatory breeding and varietal deployment. During 2019-21, a total of 394 yellow rust samples collected from farmers' fields or wheat disease monitoring nurseries (WDMN) that falls in six Indian states and pathotyped on 30 differentials. We distinguished nine different Pst pathotypes (238S119, 110S119, 46S119, 110S84, 14S64, 46S102, 47S103, 6S0, and 7S0). None of the pathotypes was virulent to *Yr5, Yr10, Yr15, Yr16, Yr24, Yr32*, and *YrSP*. Pathotype 238S119 (238E159) was the most virulent [(to *Yr2, Yr3, Yr3a, Yr3b, Yr4, Yr4a, Yr4b, Yr6, Yr7, Yr8, Yr9* (*Yr9*/6*Tc, Riebesel), *Yr11, Yr14, Yr19, Yr22, Yr23, Yr25, Yr27, YrA,* and *YrSU*)] and prevalent throughout the zone with the highest frequency (47.8%) followed by 46S119 (110E159, 30.2%). Over the period, the frequency of 46S119 decreased from 62.0% (2015-16) to 15.8% (2020-21). In contrast, the frequency of Pathotype 238S119 had increased consistently since its first detection in 2014 and superseded the frequency of erstwhile predominant pathotype 46S119 during 2019-20. The populations of three pathotypes 46S119, 110S119 and 238S119 are currently constituting nearly 97% of the total *Pst* population. This information will be helpful in deployment of resistant cultivars in yellow rust-prone areas to manage the yellow rust effectively.

OP09(2B): Fusarium infection and mycotoxin production in soybeans in Kazakhstan

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This study was conducted to identify *Fusarium* species infecting soybeans in southern Kazakhstan and mycotoxins produced. *F. equiseti* was the main pathogen causing root rot of soybean, although *F. nygamai* was also isolated from most of the symptomatic plants. In greenhouse studies, *F. nygamai* did not cause any obvious symptoms. The severity of root rot differed in soybean cultivars. The lowest seedling death by *F. equiseti* was on soybean cultivar Tanais with an incidence of 12%. Thirteen mycotoxins were produced by isolates of *F. equiseti*, among which deoxynivalenol (DON), zearalenone (ZON), and T2 toxin had higher concentrations and were more frequently detected. In the susceptible cultivar Maple Ridge to *F. equiseti*, concentrations of DON, ZON, T2 toxin were 224.4, 175.3, 100.5 µg/kg of plant tissues, respectively. Although *F. nygamai* did not cause symptoms in inoculated soybean seedlings, the above-mentioned mycotoxins were detected in the plants. The concentration of T2 toxin was higher than the concentration of ZON in soybean seedlings of Tanais cultivar inoculated with *F. nygamai.*

OP10(2B): Cultural and morphological variability of *Sclerotium rolfsii* isolates causing collar rot of brinjal

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Brinjal or eggplant (*Solanum melongena* L.) is an important solanaceous crop of sub-tropics and tropics of *Solanaceae* family. It is known as king of vegetables in India. It is an important tropical vegetable crop grown all over India because of its adaptability to wide range of agro-climatic conditions. It is a perennial but grown commercially as an annual crop. Brinjal is probably originated in India and shows secondary diversity in south east Asia. The nutritional value per 100 g of brinjal fruit contains 92.70 per cent moisture, 0.1 g fat, 5.7 g carbohydrate and 1.0 g protein. It is a good source of minerals and vitamins and is rich in total water soluble sugars, free reducing sugars, amide proteins, anthocyanin, phenols and glycoalkaloids. Collar rot of brinjal (*Solanum melongena* L.) caused by *Sclerotium rolfsii* Sacc. is currently occurring in brinjal growing areas of Northern Karnataka region in India. Cultural and morphological variability of ten isolates of *S. rolfsii*, collected from five districts of Northern Karnataka were studied. Out of ten isolates tested for their cultural and morphological variations, majority were observed with flat mycelial growth and smooth texture. Shape of sclerotia varied from oval to round, size from 0.93 to 1.15 mm, colour from light brown to dark brown, test weight from 89.2 to 298 mg and days to initiate sclerotia varied from 9 to 15. Significant variability with reference to mycelial and sclerotial characters among isolates of *S. rolfsii*, isolated from different locations of Northern Karnataka region was observed.

OP11(2B): Genetic diversity and population structure analysis of *Puccinia graminis* f. sp. *tritici* from Indian sub-continent

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Wheat (*Triticum aestivum* L.) is one of the most important sources of human nutrition and plays a critical role in global food security. The global wheat production reached 760.7 million tonnes during 2019 and 31% of it came from the two Asian countries i.e. China and India, ranked first and second in global wheat production, respectively. Wheat production has been continuously threatened by several abiotic and biotic factors including diseases. Stem (black) rust caused by *Puccinia graminis* f. sp. *tritici* Eriks. & Henn. (*Pgt*) is a highly devastating disease of wheat and could result in wheat yield losses up to 100% on susceptible wheat cultivars. The present study report virulence-based phenotype and 37 reproducible polymorphic SSR markers-based genotype patterns, population structure, and other diversity parameters in a repository of 29 Pgt pathotypes collected during the last <“90 years from India and neighboring countries. Virulence phenotypes were used to evaluate the virulence frequency (VF) and construct hypothetical evolutionary hierarchy (HEH) of these pathotypes. We projected seven lineages to explain the evolutionary pattern of the Pgt population. The VF of these pathotypes ranged between 0 to 100%. The virulence-based NJ cluster analysis grouped Pgt pathotypes into five virulence groups. Likewise, five molecular groups were categorized using molecular genotypes. The molecular grouping was supported by PCoA, which showed that 25% of the cumulative variance was contributed by the first two axes. AMOVA revealed 8% and 92% of the variation among and within the populations, respectively. The Mantel test confirmed a positive but weak correlation (R^2=0.15) between virulence phenotypes and SSR genotypes. The population structure analysis clustered 29 Pgt pathotypes into two sub-populations, and an admixture. Our results demonstrated that there was significant genetic diversity among Pgt pathotypes resulting from

their long-distance dispersal ability together with gene flow. These findings provide insights into the virulence patterns, genetic variations, and possible evolution of Pgt pathotypes, which would support strategic stem rust resistance breeding.

OP12(2B): Emergence of poleroviruses and criniviruses affecting cucurbitaceous crops in India

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Globally, the first cucurbit-infecting polerovirus, cucurbit aphid borne yellows virus (CABYV), was reported in the year 1992, and its first occurrence was recorded in India in the year 2017. Although several criniviruses are also known to infect cucurbit crops globally, their incidence has not yet been reported in India. However, looking at the emergence of newer viruses as well as the open trade and travel, their possible occurrence on different cucurbit hosts and locations cannot be ruled out. To investigate this, the surveys were conducted at experimental farms of ICAR-IARI, New Delhi, and ICAR-CIAH, Bikaner, Rajasthan during the years 2019-2021. Different cucurbit plants exhibiting varying symptoms were collected. Upon transmission electron microscopy, the association of geminate (~38nmx15nm), flexuous rod-shaped (~650-950nm×10-12nm), and small isometric (~25-30nm) virions was observed. Subsequent molecular analyses revealed the association of a known polerovirus species, CABYV, with bitter gourd & cucumber samples as well as *Pumpkin yellows virus* (PuYV), a novel polerovirus species, with the pumpkin samples of New Delhi, and with the ridge gourd & round melon samples of Bikaner. Besides, two crinivirus species *viz*., *Cucurbit chlorotic yellows virus* (CCYV) in the pumpkin samples of New Delhi and *Cucurbit yellow stunting disorder virus* (CYSDV) in the bitter gourd and watermelon samples of CIAH, Bikaner were also detected. These findings suggest that the polero- and crini-viruses, including their new species, are emerging in India in the cucurbit crops with a wider host range. This further alarms the bell for an urgent need to strengthen the research works on NGS-based diagnosis and to develop preparedness to save the vulnerable crops before being hit by these viruses.

OP13(2B): Characterization of *Fusarium graminearum* isolates causing head scab of wheat for their aggressiveness and trichothecene toxins

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Wheat is prime most staple food crop for major proportion of the world population. In India it occupies second position after rice in both area and production. Head scab of wheat caused by *Fusarium graminearum* being an emerging disease posing major threat to the grain production throughout the world including India. Twenty-seven pure cultures of pathogen were established from the 120 diseased wheat spikes collected from the Wellington (Tamilnadu). Morphological, cultural characterization coupled with molecular characterization with species specific markers (Fg16F and Fg16R) were carried out to identify the *Fusarium* species associated with the disease and it is found that all the isolates belong to *Fusarium graminearum* species. To characterize the *F. graminearum* isolates for toxins such as DON, NIV, 15-ADON and 3-ADON, toxin specific primers were synthesized and PCR assays were carried out. Twenty-four isolates were tested positive for the genes responsible for the production of DON toxin whereas all 27 isolates showed positive result for genes responsible for 15-ADON toxin. Pathogenic variation among the *F. graminearum* isolates was studied on a set of durum genotypes viz., HI 8591, HI 8708, HI 8713, HI 8737, HI 8765, HI 8774, HI 8777 and HI 8802. Spore suspension of all the isolates was prepared and inoculated onto the durum genotypes using cotton web technique. The percent spikelet infection was recorded at 7 and 14 days after inoculation. The isolates Fg-W20-8 and Fg-W20-18 were found more aggressive as compared to other isolates. Isolate Fg-W20-6 was found least virulent after 14 days of inoculation.

OP14(2B): Assessment of Mating type alleles and fertility of Magnaporthe population adapted to millets in India

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One hundred and twenty seven pure monoconidial cultures of *Magnaporthe* isolates infecting different millets (Pearl millet, Finger millet, Foxtail millet and Barnyard millet) were established from major millet growing blast hotspot locations in India. All isolates were assessed for their fertility using MAT gene specific primers *viz*., MAT1-1 (Male fertile) and MAT1-2 (Female fertile). The fungal DNA was extracted and mating type genes were amplified using specific primers which yielded a product size of 960 bp and 800 bp for MAT1-1 and MAT1-2 respectively. Out of 127 isolates assessed 46 (36.22 %) isolates showed mating MAT1-1 (male fertile), 34 (26.77%) showed mating type MAT1-2 (female fertile), while 22 (17.32%) isolates depicted hermaphrodite nature and remaining 25 (19.68%) isolates belonged to unknown mating type. The frequency of male fertility (MAT1-1) is high finger and foxtail millet compared to female fertility (MAT1-2) as evidenced by 37.18 and 43.24 per cent respectively. The hermaphrodite nature of fertility accounted for 17.95, 18.92 and 25 per cent in finger, foxtail and barmyard millet respectively whereas in pearl millet none of the tested isolates showed either male/ female or hermaphrodite nature of fertility and all tested isolates showed unknown mating type and in bajra-napier hybrid grass (fodder) one isolate was obtained with unknown mating type. The mating type assay revealed that the mating-types, male fertile, female fertile and hermaphrodite nature of fertility existed in the country in finger millet, foxtail millet and barnyard millet.Which indicates the possibility of sexual recombination in field level and which may lead to high variability in pathogenicity and diversity in *Magnaporthe* population adapted to millets in

India. The fertility of pearl millet isolates has to be confirmed using range of tester isolates and *Magnaporthe* populations showing evidence for both mating types from different geographical areas. The identified hermaphrodite isolates and both mating types from this study can be used as testers in future for a systematic survey of local field isolates. Further, production of fertile perithecia and ascospore progeny from crosses of field isolates across different crops and within the crops need to be studied in detail to know the host range, pathogenicity and variability in aggressiveness/virulence of *Magnaporthe* spp infecting millets.

OP15(2B): *Bipolaris sorokiniana* incitant of spot blotch in spring barley in southeast Kazakhstan

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Spot blotch is an annually-occurring disease in spring barley fields in Kazakhstan. This study was conducted to determine the causal agent of spot blotch of spring barley in southern Kazakhstan. In 2020, symptomatic leaves of spring barley were collected from the southern region of Kazakhstan, and tissues from affected lesions were cultured on Saburo agar and Czapek agar media. Alternaria alternata, A. tenuissima, A. infectoria, Bipolaris sorokiniana, Lecanicillium aphanocladii, and Cladosporium sp. were commonly isolated from barley leaves with spot blotch. Following a series of plant inoculation, B. sorokiniana was determined to be the incitant of spot blotch of spring barley. This pathogen grew rapidly on both Saburo agar and Czapek agar media and colony diameter reached 7.9 cm on Czapek agar in Petri plates in 5 days. Conidia of identified B. sorokiniana on Czapek agar measured 15.6 x 99.7 µm, had 5-7 septa, and were olive-brown (color). DNA from isolates of P-08 and P-15 of morphologically identified B. sorokiniana was isolated and PCR tests, including pathogenicity test, were conducted. Sequences of internal transcribed spacer regions (ITS) of rDNA showed that the isolated belonged to B. sorokiniana.

OP16(2B): Variability among different isolates of sclerotium rolfsii sacc. Associated with stem rot disease of groundnut

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Groundnut (*Arachis hypogea* L.) the king of oilseeds remains as the valuable source of all nutrients. Stem rot caused by *Sclerotium rolfsii* is a destructive disease that induces serious yield losses in groundnut around the world. Variation in morphological and cultural characteristics of thirty isolates of *Sclerotium rolfsii* were studied based on their growth rate, colony type, growth type, sclerotial pattern, sclerotial type, scleroial color and sclerotial size using potato dextrose agar (PDA). Significant variability with reference to mycelial and sclerotial characters across isolates of *S.rolfsii*, collected from Warangal, Wanaparthy and Nagarkurnool districts of Telanagna

was observed. The growth rate ranged from 0.76 to 1.35 mm/hr. All the isolates produced sclerotia on PDA medium. Most of the isolates produced the colonies which were raised at ends (*n*=14) followed by flat type (*n*=12) and raised type (*n*=4). As per mycelial growth type, most of the isolates were found highly profuse in growth (*n*=18) and few were profuse in growth (*n*=12). Likewise, the isolates exhibited considerable variation with respect to morphological characteristics. Wide variation was also found with respect to number of sclerotia per plate (58 to 536), pattern of sclerotia produced in petri dish (scattered category (*n*=23) and peripheral (*n*=7)), colour of sclerotia (brown colour (*n*=13) followed by dark brown (*n*=9) and light brown (*n*=7)), size of sclerotia (0.17 mm to 2.34 mm). PCA analysis extracted four main components, growth rate, colony type, growth type and sclerotial pattern, from the population that described the variability in the population most appropriately.

2C. Genomics of plant pathogens

Keynote Lectures

KN01(2C): Long-term continental surveillance and integrated rust genomics underpin sustained cereal rust control in Australia

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Long-term surveys of cereal rust fungi in Australia began in 1921 and have continued uninterrupted since. These studies have underpinned efforts to control rusts using both genetic resistance and fungicides that continue to contribute significantly to enduring profitability for Australian oat, barley and wheat growers in particular. For example, annual savings due to rust control (resistance breeding and fungicides) in wheat have been estimated at some AUD$1.4 billion, and in barley AUD$78 million. Prior to the 1980s, rust surveillance monitored pathogenicity (virulence/ avirulence) based on greenhouse seedling assays of virulence/ avirulence for important major resistance genes. Since then, these assays have been increasingly supplemented with information from biochemical (eg isozyme) or DNA markers. In recent years, the application of whole genome sequencing to rust pathogens has advanced rapidly and is now providing much greater insight into pathogen evolution/ evolutionary potential, and the threats they pose to cereal crops. This presentation will provide details of two important very recent discoveries; asexual somatic hybridisation in a wheat rust pathogen, and the emergence of fungicide insensitivity in a barley rust pathogen. Both of these discoveries have important implications for rust control, providing clear examples of how monitoring and researching genetic variability in rust pathogens are crucial to the sustainable control of rust in cereals.

KN02(2C): *Xanthomonas oryzae* pv. *oryzae*-effectors *vs* rice: an unending tug of war

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Xanthomonas oryzae pv. *oryzae* (Xoo), the bacterial blight (BB) pathogen employs T3SS-effectors to undermine rice PTI for its limitless proliferation inside the rice during disease development. We deciphered T3SS-effectors repertoire of a virulent Indian strain Xoo race 4 that possesses 21 Xop and 18 TALE effectors. The TALEs include both complete (tTALEs) as well as incomplete or pseudo/iTALEs. We carried out systematic study to understand the functional role of these effectors through loss-and-gain of effector. Two key Xoo-effectors, namely XopF and XopR contribute immensely during BB development. The mutants lacking either one of the effectors (Xoo *“xopF* or Xoo *“xopR*) displayed significantly reduced *in planta* colonization ability, reduced BB intensity while induced more callose deposition. Xoo mutants when inoculated on rice caused significantly increased expression of rice PTI genes. The both the effectors are tracked to localize to the rice plasma membrane. Subsequent investigation with XopF led to the identification of two rice interactors, namely photosystem-I reaction subunit V (PSI-G) and cyclophilin II. PSI-G is known to interact with arrays of proteins associated with photosystem I, while cyclophilin II is shown to interact with proteins that are involved in protein-folding, signal transduction and ubiquitination. This advocates that Xoo XopF interacts with the two interactors to accomplish its common goal of undermining the plant immunity, either through interfering photosystem I or through weakening plant immune protection system like cyclophilin. Altogether, this understanding into the Xoo-effectors vs rice exposes novel rice gene(s) for their sensible use in BB resistance programme.

Invited Lectures

IL01(2C): Current status of Cotton leaf curl begomovirus disease complex in India: incidence, distribution, genomics, pathogenecity and biotechnology-based management

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Cotton leaf curls disease (CLCuD), caused by whitefly transmitted monopartite begomovirus complex with association of beta- and alpha-satellites, is a serious constraint for cultivation of cotton in Northwest (NW) India. CLCuD was surveyed in different cotton growing areas of Haryana, Punjab and Rajasthan in NW India from the years of 2012 to till date and disease incidence, varied in year to year, were recorded. Complete genomes of 18 CLCuD-begomovirus isolates, associated betasatellites and alphasatellites were amplified through RCA, cloned, sequenced and characterized. *Cotton leaf curl Multan virus* -Rajasthan (CLCuMuV-Ra), -Faislabad (CLCuMuV-Fai), -Pakistan (CLCuMuV-PK); *Cotton leaf curl Kokhran virus* -Burewala (CLCuKoV-Bu) are identified in NW India. CLCuMuV-Ra is detected as predominant in NW India and mmajorities of the population of this virus were detected as recombinants The sequence of complete genome of 19 betasatellites and 21 alphasatellites were analysed. The betasatellites were members of Cotton leaf curl Multan betasatellite (CLCuMB). Sequence analysis showed that four species of alphasatellites, GDarSLA, CLCuMA, CLCuBuA and CrYVMoA are present in NW India. The CLCuD outbreak has been changing constantly in year to year and area in NW India. The recombinant CLCuMuV-Ra strain is the most predominant begomovirus, which is evolved from inter-species recombination. To a much lesser extent, the CLCuKoV-Bu, CLCuMuV-PK, CLCuMuV-Fai were identified in NW India. Single betasatellite species CLCuMB but diverse in genetic composition, and more numbers of alphasatellite species, GDarSLA, CLCuMA, CLCuBuA and CrYVMoA are associated with the CLCuD complex. Therefore, it is concluded that the recombinant CLCuD-begomovirus, particularly recombinant CLCuMuV-Ra, in association with recombinant CLCuMB betasatellite are the important causes for outbreak of CLCuD in NW India in present condition.The multiplex PCR using specific primers has been developed and evaluated, which is simple, sensitive and cost effective method for rapid and simultaneous detection of begomovirus, betasatellite and alphasatellite DNA associated with CLCuD complex. Two infectious clones (DNA-A), 1.4 mer tandem repeat of CLCuMuV-S-11 (pCAMBIA+S-11) and CLCuKoV-IARI-45 (pCAMBIA+IARI-45), and two infectious clone of betasatellite (dimer), S-11B (pCAMBIA+S-11B) and IARI-30B (pCAMBIA+IARI 30B) were developed. Infectivity test of infectious clone in cotton and tobacco plant revealed that both of DNA-A and betasatellite are necessary for the CLCuD symptom development. For development of transgenic cotton against CLCuD, RNAi-based gene constructs; antisense pBinAR-²C1-AS targeting ²C1 gene betasatellite and intron hairpin construct, pRNAi-GG- AV2_irp targeting CP (AV2) of CLCuD-begomovirus were developed and Agrobacterium mediated *in planta* cotton transformation with gene constructs was developed. Gus assay and PCR analysis confirmed transgenic T3 (pCAMBIA-As-²C1) and T2 (pRNAi-GG-AV2_irp) cotton plants were survived.

IL02(2C): Multifunctional role of V2 protein of croton yellow vein mosaic virus: suppression of RNA silencing, determination of pathogenicity and cell-to-cell movement

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Croton yellow vein mosaic virus (CYVMV), a species under the genus *Begomovirus*, is a prolific monopartite begomovirus in the Indian sub-continent. In this investigation we functionally characterize the V2 protein of the virus. V2 ORF was amplified, initially cloned in dTOPO gateway entry vector and sequenced. The V2 ORF was then sub-cloned to different gateway destination vectors. A reversal of RNA silencing assay using a GUS-reporter-GUS-hairpin system in *Nicotiana benthamiana* plant, indicated that V2 can suppressor the silencing activity of the GUS-hairpin. Sub-cellular localization of the eGFP-tagged V2 alone was found to aggregate as large clumps in various locations within the cytoplasm, majorly surrounding the nucleus. Co-infiltration of V2-GFP and CYVMV turned some large V2-GFP clumps into smaller particles, which were loosely associated with the cell wall and moved to reach plasmodesmata. As subcellular localization results suggested that V2 may interact with other viral proteins and may involve in cell-to-cell movement, its protein binding capacity was further investigated. In a targeted yeast-two-hybrid assay, CYVMV V2 protein physically self-interacted as well as interacted with V1 protein. V2 self-interaction was further confirmed through bimolecular fluorescence complementation (BiFC) assay and V1-V2 interaction was confirmed through a pull-down assay. These results indicated that V2 may fulfil its silencing suppressor function in the form of a homodimers or multimers. V1 and V2 interaction encouraged us to address whether such interaction is necessary for the cell-to-cell movement of the virus. V1 and V2 deletion constructs and the double deletion construct were created for infectivity in *N. benthamiana* followed by the molecular assays. All three deletion constructs were detected in infiltrated leaves only when using the abutting primers. Replacement of either V1 or V2 with GFP also showed localized GFP expression. Thus it is concluded that in absence of either V1 or V2 protein, cell-to-cell movement is hampered. Transient expression of V2 protein in *N. benthamiana* exhibited the typical symptoms of the disease indicated V2 is a pathogenicity determinant. The study thus elucidated the role of V2 protein of CYVMV as silencing suppressor, pathogenicity determinant and in cell-to-cell movement of the virus in coordination with V1 protein.

IL03(2C): Understanding host-pathogen interaction between Rice-*Rhizoctonia solani* using omics approach

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Rice sheath blight (ShB) disease, caused by the fungal pathogen *Rhizoctonia solani* AG1-IA, is one of the devastating diseases and causes severe yield loss all over the world. No complete resistant germplasm is reported till now, and as a result, the progress in resistance breeding is unsatisfactory. Basic studies to identify candidate genes, QTLs, and for better understanding the host-pathogen interaction are also scanty. Also, the mechanism of resistance against sheath blight is yet to be understood clearly. Transcriptome analysis enables us to measure the spatial and temporal expression of an organism's gene in response to a stimulus and to understand how the genes are regulated and what are the genes responsive to that stimulus. In regard to host-pathogen interaction, analysis of host transcriptome aids in identification of pathogen responsive candidate genes and has great potential to shed light on their molecular interaction. The most recent report of Samal et al. (2021) clearly indicated that the regulatory and signalling pathways play a pivotal role in host-pathogen (Rice-*R. solani*) interaction. In this study, a new ShB tolerant rice genotype CR 1014 has been identified out of 200 rice genotypes screened against a virulent strain of *Rhizoctonia solani*. Further, CR 1014 has been used for transcriptomics study to understand the mechanism underlying resistance against sheath blight disease. The transcriptome study enlightened the basis of tolerance in CR 1014 by exploring the disease responsive differentially expressed transcriptome and comparing them with that of a susceptible variety, Swarna-Sub1. A total of 815 and 551 genes were found to be differentially regulated in CR 1014 and Swarna-Sub1, respectively at two different time points. The result shows that the ability to upregulate genes for glycosyl hydrolase, secondary metabolite biosynthesis, cytoskeleton and membrane integrity, the glycolytic pathway, and maintaining photosynthesis make CR 1014 a superior performer in resisting the ShB pathogen. The DEGs were validated through quantitative real time PCR which can be used further for understanding the host pathogen interaction. The present study, for the first time, revealed the basis of ShB tolerance in the germplasm CR 1014 and should prove to be particularly valuable in understanding molecular response to ShB infection. The knowledge could be utilized to devise strategies to manage the disease better and also the genotype can be used in resistance breeding for developing ShB resistant variety.

Oral Presentations

OP01(2C): High-throughput transcript profiling to decipher smut resistance in sugarcane

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Sugarcane smut caused by the basidiomycetous fungus *Sporisorium scitamineum* is one of the most devastating diseases which causes considerable yield loss. At present, the most practical and effective management strategy of the disease is cultivation of resistant cultivars. A comparative whole transcriptome analysis employing Illumina RNA-seq in the smut susceptible cultivar Co 97009 inoculated with two distinct *S. scitamineum* isolates, Ss97009 (high-virulent) and SsV89101 (low-virulent) during the early phase of infection (2 dpi and 5 dpi) and at the phase of sporogenesis (whip emergence) (60 dpi) was performed. The number of differentially expressed genes (DEGs) were more abundant at 60 dpi during interaction with the high virulent isolate Ss97009, as compared to the low virulent isolate SsV89101. Gene ontology analysis of these DEGs revealed that a majority of them were associated with hormone signaling and synthesis of defense-related metabolites, suggesting a complex network of defense mechanism is being operated in response to specific isolates of the smut pathogen. Up-regulation of transcription factors and genes involved in the flavonoid biosynthesis pathway was found to be associated with both the early phase and whip emergence stage of infection. On the other hand, the whole transcriptomic analysis of high (Ss97009) and low virulent (SsV89101) smut pathogen isolates at *in vitro* condition resulted in the elucidation of the virulence factors responsible for the switch over from haploid sporidia to infective dikaryotic mycelia for successful invasion of host. Altogether, these two studies provided novel insights into the virulence factors responsible for *S. scitamineum* transitions and molecular mechanisms of sugarcane-smut interaction involving major switching of defense signalling pathways in response to *S. scitamineum* isolates with different virulence attributes.

OP02(2C): Host-induced gene silencing: a powerful approach for engineering Sclerotinia resistance in Oilseed Brassicas

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Sclerotinia rot caused by *Sclerotinia sclerotiorum* is a destructive disease of crop brassicas with worldwide distribution. Redox regulation and oxalic acid biosynthesis seem to play an important role in the Sclerotinia pathosystem. This study involved functional characterization of *S. sclerotiorum thioredoxin* (*SsTrx1*) *and S. sclerotiorum* oxaloacetate acetylhydrolase (*Ssoah1*) for its role in pathogenicity, virulence and in oxidative stress tolerance of *S. sclerotiorum*. To facilitate that, the *SsTrx1* and *Ssoah1* gene-based RNAi and HIGS vector was constructed and mobilized into *S. sclerotiorum*, *Arabidopsis thaliana*, *Nicotiana benthamiana.* Ssoah1 and Sstrx1 gene silenced strains showed significant effects on hyphal growth rate, mycelial morphology and fungal pathogenicity in different plant hosts. Host induced silencing of the *SsTrx1* gene led to reduced gene expression, lesion size, hyphae growth and sclerotial development in HIGS-*A. thaliana* and HIGS-*N. benthamiana* lines as compared with the non- transgenic controls. Taken together, our studies revealed the role of *SsTrx1* and *Ssoah1* gene is associated with pathogenicity, virulence, sclerotial development, and oxidative stress tolerance. Functional validation of these crucial genes will help in better understanding of Sclerotinia pathosystem and also open up the possibility of using HIGS to enhance resistance against this pathogen

OP03(2C): Genome assisted population biology and genetic analysis of blast pathogen, *Magnaporthe grisea* infecting pearl millet

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In the past ten years, the blast or leaf spot disease is caused by the fungus *Magnaporthe grisea* (Herbert) Barr [anamorph: *Pyricularia grisea* (Cooke) Sacc.] has turned up as a very serious threat for pearl millet cultivation in India. The disease is omnipresent in our country wherever pearl millet cultivation takes place. Whole genome sequencing of *Magnaporthe grisea* strain PMg_Dl infecting pearl millet was performed using Illumina-Nextseq500 2x150-bp chemistry and PacBioRSII-platform with P6-C4 chemistry. In total, the assembly of 341 scaffolds resulted in a genome size of 47.90 Mb with a N50 of 765,468 bp. A total of 20 isolates of *Magnaporthe grisea* causing blast disease on pearl millet (17 isolates) and other host plants such as rice (*Oryzae sativa*), finger millet (*Eleusine corocona*), and grass (*Eleusine indica*) (3 isolates) representing diverse blast hot spot geographical locations in India were characterized by adopting pathological, phenotypic and genotypic methods. By utilizing the whole genome sequence data, the *Magnaporthe* isolates were genotyped by exploiting sequence variations in six selected housekeeping (*Pgk, Pfk, Cal*) and effector coding (*Mpg1, Slp1 and Mlc1*) genes. Sequence analysis revealed *ACTC* deletion polymorphism in the 36-39th nucleotide sequence position of the genetic locus, pfk coding for 6-phosphofructo-2-kinase 1 only in the pearl millet blast isolates. The pearl millet infecting isolates formed a separate cluster in the molecular phylogenetic analysis of concatenated sequence representing six genetic loci suggestive of genetic divergence. Mating type marker-based PCR screening of *M. grisea* infecting pearl millet for the detection of mating types potential for sexual recombination revealed the prevalence of Mating Type 1 and Mating Type 2 in India. However, the prevalence of Mating Type 1 was more frequent than Mating Type 2. This study conclusively demonstrates that *Magnaporthe* population infecting Pearl millet is distinct from *Magnaporthe* infecting other cereal crops.

OP04(2C): Draft Genome Sequence of *Ca.* Phytoplasma australasia, strain SS02 associated with sesame phyllody disease

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Candidatus Phytoplasma is an uncultivated, intracellular bacterial plant pathogen transmitted by phloem-feeding insects. Among the group of phytoplasmas, the Peanut Witches' Broom (PWB) or

16SrII group of phytoplasmas associated with various diseases in economically important crops cause serious losses every year in India. The strain SS02 belonging to *Ca*. Phytoplasma australasia (Peanut Witches' Broom or 16SrII-D group) was identified associated with sesame phyllody disease. To understand better the genome structure of this pathogen, the genome of strain SS02 was obtained using its genomic DNA enrichment and hybrid assembly of sequences generated on Illumina and Oxford Nanopore Technologies (ONT) platforms. The hybrid assembly generated a draft genome with 47 contigs totalling to 536,153 bp chromosome with more than 400x depth coverage and 92.47% of the estimated genome size. The SS02 genome draft sequence contains 432 protein-coding genes, 16 tRNA genes and three rRNA genes. The availability of this high-quality whole genome also provided a foundation for genome-scale genotypic analysis along with study on its pathogenicity.

OP05(2C): Identification and characterization of putative virulence factors of *Magnaporthe* species inciting blast disease in rice and pearl millet

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The pathogen continually evolves new effectors and plants are also compelled to develop new R-gene(s) as never ending co-evolutionary "arms-race". To impart durable resistance to the host plants the detailed knowledge of the molecular mechanisms with special emphasis on pathogen virulence factors is a pre-requisite. Advancement in the molecular techniques has facilitated to generate the transcriptomic and genomic data and that information can be used to gain the insight about gene(s), biological networks involved and mode of action of the fungus. We have shortlisted specific virulence factors from *Magnaporthe oryzae* strain RMg-DI and *M. grisea* strain PMg-DI whole genome data by comparative annotation with the reference genome *Pyricularia oryzae* 70-15. The presence of these putative virulence factors in both fungal systems was proved with PCR assays. Real-Time PCR assisted expression analysis of putative virulence factors such as *MBSD02000619.1.g3349*, *MBSD02000495.1.g5524*, and *MBSD02000009.1.g8852* (annotated in the genome of rice infecting RMg_DI) revealed nearly identical expression patterns in all tested susceptible plants such as rice, finger millet, and pearl millet. In case of pearl millet blast isolated genes *20007-Mg.00g31250-v1.0.a, 20007-Mg.00g080210-v1.0.a, 20007-Mg.00g080580-v1.0.a, 20007-Mg.00g034390-v1.0.a,* and *20007-Mg.00g016130-v1.0.a* (annotated in the genome of pearl millet infecting, PMg_DI) maximum expression was observed in pearl millet host compared to rice and finger millet. Generally, the expression was higher in susceptible lines, however in rice some contradictory results were obtained where gene *20007-Mg.00g080210-v1.0.a, 20007-Mg.00g080580-v1.0.a, 20007-Mg.00g034390-v1.0.a, 20007-Mg.00g016130-v1.0.a* showed higher fold expression in resistant line rather than susceptible. Also insignificant level of expression in fungal mycelium also supports the idea that these genes are virulence factors which gets activated upon interaction with host. These genes plays a key role in modulating the blast susceptibility in rice and pearl millet hosts.

OP06(2C): Genome-Wide Association Mapping of Virulence Genes in Wheat Karnal Bunt Fungus *Tilletia Indica* Using ddRADseq-Genotyping By Sequencing Approach

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Tilletia indica is a quarantine fungal pathogen, poses a serious biosecurity concern to wheat exporting countries around the world. The genetic information related to the pathogenicity characters of *Tilletia indica* is still scarce, which makes breeding for resistance variety a big challenge for wheat breeders and geneticists. In the current study, thirty-nine *Tilletia indica* isolates were collected from different locations in India and genotyped using double digest restriction-site associated -DNA genotyping by sequencing. The generated libraries upon sequencing were with 3,346,759 raw reads in average, and 151x2 nucleotides read length. The obtained bases per read ranged from 87 Mb in Ti 25 to 1708 Mb in Ti 39, with 505 Mb in average per read. Population structure analysis divided *T. indica* population in India into three subpopulations with genetic mixing in each subpopulation. However, the division was not in accordance with the degree of virulence. Trait association mapping of virulence genes was performed using 41,473 SNPs, phenotyping data, population structure and Kinship matrix, revealed the presence of 13 SNPs associated with virulence. Using sequences analysis tools, 43 genes were predicted near significant SNPs, out of them one gene (g4132) was predicted to be an effector, and its relative expression was assessed and found up-regulated upon infection.

2D. Mechanism of disease development

Keynote Lectures

KN01(2D): Host cultivar adaptation and acquiring higher virulence in sugarcane red rot pathogen *Colletotrichum falcatum*

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Red rot caused by *Colletotrichum falcatum* was reported more than 120 years ago in India and still, it continues to be a major threat to sugarcane cultivation in the country. The continuous evolution of new variants and their adaptation to the selected varieties contributed to the appearance of new pathogenic variants of *C. falcatum*. Earlier the variants were categorized into 'light' and 'dark' isolates and the former was considered as highly sporulating and virulent and the latter as less sporulating and less virulent. A large number of *C. falcatum* isolates were characterized for pathogenic variability on a set of host differentials and 11 pathotypes with distinct pathogenicity profiles were designated in the country. The newly designated pathotypes were found to be virulent and represent the prevailing pathogenic population in the ecosystem. The recently designated *C. falcatum* pathotype CF12 in the tropical region was found to be highly virulent over the erstwhile predominant pathotype CF06. Later studies on the behavior of 12 isolates from the tropical region on popular varieties revealed that the older isolates have lost their virulence, probably due to the loss of pathogenicity factors to infect their host varieties. Further, recurrent red rot epidemics cause breakdown of resistance in popular sugarcane varieties referred to as 'varietal breakdown' thus popular varieties with red rot resistance succumb to new variants of *C. falcatum* and cause huge economic losses. Investigation on the recent red rot epidemic and breakdown of the popular cv Co 0238 in subtropical India revealed that isolates from the variety maintained a discrete pathogenicity pattern to infect the host cv Co 0238, whereas, the designated pathotypes from the region exhibited resistant reactions on the variety. This disease outbreak clearly showed specific adaptation of the pathogen with higher virulence and emergence of a new pathotype, which is capable of breaking host resistance in the cv Co 0238 in the region. Further, monoculture of the variety in >80% area created a selection pressure for rapid evolution and adaptation of a virulent pathotype, causing the breakdown of resistance. This situation mimics the 'Vertifolia effect' in sugarcane and the history of such phenomenon repeats with the evolution of new pathotypes. Studies conducted over the years conclusively proved that adaptation of *C. falcatum* to the host cultivars is the major strategy towards the evolution of new variants with acquired virulence and resistance breakdown.

KN02(2D): Small RNAs in plant-microbe interactions: RNA effectors in mutualism and as novel tools for plant protection

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Plant small RNA molecules (sRNAs) are known to be induced during plant-microbe interactions and exchanged between interactors, thereby acting as mediators of RNA interference-based cross-king communication (ck). Fungal sRNAs act as virulence factors targeting genes involved in plant immunity, while plant sRNAs target fungal genes important for pathogenicity (Weiberg et al. 2013, Science 342; Zhang et al. 2016, Nature Plants 2:16153). Recently, the exchange of sRNAs and corresponding target silencing was predicted in arbuscular mycorrhiza (Silvestri et al. 2019, BMC Genomics 20:1-18) and in root colonisation by the beneficial endophyte *Piriformospora* (syn. *Serendipita*) *indica* (Šei et al. 2021, BMC Biol 19:171). Here we report on the study of reciprocal sRNA profiles in the interaction of *P. indica* with *Brachypodium distachyon*, a model grass plant that exchanges sRNAs with various microbes, including the important fungal pathogen *Magnaporthe oryzae* (Zanini et al. 2021, Int J Mol Sci, 22). We have characterised and verified novel sRNA effectors from *P. indica*. Selected effectors were used to knock down Brachypodium target genes. In addition, we will discuss in our presentation the possibility of using sRNA as novel biopesticides.

Invited Lectures

IL01(2D): Unraveling the Mechanism of Disease Development in Plantation Crops: Limitations and Prospects

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Coconut and arecanut are the palms grown by small and marginal farmers in India and millions of people are depended on these crops or the related industries for their livelihood. Though the areas occupied by these crops are very meagre at the macro level, these crops are very important in certain regions and play a significant role in the national economy. Though coconut and arecanut are grown in many states of India, the major cultivation and production of these crops are from four southern states namely Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. The cocoa is being grown as an intercrop within coconut, arecanut and oil palm plantations in India. Diseases are the major constraints in the production of these crops. The diseases caused by oomycete fungus *Phytophthora* alone cause an average of 10% annual loss. The pathogen attacks the growing bud of coconut palms causes the lethal bud rot disease. Though the disease is sporadic and from time to time refined integrated management practices are advocated, every year hundreds of coconut trees are killed by this pathogen. Similarly, fruit rot, crown rot and bud rot of arecanut caused by *Phytophthora meadii* cause devastating losses during certain years. Black pod rot of cocoa and stem cankers caused by *P. palmivora* is also a major problem. Other pathogens namely *Ganoderma* and Phytoplasma are the major threats for coconut and arecanut palms. A significant number of coconut and arecanut palms are lost every year due to infection by opportunistic fungal pathogen *Ganoderma lucidum.* Root wilt of coconut and yellow leaf disease of arecanut caused by phytoplasma are debilitating diseases and cause significant reduction in yield. The affected weakened palms eventually succumb to attack by other insect pests and fungal pathogens. The diseases caused by these pathogens on coconut and arecanut are known a century back. Quite a lot of work has been done and integrated disease management has been developed. Diagnosis of the disease before the visible symptoms appear is a major challenge in all these diseases. Understanding the exact process of disease development using advanced molecular techniques is essential for the effective management of these diseases. This will also help in developing effective disease prediction and forecasting models. The gaps in understanding of the diseases caused by these pathogens in coconut, arecanut and cocoa and future research required to understand the same are discussed in the paper.

IL02(2D): Pathogenicity, virulence system in *R. solanacearum* causing bacterial wilt disease in crop plants

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Ralstonia solanacearum is a soil borne plant pathogen, which causes bacterial wilt disease in many crop plants and is responsible for severe crop losses in economically important crops. Due to the extensive genetic diversity of *R. solanacearum* strains, the organism is now referred as *R. solanacearum* species complex (RSSC). Management of bacterial wilt disease is very challenging due to the existence of diverse strains, its survival ability for long periods in adverse conditions, wide host range and efficient mechanism of invading the host. *R. solanacearum* enters the plant through wounds in the roots and causes wilt by blocking the transport of water in the xylem leads to the death of the infected plant. The pathogenicity and virulence of *R. solanacearum* is due to the secretion of effector proteins into the host cell and the presence of various virulence factors. Type II and type III bacterial secretion systems (T2SS, T3SS) play a major role in the pathogenicity and virulence of this pathogen. Type III effectors (T3E) secreted through T3SS are the major pathogenicity factors that initiates the infection process and colonization in the host. The T2SS secretes various plant cell wall degrading enzymes (PCWDE) that include cellulolytic and pectinolytic enzymes which promote the colonization of the bacterium in the plant tissue. Exopolysacharide (EPS) produced by the bacterium within its susceptible host is the major factor that impairs water transport. In addition to EPS, PCWDE other factors viz. chemotaxis, swimming, twitching motility also contribute towards the virulence of this bacterium.

IL03(2D): Role of small RNAs in disease development with special reference to cassava mosaic disease

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Small RNAs have diverse regulatory roles in the interplay of genes inside the host plants during the onset of an infection by a pathogen or an attack by a parasite or vector. These regulatory roles are endless because their actions are not limited intraspecifically but they may happen even between host and pathogen. The viral infection leads to various biological responses inside the plant such as progression of viral replication and initiation of plant immune response. Plants infected with viruses acquire immunity by producing Dicer-Like Proteins (DCL) dependent and virus-derived siRNAs, which guide argonautes (AGO) proteins to viral RNAs and thus help to arrest the infection. Micro-RNAs are endogenous, non-coding, 20-24 nucleotides long RNA molecules that can regulate gene expression either by directing cleavage or translational inhibition of mRNAs in cells. MicroRNAs are generated from their pre-miRNAs by RNase III-like Dicer-like enzymes in plants and then associate with Argonaute (AGO) protein to inhibit gene expression at the level of transcriptional gene silencing (TGS) or posttranscriptional gene silencing (PTGS). Quantification and differential expression analysis of the plant microRNAs during a viral infection helps to explore their important role in the development of disease symptoms and how they are utilized by the virus to regulate host gene expression for their own benefit. In our study, 158 conserved miRNAs belonging to 22 families were identified in leaf libraries of cassava line CMR123, a cassava mosaic disease (CMD) tolerant cassava variety, and H-226, a CMD susceptible variety using deep-sequencing data. Cassava microRNA mes-miR159b was the most abundant followed by mes-miR166e, mes-miR9386, mes-miR395d, mes-miR167c. Regulation of these microRNAs in resistance (R) genes and different transcriptional factors related to immune response were analyzed. Species-specific microRNAs and their significant variation in differential expression in both susceptible and tolerant varieties upon Sri Lankan Cassava Mosaic Virus infection were studied.

Oral Presentations

OP01(2D): Effect of temperature on systemic infection and symptom expression induced by Soybean yellow mottle mosaic virus in leguminous hosts

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Temperature is one of the key factors influencing the viral disease development in plants. In this study effect of temperature on soybean yellow mottle mosaic virus (SYMMV) accumulation and systemic movement was studied in French bean, mungbean and soybean cultivars by keeping them at temperatures range 22-25oC, 26-29oC and 30-33oC. The proliferation of the virus under these conditions was confirmed through symptomatology, direct antigen coated enzyme linked immunosorbent assay (DAC-ELISA), RT-PCR with coat protein specific primers and RT-qPCR. French bean plants displayed symptoms by 12dpi at low temperature (22-25oC) and by 3dpi at medium temperatures (26-29oC) with continuous increase in viral accumulation from 0 to 24dpi. At high temperatures (30-33oC), French bean did not show symptoms up to 12dpi but the virus accumulated and moved systemically. However, there was a decline in viral copy number after 12dpi. Mungbean plants showed mottling, mosaic and puckering symptoms at 22-25oC and 26-29oC and necrotic symptoms at 30-33oC. Irrespective of temperature there was an increase in viral accumulation in mungbean from 0 days to 24dpi. Soybean plants showed veinal mild mottling at low and medium temperatures where as no peculiar symptom expression observed at high temperatures. Soybean also showed the reduction of viral copy number from 12 days to 24dpi at low and medium temperatures and from 6 days to 24dpi at high temperatures. These results indicate that temperature played an important role in SYMMV accumulation, movement and symptom expression in these three leguminous plant species. This study also demonstrates that SYMMV can replicate and spread in mungbean plants irrespective of the temperature.

OP02(2D): A Rapid inoculation technique for inducing *Ganoderma lucidum* infection in coconut and arecanut seedlings

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Ganoderma lucidum is a soil borne fungi known to cause Basal stem rot (BSR), also known as Thanjavur wilt or *Ganoderma* wilt disease in coconut as well as Foot rot or *Anabe roga* disease in arecanut plantations. Because of the soil borne nature of the pathogen, incorporation of effective methods of management of disease is extremely difficult in field conditions. To overcome the disease, development of resistant or tolerant coconut and arecanut seedlings are crucial for sustainable production of coconut-arecanut palms. Thus a reliable and rapid method to assess resistance of palms to *Ganoderma* disease is important. Here we report an inoculation technique designated as 'mycelium inoculation technique' wherein seedlings were soaked in 4 days old mycelia cultures supplemented with 0.002% Tween 20 for a period of 30 minutes. The initial symptoms could be noticed 15 days after inoculation in case of coconut and 5 days in case of arecanut seedlings. This method is faster and simpler compared to the traditional technique using sorghum seed method or rubberwood block method. The technique provides consistency of infection and disease can be evaluated as early as two weeks after inoculation with *G. lucidum*. The results show that this new inoculation technique can be used as a routine method to screen coconut and arecanut seedlings for BSR disease and for evaluating the resistance of coconut and arecanut cultivars to *G. lucidum.*

OP03(2D): Drought stress impacts endodermal barrier, rendering chickpea plants hyper-susceptible to dry root rot disease

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Dry root rot (DRR), an economically devastating disease, is an example to show how abiotic stresses are responsible for emergence and severity of diseases in agricultural fields. Chickpea-specific strains of a necrotic fungal phytopathogen, *Macrophomina phaseolina* (formerly referred to as *Rhizoctonia bataticola*), cause DRR. Microsclerotia of this fungus, which are capable of withstanding harsh environmental conditions, serve as primary inoculum. Initial symptoms are scattered necrotic spots in roots, progressing to rotting and withering lateral roots, accompanied by prematurely dried, straw-coloured foliage. The recent rise in global temperature and worsening of drought spells have aggravated DRR outbreaks in chickpea. To date, DRR epidemiology has not been clarified in detail. In this talk, research progress on the influence of these abiotic factors on DRR occurrence in the field will be explained. In addition, the current understanding of taxonomy and management practices will be elaborated. I will also provide a glimpse of molecular understanding on impact of drought and high temperature on DRR severity. I will also propose new research priorities and a corresponding plan for the mitigation of DRR. For example, our observations suggested that drought stress intensifies the progression of already ongoing infection by weakening the endodermal barrier and overall defense. Transcriptomic analysis suggested that the plant's innate immune defense program is downregulated in infected roots when subjected to drought stress. Further, genes involved in hormonal regulation are differentially expressed under drought stress. Taken together, a story on comprehensive understanding of how drought stress influence the plant-pathogen interaction will be presented.

OP04(2D): Thermal stress induced changes in *Alternaria brassicicola* – Mustard Interaction

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Among the various oilseed crops Indian mustard occupies a major share in production as well as consumption in Indian subcontinent. This crop suffers from major abiotic stress in form of blight incidence caused by *Alternaria spp*. Among the various species associated with Alternaria blight; *Alternaria brassicicola* becomes the dominant necrotroph causing black spot disease on crucifers under relatively warmer conditions. As per predictions by Intergovernmental Panel on Climate Change average global temperatures are expected to increase by 2.7 °C with respect to present greenhouse emissions that might lead to significant changes in pathogen and their host. Investigations were undertaken to find out the likely effect of warmer condition on the biology, extracellular enzyme (cellulase, amylase and lipase) production and its association with melanin. Results indicated that restricted radial growth and reduced spore production in the pathogen upon exposure to warmer conditions of 35 °C when compared to those at 25 °C. *In vitro* studies also revealed a shift from dark coloured to white coloured mycelial growth at 35°C. Reduced melanin production was accompanied by increase in extracellular production of amylase, cellulase and lipase per unit mycelial weight at 35°C when compared to 25°C. Artificial inoculations of leaves of *Brassica juncea* var *varuna* with *A. brassicicola* at 35°C resulted in larger chlorotic zones. Indicating increased virulence of the pathogen at higher temperature most likely due to higher production of extracellular enzymes as a result of reduction in melanin productions in the cell walls of melanised fungi *A. brassicicola*. Melanin in cell walls acted as barrier for the release of enzymes extracellularly. Therefore, reduction in barriers imposed by melanin under warmer conditions resulted in enhanced release of extracellular amylase as evident by larger clear zones at 35°C in biochemical assays. Field evaluations also revealed increased incidence of Alternaria blight under delayed dates of sowing.

OP05(2D): Soft rot disease of *Aloe vera*: Etiology, Characterization of associated pathogens and management strategies

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Soft rot is a devastating disease of aloe. The infected plants developed rotting of tissues from collar upwards but they possessed normal root systems. The plants artificially inoculated with a *Dickeya* sp. (reported earlier as the causal agent) at the root zone did not develop disease symptoms, eliminating possibility of the pathogen entering through roots. Beside, a *Fusarium* sp. was repeatedly isolated from collar regions of the naturally infected plants. Further, it was established that lesions produced due to fungal infection predisposed subsequent infection of the bacterial pathogen. Sequences and phylogenetic analyses based on three partial genes of bacteria (*dnaX, icdA* and *mdh*) and fungi (*ITS, TEF-1±* and *RPB-2*) confirmed identity of the pathogens as *Dickeya zeae* and *Fusarium falciforme*, respectively. An artificial inoculation technique was developed for quick screening of aloe germplasm for resistance of bacterium. However, among the 40 accessions screened, none was found resistant. *F. falciforme* failed to produce lesion on two accessions (Guj4 and Raj3), consequently making them resistant to soft rot disease upon combined inoculation with both the pathogens. Temperature played a crucial role in soft rot symptoms development on detached leaf. Rapid rotting observed at 35°C but not at 15°C. *In planta* bacterium concentration increased gradually with the rise of incubation temperature between 15 and 35°C. The present study suggests possibility of management of the problem through (i) exploiting host resistance and (ii) escaping post–harvest decay by storing and transporting aloe leaves at temperatures d"15°C (iii) avoidance of water stagnation in field.

OP06(2D): Management of Root-knot Nematode (Meloidogyne incognita) through Integrated Approaches in Tomato (Solanum lycopersicum L.)

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The research trial was carried out for three years at different locations Agricultural Research Station (ARS) Navgaon-Alwar during Kharif 2018 & 2019, Rajasthan Agricultural Research Institute, Durgapura-Jaipur Rajasthan during Kharif 2021 on Tomato. In this research trial applied two fungal bio-agents and one chemical as nursery treatment. Okra (Abelmoschus esculentus) was used as trap crop except untreated check for the nematode trapped at initial stage and okra plants were uprooted after 18 days from date of germination. Fungal bio-agents viz. Paecilomyces lilacinus and Trichoderma harzianum @ 5.0 and 10 g /m2 doses were applied of each respectively and one chemical Carbofuran 3G @ 2.5 and 5.0 g /m2 were applied untreated check (control) was maintained. Research findings of the research trial was Paecilomyces lilacinus @ 10g/ m2 area in nursery treatment was found best fungal bio-agent for the management of root-knot nematode, Meloidogyne incognita. Paecilomyces lilacinus @ 10g/ m2 area plant parameters recorded highest shoot length pooled of the three years (72.56 cm), root length (28.61 cm), shoot weight (528.94 g), root weight (49.36 g) and tomato yield were recorded (249.46 q/ha). Nematode reproductive parameters were recorded minimum, number of females (galls) / plant pooled of the three years (4.00), number of egg masses / plant (1.78), number of eggs and larvae / egg mass (165.56) nematode population / 200 cc soil (157.78) and final nematode population (461.78). Tomato growth and yield was improved and nematode population was decreased. KEY WORDS: Bioagents, Chemicals, Meloidogyne incognita, Okra, Trap crop and Tomato.

OP07(2D): *In-silico* identification and characterization of putative pathogenicity genes of *Colletotrichum orbiculare* inciting anthracnose in cucumber

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Hypothetical pathogenicity genes (1566) identified by *in silico* analyses of the publicly available genomic database of the *C. orbiculare* strain 104-T/MAFF 240422 were evaluated in PHI blast. PHI blast identified the pathogenicity genes as potential ones for demonstrating an e-value of 1e”05, Upon culturing of CUCO-MT causing anthracnose in cucumber in the minimal broth, only 6 of the 51 potentials *in silico* genes identified in PHI blast were constitutively expressive, and among them, only ENH87679, ENH81967 and ENH87556 were induced in the cucumber plant cv. Pusa Uday and hence was identified as the candidate ones. In assessing their responses to reactive oxygen species produced due to oxidative burst and constitutive or induced phenolics, at the lowest concentration of 1 mM, ferulic and chlorogenic acids were less toxic to the pathogen. Among the phenolics, a less significant expression of superoxide dismutase coupled with a strong expression of catalase in ferulic acid greater than that in menadione and hydrogen peroxide respectively indicated its oxidative effect through the generation of radicles similar to that of hydrogen peroxide. In planta expression followed by constitutive expression of uncharacterized and hypothetical pathogenicity genes of C. orbiculare in a minimal medium indicated that 6 of the genes are not redundant and may function under stress conditions. Among the genes, significant expression of *ENH87556* in menadione (1.3-fold) together with a weak expression in hydrogen peroxide in relation to untreated control indicated its role in oxidative stress generated due to the superoxide radicle of menadione. Additionally, a strong expression (3.8-fold) of the gene in ferulic acid greater than that of either control, minimal medium or minimal medium with leaf extract indicated its role in phenol metabolism.

OP08(2D): Pathogenicity genes as molecular stooges for physiological race characterisation of Fusarium oxysporum strains

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To assess the roles of two candidate genes of *Fusarium oxysporum* f.sp. *lycopersici*, *Fow1* and *Fow2* in pathogen virulence, physiological races of 14 strains were established by PCR profiling SIX gene expressions. No amplification of the SIX4 (*Avr*1) gene was observed in any of the 14 strains. Based on amplification of the SIX3 *(Avr*2) gene, 6 strains were distinguished as race 2. Race 2 strains are known to contain identical SIX3 sequences and differ from race 3 strains by single point mutations. Hence, based on polymorphic amplicons of the SIX3 gene detected by stringent PCR conditions, 8 strains were identified as race 3. The identity of the physiological races of the strains was validated by inoculating on three germplasm lines, EC-814916, FEB-2 and Pusa Rohini carrying *I-2, I-3* and no *I* gene, respectively. The race 2 and race 3 strains were avirulent on EC-814916 and FEB-2 lines, respectively. All the 14 fungal strains were pathogenic on Pusa Rohini, the Fusarium wilt susceptible cultivar lacking R genes and exhibited different levels of virulence. Since the expressions of *Fow1* and *Fow2* were observed among both the races of the Fol strains, these pathogenicity genes are not potential candidates for physiological race discrimination. However, strong expressions of the genes in the root tissues inoculated with the highly virulent strain, TOFU-IHBT in comparison to the uninoculated control indicated their roles in fungal pathogenicity. To understand the role of these pathogenicity genes in countering the host defence mechanisms, their expressions in response to ROS and phenolics, the earliest known defence mechanisms of host plants were assessed. In H2O2, the *Fow2* gene expressed 1.4-fold greater than that of the control. On the contrary, in relation to the control, the expressions of *Fow1* were strongly repressed exhibiting 0.7-to 0.8-fold lesser at 0.1 mM through 3 mM concentrations than that of the control indicating that the gene is modulated by the phenolic acid indicating the roles of *Fow2* and *Fow1* in alleviating oxidative stress and targeted by the phenolic acid, respectively.

OP09(2D): RNA-directed DNA methylation of geminivirus genomes and viral adaptations - an arm race

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Mother earth is full of bizarre interactions which have evolved over a period of millions of years. Some of these interactions facilitate the survival of the partners and increase their fitness while others act against each other. Plants and viruses present one of the most interesting negative interactions. They provide an insight into the arms race that has evolved over time in order to overpower each other. Geminiviruses are a group of single-stranded DNA viruses that are obligate parasites and depend on the host for their survival. They utilize host machinery in order to replicate, transcribe, and for efficient spread. Plants on the other hand have developed a diverse array of methods to contain these biotrophs. One typical strategy developed by plants is to methylate the viral DNA in order to suppress viral transcription and halt their spread. Methylation is a highly conserved epigenetic phenomenon that plays an important regulatory role in the development of plants. Plants have devised varied mechanisms to ensure proper regulation of these epigenetic marks and aberrant changes lead to different developmental abnormalities. In all the organisms the S-adenosyl-L-methionine acts as a methyl donor and is maintained by varied methyltransferases. In plants, de-novo methylation is established by the RNA-directed DNA methylation pathway (RdDM), which utilizes siRNAs and an array of other proteins. The viral partner ensures own survival by synthesizing handful of proteins which halt the methylation mechanism. Over the years a number of viral proteins have been identified that either blocks the methyl cycle or demethylate their DNA to ensure viral propagation. Therefore, it is imperative to unravel precise function of the viral proteins in order to develop a broad-spectrum and efficient mechanism to counter these biotrophs in future.

2E. Host plant resistance

Keynote Lectures

KN01(2E): Molecular breeding for durable disease resistance in the realm of a rapidly changing climate

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KN02(2E): Host Plant Resistance- A Sustainable Strategy for Rice Blast Disease Management

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Rice blast caused by *Magnaporthe oryzae* is extremely widespread and explosive disease throughout the world. All the growth stages of rice crop are vulnerable to blast attack. Among the various disease protection measures, host-plant resistance is a proven means for effective blast disease management. Virulence analysis of rice blast pathogen occurring in different hot-spot areas of India has enabled us to identify effective Resistance (*R)* genes, which in turn have been utilized in gene deployment strategy for the disease management. So far, about 145 blast *R*-genes have been identified in rice and 36 *R*-genes have been efficaciously cloned and characterized. Conventional breeding methods & Marker-assisted selection tools together expedite *R*-gene pyramiding in elite rice varieties and strengthen the durability of blast resistance. These resistance genes, individually or in combination have been utilized in gene deployment strategy for the management of blast disease. Thus, the prerequisites for developing blast resistant rice cultivars are identification of effective *R*-gene/s, selection of differential isolates and performance of newly developed cultivars to the predominant field isolates in the blast endemic locations. During last two decades, a combination of *R*-genes has been utilised for developing blast resistant Basmati and Non-Basmati rice varieties, *viz.* Pusa Basmati 1609 (*Piz5 +Pi54*), Pusa1612 (*Piz5+Pi54*), Pusa Basmati 1637 (*Pi9)*, Pusa Basmati 1884 (*Piz5 +Pi54)* and Pusa Samba 1850 (*Pi54+ Pi1+ Pita*). Along with blast resistance, gene pyramiding for bacterial leaf blight has also been successfully done in some elite Basmati rice varieties, *viz*., Pusa Basmati 1847 (*Piz5 +Pi54 & Xa21+xa13)*, Pusa Basmati 1885 (*Piz5 +Pi54 & Xa21+xa13)* and Pusa Basmati 1886 (*Piz5 +Pi54 & Xa21+xa13).*

KN03(2E): Fusarium head blight of wheat in India-an overview

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Wheat (*Triticum aestivum* L.), is the second most important staple food crop of the world. Wheat production in India has increased many folds from 6.4 mt in 1950 to 109.52 mt during 2021. *Fusarium* head blight or head scab of wheat caused by *Fusarium* spp. is a devastating disease that cause significant yield and quality losses in humid and sub humid regions of the world. Disease is likely to increase due to global climate change and the preference of farmers for reduced tillage practices in the northern plains of India. Extensive disease surveys undertaken in different wheat growing zones of the country during 2010-22 revealed the association of six *Fusarium* species *viz*., *F. graminearum*, *F. verticillioides*, *F. oxysporum*, *F. equiseti*, *F. solani* and *F. semitectum* with head scab disease. *Fusarium graminearum* was found in most of the samples collected from Lahaul valley, Punjab as well as from Wellington. Pathogenic variation among *Fusarium* spp./isolates have been studied by inoculating on a set of bread wheat varieties as well on a set of durum wheat varieties under artificially inoculated conditions. *Fusarium graminearum* was found most pathogenic as compared to other *Fusarium* species. New micro satellite and SSR primers were developed and genetic variation among *F. graminearum* isolates was studied. Twenty-seven pure cultures of pathogen isolated from Wellington (Tamilnadu) during 2021 have been characterized morphologically and species-specific markers (Fg16F and Fg16R) confirmed that all the isolates belonged to *Fusarium graminearum*. *Fusarium graminearum* isolates were also characterized for toxins such as DON, NIV, 15-ADON and 3-ADON with toxin specific primers. Evaluation of more than 5000 wheat lines during last two decades led to conclude that very limited sources are available for FHB resistance in presently grown wheat varieties thus there is need to evaluate more lines from indigenous germplasm and wild relatives.

Invited Lectures

IL01(2E): Comparative genomics of wheat spot blotch pathogen *Bipolaris sorokiniana* and identification of new antifungal targets

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Spot blotch is a highly destructive wheat disease caused by the fungal pathogen Bipolaris sorokiniana. The pathogenicity of 12 B. sorokiniana isolates, collected from three geographical regions of India, was assessed on a spot blotch susceptible variety. The isolate D2 exhibited the highest virulence, followed by SI and BS52. These three isolates were sequenced using the Illumina HiSeq1000 platform. The estimated genome sizes were 35.19 MB, 39.32 MB, and 32.76 MB for BS52, D2, and SI, with their final assemblies complete to about 99.08%, 99.06%, and 90.87%, respectively. Pathogenesis-related gene classes were found to be expanded. The PHI-base analysis revealed few pathogenicity genes uniquely present in the isolates. A limited number of potent antifungal compounds and the emergence of fungicide resistant strains are the acute issues in managing fungal diseases. Propiconazole is a widely used azole fungicide to control spot blotch in wheat. Through RNA-Seq analysis, we analyzed the global gene expression profile of B. sorokiniana on exposure to sub-lethal doses of propiconazole. Sterol biosynthesis pathway genes over-expressed, supporting the reported mode of resistance against azoles. Moreover, some new potential targets were also identified, which could be explored to develop new fungicides and plant protection strategies.

IL02(2E): Managing Potato Late Blight through Host Resistance

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Late blight, caused by the oomycete *Phytophthora infestans* (Mont.) de Bary has historically been an important disease of potatoes and still continues to be the main biotic constraint of potato production. Presently the disease is managed through cultural practices, fungicides (including forecasting) and host resistance. Of these, management of late blight through host resistance will remain the most environmentally and economically preferred option globally despite the fact that none of the variety could sustain the blight onslaught for more than 5-7 years. Indian blight resistance breeding programme is not an exception. Earlier the objective of late blight resistance breeding was to breed and select resistant hybrids irrespective of nature of resistance but later on necessity of incorporating field resistance was visualized due to run down of R-gene based resistance. Breeding efforts using host resistance derived from *S. demissum*, a Mexican hexaploid species possessing both major and minor genes led to development and release of several resistant varieties *viz.* Kufri Jyoti, Kufri Khasigaro, Kufri Naveen, Kufri Jeevan, Kufri Neela and Kufri Muhtu. Of these, Kufri Jyoti became popular in all the hill regions. However, due to development of matching virulences, the breakdown of major gene resistance in Kufri Jyoti in mid seventies necessitated use of genes providing field resistance. Breeding for exclusive field resistance was initiated in 1975 using *S. verrucosum* as resistance source. Similarly, a programme was initiated for developing parental lines with late blight resistance derived from different wild species like *S. microdontum*, *S. phureja*, *S. stenotomum* and *S. chacoense*. Attempts are also being made to pyramid 'R' genes through Marker Assisted Selection (MAS) and a variety *Kufri Karan* has recently released possessing multiple disease resistance. Somatic hybrids with moderate levels of resistance to foliage blight have been identified for *in situ* hybridization in potato breeding. Besides conventional and marker assisted breeding, efforts are on to integrate resistance genes in commercial cultivars of potato through transgenic/molecular approach. A resistance gene effective against most known strains of blight has been identified from a wild relative of the potato, *Solanum bulbocastanum*, and introduced by genetic engineering into cultivated varieties of potato. Introgression of RB gene in Indian popular potato cultivars has demonstrated enhanced late blight resistance and generation of valuable genetic material for resistance breeding. RNA interference (RNAi) has proved a powerful genetic tool for silencing genes in plants. Using this approach, attempts have been made to silence the Avr3a gene of *P. infestans* through siRNAi technology which could impart moderate resistance to *P. infestans*. Approaches being followed in India for managing late blight of potato through host resistance will be discussed.

IL03(2E): Role of candidate hypothetical pathogenicity genes of Fusarium spp. in vascular wilt of tomato

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The necessity to develop new strategies for control of *Fusarium* wilt of tomato signifies identification of potential pathogenicity genes and ascertain their role to use them as molecular stooges for fungicide development or to develop transgenics. Gene expression studies identified two effector pathogenicity genes, *FOW2* and *chsV* reported as Zn(II)2Cys6-type transcription regulator and class V chitin synthase, respectively as potential ones for being secreted all the time. The roles of these genes in the pathogenicity of *Fusarium* spp. were established by RNA interference (RNAi) induced silencing (knockdown). Silencing of either of the genes resulted in less virulent fungal phenotypes with altered physiological characteristics like sporulation and growth on solid media and a reduction of mRNA expression. Co-expression of these two RNAi constructs in two independent elite tomato cultivar transgenic lines conferred high levels of stable, consistent resistance to *Fusarium* with delayed or reduced disease symptom development. The transgenic lines exhibited more than 75% survival, which was significantly higher than that of the control wild type plants. *F. oxysporum* infecting transgenic lines displayed substantially reduced mRNA levels of two targeted genes, *FOW2, and ChsV*. Confocal microscopy revealed profoundly restricted mycelia in *Fusarium* infected transgenic plants. There was efficient downregulation of the target genes in the colonizing *Fusarium* pathogens on tomato seedlings. To understand the role of these pathogenicity genes in countering the host defence mechanisms, their expressions in response to ROS and phenolics, the earliest known defence mechanisms of host plants were assessed. The results indicated that the gene is modulated by the phenolic acid indicating the roles of *Fow2* and *Fow1* in alleviating oxidative stress and targeted by the phenolic acid, respectively.

Oral Presentations

OP01(2E): Management of Black Scurf of Potato by Foliar Spray of Systemic Acquired Resistance Inducing Chemicals under Screen House Conditions

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Black scurf disease of potato caused by *Rhizoctonia solani* Kuhn is a major problem all over the world. Different options available to control diseases include use of organic amendments, bio-agents, fungicides and non-conventional chemicals. Plants are able to enhance their level of basal resistance against pathogen attack through a phenomenon known as induced resistance, which can be achieved by different abiotic and biotic stimuli. The classic examples of inducible plant defense are systemic acquired resistance (SAR) and induced systemic resistance (ISR), which differ according to the nature of the elicitor and the regulatory pathways involved. A pot experiment was carried out during seasons 2015-16 in the screen house of Deptt. of Plant Pathology, CCS HAU, Hisar for the management of black scurf of potato caused by *Rhizoctonia solani* by foliar spray with different systemic acquired resistance inducing chemicals. A different set of plastic pots with sterilized soil also maintained for the efficacy of systemic acquired resistance (SAR) inducing chemicals against *R. solani* at two concentrations i.e. 150 and 250 ¼g/ml for all chemical inducers separately by foliar sprays at tuber initiation stage (after 40 days of planting). The results from the present study revealed that least disease incidence was recorded with salicylic acid (35.00 and 23.34%) followed by jasmonic acid (36.7 and 25.0%), hydrogen peroxide (38.3 and 30.0%), BABA (43.3 and 40.0%) and GABA (45.0 and 41.7%) as compared to inoculated control (63.3%) and un-inoculated control (06.7%) at both the concentrations i.e. 150 and 250 ¼g/ml, respectively. All the SAR activators were found significantly superior in reducing disease incidence over the control. Highest reduction in disease incidence over control was observed with SA (44.7 and 63.2%) followed by JA (42.1 and 60.5%), H2O2 (39.5 and 52.6%) and BABA (31.6 and 36.8%) over the control at both the concentrations respectively. The least reduction in disease incidence was observed with ³-aminobutyric acid (28.9 and 34.2%).

OP02(2E): Rice leaf endophytic *Microbacterium*: unexplored bacterial genus with potential for blast disease suppression

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Rice leaf endophytic and pigmented bacterial species belonging to *Microbacterium* showed promise for blast disease suppression. Our polyphasic taxonomic approaches along with transmission electron microscopy revealed the species identity of the antifungal isolate, OsEnb-ALM-D18, as *Microbacterium testaceum.* Besides, the endophytic *Microbacterium* displayed plant probiotic features such as mineral solubilization, hydrolytic enzyme & phytohormone production, and endophytism in rice. Endophytism was confirmed by a green fluorescence signal from the endophytic colonization of *Microbacterium* tagged with the gfp gene. Activity testing of *M. testaceum* OsEnb-ALM-D18 showed antifungal activity with over 18.86 % mycelial growth inhibition of *Magnaporthe oryzae* via secretary compounds and over 95.5% fungal growth inhibition by volatile compounds. Chemical profiling of volatiles emitted by *M. testaceum* OsEnb-ALM-D18 indicated the abundance of 9-Octadecenoic acid, Hexadecanoic acid, 4-Methyl-2-pentanol, 2, 5-Dihydro-thiophene, and other antimicrobial compounds. Upon seedling bacterization, *Microbacterium testaceum* not only triggered altered growth patterns of rice seedlings but also suppressed blast disease (80.0% reduction of blast severity over mock) under greenhouse conditions. qPCR-based transcriptional analysis showed enhanced expression of defense genes such as *OsCERK*, *OsPAD4*, *OsNPR1*.3, and *OsFMO1*. *Microbacterium testaceum* OsEnb- ALM-D18 mediated antifungal activity, and host defense induction can be a potential alternative to fungicide-based blast management.

OP03(2E): New sources of resistance to *Exserohilum turcicum* causing turcicum leaf blight of maize

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Maize is the most important crop due to its potential and greater demand for food, feed and industrial usage. Turcicum leaf blight (TLB) disease of maize caused by *Exserohilum turicum* is a serious concern for maize growers due to significant yield loss and this disease is taking heavy toll where the climate conditions are cool with high relative humidity. Host plant resistance is the most effective way to control the disease. Various maize germplasms from AICRP Maize breeding programme and hybrids were evaluated for resistance to *Exserohilum turicum* under artificially inoculated field conditions during *Kharif* season 2019 to 2021. IML-11, IML-12, IML-13 and IML-21 shown durable resistance and has been registered by ICAR-NBPGR during 2021

(Genome wide association studies in tropical maize germplasms revealed novel and known genomic regions for resistance to TLB. The germplasam lines VL-18718, CIMT- 20, CUBA-377, DMSC-4, INDIMGT-345, LM-13, IAMI-83, DQL-2299, DMI-1210, PDM-4641, GPM-340, BML-7, BGS-24, IMLSB-334 B-1, IMLSB-80-1-2, IMLSB-1041-4-1, IMIC-2009, IMIC-2019, IMIC-2022, CIMT-9, CIMT-27 and VL-18672 has been identified for resistance to TLB. Among the hybrids, DKC-7074, DKC-7173, DKC-9157, DKC-9145, CAH-153, CAH-1418, DKC-9144, GH-1523, CP-333, PAC-753, NK-6802, P8225C, PAC-745, P-3304, BIO-605, BIO 9544, RCRMH-7, BIO 9682, FH-3801, AH-8181, AH-8622, GH-20242, GH-20237 and HT-5109 were identified as resistant to TLB. The newly identified resistant sources may be utilized as potential parent in hybrid development program and resistant hybrids may be deployed in disease endemic regions for the management of TLB.

OP04(2E): Lipopolysaccharide-induced priming enhances defense responses in pearl millet against downy mildew

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Lipopolysaccharide elicitors isolated from *Pseudomonas fluorescens* effectively induced systemic and durable resistance against pearl millet downy mildew disease caused by the oomycete *Sclerospora graminicola*. Rapid and increased callose deposition and H_2O_2 accumulation were evidenced in downy mildew susceptible seeds pre-treated with LPS in comparison with the control seedlings, which also correlated with expression of various other defense responses. Biochemical analysis of enzymes and quantitative real-time polymerase chain reaction data suggested that LPS protects pearl millet against downy mildew through the activation of plant defense mechanisms such as generation of nitric oxide, increased expression, and activities of defense enzymes and proteins. Elevation of NO concentrations was shown to be essential for LPS-mediated defense manifestation in pearl millet and had an impact on the other downstream defense responses like enhanced activation of enzymes and pathogen-related proteins. Temporal expression analysis of defense enzymes and PR-proteins in SLPS seedlings challenged with the downy mildew pathogen revealed that the activity and expression of peroxidase, phenylalanine ammonia lyase, and the PR-proteins were significantly enhanced compared to untreated control. Higher gene expression and protein activities of hydroxyproline-rich glycoproteins were observed in SLPS seedlings which were similar to that of the resistant check. Collectively, our results suggest that, in pearl millet-downy mildew interaction, LPS pre-treatment affects defense signaling through the central regulator NO which triggers the activities of PAL, POX, PR-1, PR-5, and HRGPs.

OP05(2E): Molecular-genetic characterization of resistance to sclerotinia stem rot in two sets of alien introgression lines of Indian mustard (Brassica juncea L. Czern)

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Sclerotinia stem rot (SSR) caused by *Scleritinia sclerotiorum* is emerging as a major biotic stress in Indian mustard (*Brassica juncea*), in key mustard growing areas of India. Unfortunately, none of the presently cultivated mustard varieties is SSR-resistant and farmers are compelled to rely on fungicides with high cost and uncertain disease control. Brassica group at Punjab Agricultural University has been able to introgress alien chromosome fragments bearing genes for SSR resistance from wild *Brassicaceae* species into some mustard genotypes. Genome-wide association analysis later helped identify many marker trait associations (MTAs) in *B. juncea* - *B. fruticulosa*. Annotation led to the identification of 20 candidate genes coding for major disease resistance protein families e.g., TIR-NBS-LRR class, Chitinase, Malectin/receptor-like protein kinase, defensin-like (*DEFL*), desulfoglucosinolate sulfotransferase protein and lipoxygenase. We identify many resistance-associated SNPs on chromosomes A03, A06, and B03 in *B. juncea* - *Erucastrum cardaminoies* ILs. Similarly, the role of genes associated with hypersensitive responses, signal transduction pathways and synthesis of anti-fungal proteins. Our studies also predicted the role of pathogen-associated molecular patterns (PAMPs) and effector-triggered immunity (ETI) in conferring resistance. Studies are currently underway to narrow down the number-predicted genes to most important ones, through genomic and evolutionary comparison of expression profiles of protein-coding sequences in resistant and susceptible ILs after stem inoculation. We will also present our attempts to transfer genes for introgressed resistance to high value-inbred lines and male fertility restorers for developing sclerotinia-resistant mustard hybrids.

OP06(2E): Expression of defense genes in cotton plants treated with *Bacillus amyloliquefaciens* against bacterial blight disease caused by *Xanthomonas citri* pv. *malvacearum*

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Cotton bacterial blight caused by *Xanthomonas citri* pv. *malvacearum* is a major disease prevailing in all cotton growing regions of India. Yield losses have been estimated to range from 10 to 30% and may sometime exceed 50%. The use of microbial based biocontrol agents as replacement for chemicals has attracted interest in recent years. Antagonistic potential of *Bacillus* spp. against

X. citri pv. *malvacearum* have been studied in cotton. Among the various endophytic *Bacillus* spp. tested, the highest inhibition zone was recorded in the isolate ETL2 collected from leaf sample of cotton. The effective isolate ETL2 was identified as *Bacillus amyloliquefaciens*. The expression of defense genes *viz*. *PR1* and *PR5* were observed in the plants treated with *B. amyloliquefaciens* (ETL2). The *PR5* gene expression was higher than *PR1* gene.

OP07(2E): Novel genomic regions associated with seedling and adult plant stage leaf rust resistance in bread wheat (*Triticum aestivum* L.) identified through multi-locus genome-wide association studies (ML-GWAS)

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Leaf rust is one of the important diseases of wheat limiting production and productivity. To identify quantitative trait nucleotides (QTNs) or genomic regions associated with seedling and adult plant leaf rust resistance, multilocus genome-wide association studies (ML-GWAS) were performed on a panel of 400 diverse wheat genotypes using 35K single-nucleotide polymorphism (SNP) genotyping assays and phenotypic trait data of leaf rust resistance. Association analyses using six multi-locus GWAS models revealed a set of 201 significantly associated QTNs for seedling and 65 QTNs for adult plant resistance (APR), explaining 1.98-31.72% of the phenotypic variation for leaf rust. Among these QTNs, 51 reliable QTNs for seedling and 15 QTNs for APR were consistently detected in at least two GWAS models and were considered reliable QTNs. Three genomic regions were pleiotropic, each controlling two to three pathotype-specific seedling resistances to leaf rust. We also identified candidate genes, such as leucine-rich repeat receptor-like (LRR) protein kinases, P-loop containing nucleoside triphosphate hydrolase and serine-threonine/tyrosine-protein kinases (STPK), which have a role in pathogen recognition and disease resistance linked to the significantly associated genomic regions. The QTNs identified in this study can prove useful in wheat molecular breeding programs aimed at enhancing resistance to leaf rust and developing next-generation leaf rust-resistant varieties.

OP08(2E): Screening of local lentil germplasm against Stemphylium blight with higher economic gains using gamma rays

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Lentil (*Lens culinaris* Medik.) is one of the most important cool season food legume crops grown worldwide in semi-arid regions. Pulses are the second most important group of crops which are high in proteins but, this is affected by numerous pathogens causing economic losses. In the present study, forty disease samples were collected from six districts of West Bengal and isolated using tissue culture method. The most virulent strain of the *Stemphylium botrysuum* , SC6 was selected using the in vitro studies The lentil cultivars Moitree (WBL 77) was selected as a parent material, the healthy and viable seeds of Lentil cultivars Maitry were directly irradiated with 250 Gy of gamma rays with Co_{60}. 200 gram of irradiated seeds of Moitree (WBL 77) cultivar was sown during the year 2018-19. M1 Population was harvested singly and putative mutants were selected on the basis of disease resistance against SB and other morphological traits. The putative mutants plants were selected in M2 generation and continued upto M4 generation. The Stemphylium resistant mutant showed significant morphological variation compared to parent genotypes. Percent of disease index was observed as (49.5275) in T1 followed by T2 (38.455) The line number 136[B,]188[H,] found to yield bold seeds in plants B & H in the year 2018-19 and 2019-20. Similarly 193[I] found to be double seeded/ pod both the year. Line number 226, plant E and from line number 171, plant H was found to be resistant against the *Stemphylium* blight pathogen. Thus, we are aiming obtain the lines which are resistant to SB along with higher economic gains.

OP09(2E): Transcriptome Reprogramming of Tomato Orchestrate the Hormone Signaling Network of Systemic Resistance Induced by *Chaetomium globosum*

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Chaetomium globosum is a potential biological control agent effective against various plant pathogens. Several reports are available on the mycoparastism and antibiosis mechanisms of *C. globosum* against plant pathogenic fungi, whereas a few states induced resistance. The potential induced defense component of *C. globosum* (Cg-2) was evaluated against early blight disease of tomato and further, global RNA sequencing was performed to gain deep insight into its mechanism. The expression of marker genes of hormone signaling pathways, such as PR1, PiII, PS, PAL, Le4, and GluB were analyzed using real-time quantitative reverse transcription PCR (qRT-PCR) to determine the best time point for RNA sequencing. The transcriptome data revealed that 22,473 differentially expressed genes (DEGs) were expressed in tomato at 12 h post Cg-2 inoculation as compared with control plants and among these 922 DEGs had a fold change of “2 to +2 with $p < 0.05$. The KEGG pathway analysis revealed that most of the DEGs were belonging to metabolic pathways, biosynthesis of secondary metabolites and plant hormone signal transduction. Gene Ontology analysis revealed that DEGs were enriched mainly related to binding activity (GO:0005488), catalytic activity (GO:0003824), metabolic process (GO:0008152), cellular process (GO:0009987), and response to stimulus (GO:0050896). The gene modulations in hormone signaling transduction, phenylpropanoid biosynthesis, and mitogen-activated protein kinases (MPK) signaling indicated the upregulation of genes in these pathways. The results revealed active participation of jasmonic acid (JA) and salicylic acid (SA) signaling transduction pathways which further indicated the involvement of induced systemic resistance (ISR) and systemic acquired resistance (SAR) in the systemic resistance induced by Cg-2 in tomato.

OP10(2E): Pathotype distribution of stripe rust (*Puccinia striiformis*) of wheat in North India

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Wheat is one of the world’s major staple food cereal crop. Stripe rust caused by *Puccinia striiformis* f.sp.*tritici* (*Pst*), is a major disease of wheat. *Pst* is a macrocyclic, heteroecious fungus that requires two living hosts to complete its sexual life cycle. Urediniospores can travel through the wind over long distances extending to thousands of kilometres from the initial infection sites. Hence, pathotype frequency and distribution were studied. A total of 46 samples of stripe rust of wheat collected from seven Indian states were analyzed at ICAR-Indian Institute of Wheat and Barley Research, Regional Station, Shimla for pathotype status during 2019-20. Pathotyping of rust samples revealed that the frequency of Pst pathotype 238S119 was maximum followed by pathotype 46S119 and 110S119 in the analyzed samples. A total of 30 samples of stripe rust of wheat from seven Indian states were analyzed during 2020-21. Pathotyping of rust samples revealed that the frequency of Pst pathotype 238S119 was maximum followed by pathotype 110S119 and 46S119 in the analyzed samples.

OP11(2E): Standardization of inoculation technique for Fusarium ear rot of maize (*Zea mays* L.)

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Fusarium ear rot (FER) caused by *Fusarium verticilloides* is the major constraint in maize production as it causes yield losses of upto 7-17 per cent. The fungus also causes qualitative losses to the crop with the production of fumonisins in warm and dry regions. Information on ear rot susceptibility and mycotoxin contamination of maize germplasm inoculated with *F. verticilloides* under field conditions is not available in North West India. Since standard inoculation technique is pre requisite for effective screening of maize germplasm, the present study was planned to standardize artificial inoculation technique for ear rot of maize. Four artificial inoculation techniques *viz.* needle inoculation into cob, tooth pick inoculation in the ear, needle inoculation into silk channel and spray silk inoculation were evaluated at three different intervals during *Spring* and *Kharif* seasons. The inoculations were carried out using 5 ml of spore suspension (concentration 2×106 spores/ml) of Fus 3 isolate of *F. verticilloides*. The disease severity was recorded at the time of harvesting using 1-9 scale. Disease rating scale in these four techniques varied from 1-5 being maximum in needle inoculation technique into the cob done at 7 days after silking. Significant differences in inoculation techniques were observerd with respect to time of inoculation. Maximum infection was observed in the plots inoculated at seven days followed by 14 days after silking. On comparing seasons, disease severity was comparatively more in *Kharif* season than *Spring* season. Our results concluded that 5 ml inoculum (concentration 2×106 spores/ml) of *F. verticilloides* inoculated into the cob using needle at seven days after silking is the best technique for evaluating maize cultivars/inbreds for FER.

OP12(2E): Elicitation of defense in rice against blast disease by Exo and Lipopolysachharides isolated from endophytic *Pseudomonas putida* BP25

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Plant defense elicitation by microbial components and metabolites is one of the unexplored options for eco-friendly crop protection. Black pepper-associated endophyte *Pseudomonas putida* BP25 is previously proven to show endophytism in rice with a consequence activation of the SA pathway. Here, we report defense elicitation by *Pseudomonas putida* exopolysaccharides (EPS) and lipopolysaccharides (LPS) in rice cv. Pusa Basmati 1 upon seed priming. The defense elicited rice seedling displayed altered root and shoot phenotype as an indicator of Microbe Associated Molecular Pattern (MAMP) triggered immunity. A detached leaf assay was designed to screen the *Pseudomonas putida* BP25 and its EPS and LPS against rice blast pathogen *Magnaporthe oryzae*. The data revealed prophylactic blast suppressive activity of *Pseudomonas putida* BP25 with 79.8% disease reduction seven days post-inoculation (dpi). While the EPS showed blast suppressive activity (79.80-86.87% reduction over mock) in the concentration range of 1-20ug range), the LPS exhibited 78-79.8% reduction at 20-200ug. Defense-related enzymes such as peroxidase and polyphenol oxidase activity were found to be elevated in EPS and LPS primed plants. qPCR-based transcriptional analysis revealed overexpression of Pathogenesis Related- genes, *OsPR1.1* (2.4 to 9.8-fold) and *OsPR3* (2.9 to 5.9-fold) in EPS and LPS treated seedlings. Taken together, we showed that the bacterial LPS and EPS elicited defense responses in rice against *Magnaporthe oryzae* for sustainable crop protection in the future.

OP13(2E): Global transcriptomic analysis provides evidence for host priming and growth induction effects by seaweed extracts in tomato and sweet pepper

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Seaweed extracts have been reported as plant biostimulants that could offer safer, organic alternative inputs for crop production. Trinidad and Tobago and the wider Caribbean basin host a myriad of seaweed species that currently remains untapped. Therefore, there exists great potential for exploration for elite seaweed species for biostimulant production. In the current study, two seaweed species (*Sargassum vulgare* and *Acanthophora spicifera*) were selected for the evaluation of biostimulatory effects on tomato and sweet pepper plants. Foliar treatment with seaweed extracts led to significant increases in plant growth and yields and significant reductions in infections by both bacterial spot and early blight pathogens. Investigations were carried out to reveal the mechanisms of action of these extracts on plants, whereby transcriptome-wide profiling via RNA sequencing of tomato and sweet pepper was carried out to capture the bioelicitor effects. The results of the study showed that seaweed extracts were able to significantly upregulate multiple genes responsible for defense responses to both abiotic and biotic stresses. Additionally, the transcriptome survey revealed the upregulation of genes responsible for the biosynthesis of growth hormones, defense enzymes, PR proteins, and other defense-related secondary metabolites. There was also upregulation of genes responsible for tolerance to abiotic stresses including heat, cold, drought, and salinity. These effects could potentially implicate the benefits of seaweed extract and authenticate its usage in sustainable crop production.

2F. Epidemiology and crop loss assessment

Keynote Lectures

KN01(2F): Simulation modelling in plant disease epidemiology and crop loss analysis: an online, open source course and the associated workshops for students across the world

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Systems analysis and its applications in plant disease epidemiology are seldom part of curricula of students who specialise in the field of plant pathology. An online course “Simulation Modeling in Botanical Epidemiology and Crop Loss Analysis” was published on the American Phytopathological Society website (The Plant Health Instructor of the APSnet Education Center). The course focuses on processes, thus bridging the gap between ‘observers’ and ‘modellers’. Simulation models are powerful educational tools to explore plant-pathogen dynamics, and identify key processes that govern epidemics. This course first introduces basic concepts and examples of systems analysis and simulation modelling. It then focuses on plant disease epidemics and crop yield losses. Simulation models are provided to explore model structures, their behaviour, and the effect of key parameters on system dynamics. This material is primarily intended for graduate students, but also for undergraduate students and biologists wishing to gain exposure to simulation modelling applied to ecological systems. This online course was used to conduct 12 workshops (course and practical, 1-5 day each) across the world (Brazil, Costa Rica, France, India, Norway, South Africa, USA), training about 250 participants from around 20 countries, between 2013 and 2021. The same material can be used for online workshops, as in November 2020 at GBPUAT. Teaching models are also posted on isee-stella: (https://exchange.iseesystems.com) and can be run and downloaded. The usefulness and perspectives of using such online educational material is discussed.

KN02(2F): Using spore trap data to inform plant disease management decisions

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Numerous crop pathogens are dispersed via air-borne spores. these pathogens are often managed on calendar-based schedules but often without knowledge if spores are present in the area or at the required threshold for disease development. Since 2018 a spore trap network has been operated by land grant universities in the Pacific Northwest. The network is mainly focused on potato diseases although selected traps also monitor for sugar beet powdery mildew and Stemphylium leaf blight in onions. Each growing season, approximately 20 Burkard multi-vial cyclone spore samplers are deployed across eastern Washington, southern Idaho and eastern Oregon. Samples are collected weekly and dispatched to the lab at Parma for real-time PCR analysis with results distributed to growers on Wednesday. The versatility of this system will be discussed in terms of providing a disease forecast to growers and producing information on spore population dynamics that can inform epidemiological models.

Invited Lectures

IL01(2F): Mathematical treatment of the sedimentation rate of microbial cells under the influence of gravitational acceleration

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Microbial cells in the atmosphere tend to sediment constantly in spite of local turbulence and counter current of wind. Microbial cell and spore shapes include spheres, oblate spheroids prolate spheroids and ellipsoids. In this paper equations for the terminal velocity of spores of different shapes are derived. The terminal velocity determines the fate of the microbe as plant pathogen or saprophyte.

IL02(2F): Bacterial Spot Incited by *Xanthomonas cucurbitae*: An Emerging Disease and a Serious Threat to Cucurbit Production

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Leaf and fruit spot of cucurbits, caused by *Xanthomonas cucurbitae*, is an emerging disease. This disease has become one of the most important factors limiting cucurbit production. The disease is characterized by dark, water-soaked chlorotic lesions, 1-2 mm in diameter on leaves. Symptoms on the fruits include small, slightly sunken lesions with beige centers and dark-brown halo. The lesions produced by *X. cucurbitae* serve as entry points for opportunistic microorganisms such as *Fusarium* species and soft rot bacteria that usually results in fruit rot. Our 3-year surveys of pumpkin and winter squash fields in nine states (Illinois, Indiana, Iowa, Kansas, Michigan, Missouri, Nebraska, Ohio, and Wisconsin) showed that 165 of 187 (88.24%) of pumpkin fields and of 52 of 58 (92.86%) of squash fields had fruits with the bacterial spot. Up to 96% fruits with *X. cucurbitae* (96% yield losses) was documented in pumpkin fields, demonstrating economic importance of the disease. Currently, there is no cucurbit cultivar resistant to *X. cucurbitae* available. After screening 81 commercial cultivars and 300 accessions of *Cucurbita* species, we determined 30 resistant accessions to *X. cucurbitae.* We have developed seed treatments for eradication of *X. cucurbitae* in seed, determined survival of the pathogen in infected plant debris and weeks in the field, and studied effectiveness of crop rotation and chemical applications for managing the disease.

IL03(2F): Major and emerging transboundary diseases of tropical maize affecting livelihood and food security in Sub-Saharan Africa

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Maize (*Zea mays* L.) is the most important cereal crop in sub-Saharan Africa (SSA), covering over 35 million ha, largely in smallholder farming systems that produce over 70 million metric tons (MMT) of grain. Maize production in sub-Saharan Africa is affected by a wide array of diseases. Environmental conditions prevalent in the different agro-ecological zones are conducive to the growth and spread of pathogens. There are many fungal and viral diseases that have been affecting the maize crop and its productivity. Diseases often reduce production and cause up to 100% yield loss under severe epidemics depending on environmental conditions. The key diseases in sub-Saharan Africa affecting crop production are Turcicum leaf blight, gray leaf spot, Common rust, ear rot caused due to mixture of pathogens, Maize streak Virus, and Maize Lethal Necrosis disease. Maize Lethal Necrosis (MLN) disease first appeared in Kenya in 2011 and became a major threat to maize production in eastern Africa in subsequent years. In eastern Africa, MLN is caused mainly by the synergistic interaction between two viruses, Maize Chlorotic Mottle Virus (MCMV) and Sugarcane Mosaic Virus (SCMV). MLN can cause up to 100% yield loss in susceptible maize varieties. The disease poses a complex challenge as the MLN-causing viruses are transmitted by insect vectors, and also through contamination of the seed, especially by MCMV. CIMMYT implemented a multipronged strategy in partnership with several international and national partners to tackle the MLN challenge. These efforts included: a) b) establishing a state-of-the-art MLN Screening Facility in partnership with Kenya Agriculture and Livestock Research Organization (KALRO) in Naivasha for identifying sources of resistance to MLN, MCMV and SCMV under artificial inoculation; b) accelerated breeding and deployment of MLN-tolerant/ resistant maize varieties with other relevant traits preferred by African smallholders; c) optimizing MLN diagnostic protocols; c) strengthening capacities of national plant protection organizations (NPPOs) across sub-Saharan Africa on MLN diagnostics, monitoring and surveillance system; d) creating awareness among the maize seed sector institutions on SOPs for producing and exchanging MLN-free commercial seed; e) disseminating information on farming practices for minimizing MLN incidence; e) establishing an MLN Phystosanitary Community of Practice involving various stakeholders, including national plant protection organizations (NPPOs), seed companies, regional/sub-regional organizations, etc.; and f) probing the epidemiology of the disease, especially the factors underlying seed contamination by MCMV. These comprehensive efforts have led not only in preventing the further spread of MLN into other major maize-growing countries in sub-Saharan Africa, especially southern and West Africa, but also minimized the incidence of the disease in the MLN-endemic countries in eastern Africa.

IL04(2F): Prevalence of the collar rot diseases caused by *sclerotium rolfsii* on some vegetables and gold duranta (*Duranta erecta*) plant in the cape coast municipality of ghana

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Crop production in Ghana is affected by so many disease-causing pathogens from different genera. Notable among them are Phytophthora, Sclerotium, Cercospora, Colletotrichum, Fusarium and Rhizoctonia. Sclerotium wilt disease caused by *Sclerotium rolfsii* has been reported to attack different crops in Ghana and recent observations on farmers' fields have revealed that it attacks vegetables, root and tuber crops, and ornamental plants. To get a preliminary idea regarding the behaviour of the pathogen and pattern of distribution of the disease in the Cape Coast Municipality of Central region of Ghana, a survey was conducted on different plants (cocoyam, garden eggs, pepper, tomatoes and cassava at different locations during the wet and dry seasons. Laboratory studies on the isolates confirmed *Sclerotium rolfsii* as the causal pathogen of the disease on the different crops. The different isolates showed differences in radial growth on PDA under room temperature. The pooled analysis of two seasons data revealed that disease incidence ranged from 6 to 30 % at different locations, 35 to 36 % on different plants and 29 to 71 % at two different seasons. The mean severity ranged from 1.333 to 2.225 at different locations, 1.933 to 2.156 on different plants and 1.567 to 2.15 at the wet and dry seasons. This study provided an elementary idea about the differences in strains of *Sclerotium rolfsii* and the prevalence of the diseases it causes on different crops in Ghana, as well as paved the path for seeking resistance sources under local conditions and recommendation of proper farming practices to combat the drastic effects of the pathogen.

IL05(2F): Integrating advances in genomics to accelerate disease surveillance

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With the increase in trade, human migration and rapid climatic changes, frequent emergence and spread of new strains of plant pathogens have become a significant issue for profitable agriculture and human food security. For instance, the new strains of stem and stripe rust pathogens with the ability to adapt to cooler and warm climatic conditions, respectively, has become a significant issue for global wheat production. Further, there is clear evidence for the rapid spread of new rust strains across and within continents due to contamination through human trafficking that has increased enormously. Thanks to advances in DNA sequencing, assembly, genome variation detection, and molecular markers techniques, we can now rapidly detect and characterise new strains of crop pathogens. Therefore using rust disease of wheat as a model and based on our recent work on the new strains of wheat stripe rust pathogen in Australia, I will discuss the various opportunities available to integrate genomics with the conventional disease surveillance programs. In addition to the fast detection of new pathogen strains before their onset of large-scale epidemics, the genomic analysis provides rapid insight into the virulence profile for the precise deployment of resistance genes for disease management.

IL06(2F): Simulation of leaf curl epidemic in chilli for evolution of management strategy

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Chili is an important commercial crop grown in tropical and subtropical climates across worldwide. Leaf curl incited by whitefly transmitted chili leaf curl virus (ChilCV-begomovirus) is one of the major constraints in its cultivation. Field assessment has indicated from the very first week of transplantation tender leaves are infected by ChilCV (PCR test). Within 2-3-week period appearance of typical leaf symptoms indicates in addition to whitefly, it is also simultaneously infested by thrips, mites and aphids. Leaf curl symptoms commonly encountered is not only viral infection but also due to direct feeding effect of the insects and mites. Simulating the effect of rate parameter (immigration of viruliferous whitefly) in a population dynamical modelling setup has indicated migrant viruliferouswhiteflies play the driving role in the epidemic process. Interception of migrant vectors from the very beginning (plant cover immediately after transplantation) has increased survival probability to remain infection free and ensured early vegetative growth. Plant cover (4 weeks) from the transplantation has been effective as median survival time (to remain virus free) for the 80% of the plants was 5 weeks.However, plant cover for 6 weeks'period is noted to be of optimum for protection from pests and virus infection.Relative plant growth rate (measure of growth and yield) is observed to be maintained in the covered plants in comparison to the plants having no interception. Therefore, basis for leaf curl management strategy has been proved in sound footing for evolving effective disease management strategy.

IL07(2F): Impact of climate variation on plant disease and its management

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Climate variation is the result of the acceleration in the increase in temperature and CO2 concentration over the last 100 years. The impacts are being felt most keenly in developing countries, where damage to agricultural production from extreme weather linked to climate variation is contributing to deaths from malnutrition, poverty and their associated diseases. Throughout the 21st century, India is projected to experience warming above the global mean. Climate variation is the realist now and biggest threat of the present century. The impacts of climate variation have been observed in many dimensions such as effects on biodiversity, food grain production, insects and plant diseases. Out of this, impacts on plant diseases is also one of the important dimension that has to be seen in broader perspective. Since environment and diseases are closely related, climate variation probably alter the geographical and temporal distribution of phyto-sanitary problems. Change in temperature directly influence infection, reproduction, dispersal, and survival between seasons and other critical stages in the life cycle of a pathogen. Moisture is particularly important for fungal and bacterial pathogens on plants. Rising CO2 level, atmospheric pollutant and ultraviolet B components play important impact on host pathogen system in cultivation practices. The climate variation has various impacts on biotic, abiotic and mesobiotic stress on plants. Therefore, understanding the potential effects of climate variation on agriculture in terms of its impacts on severity and incidence of pests and diseases is an important issue. Our knowledge is limited on how multifactor climate variations may affect plant health. The prediction is that climate variations may alter rates of pathogen development, modify host resistance and lead to changes in the physiology of host - pathogen interactions, which again may influence the severity of plant diseases. Climate variation can have positive, negative, or neutral impact on individual pathosystems because of the specific nature of the interactions of host and pathogen. Climate variation operates at a global scale; a lack of understanding of epidemic processes at relevant environmental and spatial scales has hampered progress. In such scenarios, weather-based disease monitoring, inoculums monitoring, especially for soil-borne diseases and rapid diagnostics would play a significant role. There is need to develop Integrated disease management strategies to decrease dependence on fungicides. In addition, monitoring and early warning systems for forecasting disease epidemics need to be developed for important host-pathogens which have a direct bearing on the earnings of the farmers and food security at large. The use of information technology can also help in proper compilation of the data for forecasting as per the climate variation and management of plant diseases.

IL08(2F): Pokkah boeng an emerging threat to sugarcane crop in India

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Sugarcane (*Saccharum* spp. hybrid) is an important cash, food and bioenergy crop of tropical and sub-tropical areas of the world and supporting world economy to a great extent. Production and productivity of crop is hampered by various diseases of which pokkah boeng caused by *Fusarium* spp. complex has emerged as an economically important disease in most of the sugarcane growing areas of India, leading to considerable qualitative and quantitative losses in sugarcane. The present investigation on epidemiology, yield losses and management of pokkah boeng was carried out under Haryana conditions during 2018- 20. Out of four dates of sowing of sugarcane, the highest PDI was observed in IIIrd date of sowing (14 July) followed by IInd date of sowing (23 March), IVth date of sowing (1 May) and least PDI in Ist date of sowing (24 February) on three sugarcane varieties. Fungicides evaluated against pokkah boeng, carbendazim, copper oxychloride, propiconazole and carbendazim + mancozeb provided maximum disease control under field conditions. Symptomatic varieties exhibited significant reduction (%) as comparison to asymptomatic varieties in yield and juice quality parameters (cane length, number of internodes, cane weight with top and without top, girth, total juice, brix (%), sucrose (%) and CCS (%)) ranging from 3.94-40.51 %. Several genotypes were identified resistant to pokkha boeing .Neem leaves and garlic clove extracts at 20 per cent concentration were found most effective both under *in vitro* and under field conditions. *Trichoderma viride* and *T. harzianum* found most effective under *in vitro* and field conditions. Current disease scenario and new approaches to manage the diseases are summarized

IL09(2F): Geographical Distribution and Severity of Rapeseed-Mustard Diseases under Changing Climatic Scenario in India

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In the galaxy of plant biodiversity at a global level, rapeseed-mustard share a significant role as edible oil crop of rich nutrients source. At present, net per capita intake of edible oil is nearly 19.5gm/person/day in India. Several species and sub-species of crucifers are cultivated in India under the trade name of rapeseed-mustard, and are being cultivated in about 53 countries spreading all over the globe. Canada, China, India, France, and Germany are the top five rapeseed-mustard producing countries worldwide. During 2019-20, area, production and productivity of rapeseed-mustard in the world were 35.96 mha, 71.5 mt, and 1990 kg/ ha. In India, about 80% of total rapeseed-mustard cultivation is under *B. juncea* mainly in Rajasthan, MP, Gujarat, UP, Haryana, and West Bengal states of the country. Among other *Brassica* species, *B. rapa* ssp. Brown Sarson is grown under upper Himalayan temperate regions in Srinagar while, *B. napus* is under cultivation in Jammu, Himachal Pradesh, and Punjab states. Although, *B. rapa* ssp. Toria is mainly grown in foothills regions of Himalayas particularly in Uttrakhand, Eastern Uttar Pradesh, Bihar, Eastern parts of the country and Odisha. Other species including *B. rapa* ssp. Yellow Sarson is widely cultivated in West Bengal and Taramira (*Eruca sativa*) is grown in some pockets of Rajasthan and Haryana states. During 2009-10, area, production and productivity of rapeseed-mustard in India were 5.6 mha, 6.6 mt, and 1183 kg/ ha which have been increased by 11% to 6.86 mha, 9.12 mt with 1331 kg/ha yield respectively during 2019-20. Under favorable environmental conditions, oilseed Brassica crops are persistently threatened by 167 biotic (44 pathogens, 87 pests, and 36 weeds) and 19 abiotic stresses. Out of 44 pathogens known to infect crucifers, 16 pathogens causing crucifers diseases are considered as of major consequences based on their geographical distribution, host range, losses caused, and resources spend to manage them. Among biotic stresses, some important diseases in India cause damage to crop at different stages of plant growth starting from seedling stage (Downy mildew and white rust), leaf development stage (white rust), stem elongation (Alternaria blight), flowering stage (Sclerotinia rot), silique development, and ripening stage (powdery mildew) and others are minor, which occasionally causes considerable damage to the crop. Among minor diseases, stem blight disease caused by *Nigrospora oryzae* (Berk. & Broome) Petch, and wilt disease caused by *Fusarium equiseti* (Corda) Sacc., have been reported for the first time from rapeseed-mustard growing regions of India. While, root rot caused by *Erwinia carotovora* pv. *carotovora*, and *Sclerotium rolfsii* is an emerging threat for rapeseed-mustard production system, recently reported from the farmers' field in some pockets of the country. Trends of disease occurrence revealed that the mean highest WR severity (22.1 %) has been observed during 2019-2020 followed by 17.6 % during 2004-2005 crop season which was prevalent on different *Brassica* species in 17 states of the country. Sclerotinia rot has been considered as most damaging disease for rapeseed-mustard crop in India since 1999 which was at peak during 2012, 2013, and 2014, afterward, the disease significantly decreased may be due to climatic effects and technological advances for its management. Though, the disease has been considered as major problem particularly in Rajasthan, Haryana, Madhya Pradesh, Uttar Pradesh, Bihar and Punjab states of the country. Similar trends were also observed for powdery mildew disease in different parts of the country. Alternaria blight was considered number one threat for the crop earlier but now the data revealed decreasing trend of this disease particularly in Rajasthan, Haryana, Madhya Pradesh states of the country. Alternaria blight disease is not a problem on rapeseed-mustard crop cultivation in western Rajasthan and Gujarat states where, powdery mildew considered as the major problem as it appeared severely. Although, AB is a severe problem in Uttarakhand, HP, Bihar, UP, Assam and West Bengal states of the country. Amongst these four diseases (AB, WR, SR, and PM), Alternaria blight covered 32% share with average 26.6% disease severity on different *Brassica* species over the period mainly in humid areas where rapeseed-mustard is under cultivation. While, powdery mildew holds 30% share among diseases with 25.1% mean severity particularly in Gujarat, Maharashtra, Rajasthan, Haryana, Chhattisgarh states of the country. Whereas, 17.3% white rust mean disease severity occurred with a 21% share on *B. napus* and *B. carinata* crops which are considered as resistant to the disease. Sclerotinia rot disease incidence appeared upto 14.2% and contributed 17% share of all the diseases on oilseed Brassica. Maximum white rust severity was observed on *B. juncea* (27.1%) whereas *B. carinata*, *B. napus* and *B. rapa* ssp. Yellow Sarson showed resistant against *Albugo candida*. In these species resistance against WR is mainly goverend by single dominant gene, and possible to transfer it in the major cultivated *Brassica juncea* crop in India. Different *Brassica* speices showed variations in Alternaria blight severity with highest 38.9 per cent on *Eruca sativa* followed by *B. rapa* ssp. Toria (37.3%), *B. rapa* ssp. Yellow Sarson (34.9%), and *B. juncea* (31.1%). Although, lowest AB severity was on *B. carinata* (22.1%) and *B. napus* (26.0%). Powdery mildew is emerging severely on *B. juncea* (43.2%) followed by *B. rapa* spp. Toria (28.6%). Whereas, Sclerotinia rot was recorded maximum on *B. rapa* ssp. Yellow Sarson (51.2%), *B. rapa* ssp. Toria (50.2%), *Eruca sativa* (49%), *B. napus* (38.5%) and *B. carinata* (33.4%). In India, *Brassica carinata* and *B. napus* crops showed lower attack of pathogens followed by *Eruca sativa*, and *B. rapa* ssp. Toria. *B. juncea* comparatively suffered more with the attack of different pathogens. Maximum SR disease incidence has been observed on *B. rapa* ssp. Yellow Sarson, *B. rapa* ssp. Toria and *Eruca sativa.*

Oral Presentations

OP01(2F): Occurrence of Pineapple Marbling Disease in Siang Regions of Arunachal Pradesh (India)

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Pineapple [*Ananas comosus* (L.) Merr.] belongs to the family Bromeliaceae is most productive under a xerophytic environment where low rainfall is supplemented by irrigation in well drained soils. Pineapple is one of the most important fruit crops of NEH Region of India. ‘Kew’ of the smooth leaf ‘Smooth Cayenne’ group and ‘Auritius’ of the rough leaf ‘Queen’ group are the two varieties of pineapple grown in India. Marbling disease is caused by the acetic acid bacteria *Acetobacter peroxydans* Visser’t Hooft and *Erwinia herbicola* var*. ananas* (Serrano) Dye. The disease has been reported in essentially all pineapple production areas of the World. However, sporadically levels occur only in the lowland tropics and epidemic also occurring of the hot and humid. Infection by marbling bacteria occurs through the open flower. The pineapple fruit purchased from local market of Siang regions of Arunachal Pradesh. Infected fruit do not show any symptom but the most common internal symptom appears as yellowish to reddish brown to very dark dull brown discoloration of the infected fruit tissue. Infected tissues generally become hardened, granular and brittle in texture with colour variation in the form of speckling. Marbling of pineapple is an asymptomatic disease in the field and is evidenced with a brownish coloration when the infected fruit is use to eat and processed. Although, maximum disease incidence (32.48%) recorded from East Siang in the month of August, The marbling disease is threat to pineapple growers because there is no cost effective disease management method to cultivation of pineapple in Siang regions.

OP02(2F): Impact of climate change on coffee diseases in India with special reference to rot diseases occurring during monsoon period

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Coffee growing regions in South India received unusual rains with erratic distribution patterns during monsoon season for the last four years may be due to change in climate. This high quantum of rainfall in short periods led to flash floods in coffee plantations resulting in soil erosion and water logging in root zone causing wet feet condition. Thus, the soil saturation coupled with cool ambient temperature, relative humidity and persistent hanging mists during monsoon provided ideal conditions for flare up of rot diseases such as black rot, stalk rot, leaf spot and berry diseases causing defoliation and also premature fruit drop affecting yield loss to an extent of 15 to 20%. In the past years, prevalence of monsoon rot diseases was confined for a period of 3-4 months during the rainy season. However, in the recent years due to receipt of unusual rains throughout the year, because of availability of pathogen inoculum due to wetness throughout the year with hasty gaps, high relative humidity, low temperature which triggered and activated the fungal pathogens and plants developed high foliage which creates microclimate in coffee bushes and less soil aeration due to water stagnation as a result severity of rot diseases increased leading to relatively maximum reduction in yield. After extensive studies, an integrated disease management (IDM) package for rot diseases was updated with new fungicide molecules *viz*., pyraclostrobin 13.3% + epoxyconazole 5% SE @ 1ml/L, tebuconazole 25 EC @ 1ml/L and trifloxystrobin 25% + tebuconazole 50% WG @ 1 g/L which have higher efficacy. Apart from the monsoon rots, behaviour of coffee leaf rust (CLR) pathogen *Hemileia vastatrix* also altered. However, availability of tolerant varieties and efficient fungicide molecules aided in CLR management.

OP03(2F): Study on Occurrence, Distribution and Yield loss due to Root Rot in Ajwain (*Trachyspermum ammi* L.) caused by *Rhizoctonia solani* in Southern Rajasthan

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Ajwain (*Trachyspermum ammi* L.) also known as Bishops weed and Carom seed, is one of the most important seed spices crops it's belonged to family *Apiaceae*, is a native of Egypt. Ajwain is erect, glabrous or minutely pubescent branched annual herb which grows up to 75-80 cm in height. In Rajasthan, it is cultivated in the districts of Chittorgarh, Udaipur, Jhalawar, Baran, Rajsamand, Bhilwara and Kota covering an area of 11658 hectares with the production and productivity is 4672 tonnes / annum and 401 kg/ha, respectively (Anonymous, 2015-16). In India, Rajasthan contributes 73 per cent of total production of ajwain. The root rot disease is most common and destructive disease of ajwain, caused by *R. solani*, caused losses in yield as well as quality of the crop. Yield losses vary between 10 to 100 per cent depending on varietal susceptibility and agro-climatic conditions. The disease was surveyed in 40 villages of different districts *viz.,* Udaipur, Rajsamand, Chittorgarh and Pratapgarh of Southern Rajasthan in the year of 2015-16 and 2016-17 and recorded disease progress and per cent mortality at 45th and 75th DAS in both the years. The per cent mortality was ranged from 12.80-32.50 and 15.00-35.50 per cent at 45th DAS in both the years, respectively. The maximum and minimum plant mortality was recorded in Bhatewar (Udaipur) and Phoonkiya (Rajsamand) in both the years. The overall per cent plant mortality was more in 2016-17 year as compared to 2015-16. The root rot pathogens (*R. solani*) were isolated from disease ajwain plants showing root rot symptoms collected from farmer's field of different ajwain growing districts of Southern Rajasthan *viz*., Udaipur, Rajsamand, Chittorgarh and Pratapgarh. *Rhizoctonia solani* were isolated from eight disease samples and their pathogenicity was confirmed by growing in pathogen inoculated soil.

OP04(2F): Epidemiology of Ginger leaf spot in high altitude and high rainfall region of Kodagu

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Leaf spot caused by *Phyllosticta zingiberi* is one among the most cosmopolitan and destructive diseases of ginger causing crop loss to the magnitude of thirty per cent under epiphytotic conditions. The disease generally manifests during June and attains epiphytotic proportions during September-October. Delineating vulnerable crop stages with respect to weather factors and disease pattern helps to formulate and implement plant protection strategies economically and efficiently. Hence, the present study was conducted for three consecutive (2019-2021) in Kodagu region with three released varieties of ginger (IISR Varada, IISR Mahima and IISR Rejatha).
The mean Percent Disease Index (PDI) ranged from 0.37% to 35.53%. The maximum disease incidence was recorded during September in IISR Rejatha 35.55% correspondingly IISR Varada showed minimum incidence of 26.85%. The maximum AUDPC was recorded in IISR Rejatha (456.7) during August contrastingly to PDI which recorded maximum during September. A correlation was made with the weather parameters (rainfall, rainy days, temperature maximum and temperature minimum). The results indicated that only rainfall and rainy days has positive correlation with the PDI and temperature is negatively correlated. Based on the results, a linear regression model was developed using R statistics and fitted for early prediction. It is concluded from the present study that, the infection aggravates during monsoon and reaches maximum when the rainfall recedes and once the temperature increases after September the disease incidence decreases, further for the management of the disease pre-monsoon spraying of recommended fungicide will reduce the incidence and benefit the growers.

OP05(2F): Viral incidence and distribution of *citrus tristeza virus* (CTV) in khasi mandarin of north eastern Himalayan region of India

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Khasi mandarin is one of the most remunerative crops in North Eastern Hills region of India playing a very critical role in the socio-economic upliftment of the people. The orchards of this region were found to express the typical symptoms of CTV. An extensive survey of the Khasi mandarin orchard for six North Eastern states of India namely Arunachal Pradesh, Meghalaya, Assam, Nagaland, Sikkim and Tripura was carried out to establish the identity of CTV using ELISA and PCR/RT-PCR techniques. Out of 300 Khasi mandarin tree samples, 172 were found to be positive for CTV infection by DAS-ELISA indicating 57.33% overall CTV disease incidence. Results revealed presence of CTV in all the surveyed states with maximum incidence of 66.00% in Arunachal Pradesh followed by 62.00% in Assam, 60.00% in Meghalaya and Nagaland, 54.00% in Sikkim and 42.33% in Tripura. Higher CTV concentration was recorded in the age group 15 years (69.09%) followed by 10–15 (57%) and 5–10 years (43.33%). This study, to the best of our knowledge, is the first report for the detection of CTV in Khasi mandarin from Arunachal Pradesh, Nagaland and Tripura and also the first authentic survey of overall disease incidence of CTV Khasi mandarins from the six major mandarin growing North Eastern states of India.

OP06(2F): Assessment of yield loss due to Maydis leaf blight disease of maize in West Bengal

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Maize has the highest yield potential among all cereals and considered as the “Queen of Cereals”. This unique cereal has diversified uses as food, feed and industrial purposes. This is the third most important cereal crop in India and presently the second most important cereal in West Bengal. Among the obstacles of maize cultivation biotic stresses as well as diseases are very much important. In West Bengal mainly leaf blight diseases mainly Maydis leaf blight and Turcicum leaf blight are predominant. Global scenario is expressing an yield loss of 16% due to attack of plant pathogens and the ultimate objective of all types of research under plant diseases is to minimize the yield loss of crops which is not only dependent on disease severity but also on weather factors & virulence level of the pathogens. The relationship between disease and yield loss in certain pathogen-host system is liable to change from year to year and very much difficult to predict at regional as well as farmer’s level. For determining proper management strategies for diseases, estimation of yield loss is inevitable and to assess the loss in yield due to one of the important. Field experiments were conducted in District Seed Farm at Kalyani with susceptible maize hybrid, Disha during 2017, 2018 and 2019 Kharif seasons. The experiments were used to determine yield losses due to Maydis leaf blight disease in West Bengal. The trials were laid out in paired plot techniques with two treatments replicated for nine times under artificial epiphytotic condition. The fungicide Mancozeb was sprayed in protected treatment for five times at weekly interval from 35 days after sowing and after initiation of first disease symptom. In protected plots there was more yield compared to unprotected plots. Mean avoidable percent yield loss was 22.01, 19.93, 22.41 respectively during 2017, 2018 and 2019 and average yield loss percentage is 21.45 due to maydis leaf blight disease of maize.

OP07(2F): Effect of temperature and leaf wetness duration on development of blast disease of pearl millet caused by *Magnaporthe grisea*

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Pearl millet blast casued by *Magnaporthe grisea* has become a major threat to pearl millet production next to downy mildew disease in India. The effect of different leaf wetness durations ranging from 0-72 hours (0, 6, 12, 24, 36, 48, 60 and 72 hours) and different incubation temperatures with alternate day (12h) and night (12h) temperatures of (25±1/20±1oC,28±1/20±1oC, 30±1/22±1oC, 35±1/25±1oC and 40±1/28±1oC) was evaluated separately using a blast susceptible line ICMB 95444 and a resistant line ICMR 06444 and four *M. grisea* isolates (MgPM 45, MgPM 53, MgPM 56 and MgPM 118) under *invitro* conditions. The infection of *M. oryzae* was visualized only on ICMB 95444. The disease progressed more rapidly (> 92% PDI) at 12 hours wetness durations compared with 0 and 6 hour, and maximum (100%) PDI was recorded at 48 hours and above wetness durations. Thus, for 48, 60 and 72 hour wetness duration periods, disease symptoms were first visible at 3 days after inoculation and increased to final average severities of 4.55 to 5.91 mm lesion length, and 33.86 to 41.30 lesions per leaf at 8 days after inoculation. The optimum temperature observed for disease development (>94% PDI) ranged from 25±1/20±1oC to 35±1/25±1oC. The mean maximum disease index (96.48%) occurred at 30±1/22±1oC temperature and the mean disease index increased from 25±1/20±1oC to 30±1/22±1oC temperature and declined with the further increase in the temperature (35±1/25±1oC and 40±1/28±1oC). It can be concluded based on the results of both leaf wetness duration and temperature experiments that blast on pearl millet becomes more severe at longer wetness durations beyond 48 hours during optimum day/night temperature ranging from 25±1/20±1oC, to 30±1/22±1oC. Among the *M. grisea* isolates tested, MgPM 56 from Nagaur district of Rajasthan was found to be more aggressive.

OP08(2F): Surveillance on target spot of cotton caused by *Corynespora cassiicola* and its variability study: An emerging disease of cotton in India

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Target spot of cotton caused by *Corynespora cassiicola* (Berk. & Curt.) Wei is a necrotrophic and cosmopolitan plant pathogen that causes leaf spots in 530 plant species from 380 genera. It's an emerging threat to cotton cultivation in Maharashtra, Andhra Pradesh in India and other countries. It causes premature defoliation during frequent showers/irrigation. The lint yield loss due to this is estimated up to 448 kg/ha on susceptible cultivars. Little is known about its etiology, epidemiology and its effect on cotton yield in India. Hence, a survey was conducted during 2020 and 2021 in different cotton growing areas of India with the focus to estimate the incidence of target spot, examine the cultural and morphological characteristics of *C. cassiicola*. A varying level of incidences of target leaf spot were reported in Haryana, Punjab, Rajasthan, Gujarat and Andhra Pradesh. All fourteen *C. cassiicola* isolates were phenotypically differed. Colonies were whitish gray to grey, with tan brown to brownish gray pigmentation, having woolly, cottony, and smooth texture on PDA. Conidia varied in their shape, had 2 to 18 pseudosepta, were 42.53 to 109.39 µm long, 8.4 to 17.7 µm wide, obclavate to cylindrical, solitary or catenate, pale olivaceous brown or brown in colour. Koch's postulate tests were performed to confirm the pathogenicity. To our knowledge, this is the first report of target spot on Bt-cotton (*G. hirsutum*) in Gujarat and North Western India. Given the increasing prevalence of this disease, its confirmation is a significant step toward developing management recommendations for growers.

Technical Session 3:
Applied research in plant pathology

3A. Diagnosis of plant pathogens

Keynote Lecture

KN01(S3A): Advanced techniques in Plant Pathogens diagnosis: A critical appraisal of methods, from detection to field survey and monitoring

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Technical innovations are the key drivers for the advent of new concepts in plant pathology, from novel approaches to plant disease diagnosis in the laboratory as well as on-site to monitoring and surveillance of disease outbreaks and forecasting. In recent years, high throughput sequencing (HTS) has revolutionized the analysis of plants to resolve pathogen-derived sequences, discover new species and assemble complete genomes. Without any a priori knowledge of diseases or technical expertise, this new technology helps to elucidate the etiology of diseases but also the discovery of pathogen genomes that are not associated with diseases. HTS approaches can be used for virus indexing of germplasm, to reduce lengthy certification processes, designed to rapidly detect the composition of known pathogens in pooled samples thus combining parallel and high throughput analysis. On the greenhouse and field level, rapid and automated phenotyping tools based on image analysis are developed to provide an overview of disease incidence and severity and the resistant status of plants. While the proof of concept phase has not been passed for most of these approaches, it shows future trends towards automated surveillance of crop attributes to assist breeders, farmers and health inspectors in developing healthy plants. The challenges and opportunities of these novel technological advancements are critically examined.

Invited Lectures

IL01(S3A): Stem end rot (SER) in Mango – Identity of associated organism

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Mango (*Mangifera indica* L.) – the king of all indigenous fruits in India is ranked as one of the better fruits in the international market because of its delicious taste and high caloric value. The crop suffers from a number of diseases, among them 'post harvest rots' are most important. These not only deteriorate the nutritive value and quality in mango fruits but also render them unfit for consumption and trade, resulting into great economic losses Due to impact of climate change the diseases that were considered not economically important and minor earlier have become severe and the exact identity of the associated pathogen lacking. Among them stem end rot (SER) has become very serious. The infection of the pathogens occurs in the field in quiescent form during the premature stage as well as during harvesting, transportation and

storage. Isolations were made from the infected Mango fruits var. Alphonso and pure cultures were obtained following standard tissue isolation. Associated organism were characterized morphologically, culturally and besides molecular characterization was done following Raeder and Broda (1985). The isolated DNA was used for molecular analysis using Internally Transcribed Spacer (ITS) 1 and 4 primers forward and reverse. Out of the 50 bit used for the isolation of associated organism with stem end rot disease 24 (48%) isolates confined to Group 1 whereas 16 (32%) confined to Group II - Only 04 (08%) to Group III. Based on their characteristics the organisms were identified as *Lasiodiplodia theobromae* (Group I), *Phomopsis mangiferae* (Group II) and *Neofucicoccus parvum* (Group III). Amplification of the PCR products obtained from molecular analysis recorded their respective length (approximately) as 550bp (*Phomopsis mangiferae*), 540bp (*Lasiodiplodia theobromae*) and 460bp (*Neofusicoccus parvum*). The identity of different associated organisms (pathogens) was further confirmed on blasting respective gene sequences in NCBI gene bank with gene sequence homology of 99% in case of *L. theobromae* and *P. mangiferae* 96% for *N. parvum.* In mango Stem end rot has attained serious proportion. Besides *Lasiodiplodia theobromae*, *Phomopsis mangiferae* and *Neofusicoccum parvum* proved pathogens. Among them *P. mangiferare* is dominating. Pathogens exhibited considerable cultural, morphological and molecular variability. This is the first report on 'genes sequencing' on the above pathogens from India. Management strategies has to based on the associated of pathogen (s) with SER.

IL02(S3A): Advanced Molecular Diagnostics for Detection of Pathogenic Bacteria

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Accurate detection and identification of disease causing agents is a prerequisite for developing the appropriate and suitable management practices of any diseases caused by pathogenic microorganisms. Although the use of traditional methods for the diagnosis of the disease causing organisms is the best method available, but because of the laborious procedures which prompts to think for alternative methods for disease diagnosis. In the present studies we have attempted to exploit the nucleic acid based diagnostic methods for specific identification of disease causing bacteria. We have used bacterial pathogens from vegetable crops like tomato, chilli, brinjal, cole vegetables alongwith food-borne pathogens. We have exploited the deviations in the nucleic acid amplifications techniques like SSCP-PCR, Multiplex PCR, RT-PCR, LSSP-PCR and qPCR. *Ralstonia solanacearum, Xanthomonas perforans, X. campestris pv. campestris, X. axonopodis pv. vesicatoria, and X. oryzae pv. oryzae* were detected using nucleic acid amplification techniques in the present studies. Present studies have exploited the use of universal primers as well as species-specific primers. We have also attempted to develop the molecular techniques for the detection of Leptospirosis and Brucellosis pathogens from domestic animals, in addition food borne pathogens. The discriminative power of SSCP in species differentiation was demonstrated by comparative studies of representative groups of various pathogenic species. .In the present studies we have developed most recent state-of-the-art molecular diagnostic techniques enabling fast and accurate detection and identification of plant and food borne pathogens based on well-developed genotyping techniques. Precise molecular diagnosis of pathogenic bacterial infections decreases the spread of the disease and facilitates to make suitable disease management strategies. Advanced molecular diagnostics has taken a noticeable place and has revealed advantageous in diagnostic laboratory for routine detection, fingerprinting and epidemiologic analysis of infectious microorganisms. Molecular tests reduce the exposure to infectious agents and decrease the health risk for the consumers.

IL03(S3A): Loop Mediated Isothermal Assay (LAMP): New Addition to Rapid Diagnostics

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The study aims to standardize a real-time Loop Mediated Isothermal Assay (LAMP) for effective, sensitive and rapid detection of a DNA containing virus, Bunchy top of virus (BBTV) and tow RNA containing viruses viz., Potato leaf roll virus (PLRV) and Potato virus Y (PVY). Three different sets of LAMP primers were designed against BBTV, PLRV and PVY, respectively, and were tested using LAMP assay against PCR positive samples. Sensitivity test of BBTV, PLRV and PVY LAMP assays were compared with conventional PCR and RT-PCR assays. The Real-Time LAMP assay for BBTV detection resulted in typical sigmoidal amplification curves with the peak values ranging between 8.00 to 12.15 minutes and annealing derivatives ranging between 83.3 ^{0}C to 84.3 ^{0}C in the tested samples. Sensitivity comparison of BBTV Real-Time LAMP assay with conventional PCR revealed that the BBTV LAMP assay could efficiently detect up to 0.0001ng/μl of total DNA as against 0.01ng/μl in conventional PCR. Similarly, for PLRV and PVY, the minimum threshold time to detect positive RT-LAMP of PLRV and PVY were ranging from 11-15 minutes for PLRV and 11-14 minutes for PVY, respectively. The annealing temperature for PLRV was 88 ^{0}C while that for PVY ranged between 84–85 ^{0}C. For both PLRV and PVY, the RT-PCR could perfectly detect 100 to 10^{-1} diluted RNA and DNA, while LAMP and RT-LAMP could detect all diluted RNA. This method can be preferred over conventional diagnostic techniques like PCR or ELISA for rapid detection of BBTV, PLRV and PVY.

IL04(S3A): Occurrence and geographical distribution of date palm fungal pathogens

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Date palm (*Phoenix dactylifera*) belongs to the family Arecaceae (syn. Palmaceae), which also includes 200 genera and 1500 species. Palm trees are cultivated mainly in tropical regions, but they are also found in subtropical and temperate zones. Date palm is a strategic crop for many countries in Asia and Africa, with more than 8 million tons per year worldwide. Date palm products are utilized worldwide as foods, fiber, pharmaceuticals and medical care, cosmetics, and other industrials that have a significant role (economically, socially, and culturally) on the income and lives of the people in many countries. Like other plants, palm trees are prone to attack by fungal pathogens and subject to diseases responsible for considerable damage. An increase in the international trade of plant materials is a major way for the distribution of fungal species. Since fungi are the leading cause of these diseases, knowing the fungi associated with them is vital. The study of fungi associated with date palm trees makes it possible to explore different types of research in the Mycology area. The most severe fungal genera which affect date palm are *Fusarium, Alternaria, Bipolaris, Botrydiplodia, Ceratocystis, Chalara, Chaetophaeria, Cladosporium, Cocoicola, Colletotrichum, Curvularia, Didymella, Diplodia, Drechslera, Ganoderma, Graphiola, Helminthosporium, Mauginiella, Nigrospora, Omphalia, Pestalotiopsis, Phialophora, Phoma, Phomopsis, Phytophthora, Pythium, Rhizoctonia, Serenomyces, Stemphylium, Sordaria, Sordariomyces, Thielaviopsis*. It should be noted that the relevance of the studies on microfungi associated with palms made them begin to be considered an important and taxonomically diverse assemblage that is often referred to as "palm fungi" or "palmicolous fungi." The present study attempts to provide a piece of updated information on the reported fungal pathogens on date palm trees.

IL05(S3A): New Report: Die-Back of Okra (*Abelmoschus Esculentus* L. Moench) caused by *Colletotrichum coffeanum* (Noack)

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Okra (*Abelmoschus esculentus* L. Moench) is one of the most important annual vegetable crops grown in tropics and sub-tropics, which is very nutritious and delicious among Indian food. Among different plant pathogens, *Colletotrichum coffeanum* (Noack) is considered as one of the most destructive fungal pathogen of okra causing die-back. Considering the emergence of the inokra in South Gujarat. The die-backed twigs showed symptom usually developed from the tip, which is characterized by blackening of the stem. Apex of the twig showed the development of sunken lesions which became dark brown in advance stage of the disease resulting in quick dried up portion when the typical die-back set in. The fruiting bodies of the pathogen in the form of acervuli were visible as minute black dots under severe infection. The repeated isolations from infected twigs of okra revealed the association of *Colletotrichum* sp., which was identified after the morphological and cultural studies as *Colletotrichum coffeanum* and was also confirmed by Agharkar Research Institute, Pune as *Colletotrichum coffeanum* (Noack).

IL06(S3A): Appropriate Surveillance and diagnostics tools in Prevention of spread of Maize Lethal Necrosis (MLN) to Southern Africa

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Since 2011, Maize Lethal Necrosis (MLN) disease has emerged as a major threat to food security in Sub-Saharan Africa. There are several strategies in the management and in preventing further spread of the disease to southern African countries where Maize is a staple food, and the seed maize industry is vibrant. One of the approaches is to have a robust disease surveillance structure and appropriate diagnostics tools within the Phytosanitary systems and NPPOs from the countries in the region. CIMMYT through the MLN Diagnostics and Management project has worked with NPPOs and other institutions from the five MLN endemic countries in eastern Africa (Kenya, Uganda, Tanzania, Rwanda, and Ethiopia) and the three countries in southern Africa (Zambia, Malawi, and Zimbabwe) in strengthening their Phytosanitary systems towards this end. An effective MLN surveillance system was established, including web-based information exchange amongst relevant institutions. Using the latest technology in surveillance, the android based Open Data Kit (ODK), the MLN surveillance protocols were designed and uploaded in the application for use. Further, an MLN data Toolbox was also set up to manage surveillance data generated from the massive regional surveillance exercise. The data generated is published in the MLN Web portal, a product of the Project. Harmonized surveillance, sampling, and diagnostics protocols for detecting MLN-causing viruses especially MCMV in farmers' fields, seed fields, and in commercial seed lots were designed and implemented. Various stakeholders have been trained on the ODK surveillance tool, field testing for MCMV using immunostrips, and testing for MLN viruses in seed using ELISA. The establishment of the MLN Phytosanitary Community of Practice, understanding seed transmission of MCMV, appropriate surveillance and diagnostic protocols have contributed immensely in the management strategies for MLN in eastern Africa and hence prevented its spread to southern Africa

Oral Presentations

OP01(S3A): Virome analysis of Tuberose (*Polianthes tuberosa*) plants reveals novel potyvirus from India

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Tuberose (*Polianthes tuberosa)* plants being grown at the experimental fields of Horticulture Research Center, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, India were observed exhibiting mild mosaic symptoms characteristic of virus infection. cDNA library generated from a symptomatic plant underwent high-throughput sequencing to determine if viral pathogens were present. Approximately 53 million 75 bp paired-end reads were obtained. A total of 73,417 contigs were generated by *de novo* assembly and homology search with the sequences in BLASTn and BLASTx programs against the Nr database. Sequence data revealed the presence of two novel viral genomes, both with properties congruent with members of the genus *Potyvirus* (family *Potyviridae*). Sequence comparisons and phylogenetic placement indicate that both viruses represent novel species. The names "Polianthes potyvirus A" and "Polianthes potyvirus B" are proposed for the *potyvirus*.

OP02(S3A): Spatial and temporal distribution of Ilarviruses ApMV and ApNMV associated with mosaic disease of apple for optimization of tissue and time for real time detection

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Apple mosaic disease (AMD) is economically important viral disease, having widespread distribution and results in yield losses up to 40%. Besides apple mosaic virus (ApMV), apple necrotic mosaic virus (ApNMV) has also been found associated with AMD. Both ApMV and ApNMV being labile in nature, their titer varies negatively with high temperatures, so proper tissue as well as proper time is necessary for detection. During 2021-22, detection and relative quantification of ApMV and ApNMV using RT-PCR and RT-qPCR was done from plant parts viz., anther, leaf, petal, pedicel, stigma with style, bark, fruit and seed (spatial) in two cultivars (Oregon Spur and Golden Delicious) of apple during three seasons viz., spring, summer and autumn (temporal) to optimize tissue and time for real time detection. Depends upon the availability of tissues during different seasons, both ApMV and ApNMV were detected in all the plant parts during spring season, in seed and fruits during summer, whereas in leaves and pedicel during autumn using RT-PCR. For relative quantification of the virus titer in different parts during three seasons using RT-qPCR, the results showed that, the ApMV and ApNMV expression was higher in leaves and minimum in petals during spring, in summer the titer was highest in fruit and minimum in leaves and bark., whereas in autumn season, the expression was more in leaves and minimum in fruit and bark. Periodic detection of these viruses in different plant parts during all the seasons revealed varied virus titer from one season to another in the same plants. The results confirmed that leaves and pedicels during spring season and fruits/seeds during summer via RT-PCR are suitable tissues for detection of both the viruses.

OP03(S3A): Morphological and molecular characterization of *Nakataea oryzae* causing stem rot of rice

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High incidence of stem rot in rice (*Oryza sativa* L.) was observed in Cuddalore district of Tamil Nadu state in rice irrigated ecosystem in July and August of the years 2020-21 at the maximum tillering stage of the rice plants. A survey was conducted for the prevalence of rice diseases in the Cuddalore district of Tamil Nadu. Stem rot incidence (22-34%) was observed in widely cultivated rice variety AST-16. Brownish to black lesions that expanded and girdled the sheath was observed. Isolated colonies of pure cultures were white at first and then turned brown about 6 days later. Hyphal diameters ranged from 3.2 to 7.4 ¼m. Large numbers of round or oval sclerotia formed on the surface of the colonies at 8 days. The sclerotia were initially white, turning reddish-brown to black upon maturity and measuring 286–549 × 229–443 µm. DNA of a representative isolate was extracted, and the internal transcribed spacer region was amplified by PCR with universal primer pair ITS1/ITS4. Sequence analysis showed 99% identity with *Nakataea oryzae* isolate TNC24721 and accession number OL841539.1. Phylogenetic analysis based on the neighbor-joining method grouped the isolates along with other isolates from Asia. Koch's postulates, four-

week-old rice sheath tissues (var. AST-16) were inoculated with 4 mm diameter discs of five-day-old cultures that contained mycelium and sclerotia. The discs were covered with parafilm and the plants were maintained in a greenhouse. Symptoms similar to those originally observed in the field began to appear on the leaf sheaths after 10 days. The fungus was successfully reisolated from the symptoms of artificially inoculated plants. Histological observations revealed brownish runner hyphae and lobed hyphopodia were produced on the surface of infected leaf sheaths by *N. oryzae*. The pathogen was identified as *N. oryzae* based on its cultural, morphological, pathogenic, and molecular characteristics.

OP04(S3A): High throughput characterization and robust diagnosis of virus and virus-like pathogens of major horticultural crops of North East India

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North East Region (NER) of India with its large biodiversity and diversified cropping patterns encompasses the unique array of virus and virus-like pathogens. The virus complex of chilli, citrus, passion fruit was deciphered using standard molecular assays followed by high throughput sequencing (HTS) based virome analysis. The assembly and mapping of HTS read helped in the identification of the entire viral genetic diversity infecting these crops. The characterization of either new viruses or their distinct genetic variants infecting passion fruit (potyviruses), chilli (six viruses) and citrus (citrus tristeza virus and *Candidatus* Liberibacter asiaticus) crops in the NER region enabled us to successfully develop simplified and high throughput diagnostic assays. A multiplex-PCR assay capable of simultaneous detection of six chilli viruses (capsicum chlorosis virus, chilli veinal mottle virus, large cardamom chirke virus, cucumber mosaic virus, pepper mild mottle virus and chilli leaf curl virus) with sensitivity similar to singleplex PCR was developed and validated. Isothermal recombinase polymerase amplification (RPA) assays for the predominant virus and virus-like pathogens (*Candidatus* Liberibacter asiaticus, chilli veinal mottle virus and passion fruit potyvirus) using total plant extract as template was deployed to carry out the detection at an isothermal temperature of 37 ÚC. The developed RPA assays could detect the respective target pathogens up to 10-6 to 10-8 dilution of crude sap and was as sensitive as benchmark PCR. The diagnostic assays were only field validated but also used in routine indexing and production of virus-free plantlets in NER.

OP05(S3A): Development of simplified isothermal recombinase polymerase amplification assay for detection of sugarcane bacilliform viruses

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Sugarcane bacilliform viruses (SCBV), a group of genetically diverse double-stranded DNA viruses of genus *Badnavirus*, family *Caulimoviridae* causes leaf freckle, mottling, chlorosis and stunted growth on different sugarcane cultivars across the globe. Polymerase chain reaction has been widely used as bench-mark assay for the detection of SCBV infection in sugarcane. The efficient management of SCBV largely relies on availability and application of sensitive, quick, simple and cost-effective detection methods for production, supply and distribution of indexed clean planting materials. Lab-on-Chip is a trending method that addresses the commoner concern over many advantages like very economical, fast, user-friendly and high sensitivity. It is made of a small or micro-level diagnostic platform where it needs a minimal amount of sample for detection. Elsewhere this technique is performed in simple paper-based microfluidics (also called Lab-on-Chip) platform, which is mostly semi-quantitative. To achieve this, present study was conducted and successfully developed rapid and simple isothermal recombinase polymerase amplification (RPA) assay for SCBV for the first time. Primers targeting taxonomically important RT-RNase H genomic region were successfully employed in RPA based detection of SCBV using total plant extract as template. While total plant extract when used as template, bench-mark PCR did not yield any amplification, the RPA assay gave sufficient amplification exhibiting its applicability as routine indexing procedure. The developed RPA assay exhibited sufficient sensitivity and accuracy in detection of SCBV infection. To the best of our knowledge, this is the first report on development of simplified isothermal RPA assay for detection of SCBV infection in sugarcane, which will find place in routine indexing of sugarcane and production of clean clonal planting materials.

OP06(S3A): Occurrence of a new cucurbit infecting polerovirus species associated with pumpkin plants in India

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Of 26 polerovirus species recorded so far, six are known to infect cucurbit hosts worldwide and only cucurbit aphid-borne yellows virus (CABYV) has been reported in India infecting bitter gourd (*Momordica charantia*), cucumber (*Cucumis sativus*), and teasel gourd (*Momordica subangulata* subsp. renigera). Realizing the expanding host range of CABYV in India, the present study was executed to explore the possible association of other polerovirus species with cucurbit hosts. The leaf samples from four different cucurbit hosts (bitter gourd, cucumber, muskmelon, and pumpkin) exhibiting severe chlorosis, bleaching, and yellowing symptoms were collected from

the vegetable experimental fields of IARI, New Delhi, and subjected to leaf-dip transmission electron microscopy (TEM). Except muskmelon, the association of isometric virions (~25) nm was observed with the other three cucurbits. The RT-PCR assays using polerovirus generic primers Pol G F 52 GAYTGCTCYGGYTTYGACTGGAG 32 and Pol G R 52 GATYTTATAYTCATGG TAGGCCTTGAG 32 covering the partial RNA dependent RNA polymerase (RdRp, intergenic region (IR), and partial coat protein (CP) coding region followed by sequencing and NCBI BLAST analysis, further suggested the association of polerovirus related to previously reported CABYV (100% aa identities) with bitter gourd and cucumber samples and to luffa aphid-borne yellows virus (LABYV; 84-85% aa identities) with pumpkin samples. To confirm the association of specific polerovirus with pumpkin, the CP gene from three isolates was sequenced (MZ277872, MZ277873, MZ277874). Sequence analyses revealed the association of a distinct species of *Polerovirus* with the pumpkin samples as these isolates shared the sequence identities below the species demarcation limit (90%) with the corresponding gene sequences of polerovirus species. This study forms the first report to provide the molecular evidence for the occurrence of a new species of *Polerovirus*, named tentatively *Pumpkin yellows virus* (PuYV) in India.

OP07(S3A): Pathogens associated with mango wilt and their molecular diagnostics

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India is leading in global mango fruit production with 55 percent share (21378 thousand MT) from a cultivated area of 22.96 thousand hectares in 2018-19. One of the major constraints in sustaining the mango productivity is recent emergence of wilt/decline disease, due to which the whole tree declines and ultimately wilts completely leading to huge loss. Until 2018, the main cause of this disease was identified as *Ceratocystis fimbriata* (MF062274.1) in India and abroad. In 2019, association of root rot fungus, *Berkeleyomyces basicola* (MT786402) with mango wilt was also established. Additionally, another pathogenic fungus belonging to *Botryospahericeae* family has been frequently isolated. The identified pathogens *viz*., *C*. *fimbriata* and *B*. *basicola* are soil borne in nature and once they infest the soil, the area becomes unsuitable for mango cultivation. It has always been a difficult task to manage the disease in infested orchards and early detection of *C*. *fimbriata* and *B*. *basicola* has never been easy due to difficulties in the isolation of these fungi. Therefore, we initiated the efforts to develop early molecular detection methods at ICAR-CISH, Lucknow. Primer pairs targeting the ITS region of rDNA of *C*. *fimbriata* have been already developed. These primers are capable of detecting the fungus from soil at DNA concentration of 0.1pg/ 25 ¼l of total volume. Efforts have been initiated for developing time-efficient and sensitive molecular diagnostics that facilitate more sensitive screening of imported plant germplasm, and rapid tracking of pathogens of mango wilt.

OP08(S3A): Morphological, molecular identification and pathogenicity of Neoscytalidium dimidiatum causing stem canker of dragon fruit (Hylocereus spp.) in India

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In recent years dragon fruit (*Hylocereus spp*), an exotic fruit crop became increasingly popular in India. Health benefits as well as ability to withstand under adverse climatic condition may added its world acceptance. In India, mainly *Hylocereus undatus* & *H. polyrhizus* has taken up for cultivation across the various states. However, certain production constraints may affect its marked profitability. Among these climate change invited biotic stress events are major one. In 2021, *H. undatus* & *H. polyrhizus* plantations from Pune, Satara and Solapur districts of Maharashtra showed stem canker incidence. Initially small, circular, sunken, orange-brown spots developed on the cladodes of *H. undatus* & *H. polyrhizus*, turned to canker lesions with black erumpent pycnidia and subsequent yellowing & stem rotting was observed in affected plants. In the study, detailed diagnosis of stem canker pathogen was carried out. Based on morphological, phylogenetic analyses of internal transcribed spacer (ITS), ²-tubulin (tub2) and translation elongation factor 1-± (Tef-1±) gene sequences of isolates, the fungi was identified as *Neoscytalidium dimidiatum*. Pathogenicity tests were performed by detached stem assay and confirmed the association of *N. dimidiatum* with stem canker in *H. undatus & H. polyrhizus*. This is the first report of *N. dimidiatum* causing dragon fruit stem canker in India. Knowledge of the diagnosis of plant diseases is an important step for managing plant diseases and therefore, this finding provides basic information for the development of appropriate strategies for stem canker management in dragon fruit.

OP09(S3A): Klebsiella aerogenes: An endophytic bacterium establishing pathogenicity in pearl millet in Haryana

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The genus *Klebsiella*, in the family *Enterobacteriaceae*, is known for endophytic life style in varying habitats viz., Human beings, animals and plants. The genus is regularly involved in nosocomial infections, but now becoming phytopathogenic also. During Kharif 2018 to 2021, a new devastating disease namely stem rot of pearl millet in major pearl millet growing districts of Haryana namely Hisar, Bhiwani, Rewari and Mohindergarh. The disease was noticed as few to numerous longitudinal leaf streaks on leaves of infected plants. The brown to black water-soaked lesions were observed on the diseased stem displaying slimy rot symptoms. Severely diseased plants exhibited hollowing of the stem with disintegrated pith and ultimately lodging of the plant or whole clump. The isolated bacterium was proved to be rod-shaped, gram-negative forming creamish white colony on nutrient agar medium. The molecular analysis based on 16S rDNA and DNA gyrase gene gyrA nucleotide sequences was carried out, where the consensus sequences of different isolates deposited in NCBI GenBank conferred its nearness to *Klebsiella aerogenes*. The isolated *K. aerogenes* strains made close clusters with NCBI sequences viz., MZ577128.1, MT373521.1, MF682950.1, MT355368.1 etc. in phylogenetic analysis using maximum likelihood method. The DNA gyrase genomic sequence of isolated *K. aerogenes* also stayed its higher homology to NCBI recognised strains. The Koch's postulates were proved under controlled as well as field conditions, where reisolated bacterium exhibited same morphological and molecular characters. The incidence of this newly reported disease is increasing every year affecting the different genetic resources at farmers' field.

OP10(S3A): Application of recombinase polymerase amplification (RPA) for rapid and sensitive detection of Ustilaginoidea virens: Comparative evaluation with PCR, nested PCR and LAMP

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The ascomycetes member *Ustilaginoidea virens* (Cke.) Tak. is an important fungus that causes false smut of rice. Recently it has emerged as the most devastating grain disease in majority of the rice-growing areas of the world including India. The available methods for detecting *U. virens* are time consuming and require sophisticated laboratory set up and highly skilled personnel. Recombinase polymerase amplification (RPA) is a rapid, isothermal amplification method with high specificity and sensitivity. In this study, we have developed an RPA protocol for rapid and specific detection of *U. virens* directly from mycelial mat. Three oligonucleotide primer pairs were designed from the *U. virens* GTP binding protein beta subunit (UVGbeta-1) gene (GenBank Acc. # GU014921). RPA was performed with all the three primer pairs using the Twist Amp Basic Kit at an isothermal condition (37°C) for 30 min. The developed RPA assay efficiently detected *U. virens* even in crude sap extracted from fungal mycelia. The specificity of the RPA primers was evaluated using DNA from other rice pathogens, as well as, by sequencing the RPA amplicons. Further, the sensitivity of RPA assay was compared with the normal PCR, nested PCR and another isothermal technique called loop-mediated isothermal amplification (LAMP) assay. Other than RPA, rest of the methods failed to detect *U. virens* from crude sap. Therefore, the developed assay can be a potential PCR substitute for rapid and specific screening of *U. virens*, even at a very initial stage of fungal isolation in the laboratory condition.

OP11(S3A): Rapid on-site detection of piper yellow mottle virus infecting black pepper by recombinase polymerase amplification - lateral flow assay (RPA-LFA)

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Piper yellow mottle virus (PYMoV) is a pararetrovirus associated with stunted disease in black pepper. As the primary spread of the virus occurs through vegetative propagation, effective diagnostics are required for the production of virus-free plants. Currently available PCR-based assays require sophisticated equipment, are time-consuming, and are not suitable for on-site detection. In view of this, in the present study, a rapid assay based on the recombinase polymerase amplification (RPA) coupled with lateral flow assay (LFA) was developed for the specific, and sensitive detection of PYMoV. The assay was optimized for parameters like concentration of magnesium acetate, temperature, and time. The final developed RPA-LFA was performed using TwistAmp DNA amplification reagents, crude extract from the infected plant as a template, and PYMoV specific forward and reverse primers labeled with 6-carboxyfluorescein (FAM) and biotin respectively at the 5´ end. The reaction was incubated at 37 °C for 15 min. The RPA amplified product was then diluted and applied to the sample port of a lateral flow device for visualizing the results. The formation of a coloured line at the test line is considered positive for PYMoV. The entire process from sample preparation to visualization of results can be completed in less than 30 min. The developed RPA-LFA was specific and 10 times more sensitive than PCR. The assay was validated using field samples of different black pepper varieties and was found suitable for the on-site detection of PYMoV.

OP12(S3A): Development of machine learning laser bio-speckle method for early identification of seed infection of soybean anthracnose

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There is a need for developing rapid and non-destructive techniques for the early detection of the seed-borne fungal pathogens for effective management. Existing techniques for detecting seed-borne diseases have poor sensitivity towards early stages of pathogen development (i.e., when seeds are asymptomatic) and they are also expensive, time-consuming, complex, require mycological skills and destructive testing operations. Aiming at overcoming the above limitations of the existing techniques, a novel laser biospeckle based method is proposed for early detection of seed-borne fungal infection in conjunction with machine learning. Soybean seeds infected by low to high concentrations (102-106 spores ml”1) of *Colletotrichum truncatum* were analysed by using full field biospeckle analysis to establish the possible relationship between biological activity in early stages of pathogen infection, with and without the use of frequency filtering. The results demonstrate that the biospeckle activity (BA), for both, raw and frequency filtered data was significantly high ($p < 0.05$) for the diseased seeds even for low inoculum concentrations. Moreover, the amplitude values of mid frequency spectral components for diseased seeds were higher than those of lower and higher spectral components which correspond to the BA of fungal infected seeds. Several classical machine learning algorithms were trained to model the response of healthy and diseased samples after parameter optimization. Obtained results showed that k-nearest neighbour (k-NN), decision tree (DT), and artificial neural network (ANN) based predictive models presented strong robustness and high performance with overall accuracy reaching up to 96.94% for classifying diseased seeds.>

OP13(S3A): Identification and characterization of *Colletotrichum siamense* causing leaf spot of chrysanthemum in India

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Chrysanthemum (*Asteraceae*) is an important commercial flower next to rose in the international florists trade and grown throughout the world with great potential both as loose and cut flowers including India. The production of chrysanthemum flowers yield is threatened by many fungal pathogens among which leaf spot is one of the most destructive diseases, commonly prevailing in almost all chrysanthemum growing areas of India, which causes heavy losses under field as well as under market conditions. During 2020–2021, leaf spot disease (dark brown spots) was observed in ICAR-Directorate of Floricultural Research Farm, Pune, with disease incidence of 57% in Reagan Emperor variety of chrysanthemum. The aim of this study was to identify the causal agent, to test the pathogenicity, and to carry out the molecular characterization. To know the etiology, pure culturing of the fungus was done from symptomatic leaves of chrysanthemum on potato dextrose agar medium. Morphological and molecular characterization of the fungi was carried out. Based on morphological features of colonies and conidia, the fungus was identifed as *Colletotrichum siamense*. Morphological identifcation was supported by molecular analysis of internal transcribed spacer (ITS) region. BLASTn analysis revealed 100% homology to the *Colletotrichum siamense* isolate ALSKN-CG5 (GenBank (Accession No: MT450691). Pathogenicity test was also conducted in glass house. The reference sequence was submitted to GenBank (Accession No. MZ646053). A reference isolate of *Colletotrichum siamense* was deposited to National Fungal Culture Collection of India (NFCCI-a National Facility), ARI, Pune, with culture collection number NFCCI 4929. Several new major diseases of chrysanthemums have emerged that limit production and affect quality including bacterial infections, viral and viroid infections. Identification of the pathogen *Colletotrichum siamense* causing leaf spot disease of chrysanthemum is essential for the development of effective and economical management practices for the emerging floriculture industry and to address the quarantine requirements.

OP14(S3A): Molecular detection of Tomato leaf curl virus (ToLCV) and associated beta satellite

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Leaf curl virus infecting tomato plant belongs to Geminivirus. To confirm the presence of ToLCV in the infected plants, total genomic DNA was isolated from the both infected as well as healthy leaf samples. Isolated DNA samples were subjected to PCR using Gemini A146/Gemini A672, PAL1v1978B/PAR1c715H coat protein (CP) specific primers and Beta01/ Beta02 for detection of beta satellites which were designed during this study. PCR amplification of total genomic DNA generated an amplicon of 500bp with Gemini A146/Gemini A672 of DNA-A component (pre coat protein gene, partial coat protein gene) of begomoviruses. The primers PAL1v1978B/PAR1c715H amplified 1.5kb fragment of DNA-A component (partial replication associated protein gene, pre

coat protein gene, partial coat protein gene). On blast analysis it showed 87% identity with Tomato leaf curl Karnataka virus isolate TC146 segment DNA-A, complete sequence (KP178730.1). Detection of beta satellites was done by using primers Beta01/ Beta02 that amplified ~1.3 kb fragment of beta satellite DNA. On blast analysis it showed 89%% identity with Tomato leaf curl Gandhinagar betasatellite isolate pToGNbH14, complete sequence (KC952006.1).

3B. Resistant cultivar development

Keynote Lectures

KN01(3B): Discovery, characterisation and deployment of rust resistance in wheat

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Puccinia species, causal agents of wheat rust diseases, are among the top 10 highly studied fungal pathogens. While pathotypic evolution among wheat rust pathogenis thoroughly studied in several nations including India and Australia, the windborne intercontinental spread of these pathogens has been challenging. These challenges underpinned global cooperation. Sixty-three, 80 and 83 stem rust, leaf rust and stripe rust resistance genes have been formally named. A majority of these genes belong to the all-stage category (ASR) and a few fall under the adult plant resistance (APR) category. Some resistance genes do not fit into these categories and are referred to as mid-stage resistance (MSR). The MSR genes express at the 3rd to 4th leaf stages. The deployment of ASR genes singly succumbs to evolution in pathogen populations to acquire virulence, whereas APR genes do not provide commercially acceptable level of protection when deployed individually. Hence deployment of combinations of ASR and APR genes is desirable to equip plants against rust pathogens. Breeding for resistance has been the preferred way to control these widely adapted pathogens. Discovery of widely effective and genetically diverse sources of resistance is necessary. While scientists at the global level are actively involved in understanding genetics of rust resistance in modern germplasm, it is equally important to explore the value of pre-Green Revolution tall wheat genotypes to identify diverse sources of resistance. This presentation will cover our efforts to discover, characterise and deploy new sources of rust resistance from a collection of tall wheat genotypes collected by an English botanist Arthur Watkins in the beginning of the last century, cloning and editing of resistance genes.

KN02(3B): Breeding durable rust resistant wheat

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Developing and deploying of resistant varieties is an economic, eco-friendly and hassle free tool to keep diseases and pests below threshold level. However, resistance does not last long and frequently succumbs to the changes and shifts in pathogen and pest populations. The plant pathogens and pests are dynamic and keep on changing to counter the introgressed resistance. Host and pathogen evolve hand in hand and result in boom and bust cycle followed by susceptibility of a plant variety. Therefore, breeding for resistance has to be a continuous process. We often talk of resistance breeding against pathogens. In this context there are many intriguing questions. Do we have any systemic breeding for plant resistance- I would say very limited? Mostly, we do not breed for disease resistance. The fact remains that breeding population for yield or other traits is subjected to disease screening and if we are lucky- a disease resistant progeny is selected. Are we able to create sufficient disease pressures- needs introspection as in many instances the level of infection does not come up to the expectations? Consequently a claimed disease resistant variety becomes susceptible shortly- Lal Bahadur wheat variety is an example. This variety became susceptible to leaf rust immediately after its release. We are lucky in wheat rust research. Wheat-rust is a most widely studied and totally mathematical system which works on the Flor's gene for gene hypothesis. Resistance to rusts is a genetically inherited trait. The concept of rust resistance revolves around the vertical/major genic/ race-specific and horizontal/ minor genic/ non-race-specific natures. It is a misconception to call a gene strong or weak. No a gene is a gene and it can exhibit a major or minor effect. Vertical resistance generally remains effective throughout the life of a plant and is generally effective against few races of a pathogen. It succumbs to a new race of pathogen very fast. Horizontal resistance generally is not a hypersensitive type but shows chlorotic type of expression. In wheat rusts we group rust resistance into two categories. First group is seedling (all time) resistance and second type as adult plant resistance which can be race-specific and non-race-specific (in some cases may be slow rusting). Race-specific resistance is also of two type one is hypersensitive and the other is non hypersensitive. Exceptions are there when a vertical resistance gene to rust is effective against all the pathotypes of a pathogen and has remained durable for many years. Resistance of *Sr26* (Eagle) to wheat stem rust in Australia and that of *Yr16* (Capelle Desprez) to wheat stripe rust in Europe are some of the examples where vertical resistance genes have remained effective for a long period of time. Some of the genes though named as adult plant/ slow rusting like *Lr34* and *Yr11* etc. have been observed to confer seedling resistance also in some countries. It happens due to the different centers of evolution and lineages of wheat rusts. The wheat rust population of one country/continent may be different to that of other. The seedling resistance to rusts in wheat remains effective throughout the life of plant. In addition some lines susceptible at seedling may confer resistance at adult plant stage. Adult plant resistance to rusts becomes effective after third leaf stage of wheat plant and can be race-specific and non-race-specific. Both these types of resistances can be identified with the help of pathogens. Seedling resistance can be identified through screening a number of wheat lines using mutipathotype tests of a rust pathogen in greenhouse. Adult plant resistance can be identified in evaluation at flag leaf stage in polyhouses or under field conditions. The types of pathotypes for evaluation are decided based on the objectives. It can be race-specific which considers most virulent and predominant pathotypes or non-race-specific which uses a mixture of pathotypes of a rust pathogen. In field based screening for adult plant resistance we can categorize banking upon area under disease progress curve (AUDPC). While 1-10 AUDPC is vertical resistance; 11-100 is adult plant resistance. Slow rusting to rusts occurs in wheat varieties where terminal disease severity is low and AUDPC value ranges between 101- 200. In these varieties rust develops slowly, plant may look susceptible; however, the yield losses are insignificant statistically. For the host resistance to be durable, diversity for resistance is the key. Moreover a systemic approach targeted to resistance breeding with a rigorous screening/selection under artificial epiphytotic using all the virulent races as well as natural screening under hot spot situations are the underlying principles. Deployment of diverse wheat varieties having a blend of seedling (all time), Adult plant resistance (hypersensitive and non hypersensitive types) and slow rusting resistance can lead towards durability of resistance. Durable rust resistant wheat varieties can keep the rusts under threshold level, help in avoiding frequent varietal break down and curtail the evolution of new races.

KN03(3B): Identification of resistance and development of hybrids/genotypes resistance to Viruses infecting Chilli and Tomato

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Among the biotic stresses, Begomoviruses, Cucumoviruses, Potyviruses and Tospoviruses have become serious production constraints causing considerable yield loss in the major chilli and tomato growing areas of the country. There are very few efficient control measures for viral diseases, but the use of genetic resistance appears to be the most promising strategy, often conferring effective protection without additional costs or labor and without damaging the environment. Sources of virus resistance have been identified for Begomoviruses, Cucumber mosaic virus, Chilli veinal mottle virus and Groundnut bud necrosis virus in the germplasm of Chilli and Tomato. Using the identified virus resistance in chilli and tomato, hybrids were developed with promising horticultural characters, high yielding with virus resistance and are currently cultivated in different vegetable growing areas. The successful deployment of a novel resistance gene into a crop depends more upon the identification of a positive phenotype, dissection of the phenotype leading to the identification of genetic markers for marker-assisted selective breeding (MAS) and an understanding of how the novel resistance will behave in different genetic backgrounds and under virus pressure in the field will be discussed

Invited Lectures

IL01(3B): Research progress in Sclerotinia rot management of Indian mustard (*Brassica juncea* L.)

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Sclerotinia sclerotiorum is a fungal plant pathogen affecting numerous crop species worldwide including all Brassica oilseed species grown in India. Infection occurs during flowering when airborne ascospores colonize fallen petals adhering to stems and leaves. Infection of the main stem results in most yield loss which can reach 80%. Disease management of the disease by crop rotation has limited success due to the pathogen's wide host range and long-term survival of resting bodies (sclerotia) in the soil. It depends heavily on the application of fungicides, but this may cause environmental contamination, increase farming costs, and maybe ineffective because of the difficulties associated with the application of fungicides sprays to thick canopies. A large number of Brassica germplasm were screened with artificial stem inoculation technique and based on three years observations, RH 1222-28, EC 597328, EC 766553, EC 766620, EC 765048, IC 492687, IC 492690, IC 492695, and IC 511651 were found tolerant to Sclerotinia rot in Indian mustard. The most susceptible genotypes developed large lesions (>50 cm) resulting in plant death. In contrast, the nine *B. juncea* lines did not develop lesions, two of these lines were crossed with high-yielding *B. juncea* varieties. F2 plants in RH1222-28 x RH406 and EC597328 x RH749 showed a high level of tolerance to *S. sclerotiorum* showing that stem resistance is heritable and likely dominant. We are in the process of mapping quantitative trait loci (QTL) conferring resistance to Sclerotinia using populations of recombinant inbred lines (RIL) derived from the crosses. Molecular markers around the QTLs will facilitate the development of Sclerotinia resistant *B. juncea* varieties.

IL02(3B): Taking resistance to farmers field: development and deployment

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Wheat rusts (stem rust, stripe rust and leaf rust), caused by the fungal pathogen *Puccinia* spp., are the most devastating diseases of wheat and can cause serious yield losses if not checked at proper time and space. Among these three rusts, the leaf and stripe rust are of major concern in the North Western Plain Zone of India and are making their appearance every year initially in the sub-mountainous areas and then spread further. Continuous and vigorous monitoring starting from December to locate the onset of infection at farmer field level through extensive surveys then destruction of these initial foci by application of fungicides is the only way out to prevent the spread of the disease to other areas. So here the role of cultivation of resistant varieties becomes important. A large number of rust resistance genes along with tagged markers are available; however most of them are not effective in the region. Secondly, the several rust resistant genes got defeated due to evolution of new virulence(s) of the pathogenic fungus in the region over past few decades (*Yr9*, *Yr27*, and *Yr17*). This calls for regular efforts on gene scouting, mapping and tagging to combat these diseases. At PAU, constant efforts are underway to discover new sources, develop mapping populations from these and undertaking mapping studies. Several genes have been discovers and mapped at PAU (*Yr40*, *Yr70*, *Lr58*, *Lr57*, *Lr76*) and several other such studies are underway. In addition to new sources, utilization of available known genes like *Yr5*, *Yr10*, *Yr15*, *Yr36*, *Yr40*,*Yr70*, *Yr17* have also been done at commercial scale with various varieties carrying known gene been released at National Level. These include, the first variety developed using MABB Unnat PBW343 (PBW723), followed by Unnat PBW550, PBW752, PBW757, PBW803, PBW1chapati and PBW771. Over a decade, PAU has tested more than 100 lines in coordinated breeding programme. Apart from commercially deployed ones, we maintain a nursery of around 130 ABLs having known genes across different elite genotypes, and genetic stock PBW703 carrying four genes as well. Host is one aspect in resistance the other important aspect is the pathogen. Tracking the pathogen through evolutionary studies plays important role in gene deployment. So a comprehensive field pathogenomics programme has been initiated at PAU, covering all aspects of disease triangle.

IL03(3B): Identification of resistance sources of castor against Fusarium wilt disease

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Castor is one of the important oilseed crops and its cultivation is seriously affected by major diseases of gray mold, wilt, and root rot. Wilt disease caused by Fusarium oxysporum f. sp. ricini is one of the most important diseases of castor and occurs in all castor growing areas in India. The extent of yield losses ranged from 40 to 77%, depending on the stage at which the crop infects with wilt. Breeding of resistant castor cultivars is the most promising option for wilt management and for the development of a wilt-resistant castor hybrid, both the parents should be resistant to wilt. A systematic program on the development of wilt-resistant parents was strengthened with the standard screening procedures and identification of wilt-resistant sources. During 2013-14 to 2018-19, different castor genotypes were screened against wilt disease under wilt sick plot conditions which are being maintained by the uniform inoculum load (2x103 cfu /gm of soil) and confirmed by 100% mortality of JI-35 a highly susceptible check after every 5 test entries along with resistant (48-1) genotype. The germination and wilt incidence (%) was recorded at monthly intervals up to 150 days after sowing. Nearly 574 genotypes were susceptible to wilt with more than 20% incidence, while genotypes DCS-86, DCS-118, DCS-108, DCS-105, DCS-107, DPC-21, M-574, DPC-23, DPC-24, PMC-9, PMC-11, PMC-14, PMC-15, PMC-16, PMC-17, PMC-24, PMC-38, PMC-55, PMC-60, PVT-11-3, PVT-11-18, PVT-11-17, PVT-11-21 and PVT-11-26 showed resistant reaction (<20% incidence) for two years under sick plot conditions. These can be utilized as resistance sources of the wilt disease in breeding resistant castor cultivars.

Oral Presentations

OP01(3B): Molecular characterization of '*Candidatus* phytoplasma asteris' related strain associated with fenugreek little leaf and witches' broom and screening of fenugreek germplasm for disease resistance

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Little leaf and witches' broom symptoms of 1 to 21 percent were recorded in fenugreek (*Trigonella foenum-graecum*) germplasm accessions at ICAR-NBPGR Regional Station, Jodhpur. Out of 170 accessions sown, phytoplasma suspected symptoms were noticed in 146 accessions under natural field condition. The detection of phytoplasma association was confirmed by nested PCR amplification of 16S rRNA gene specific primers (P1/P7 and R16F2n/R2) and *sec* A gene primer pairs (*secA* for-1/ *secA* for-3). 16S rRNA and SecA gene sequence comparison of fenugreek phytoplasma isolates confirmed the association of '*Candidatus* phytoplasma asteris' related strain (16Sr I-B) sub group. Out of different leaf hoppers trapped in fenugreek fields, only *Empoasca* and *Orosius albinctus* species detected positive with '*Ca*. P. asteris' related strain by utilizing similar set 16S rRNA gene specific primers. Twenty-four fenugreek accessions did not show any symptoms in any replication in fields and tested negative with 16S rRNA and *sec* A gene specific primers and therefore suggested resistant to phytoplasmas. These resistant germplasm identified in the present study can be utilized as pre-breeding materials to breed and develop fenugreek resistance to phytoplasma disease.

OP02(3B): Genome-wide association study for resistance to rice blast in India

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Rice blast is one of the most destructive and costly disease of rice causing serious yield losses under conducive conditions. In developing countries, the best way to manage blast disease is the use of resistant cultivars as resource poor farmers cannot afford costly chemical fungicides. However, blast fungus overcomes resistance, so identification of novel broad spectrum resistance genes is essential. In this study, a panel of 81 National Rice Research Institute released varieties (NRVs) spread over eight ecologies were screened against leaf blast resistance at NRRI, Cuttack for two consecutive years. Based on cluster and structure analysis, 81 NRVs were categorized into three groups. The NRVs showed 96% variation among individuals and 4% variation among population. The scatter plots, through principal coordinate analysis, partitioned the resistant and susceptible NRVs into different groups. The genome wide association studies (GWAS) was performed using 135 SSR markers to swiftly identify the blast R gene/QTLs conferring resistance to the rice blast. The GWAS identified 15 genomic regions significantly associated with the leaf blast disease resistance. This study would help in identification of the potential function, and validation of the candidate R genes/QTLs. The associated genes could be used in developing blast resistant cultivar through marker-assisted selection.

OP03(3B): Identification of resistant sources in root & stem rot (*Macrophomina phaseolina*)

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Sesame (*Sesamum indicum* L.) is an ancient oilseed crops cultivated in semi-arid Tropics and sub tropics regions in India. It play an important role in the oilseed economy throughout the world. The fungal disease root and stem rot caused by *M. phaseolina* (Tassi) Goid is the most important disease and is widely, distributed in sesame growing region. The pathogen attacks plant at all growth stages. Due to soil borne nature practically no effective field control and no source of resistant is available. Twenty one genotypes were sown on kharif 2020 &2021 along with local check VRI-1 in a Randomized block design in two rows of 3 m length and replicated thrice so as to screen for root and stem rot disease under sick plot and same genotypes were sown in pot house under artificial inoculum. The genotypes DS-61, DS-62, DSM-3-1, DSM-17-1-1, DSS-9, VS-16009, VS 19023 recorded the root and stem rot incidence less than 10% and the maximum root and stem rot incidence were recorded by SKT-1501 and CUMS-17 (45%).

OP04(3B): Disease Resistance in Crops: 21st century Prospects

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The yield stability through the development of disease resistant crops in the 21st century is one of the great challenges. The twentieth century has been productive for plant pathology and the field of host-parasitic interactions with developing plant defense against pathogens. Earlier twentieth century, plant pathology adopted a philosophy that encouraged basic scientific investigation of pathogens and disease defense. That philosophy led to the strategy of developing disease-resistant plants as a prima facie disease-control measure and avoided the use of pesticides. Plant pathology rapidly adopted molecular and its spin-off technologies. The efficient technologies for producing transgenic plants convey optimism controlled of plant diseases in the 21st century. Plants are exposed to a wide-range of pathogens. An average of 26% of the crop production is lost each year due to pathogens. In the absence of genetic resistance in crops, food production depends on chemical control. Despite their effectiveness, copper based chemicals have harmful environmental consequences. Hence, we need to engineer long-lasting and broad-spectrum disease resistance in crops. One of the major goals of plant research in the 21st century is to increase our understanding of the plant immune system and how this is manipulated by pathogens, in order to engineer transgenic crops with durable resistance and increased yields. Now we have reached the stage where it is possible to propose holistic ways to alter crop genetics with the aim of engineering low cost durable resistance mechanisms in crop plants.

OP05(3B): Screening for resistance to bacterial wilt (*Ralstonia solanacearum*) in eggplant and its wild relatives

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Bacterial wilt in eggplant caused by *Ralstonia solanacearum* race 1 is a lethal disease in India at high rainfall coastal areas of Goa, Karnataka, Kerala, Tamil Ndu, Andhra Pradesh, Orissa, and West Bengal states. The pathogen is difficult to control because it is soilborne and has a wide host range. Nevertheless, identification of new sources of resistance for the incorporation of multiple and complementary resistance genes in the same cultivar is the best strategy for durable and stable resistance. In the present study, a total of 148 accessions belongs to *Solanum melongena*, *S. torvum*, *S. incanum*, *S. melongena* var. *insanum, S. violaceum*, *S. sisymbriifolium, S. viarum, S. surattense, S. trilobatum* and *S. aethiopicum* were screened under artificial inoculation technique (root injury method). Lateral roots of 30-day-old seedlings in the field were trimmed and soil drenched with 10 ml of culture suspension (7 × 108 CFU/ml). Symptoms of either partial wilt or whole plant wilt started to appear on eggplants, a week after inoculation and continued during the peak flowering period and prior to harvest. Infected plants dried either partially or completely within 3 to 4 days after the first visible symptom was observed. Disease severity was evaluated once a week using wilting percentage and percent disease index. Out of 148 accessions screened against *R. solanacearum*, 14 accessions were not shown any visible symptoms of partial or whole plant wilting and 29 accessions completely succumbed to *R. solanacearum*. Most of the resistant accessions found in the present study were belonging to *S. melongena* (IC255756, IC256708, IC636521, IC624237, IC53224, IC383695, IC421190, Arka Kesav) and its landraces (IC636524, IC641518, *Vengeri* brinjal), and a few were belonging to *S. aethiopicum* (IC641515, IC618025) and *S. incanum* (IC599705). Accessions belonging to *S. melongena* and landraces were readily crossable with popular cultivars, whereas, taxonomically closely related resistant accessions of *S. aethiopicum* may be used as rootstock for grafting on eggplant cultivars.

OP06(3B): Potential of teosinte derived introgression lines as novel genetic resources to develop resistance for banded leaf and sheath blight resistance in maize

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The study reports the generation of stable introgesion lines (at BC3F3 stage) derived from Teosinte (*Zea. mays* ssp. *parviglumis)* and their resistance reaction to banded leaf and sheath blight (BLSB) through well standardised artificial screening technique under field conditions. The cultivated maize harbours genetic diversity but single domestication has led to reduction in genetic diversity. BLSB is an emerging and highly destructive maize disease, causing significant yield loss in *kharif* maize. Its wide host range, hard survival structures and non availability of resistant donors further aggravates this disease. At Punjab Agricultural University, Ludhiana, we have developed stable introgression lines of background of three high combining parents viz., LM 13, LM 14 and LM 21 using wild progenitor *Zea. mays* ssp. *parviglumis* following three backcrosses and selfed to obtain BC3F3 generation from 2018 to 2021 using two crop seasons in a year. The selfed seeds of each line were sown in pathology fields in *kharif* 2021 and the lines were screened against BLSB under artificial conditions. We identified stable introgression lines in three maize backgrounds which exhibited moderately resistant reaction (disease score 5 in 1-9 scale) to BLSB. The study reported generation of novel genetic resources to develop resistance against BLSB, a devastating disease of maize.

OP07(3B): Progress and prospects in tapping host resistance to manage taro leaf blight incidence in India

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Taro leaf blight (TLB) caused by *Phytophthora colocasiae* Racib. has become a major concern in all taro growing countries including India causing yield loss of 25-50%. The warm, humid days and cool, wet nights of the tropics are ideal for reproduction and spread of *P. colocasiae*. Cultivation of resistant varieties is the most practical and environment-friendly one to combat the pathogen (Nath et al. 2014). Even though, many accessions were found to have resistance during screening, only few have come to the status of a variety. Three TLB resistant varieties viz., Muktakeshi, Bhu Kripa & Bhu Sree were released from ICAR- CTCRI. Field screening, *in* *vitro* screening using zoospore suspension or elicitors, biochemical and molecular markers are the methods being used in India to locate host resistance against *P. colocasiae*. More than 350 taro accessions collected from different parts of the country and maintained ICAR - CTCRI were screened during last two decades by adopting various methods viz., detached leaf assay, floating leaf disc assay, using elicitors, biochemical and molecular markers, challenge inoculation of plants in controlled condition and field screening. The accessions which showed field tolerance were challenge inoculated with the pathogen in controlled condition (117 nos). The accessions were shortlisted every year based on the disease incidence and ten accessions viz., C-618, C-717, E-10, C-388, C-370, C-690, C-679, C-84, C-203 and U-8 showed consistent resistant reaction for the last 5 years. These accessions are being evaluated for their agronomic traits.

OP08(3B): Development of blast resistance restorers by introgression of broad spectrum resistance genes Pi54 & Pi2 by marker assisted selection in rice

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To improve the blast resistance of RP 5933-1-19-2 R a high yielding restorer, crosses were made for introgressing two major blast resistant genes viz., *Pi54* and *Pi9* from the donors Tetep and *O. minuta,* respectively*.* The donors Tetep (*Pi54*) and *O. minuta* (*Pi9*) were crossed to the R line separately and the resulting F1s from the two crosses were confirmed for their hybridity by using *Pi54*MAS and NMIMSPi9-1 gene specific markers. Confirmed F1s were intercrossed to obtain ICF1s. All the ICF1s were screened for the presence of *Pi54* + *Pi9* gene combination and the selected double gene positive plants were then backcrossed to restorer line to produce BC1F1 generation and were also selfed to raise ICF2 population. Both BC1F1 and ICF2 populations were subjected to foreground selection followed by phenotypic screening for blast resistance at UBN using standard 0-9 scale. Double positive BC1F1 plants were selected for background analysis using 76 polymorphic markers which were spread uniformly across the 12 rice chromosomes. The BC1F1 and ICF2 plants identified with both the resistance genes (*Pi54* + *Pi9*) and were advanced based on evaluation for various agro-morphological traits. The superior selected BC1F3 and ICF4 lines along with parents were evaluated for yield and yield contributing traits and genotyped with 1K RiCA mid density SNP genotyping panel consists of roughly 800 genome-wide markers, 22 quality-control markers and up to 200 trait markers distinguishing 87 high-value genes and QTLs. These blast resistance restorers would serve as potential restorers for developing blast resistance three line rice hybrids with higher heterosis.

OP09(3B): Investigations on race prevalence of *Xanthomonas citri* pv. *malvacearum* causing bacterial blight in upland cotton and development of resistant varieties through marker assisted selection

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Bacterial leaf blight (BLB) is a common disease of cotton in almost all the cotton growing countries of the world, including India incited by *Xanthomonas citri* pv. *malvacearum* (*Xcm*). Recently, the application of antibiotics for bacterial diseases management has been restricted in India, therefore the use of resistant cultivars is the most effective long-term strategy to manage this devastating disease. The procedure starts with development of resistant varieties by identification of resistant germplasm, which was identified phenotypically by artificial inoculation of *Xcm* cultures and by use of molecular markers (CIR-246) linked to genes that confer resistance. In India, B12 gene is known to confer a high level of resistance to all reported races of *Xanthomonas citri* pv. *malvacearum*. Presently, the prevalence of race 18 in Central India has alarmed the cotton growers by the aggressive nature of *Xcm* strains. The reaction of *Xcm* cultures on the host differentials became comprehensible and identified *Xcm* isolates to be race 18, currently being the most prevalent race in India. The BLB resistant germplasm CSH-3047 (a), GTHH-032 (b) and CSH-3313 (c) parents were crossed with elite susceptible parents *G. hirsutum* cv. Suraj. Genomic DNA was isolated from backcrossed plants and screened using phenotypes, SSR marker CIR-246 (146 bp amplicon) and artificial inoculation of pure *Xcm* isolates. Marker CIR-246 was found as a useful genetic marker with clear banding pattern in back crosses as well as parental lines. The back crosses were performed with elite parent Suraj to generate BC4 and BC5 BLB resistant population.

OL10(3B): Profiling of core bacterial community in rhizosphere of drought tolerant Dagaddeshi and drought susceptible MTU1010 rice varieties

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Microorganisms are the invisible colonizers of almost every substrate such as soil as well as every type of multicellular organism including plants, animals and humans on the planet. These “microbiomes” are the mysterious associations having reflective impacts on plant health and performance. Microbiome-encoded functions can manipulate plant performance under different biological and environmental conditions. Rice root associated microbiome showed the greatest diversity of bacterial species. Bacterial communities assembled in rhizosphere of Dagaddeshi and MTU1010 was profiled using high-throughput 16S metagenomics sequencing and the diversity was surveyed in two water regimes (irrigated and drought). Drought-induced changes in abundance, diversity and composition of bacterial community in the soil immediately surrounding the root i.e. rhizosphere was traced at the phylum, class, order, family, genus and species rank. There was significant alteration in the profiling of bacterial community among the two genotypes and diversity was observed with drought.

3C. Success stories in plant diseases management

Keynote Lectures

KN01(3C): Successes and Failures in Using Cover Crops for Nematode Management

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The loss or restriction of use of nematicides has stimulated an interest in the use of cover crops for managing plant parasitic nematodes.The formal definition of a cover crop is a crop planted to cover the soil rather than for the purpose of being harvested. Cover crops can be planted to help manage soil erosion, fertility, and water as well as weeds, pests, diseases and biodiversity. When discussing the use of cover crops with growers, one is likely to hear a more practical definition that a cover crop is a crop a grower would not normally plant, and is too expensive to use, even if it does control nematodes. Successful as well as unsuccessful field trials in combination with the use of molecular identification, degree day calculations, online databases, and improved understanding of nematode biology and population dynamics have made it possible to fine tune the successful use of cover crops to manage plant parasitic nematodes in annual cropping systems at costs similar to the use of nematicides.

KN02(3C): Study on Anthracnose disease on dragom fruit in the South Vietnam and brief study on its integrated management

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Dragon fruit (DF) (*Hylocereus undatus*) (Pitaya or Pitahaya) has been widely grown in Vietnam, especially in three provinces named TienGiang, LongAn, BinhThuan. Along with increasing planting area and production, the anthracnose disease (*Colletotrichum* spp.) became more dominant and seriuos problem recently with symptoms on the cladoes, shoot and fruit. The experiments had been carried out at both in the laboratory and under field conditions to identify the causal agent, suitable conditions for the disease development and study on some safe, effective control measures against it on DF. The results showed that: (i) Collected and isolated 44 strains of *Colletotrichum* spp. on DF, through morphology combining molecular biological techniques, gene sequencing, comparison and analysis, they have been confirmed strains belonging to *Colletotrichum gloeosporioides* and *Colletotrichum truncatum* species. (ii) The fungus *C. gloeosporioides* and *C. truncatum* both cause diseases on white, red and pink purple flesh DF varieties, in which *C. truncatum* caused the heaviest damage especially on red flesh variety. The results showed that eight collected strains of Colletotrichum fungus from rain drops, ditch water, plant residues and surface soil in DF orchards at three above provinces and these strains all caused anthracnose disease on DF through Koch"s postulation. It arised and caused the most damage in the month of high rainfall and humidity of the year. (iii) Chemical and biological

active ingredients such as Azoxystrobin plus Difenoconazole, Propiconazole plus Difenoconazole, Difenoconazole and Polyoxin complex were effectively inhibit the growth of the fungus *C. gloeosporioides* and *C. truncatum* with an efficacy from 72 to 93.75%. The *Impatiens balsamina* extract at a concentration of 2% had an inhibitory effect on the fungus causing anthracnose on DF from 56 to 93.7%. Selection of *Bacillus* strains had antagonistic efficiency from 62 to 68% and Actinomycete strains had antagonistic efficiency from 50 to 71.3% against the causal agent on DF under laboratory conditions. In field conditions with high disease pressure (disease rate over 20%) using active ingredients Difenoconazole, Azoxystrobin plussed Difenoconazole, Propiconazole plussed Difenoconazole, the *Impatiens balsamina* extract for high efficiency, inhibiting the growth of wound diameter and disease serverity of anthracnose. In addition, for low disease pressure (disease rate less than 20%) in the garden, using biologically active ingredients *Streptomyces lydicus* and Polyoxin complex, actinomycetes (TG17) and bacteria (VL–N–BS 2) were effective in preventing disease. On a small scale model, applied integrated management solutions such as pruning to remove pathogens from the garden and combined spraying with active ingredients Propiconazole plus Difenoconazole, the *Impatiens balsamina* extract, *Streptomyces lydicus*, Polyoxin complex, actinomycete (TG17)) and bacteria (VL–N–BS 2) reduced disease pressure, reduced the number of sprays and increased profits as compared to farmers' practices.

KN03(3C): Halolerant PGPR and enriched ameliorant for managing salinity stress and improving the health of soil-plant rhizomicrobiome and resilience rice productivity on coastal flood-PRONE area in Indonesia

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Halotolerant Plant growth-promoting rhizobacteria(H-PGPR) and ameliorant are play important role in improving the nutrient status and uptake, rhizomicrobiome-plant health, soils health and crop productivity. Researches were conducted intensively to obtain the H-PGPR isolates as bioagent combined with enriched ameliorant (EA) to alleviate the salinity stress. Composite soils samples were taken from different saline ecosystem to obtain the superior of H-PGPR and formulated as inoculant of halotolerant bioagent. Bioassay and biochemical test were used to obtain the promising halotolerant PGPR isolates that produce relatively high of gibberellic acid, IAA, organic acids, nitrogenase, phosphatase and increase the rice growth significantly. H-PGPR were characterized and identified as Azotobacter sp*,* Azospirillum sp*, Acinetobacter sp, Bacillus sp, Pseudomonas stutzeri,* and *Klebsiella pneumoniae.* The formulated halotolerant PGPR bioagent and EA combined with salt tolerant rice variety were able to improve the biodiversity of beneficial microbes, the growth and yield of rice significantly. These results suggest that application of 1000-1500 g ha-1 of HT PGPR inoculant and 2–3-ton ha-1 of EA combined with halotolerant rice varieties are the promising adaptation strategy to increase the rice farming resilience and productivity in coastal areas prone to flood.

Invited Lectures

IL01(3C): Endophytes and biocontrol based green nanoparticles in integrated management of soybean diseases and productivity enhancement in India

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Endophytes and green nano particles have emerged as a new innovative and sustainable approach to manage the diseases, abiotic stresses and to promote plant growth. The benefits of native endophytes have been recognized over the past ten years from around the world and many interesting research have been undertaken. In India, though there is research on fungal endophytes, the potentiality of endophytes in suppressing soil borne pathogens remained as untapped resources. Hence, with a view of exploiting the native endophytes and their role in suppression of soil borne pathogens of soybean, the present investigation was undertaken. Thirty fungal endophytes were isolated from major soybean growing areas of northern Karnataka and Maharashtra. Out of which eight effective fungal endophytes were obtained by in vitro screening against major soil-borne pathogens viz., *Sclerotium rolfsii*, *Rhizoctonia bataticola* and *Fusarium oxysporum*. The fungal endophytes RF-BV-3 (46.46%), SF-DM-8 (49.15%) were effective against *S. rolfsii,* and the isolate SF-DM-8 (49.32%) was effective against *R. bataticola*. The effective fungal endophytes against *F. oxysporum* were RF-BV-3 (66.61%), SF-BV-3 (59.66%), SF-DM-8 (69.21%), SF-DS-10 (56.49%), LF-HH-5 (66.31%), LF-DM-10 (59.78%), LF-DD-13 (61.15%) and LF-KK-14 (59.78%). Based molecular methods, the effective fungal endophytes were identified as *Daldinia eschscholtzi* (RF-BV-3), *Fusarium solani* (SF-BV-3 & LF-KK-14), *Neofusicoccum parvum* (SF-DM-8), *Diaporthe phaseolorum* (SF-DS-10 & LF-HH-5), *Phomopsis* sp. (LF-DM-10) and *Colletotrichum aenigma* (LF-DD-13). The antagonistic effect of 30 bacterial endophytes of soybean collected from northern Karnataka and parts of Maharashtra against *Sclerotium rolfsii, Rhizoctonia bataticola* and *Fusarium oxysprum* were assayed *in vitro* through dual culture plate technique. The bacterial endophytes RB-KK-6 (40.78 %), SB-BS-6 (50.08 %) and LB-BU-1 (47.02 %) were found effective against *S. rolfsii* and the isolates SB-DG-11 (47.41 %), LB-BiN-8 (41.22 %) were effective against *R. bataticola.* The effective bacterial endophytes against *F. oxysporum* were RB-HS-1 (41.99 %), SB-BiJ-9 (40.07 %), LB-BU-1 (54.20 %) and LB-BV-2 (51.64 %). Based on molecular characterization the effective bacterial endophytes were identified as *Acinetobacter* sp. (RB-HS-1), *Alcaligenes faecalis* (RB-KK-6), *Stenotrophomonas* sp. (SB-BiJ-9), *Bacillus pumilus* (SB- DG-11 & LB-BiN-8), *Paenalcaligenes* sp. (LB-BU-1), *Bacillus cereus* (SB-BS-6) and *Brevibacillus* sp. (LB-BV-2). Among all the endophytes evaluated to assess their antagonistic potentiality and understanding of mechanism of disease suppression, the best inhibition was noticed in *Neofusicoccum parvum* against all the tested pathogens ranging from 69.41 to 82.35 per cent by production of volatile compounds. *Neofusicoccum parvum* and *Daldinia eschscholzii* showed positive results for siderophore production and zinc solubilisation. *Neofusicoccum parvum, Daldinia eschscholzii* and *Colletotrichum aenigma* showed positive results for HCN production test. For chitinase test only *Neofusicoccum parvum* was found to be positive.

Neofusicoccum parvum and *Colletotrichum aenigma* were recorded positive for phosphate solubilization. The study was conducted to assess the effectiveness of four green synthesized nano formulations viz., chitosan-based zinc nano formulation (ChZnNF), *Pseudomonas fluorescens* based zinc nano formulation (PfZnNF), pomegranate aril-based sulphur nano formulation (PASNF) and pomegranate aril-based silver nano formulation (PAAgNF) at different concentrations under in vitro and glasshouse conditions. Entophytes and green synthesized PAAgNF can be explored as a novel technology in managing soybean diseases and productivity enhancement of soybean in India.

IL02(3C): Bio-intensive disease management in grapes

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Viticulture is not mere farming but regarded as a farming enterprise all over the world. In India, grape is a high value crop and a major export commodity. It is mainly cultivated in peninsular states viz. Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu but now the area under this crop is steadily expanding in other states also. Commercial grape cultivation is concentrated in the state of Maharashtra which accounts for more than 75% of grape area and 80% of the total production. The warm, humid and intermittently wet or cloudy weather in this region is highly conducive for disease attack which limits the economical and quality production of grapes. To overcome this, growers employ frequent preventative and curative applications of pesticides in vineyards. It is estimated that 30% of the recurring cost of grape cultivation is due to plant protection measures. The high pesticide use, 30-40 fungicides applications in a year and detection of their residues at harvest were causing huge economic losses to the grape farmers. Excessive applications of fungicides are responsible for residue detections in export consignments. Considering the significance of food safety in grapes, strengthening of the bio-intensive strategies for disease management plays prime role in production of pesticide residue free grapes. The work on developing a sustainable and effective bio-intensive disease management strategy was initiated at ICAR-NRCG in the last decade. After working on the many existing knowledge gaps it was realized that only biocontrol methods may not be effective and few fungicide applications will be necessary at high-risk periods during critical growth stages. Hence bio-intensive disease management is the best alternative strategy than chemical and biological management. Employment of efficient micro-organisms along with limited sprays of fungicides in a bio-intensive programme would reduce the total dependency on fungicides. The strategy is focusing on reduction of over-summering inoculum, increasing plant resistance to pathogens, use of insensitive biocontrol agents for suppressing spread of disease and use of bio-agents for enhancing the degradation of pesticide residue on berries. Through systematic screening and field evaluation of thirty three *Trichoderma* isolates, *T. asperelloides* and *T. afrohurzianum* were found superior bio-control strains for disease control. In case of bacterial biocontrol agents, *Bacillus subtilis* was found effective in disease control and enhancing degradation of pesticides. Successful implementation of this strategy was carried out on farmers' field at different locations in major grape growing regions. By considering these results and to check the acceptability of these technique, the effective strain of *Trichoderma asperelloides* 5R was mass multiplied and simple formulation of this strain was sold to growers on 'No Profit No Loss' basis and the registration process of the same is initiated.

IL03(3C): A technique to create ultra-low volume micro titer wells on regular slides as a substitute for cavity slides

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Cavity slides have been employed in fungal spore germination tests in studies evaluating infective morphogenetic pathways (wild type and mutants), efficacy of fungicides and botanical compounds or antifungal fractionates derived from TLC against the stages of infective morphogenetic pathway, assays on biocontrol agents and others. A commonly encountered problem in using concave cavity slides is the difficulty of focusing on the spores or other fungal structures during microscopic examination. We developed an ultra-low cost technique in which an ultra-low volume micro titer wells on regular glass slides that serves as an excellent substitute for cavity slides. This technique requires very small quantities of test samples, eliminates the difficulty of focusing in concave surfaces during microscopic examination, and improves clarity of the subjects examined under a microscope.

IL04(3C): Prevalence of root knot nematode in the nursery of rice in western U.P.

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Root knot nematode (*Meloidogyne graminicola*) is considered as a major soil borne pathogen of basmati rice. The main characteristic symptoms produced by *M. graminicola* are terminal hook shaped or spiral galls on the roots and other symptoms of damage include patches of stunted and yellowish plants. A survey was conducted during 2019 in different blocks of Meerut district to find out the prevalence and disease incidence of root knot nematode in rice field at nursery stage. During survey total 55 villages of 11 blocks was surveyed of Meerut district. In this survey it was observed that root knot disease of rice nursery has been prevalent in all surveyed blocks of Meerut district of western Uttar Pradesh. Maximum 70.83 % prevalence and 58.33% incidence of root knot nematode was observed in Daurla block followed by 66.66% prevalence and 24.44 % incidence in Meerut block. Minimum 5.26 % prevalence and 2.10% incidence of root knot nematode disease was recorded in Kharkhoda block. Overall average 43.39 % prevalence and 23.80 % disease incidence was recorded in Meerut district. Varieties wise prevalence of rice root knot nematode was also recorded. Maximum prevalence of root knot nematode was recorded in PS-5 (53.84 %) followed by PB-1121 (44.23%). Minimum 28.57% prevalence of rice root was recorded in PB-1.

IL05(3C): Success Story of Management of Sclerotinia Rot of Rapeseed-Mustard

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Sclerotinia rot {*Sclerotinia sclerotiorum* (Lib.) de Bary} has become a significant agricultural problem of rapeseed-mustard crop production, which results in 40 % loss in yield. It is a seed and soil borne pathogen with wide host range, and is difficult to manage. Multilocational validation of integrated management (IM) practices for *Sclerotinia* rot of mustard was conducted by ICAR-NCIPM, New Delhi during 2008-11 in farmers' participatory mode in Alwar, Sriganganagar zone of Rajasthan and South-west zone of Haryana on 18 ha. In 2009-10, *Sclerotinia* rot of mustard emerged as a major constraint in mustard cultivation in Haryana and Rajasthan and severe disease incidence (up to 70%) and heavy yield losses (~ 40%) was recorded. Implementation of IP practices of *Sclerotinia* rot started in Haryana and Rajasthan on wider area (60 ha) during 2011-12. In 2011, Mustard growing farmers of Siyali Khurd village (District Alwar of Rajasthan) approached NCIPM, New Delhi due to severe incidence of *Sclerotinia* rot. Prior to implementation of IM practices, farmers were taking monoculture of mustard (without crop rotation and deep summer ploughing) and no seed treatment with *Trichoderma* spp. Integrated management interventions including cultural practices as well as bio-pesticide *Trichoderma* spp. and garlic clove extract were recommended at different growth stages of crop. In addition to this, recommended dose of fertilizer along with gypsum @ 250 kg/ha and Potash @ 40 kg/ha, soil incorporation of *Trichoderma* @ 2.5 kg/ha pre-incubated in 50 kg well rotten FYM were introduced. The endemic *Sclerotinia* rot in Siyali Khurd farmers' field was managed by implementing IM practices. It resulted in significant reduction in severity of *Sclerotinia* rot and increase in yield as well as benefit-cost ratio. Increased cost-benefit ratio resulted in better monetary returns to farmers adopting IM interventions as compared to farmers' practices. Integrated management of *Sclerotinia* rot of mustard was included in package of practices of zone 1b (Sriganganagar) and IIIb (Bharatpur) of Rajasthan.

IL06(3C): Foliar microbiome assisted management of rice blast disease

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Rice is among the most consumed cereal crop in the world. Rice blast disease caused by the fungus *Magnaporthe oryzae* is one of the threats for rice production globally. Present blast management strategies including host resistance and fungicide spray are either non-durable or not compatible with environment and trade. Therefore, new management options are needed for sustainable rice production. With its adapted microbiota, the foliar niche brings a unique microbiome to the plant-holobiont-pool with a potential for modulating plant traits. However, the ecological forces driving the foliar microbiome assemblage and functions are among the under-estimated aspects of plant biology. Metabarcoding and culturomic methods were integrated to decipher the core-foliar microbiome including that of leaf endosphere of rice-genotypes grown in contrasting agroclimatic zones. Principal coordinate analysis indicated an influence of environmental factors rather than the genotype *per se* on foliar microbiome assembly. The predominance of phyla such as Proteobacteria, Actinobacteria, and Firmicutes encompassing the diverse bacterial communities was observed on the foliar niche. Network and co-occurrence analysis showed a complex intra-microbial interaction on the foliar microbiome. The culturomic validation of metabarcoding confirmed the occurrence of *Acinetobacter, Aureimonas, Bacillus, Chryseobacterium, Curtobacterium, Enterobacter, Exiguobacterium, Microbacterium, Pantoea, Pseudomonas,* and *Sphingomonas* on foliar niche. All the cultured isolates were functionally characterized for antagonism against blast fungus *M. oryzae*. Most of the isolates displayed secretory and volatile mediated antagonism against the blast fungus. Upon seed bacterization, these isolates conferred immunocompetence to rice seedlings. Further, blast disease suppression assay under artificial epiphytotic conditions culminated in the identification of several bacterial isolates showing more than significant disease suppression on blast susceptible variety, Pusa Basmati 1. Transcriptional profiles of innate immunity marker genes such as *OsCEBiP, OsCERK1, OsPAD4, OsNPR1, OsEDS1, OsPDF2.2, OsFMO1, and OsPR1.1* inrice were found altered or up-regulated in bacterized rice seedlings. Multi-pronged activities of foliar microbiome on *Magnaporthe oryzae* (antifungal activity), rice (defense elicitation), and blast disease (blast suppression) have been elaborated for management of blast by microbiome reengineering.

IL07(3C): Use of factory waste lime for managing Aphanomyces Root Rot of sugar beet

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Seedling damping-off and root rot of sugar beet caused by *Aphanomyces cochlioides* can significantly reduce root yield and quality sugar beet roots. Currently hymexazol seed treatment and tolerant cultivars are available to growers for successfully managing these diseases. Application of factory waste lime to raise soil pH has been shown to reduce Aphanomyces root rot (ARR) in 2003 in MN. A field trial was established where lime had been applied in April 2004 at 0, 6, 12, 18 and 24 Mg dry wt ha-1. Main plots were split and an additional 7.8 Mg dry wt lime ha-1 was added to half of each plot in 2014. In 2015, plant stands were only higher in plots that received supplemental lime where original lime rates were 0 and 6 Mg ha-1. Supplemental lime reduced ARR and increased root yield only in plots where lime had not been previously applied. In 2016, ARR decreased with increasing original lime rates, while plant stands and root yield increased with increasing rate of original lime. Addition of 6 Mg ha-1 supplemental lime resulted in significantly lower ARR and significantly higher stands and root yield. In 2016, twelve years after application, original lime rates with no supplemental lime significantly reduced ARR and increased plant stands and root yield. A strong positive correlation between soil extractable calcium (SEC) and root yield and strong negative correlation between SEC and ARR suggest that calcium is playing a vital role in reducing ARR.

IL08(3C): Trichoshield®: A commercial biofungicide against ganoderma basal stem rot of oil palm

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Trichoshield® is a journey that took approximately 10 years for its conception, R&D investigation, pilot plant scale-up and finally ended successfully with a commercial uptake. The product is an environmentally friendly and green technology developed by using an indigenous endophytic *Trichoderma virens* 159c. The biofungicide provides a significant control against *Ganoderma boninense*, the causal agent of Basal Stem Rot (BSR) disease that negatively affects the oil palm industry. The formulation aims to reduce the disease development in oil palm, especially in the productive years of the crop. Trichoshield® also uses oil palm waste for mass production and has been patented (PI2020001604). The microbe colonizes the internal root system of the oil palm and moves progressively as the root system develops. It provides a cost-effective, sustainable and environmentally friendly approach in managing the disease. This paper will discuss the R&D activities; isolation, screening, identification, antifungal characteristics, glasshouse assessments, formulation and finally scale up that took place in the past 10 years in developing and perfecting the formulation for commercial uptake. With the current emphasis on the integrated disease management (IDM) recommended in controlling the impact of BSR disease in the field, the prophylactic approach is highly recommended to be incorporated into the integrated management of the disease. A small reduction in disease incidences in field palms will assist in prolonging the productive life span of the palm, and in return contributes to a significant reduction of economic losses to the industry.

IL09(3C): Potential of Plant Growth-Promoting Bacteria (PGPB) for disease and pest control and yield improvement in shallots

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PGPB is a bacterium that can associate with plants from around the roots (rhizosphere), leaf surfaces (phyllosphere), or plant parts (endophytes). PGPB acts as a biocontrol agent and increases plant growth. The study aimed to obtain PGPB isolates capable of controlling diseases and pests and increasing the growth and yield of shallots. The research consisted of 3 stages of research. The first is the isolation of PGPB from the soil, roots, and bulbs of shallots in production centers and endemic areas of disease and pest in Solok and Agam districts, West Sumatra. The second is the use of PGPB to control shallot diseases and pests. The study used an experimental method carried out in the experimental garden of the Faculty of Agriculture, Universitas Andalas, Padang. The study consisted of 43 treatments and three replications. The treatments consisted of 40 PGPB isolates, pesticides, positive control (without pathogens and PGPB), and negative control (inoculated with pathogens, without PGPB). PGPB isolate was introduced to shallot seeds. The third is to identify and characterize selected PGPB isolates for disease and pest control and to increase shallot yields. The results showed that 9 of PGPB isolates could increase the resistance of shallots to the pathogen *Xanthomonas axanopodis* pv. *alii*, *Pantoea anantis*,

Fusarium oxysporum, *Stemphylium vesicarium*, and *Alternaria porri* and also the pests *Spodoptera exigua*, *Spodoptera litura*, *Liriomyza* sp, *Agrotis ipsilon*, and *Thrips tabaci* from susceptible to resistant. Five isolates can also increase onion yields 388-433% compared to control. Based on the molecular identification of the five isolates, MRTDE2.6 was *Bacillus subtilis* MRTDE2.6; MRSNRZ1.2 is *Bacillus mycoides* strain MRSNRZ1.2; MRBPRZ1.1 is *Bacillus thuringiensis* strain MRBPRZ1.1; MRRZLL2.2 is *Bacillus mycoides* strain MRRZLL2.2; MRRDE3.4 is *Bacillus weihenstephanensis* strain MRRDE3.4. The biochemical character of 5 species of PGPB are three species produce siderophore, three produce salicylic acid, two have protease enzymes, three produce ammonia, and none produce HCN. All species produced biosurfactant, and IAA, and hemolysin negative.

IL10(3C): Strategies for the management of pomegranate wilt caused by *Ceratocystis fimbriata in Karnataka*

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Pomegranate wilt (*Ceratocystis fimbriata* Ell. and Halst) disease is adversely affecting pomegranate cultivation in all major growing regions of Karnataka. The severity of wilt of pomegranate in major pomegranate growing regions of North Karnataka was assessed during *kharif* 2016 and maximum wilt (42.10 per cent) incidence was observed in Babaleswar village (Shruthi *et al.,* 2019); (45.16 per cent) was noticed in Besigeger village of Bellary district (Sonyal *et al.,* 2016); (45.80 per cent) wilt was observed in Govindkoppa village during 2015-16 (Somu *et al.,* 2018). Whereas, Raja *et al.* (2017) reported that, highest incidence (33.34 per cent) was recorded in Sira taluk of Tumakur district and 71.12 per cent incidence was noticed in Neerbudihal village of Bagalkot district (Madhushri *et al*., 2019). Among the various culture media used, oatmeal agar and Potato dextrose agar were found suitable media for good growth of *C. fimbriata*. The highest reduction of wilt incidence was observed in neem cake + Trichoderma plus applied pots (Tirmali *et al*., 2018). *Ceratocystis fimbriata* grew well in all most all hydrogen ion (pH) concentration from 2.0 to 11.0. (Sonyal *et al*., 2015). Black colored perithecium was observed with size of 5.13 x 4.27 ìm. Endoconidia were hyaline, cylindrical and average size was 23.6 x 4.90 ìm. Aleurioconidia were thick walled ellipsoidal or pyriform with size of 18.5 x 10.10 ìm, (Raja et al., 2015). Eleven bioagents were evaluated under in vitro condition, among the bio agents tested, *Trichoderma harzianum*, Trichoderma isolate 1 and Trichoderma isolate 5 recorded the maximum per cent inhibition of mycelial growth (Karakalamatti *et al*., 2019). The plant extracts *Allium sativum* (32.96 per cent) was found effective in inhibiting the mycelial growth (Sonyal *et al*., 2015). The pathogen being soil borne, hence preventive measures are prime importance to manage this disease. Among the different systemic fungicides tested, cent per cent inhibition of mycelial growth of *C. fimbriata* was recorded in propiconazole. Among the different bio agents tested against *C. fimbriata*, *T. harzianum* was found to be the most effective with the highest inhibition of mycelial growth (88.77 per cent) followed by T. viride (86.60 per cent) and *P. fluorescens* (66.33 per cent) and *Bacillus subtilis* was found less effective with (54.88 per cent) inhibition. (Khan *et al*., 2017).

IL11(3C): Efficacy of marine algal bioelicitors in tropical crop plants

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Six marine seaweed species from the southern Caribbean were screened for bioefficacy of extracts of which two were further selected for bioelicitor activity in tropical crop plants. *Sargassum filipendula* and *Acathophora spicifera* were evaluated for plant growth stimulatory and bioelicitor activities in tropical vegetable crop plants. Foliar spray of 0.5% algal extracts has resulted in significant increase in plant growth and yields. Treatment with algal elicitors significantly improved plant growth parameters including plant height, leaf number, root and shoot dry biomass and chlorophyll content. Algal elicitor application also caused significant reductions in disease incidence by the pathogens, including *Xanthomonas campestris* pv. *vesicatoria* and *Alternaria solani* in tomato and sweet pepper under greenhouse and field conditions. The mechanism of growth induction and disease resistance were investigated through transcriptome and microbiome analysis. The treated plants had elevated levels of activities of defence-related enzymes including phenylalanine ammonia-lyase, peroxidase, polyphenol oxidase, chitinase, ²-1,3-glucanase, as well as enhanced levels of total phenolic compounds. The *PR1a*, *PINII* and *ETR*-1 genes were upregulated which is indicative of upregulation of SA/JA pathways. The gene transcripts involved in auxin (IAA), gibberellin (Ga2Ox), cytokinin (IPT) synthesis and those genes (*SFT, SP, J, AN, FA* and *CO*) involved flowering regulation were highly induced by algal bioelicitor application. RNA sequencing of plants revealed upregulation of multiple defense, stress responsive and growth-related genes. A significant increase in colonization of microbes in the rhizosphere and phyllosphere of plants was also noticed in treated plants. The experimental evidence thus far points to collective evoking of multiple responses in plants by algal bioelicitors which would contribute to the overall improvement in growth and tolerance to biotic stresses of plants.

IL12(3C): Vermicompost suppresses fusarium wilt (*Fusarium oxysporum* f. Sp. *Lycopersici*) and improves tomato yield in Nigeria

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Fusarium wilt of tomato is one of the major diseases threatening tomato production especially in savannah ecological zone of Nigeria where the disease is endemic. Average tomato yield in the country is 7.5 metric tons per hectare and one of the reasons for the low yield is diseases attack. Field experiments were conducted to evaluate the efficacy of bio-enriched vermicomposts in the management of Fusarium wilt of tomato caused by *Fusarium oxysporum* f. sp. *lycopersici*. The experiments were conducted during the rainy seasons of 2015 and 2016. The experiments were 2 x 5 factorial laid out in a split plot design. The treatments consisted of two varieties of tomato; Roma VF and UC 82B as the main plots, while three bio-enriched vermicomposts: poultry manure-, cow dung, and rice bran- based bio-enriched vermicomposts; CAMAZEB® (60% Mancozeb + 40% Carbendazim WP as check) and control (u-amended soil) were arranged in the sub plots. All treatments were replicated three times. The two tomato varieties were infected with Fusarium wilt, though the incidence and severity of the disease were significantly ($P<0.01$) lower on Roma VF than UC 82B.

Application of poultry manure based bio-enriched vermicomposts (POBCO) significantly reduced incidence and severity of Fusarium wilt comparable to the synthetic fungicide CAMAZEB® at the early stage of the disease development and better than the fungicide at the latter stages. Use of Roma-VF on soil amended with POBCO recorded low disease incidence (38.7%) and severity (20.4%), and produced higher yield (9.68 tonnes ha-1) than the other treatments. This achievement is attributed to low phytotoxicity of POBCO, abundant soil nutrients and presence of bio-control agents that improved tomato growth and protection against Fusarium wilt. Fusarium wilt incidence and severity was higher in 2015 than 2016 because of low pathogen inoculum mitigated by application of bio-enriched vermicomposts in 2015. Based on the results recorded, Roma VF could be recommended to be grown on soil amended with 25 tonnes ha-1 of POBCO as eco-friendly integrated method for the management of Fusarium wilt and improving tomato yield.

IL13(3C): Comparative evaluation of biological to a chemical seed treatment to manage blackleg on oilseed rape

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Blackleg on oilseed rape is caused by *Leptosphaeria maculans*. Infection occurs when germinated ascospore penetrate the cotyledon surface at early development stages. The pathogen moves down the leaf petiole and into the stem. Stem tissue is destroyed near the soil surface. In severe cases a lesion will form on the exterior of the stem and cause eventual girdling and plant death. Under optimum conditions, yield losses greater than 50% have been recorded. Seed treatments help eliminate the seed-borne inoculum and known to provide protection against infection during the early seedling stage. The objective was to evaluate and compare the performance of biological and chemical seed treatments to manage blackleg on oilseed rape. A trial was planted with treated seed of various treatments separately on the oilseed rape cultivar 'Westar' and were compared with non-treated seed in a randomized complete block design with four replications. Twenty-five stubbles were uprooted and rated within each plot to record the incidence and severity on each stubble after swathing on a 0-5 scale and a mean disease severity index was calculated. Data indicated that oilseed rape treated with the biological at the higher rate followed by the chemical had the lowest blackleg incidence and mean disease severity index and were statistically significant from the other treatments tested. However, not the case with the yield or test weight. Current results indicate a thorough research has to be conducted on these chemicals for including these biologicals in the current management practices of blackleg on oilseed rape.

Oral Presentations

OP01(3C): Antagonistic potential of endophytic bacteria associated with cultivars of *Brassica juncea* against leaf blight pathogen *Alternaria brassicae*

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The yield potential of *Brassica juncea* is constrained by many fungal diseases among which Alternaria blight poses a major challenge worldwide. Endophytic bacteria are increasingly recognized as a promising source of novel organic natural metabolites for a variety of biological activities. However, endophytic bacteria belonging to the group Bacillus and fluorescent Pseudomonads are being reported as superior groups exploited for their role in combating phytopathogens. Therefore, the bacteria belonging to the above groups were primarily targeted for this study. In this study, fifty six endophytic bacteria were selectively isolated from seeds, roots and leaves of 20 different cultivars of *Brassica juncea* growing in various parts of North Eastern Region of India. Out of all isolates tested BS8, BS15, BS21 and FP13 showed inhibition of 59.63%, 65.93%, 58.52% and 63.33 % respectively. When tested for functional properties, BS21 produced IAA as well as ammonia, BS15 and FP13 produced only Ammonia whereas BS8 solubilised Phosphate. BS8(*Bacillus cereus*), BS15(*Bacillus subtilis*), BS21 (*Bacillus subtilis*) and FP13 (*Pseudomonas fluorescens*) were selected on the basis of antagonistic as well as plant growth promoting properties for formulating a microbial consortium and subsequent evaluation in the field.

OP02(3C): Molecular characterization of *Sclerotinia sclerotiorum* Sacc. inciting white mold disease in french bean (*Phaseolus vulgaris* L.) and its biological management

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White mold disease caused by *Sclerotinia sclerotiorum* is a serious peril to the cultivation of french bean in western Uttar Pradesh. In the present study, antagonistic activity of locally isolated bio inoculants including four fungi and three bacteria were evaluated against white mold disease of french bean. *In vitro* efficacy of bio-inoculants was tested by dual culture method against *Sclerotinia sclerotiorum.* Out of seven bio-inoculants, *Pseudomonas fluorescens* isolate Pf008 was found best causing 95.55 per cent mycelium growth reduction. The molecular characterization of isolated pathogen was performed using ITS sequencing. The pathogen (svpuat) was attributed to *Sclerotinia sclerotiorum*. The length of ITS sequence of the pathogen was 516 bp and approximately identical to publicly available *Sclerotinia sclerotiorum* sequences on NCBI date base. In field trial, the bio inoculants were tested by various inoculation methods. *Sclerotinia sclerotiorum* infested soil treated with bio inoculants as seed treatment or soil application. Results evinced that seed treatment with formulation of *Trichoderma harzianum* isolate TS004 was best and enhance the growth promotion and increase the grain yield i.e. 13.93 q/ha and 12.10 q/ha during the year 2018-19 and 2019-20 respectively. Soil application with formulation of *Trichoderma viride* isolate TS006 was the most effective in reducing disease incidence by 83.91% during the year 2018-19 and seed treatment with formulation of *Trichoderma viride* isolate TS006 reducing disease incidence by 74.83% in the year 2019-20.

OP03(3C): Protection of Assyrian plum (*Cordia myxa* L.) by systemic acquired resistance inducers and fungicides against Alternaria blight disease in arid region

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Assyrian plum (*Cordia myxa* Roxb.) which is also known by various names like *Lehsua, Lasoda, Gunda,* Indian cherry and it is an important fruit of the family *Boraginaceae* that thrive well in arid conditions of Rajasthan and India. The immature fruits are much liked in Indian cuisine for preparing mix vegetable and pickle. Alternaria blight of Assyrian plum, caused by *Alternaria alternata* is an important and major disease that causes economic yield losses during fruit bearing stage. In present study, three systemic acquired resistance inducers (²-amino butyric acid, isonicotinic acid and salicylic acid) and three fungicides (tebuconazole 50% + trifloxystrobin 25%, carbendazim 12%+ mancozeb 63% and copper oxychloride 50% WP) were evaluated through foliar applications in orchards for five consecutive years (2017 to 2021). Among fungicides, two sprays of tebuconazole + trifloxystrobin (@ 0.1%) was found the most effective in reducing disease intensity (80.10%) and in increasing yield (68.07%) over untreated check with higher B:C ratio (3.28). In systemic acquired resistance activators, single spray of salicylic acid (@ 200 ppm) at disease initiation proved efficacious in lowering disease (47.51%) and increasing fruit yield (35.82%) with B:C ratio of 2.90 followed by isonicotinic acid (34.77% and 27.84%, respectively) probably due to activating the cellular genes and defense mechanism and thereby spreading resistance throughout the plant body. Exogenous application of salicylic acid in orchard can be used as green chemicals for managing pathogen resistance as well as providing opportunity for organic production of fruits for consumers, because it does not cause bio-accumulation in eatables and environmental hazards. This is the foremost study of salicylic acid application in perennial and arid fruit crops in Rajasthan and newer combined formulations of fungicide for protecting to Alternaria blight under orchards.

OP04(3C): Validation of agrochemicals against sooty mould of cotton incited by Capnodium spp.

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Cotton is the most important Indian cash crop grown widely all around the world. The area under cotton crop is 7.37 lakh ha. with average productivity of 577 kg/ha and about 97 percent area of cotton cultivation is under Bt Cotton cultivars in Haryana. Cotton production is affected by many

fungal plant pathogens throughout the season. Among them, Capnodium species causes sooty mould disease significantly reduces the cotton production and productivity by disturbing photosynthetic rate as well as physical damages to the plant. Present investigation was carried out to find out the potential way of for the management of sooty mould . The experiment was conducted in three consecutive years from Kharif 2017 to Kharif 2019 at CCS HAU, Cotton Research Station, Sirsa. Among various treatments copper oxychloride 50 WP @ 2.25g/litre was observed the potential fungicide which significantly reduced the sooty mould disease incidence against control. Copper oxychloride 50 WP @ 2.25 g/litre of water, Propiconazole 25 EC @ 1 ml / litre of water and Copper oxychloride 50 WP @ 1.75 g/litre of water effectively reduced percent disease incidence with reduction of 53.1 %, 40.0% and 39.3% respectively. All the treatments reduce the disease incidence further positively correlated with higher seed cotton yield as compare to control one. Among various treatments Copper oxychloride 50 WP @ 2.25 g/litre of water leads the highest seed cotton yield of 2456 kg/ha. Thus use of copper oxychloride 50 WP @ 2.25 g/litre of water in cotton crop may helpful in reduction of the sooty mould incidence in the field conditions leading to increased seed cotton yield.

OP05(3C): Enhancing the shelf-life in betel leaf by ecofriendly management of post-harvest diseases

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Betelvine (*Piper betle* L.) is cultivated in India for its leaf. Betel leaves are generally spoiled and their quality is also reduced by post-harvest pathogen infection during storage and transport. The present work was undertaken with the aim to eco-friendly management of post-harvest losses by reducing infection and enhancing shelf-life of betel leaf. The betel leaves (*cultivar-Magahi)* were harvested after raining and winter season's during 2019-20 and treated with treatments; T1- Control (Normal tape water); T2- Distilled water; T3- Lime water @ 0.2 %; T4- Tulsi oil @ 0.1 %; T5- Lemongrass oil @ 0.2%) separately by dipping the leaves for 10 minutes in above solution and stored at ambient room temperature. Best treatment of post-harvest clubbed together with pre-harvest treatment on live plant where eight treatments (T1- Control Normal tape water: T2- Distilled water; T3- Lime water @ 0.2 %; T4- Tulsi oil @ 0.1 %; T5- Lemongrass oil @ 0.2%; T6- Neem oil @ 0.2%; T7- *Bucillus subtilis* @ 0.3 %; T8- *Pseudomonas fluoresces* @ 0.3%) were applied at 15 and 7 days before harvest. The higher shelf-life of betel leaves were found 25.8 days and 32.6 days of raining season and winter season leaves, respectively on pre-harvest treatment of betel leaves with T6-Neem oil @ 0.2% and post-harvest treatment with T5-lemongrass oil @ 0.2% as compared to control (10.6 days and 17.0 days), respectively. It also reduced the infection of leaf rot caused by fungi-*Phytophthora parasitica* and bactreia-*Xanthomonas betelicola* by 92.3% and 85.2 % of raining season leaves and reduced the infection of leaf rot caused by *Colletotrichum capsici* by 89.1% of winter season leaf.

OP06(3C): Microbial encapsulation technology: An emerging game changer in disease management of ginger

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Ginger (*Zingiber officinale* Rosc.), a rhizomatous tropical plant is one of the most commonly consumed dietary spices with significant applications in food, pharmaceutical and nutraceutical sectors. It is one of the most important spice crops in India. The crop is cultivated in 1,75,764 ha with an estimated production of 1.9 million tonnes during 2020-21. Diseases caused by several pathogens are considered as one of the major constraints for sustainable ginger production in the country. Though several chemical based plant protection strategies are practiced by the farmers, the high cost and the increasing concerns on food safety has underlined the urgent need for alternative biological control strategies. The microbial encapsulation technology developed by ICAR Indian Institute of Spices Technology is a novel method for storing and delivering beneficial microorganisms for disease management in several crops including ginger. The encapsulation technique involves a specific formulation of the beneficial microorganism of interest in an immobilized/inactive condition mixed with other substances that protect and maintain the encapsulated microorganism in a gelatin capsule. The technology package for ginger including encapsulated *Trichoderma asperellum* (soft rot management), *Bacillus amyloliquefaciens* (plant growth promotion and soft rot management) and *B. licheniformis* (bacterial wilt management) has been successfully tested and demonstrated in multiple locations across the country. Extensive farmer participatory trials for two seasons conducted across major ginger growing tracts of Kerala and Karnataka indicated the substantial benefits from technology adoption. The incremental benefit cost ratio was found to be 2.93 indicating significant benefits for primary producers, while providing a sustainable and environmental friendly technology for the production of food safe, quality ginger in the country.

OP07(3C): Management of charcoal rot (*Macrophomina phaseolina*) of cowpea in Rajasthan

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Cowpea (*Vigna unguiculata* L.) is an important multi-purpose grain legume extensively cultivated in arid and semi-arid tropics of India. It is a good source of food, forage, fodder, vegetable and certain snacks. Charcoal rot caused by *Macrophomina phaseolina* is an important disease of cowpea, under severe infestation it cause 40–50 % losses in grain yield. Three year field experiments were conducted in hot arid conditions at Bikaner, Rajasthan during *Kharif* 2019-2021 with the objective to find out suitable management strategies for charcoal rot. The experiment was conducted on local variety- Bidodi in RBD Design with three replications in *kharif* season. Seven different treatment combinations of seed treatment with fungicides or bio-agents and/or along with soil application of *Trichoderma harzianum* @ 2.5 kg in 500 kg FYM/ha and compared with an untreated control. Results of experiment showed that all the treatments brought significant decline in disease incidence and consequently enhancement of grain yield compared to untreated control. The treatment having combination of seed treatment with Tebuconazole 2 DS @ 1.5 g/kg seed along with soil application of *T. harzianum* @ 2.5 kg in 500 kg FYM/ha had minimum (2.78 %) charcoal rot incidence, highest grain yield (1166.31 kg/ha) and net return (Rs 8,508/ha). The seed treatment with Carboxin 37.5% + Thiram 37.5%WP @ 2g/kg seed along soil application of *Trichoderma harzianum* @ 2.5 kg in 500 kg FYM/ha was the next best treatment with 4.22 % disease incidence and 1048.56 kg/ha of grain yield. These treatments can provide an effective and economical management of charcoal rot of cowpea for cultivators.

OP08(3C): Management of leaf blight and wilt disease of groundnut occurring in western part of Rajasthan

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A trial for the management of leaf-cum-wilt disease of groundnut caused by *Fusarium incarnatum-F. equiseti* species complex conducted at ICAR-CAZRI in collaboration with ICAR-DGR, Junagadh for the years 2019, 2020, and 2021. The treatment included chemical, physical, cultural and biological control practices. The results based on the pooled data analysis of three years indicated that all the treatments applied were significantly reduced the disease incidences in the field and these treatments were also economically feasible in the benefit-cost ratio (B: C ratio) and incremental cost-benefit ratio (ICBR). Although, none of the treatments can reduce the disease below 30 per cent. Hence, in conclusion, a combination of chemical, physical, cultural, and biological control practices is required for the better management of the disease. Therefore, it is recommended that seed treatment with Tebuconazole 2 DS @ 1.25 g/kg seed, soil application of neem cake @ 200 kg/ ha (basal, 30, 55, and 75 DAS), application of Trichoderma powder formulation @ 10 kg/ ha (basal, 30, 55 and 75 DAS), inter or mixed cropping with pearl millet, alternate spraying of Carbendazim 12% + Mancozeb 63% WP (@ 10 g saaf in 5L water for 100 sq m area) and Tebuconazole 430 SC (@7.5 ml folicure in 5L water for 100 sq m area) at 30, 55 and 75 DAS can manage the disease and reduce the economic losses of the farmer.

OP09(3C): Management strategies for Alternaria leaf spot of soybean incited by *Alternaria alternata*

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Soybean (*Glycine max* (L.) is one of the most important an Asiatic oil seed crop. It has a prominent place among modern agricultural commodities, as the world's most important seed legume, which contributes 25% to the global edible oil. Alternaria leaf spot disease caused by *Alternaria alternata* is one of the most economically important disease in soybean production. Efficacy of four fungicides and two botanicals' formulations were tested by poison food technique against six isolates of *A. alternata* collected from major soybean growing areas of Rajasthan. Among the fungicides tested, Azoxystrobin 8.3% + Mancozeb 66.7% WG was the most effective fungicide caused 100% inhibition of mycelial growth of all the six isolates of *A. alternata* followed by Azoxystrobin 23% SC at 500 and 1000 ppm and neem oil at 0.5% was found most effective *in vitro*. In field condition most virulent isolate (UDP Aa-1) were used for artificial inoculation with spore suspension having concentration 1 x 103 conidia ml-1 on the plants of 45 DAS. Among them ten treatments, combination of Azoxystrobin 8.3% + Mancozeb 66.7% WG at 0.36% + Neem oil at 0.5% was found most effective in reducing the disease intensity followed by individual applications of Azoxystrobin 8.3% + Mancozeb 66.7% WG at 0.36% during *Kharif* season 2018 and 2019.

OP10(3C): Identification and in-vitro efficacy of fungal endophytes isolated from grapevine cv. Manik Chaman for management of anthracnose and bacterial leaf spot diseases in grapes

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Seventy-three fungal endophytes were isolated from cv. Manik Chaman from different plant parts *viz*., Root (MCRT: 16), Rootstock (DRRS: 7), Stem (MCS: 4), Bark (MCBK: 10), Cane (MCC:18), Sub Cane (MCSC: 4), Tiger Bud (MCTB: 2), Petiole (MCP: 6), Leaf Disk (MCLD: 5), and Berry (MCBY: 1). These fungal endophytes were characterized morphologically and based on ITS sequence information. Moreover, *in-vitro* direct confrontation results revealed that among the 73 isolates, 33 isolates inhibited the mycelial growth of *Colletotrichum gloeosporioides,* while, 17 isolates inhibited 50-80% growth of *Xanthomonas campestris pv. viticola*, the causal agents of anthracnose and bacterial spot respectively. Five isolates showed highly antagonistic activity against both the pathogens. The compatibility assay of 10 isolates revealed that the MCB1, MCB4, MCB6, and MCB10 were highly compatible with kresoxim methyl 44.3 SC and sulphur 80 WP and showed less compatibility with difenoconazole 25 EC, hexaconazole 5 EC, myclobutanil 10 WP, copper oxychloride 50 WP, mancozeb 75 WP and propineb 70 WP. MCB2 and MCB5 isolates were highly compatible with Sulphur 80 WP. ITS sequence analyses of 55 isolates revealed the identification of different species belonging to several genera *viz*., *Alternaria, Aspergillus, Colletotrichum, Cytospora, Diatrypaceae, Fusarium, Lasiodiplodia, Pseudofusicoccum,* and *Trichoderma*. The fungal endophytes isolated from grapevine cv. Manik Chaman are more diverse having antagonistic potential against the predominant pathogens of grapes in India, *C. gloeosporioides,* and *X. campestris pv. viticola.*

OP11(3C): Management of Alternaria Blight of Clusterbean [Cyamopsis tetragonoloba (L.) Taub.] Incited by Alternaria cucumerina var. cyamopsidis in Rajasthan

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Studies with fungicides and plant extracts were performed *in vitro* and *in vivo* condition to assess their potential in controlling Alternaria blight of clusterbean caused by *Alternaria cucumerina* var*. cyamopsidis.* It has become a severe menace to growers of Rajasthan in India and in general causes economic losses under changing climatic scenario. In present study, Eight fungicides (hexaconazole 5% SC, kitazin 48% EC, chlorothalonil 75% EC, carbendazim 12%+mancozeb 63% WP, carbendazim 50% WP, tebuconazole 50%+trifloxystrobin 25% WG, carbendazim 25%+iprodione 25%, capton 70%+hexaconazole 5%WP) at 100, 300 and 500 concentrations, seven plant extracts (*Azadirachta indica* (NLE& NSKE), *Allium sativum, Calotropis gigantia, Datura stramonium, Vinca rosea*, *Aegle marmeols*) at 5,10 and 15% concentrations and six micro nutrients (Boron, calcium, copper, iron, potassium, zinc) at 100, 300 and 500 ppm concentration evaluated *in vitro* by Poisoned Food Technique. In fungicides, the 100% inhibition of mycelial growth was obtained with carbendazim12%+mancozeb 63% WP at 300 and 500 ppm concentrations, followed by tebuconazole 50%+trifloxystrobin 25% WG at 500 ppm concentration. The result of *in vitro* studies with plant extracts neem seed kernel extracts show the maximum inhibition at all concentration followed by neem leaf extracts. *In vitro* studies with copper and zinc showed the most significant antifungal activity at all tested concentrations. In field condition plant extracts neem leaf, garlic bulb and neem seed kernel extract (10%), micro nutrients like urea, iron sulphate and potassium spray (0.5%) foliar spray. And five fungicides hexaconazole, carbendazim 25%+ iprodione 25%, capton70%+hexaconazole 5% ,carbendazim 12%+mancozeb 63% at (0.2%), tebuconazole 50%+trifloxystrobin 25% sprayed at 45DAI and 60DAI. Minimum intensity of disease was recorded with treatment neem seed kernel extract followed by neem leaf extract found most effective in controlling disease. Micro nutrient potassium show high disease control followed by urea spray. Fungicide carbendazim 12%+mancozeb 63% followed by tebuconazole 50% + trifloxystrobin 25% spray was recorded less disease intensity and maximum yield obtained.

OP12(3C): Search for conventional (biocontrol) and non-conventional (chemicals) agents against wilt disease in Pigeonpea caused by *Fusarium oxysporium* f.sp.*udum* under *in vitro* conditions

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One of the important diseases associated with pigeonpea is "wilt" caused by *Fusarium oxysporium* f.sp.*udum*. Management of wilt in pigeonpea is difficult and no single control measure is fully effective. In view of identifying an effective antagonist and a broad spectrum non-conventional chemicals against wilt pathogen, studies were conducted under *in vitro* conditions. A total of twenty strains of *F. oxysporium* f.sp.*udum* were isolated from wilt-affected pigeonpea plants from

various areas of Telangana state. Three fungal isolates showed irregular colony type, five were pink coloured and four were flat surfaced. Against all the isolated fungal isolates, four *Pseudomonas fluorescens* (*Pf* 3, 4, 21 and 22) strains were inhibitory in dual culture test. Carbendazim and propiconazole at 0.1 % showed good inhibition against all the *F. oxysporium* f.sp.*udum* isolates. Among the non-conventional chemicals, zinc sulphate and oxalic acid showed good inhibition towards all the fungal isolates at 50 mM concentration. While treatment with manganous sulphate was effective against one isolate *i.e.* 7, no growth was observed under treatment with salicylic acid at 25 and 50 mM concentration. Thus, the study explored zinc sulphate, oxalic acid and *P. fluorescens* as effective agents against wilt pathogen. These agents can be further tested under *in vivo* conditions.

OP13(3C): Management of blue mould rot in Indian gooseberry (*Emblica officinalis* Goertn.) caused by *Penicillium islandicum* (Sopp.) in integrated manner

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Aonla or Indian gooseberry (*Emblica officinalis* Goertn. Syn. *Phyllanthus emblica* L.) is one of the most important indigenous fruit of Indian sub-continent which cultivated since immemorial period. Among the various post-harvest diseases of aonla, blue mould rot caused by *Penicillium islandicum* Sopp. is most important as it affects the fruit yield and quality pertaining to the market value. The major losses due to blue mould rot in Indian gooseberry occur during transit to the market. In order to manage, the blue mould rot in integrated manner by chemicals, plant extracts and bioagents under *in vivo* and *in vitro* conditions at different concentrations. *In vitro*, Lowest mycelial growth was recorded in neem leaf extract showing 83.06, 90.69 and 91.88 per cent growth inhibition over control followed by haldi (turmeric) bulb extract. Significantly highest per cent growth inhibition of *P. islandicum* was observed in *Trichoderma harzianum* (83.06%) followed by *Pseudomonas fluorescens*. Amongst different boric acid was formed best showing 99.24 per cent growth inhibition at 1.0 M concentration. *In vivo*, Neem leaf extract at 20 per cent concentration was highly effective in managing the disease intensity (7.31 and 8.13%) in pre and post treatment after five days of inoculation followed by haldi bulb extract. *T. harzianum* (6.0 and 6.31% disease intensity) was rated most efficient antagonist in managing the blue mould rot followed by *P. fluorescens* against check where managing disease intensity were 34.98 and 39.75 per cent in pre and post inoculation, respectively after five days of inoculation. The similar trend was also observed in pre and post treatment after ten days of inoculation. Boric acid was found most effective in managing blue mould rot disease intensity in pre and post inoculation after five days of inoculation respectively.

OP14(3C): Association of causal Agents inciting boll Rot Complex of cotton and its Management in northern Karnataka

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Cotton is the most important cash crop of India contributing 7.00 per cent to our GDP, fetching an export earning besides providing employment in the production, promotion, processing and trade of cotton. The present investigations were under taken at Agril.Research Station,Dharwad during 2019-20.The study clearly identified the association of *Alternaria macrospora, Fusarium oxysporum* f. sp. *vasinfectum, Exserohilum rostratum, Colletotrichum gossypii, Phoma* sp., *Trichothecium roseum, Aspergillus niger, Nigrospora oryzae* and *Rhizopus stolonifer* were found to be associated in causing boll rot complex disease of Bt. cotton and were identified on the basis of pathogenicity, morphological and molecular characteristics. The various symptoms were characterized as small brown or black dots, infected inner tissue and rotted seeds and lint. Among the areas surveyed, more than two pathogens associated two places while more than three and four pathogens were associated in four and three areas. Based on results pathogens associated in boll rot complex have been divided into three groups *viz*., those capable of penetrating intact bolls, those which are introduced by insects and those are introduced after the boll are damaged by insects or after the suture of the boll lobes are broken. Among eleven different new molecules tested, spraying with trifloxystrobin 25%+tebuconazole 50%WG @ 1.0/lit at 75 and 90 days after sowing was found effective followed by tebuconazole 25.9 %EC at the rate of 1.0 ml/lit was found economical with the highest B:C ratio(1.52:1) followed by trifloxystrobin 25%+ tebuconazole 50%WG @ 1.0/lit with B:C ratio fo 1.43:1. The present study clearly demonstrated the association of more than four pathogens in causing boll rot complex and can be managed by triazole fungicides in northern Karnataka.

OP15(3C): Phytochemicals elevating induced resistance responsive effect in disease management

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Plant natural products have enormous potential to be a viable solution to the environmental troubles caused by the synthetic pesticides. Botanicals or plants extracts are effective bio-pesticides being environmentally safe, easily biodegradable suitable for plant disease management and also be fitting in organic farming. Phytochemicals from plant origin may be used as alternatives to agrochemicals for managing plant diseases. Early blight caused by *Alternaria solani* is one of the destructive seed borne disease of tomato. Antimicrobial, physiological and biochemical effects of methanolic extracts of *Eucalyptus globules* and *Azadirechta indica* on infected tomato plants was investigated using the whole plant bioassay through ROS modelling and seedling vigor study method. All the tested compounds positively enhanced the physiological traits (Root length, Shoot length and leaf area index) of treated plants and the enzymatic activities of phenyl ammonia lyase (PAL), peroxidase (PO), and polyphenol oxidase (PPO), super oxy dismutase (SOD), total phenolic content (TPC) and Secondary metabolites (alkaloids, flvonoids, tannins, saponins, terpenoids, reducing sugar and steroids). Moreover, the treatment with the plant extracts significantly increased the vigor of the plant. Considering the fungitoxicity of plant extracts against *A. solani* with no phytotoxicity on treated plants, the plant extracts might be a sustainable eco-friendly control strategy to reduce the usage of chemical fungicides partially or entirely against *A. solani* particularly and fungal diseases in general.

OP16(3C): Effect of New molecules fungicides on stem rot disease caused by *Sclerotium rolfsii* incidence and pod yield and its attributes of groundnut under rice based cropping system

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Groundnut is a most important oilseed crop cultivated extensively through the tropic and warm temperate regions of the world and it plays an important role in the economy of several countries. Groundnut crops are affected by many soil borne diseases like stem rot, root rot, collar rot and pod rot. Among all the soil borne diseases, stem rot is caused by *Scletium. rolfsii* Sacc. is an important pathogen which is attacking different growth stages of groundnut plants. Aim of studies are to manage stem rot disease and reduced yield loss by *S. rolfsii* through application of new molecule fungicides. Seven fungicides at five concentrations (50, 100, 150, 250, 500 and 1000 ppm) were evaluated against mycelial growth of *Sclerotium rolfsii* isolated from groundnut plants *in vitro.* It was observed that the fungicides namely, trifloxystrobin + tebuconazole, tebuconazole, azoxystrobin and azoxystrobin + difenconazole were found most effective in inhibition of mycelial growth of *S. rolfsii.* In field conditions, experiment was conducted three subsequent years under rice based cropping system during the year 2018-2020 in the *Summer* season and found that minimum disease index, plant mortality, pod rot per plant, and highest initial, final, plant height, pods per plants, highest pod and haulum yield kg/ha. were recorded in seeds treated with Azoxystrobin 23SC @ 1ml/kg seed+ soil application with *T.harzianum* @ 2.5 kg/ha at the time of sowing followed by seeds treated with Azoxystrobin 23SC @1ml/kg seed, seed treated with Azoxystrobin 18.2+ Difenconazole 11.4 SC @1ml/kg seed and seed treated with *T.harzianum*@ 10 g/ kg .

OP17(3C): Management of finger millet blast incited by *Magnaporthe grisea* using potential bio-agents

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Ragi blast incited by *Magnaporthe grisea* has become the major fungal disease causing more yield loss in major ragi growing regions. The present study was thus undertaken to identify potential bio-agents against *Magnaporthe grisea* infecting ragi. Field experiment was conducted at Agricultural Research Station, Vizianagaram during *kharif:* 2020-21 to control the blast disease with different bio-agents and chemicals which includes, seed treatment with Carbendazim@2g/kg seed, seed treatment with chitosan@3.75g/kg seed, seed treatment with *P. fluorescens*@10g/kg seed, seed treatment with *B. subtilis*@10g/kg seed, seed treatment with carbendazim+2 foliar sprays with *P. fluorescens*, seed treatment with chitosan+2 foliar sprays with *P. fluorescens*, seed treatment with *P. fluorescens*+2 foliar sprays with *P. fluorescens,* seed treatment with *B. subtilis*+2 foliar sprays with *B. subtilis* and control without any treatment. Among the treatments, lowest disease severity of leaf blast (2.0 Grade), neck blast (6.8%) and finger blast (7.2%) with highest grain yield of 1674.0 kg/ha and fodder yield of 4117.4 kg/ha was recorded with seed treatment with chitosan+2 foliar sprays with *P. fluorescens*. However, in control highest disease

severity (leaf blast-8.7 Grade; Neck blast-78.0% and Finger blast-78.0%) with less grain yield (876.6 kg/ha) and less fodder yield (2376.6 kg/ha) was recorded.

OP18(3C): Investigation on wheat microbiome: Identification and screening of potential fungal biocontrol agents against important pathogens of wheat

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Wheat (*Triticum aestivum* L.) is cultivated in larger areas as an important stable food crop for Indian population.Various abiotic and biotic stresses affect the yield and quality of this crop under variable environmental conditions. Nilgiri hills located in Tamil Nadu, India and it is consider as hot spot area for rusts. Other than rust, powdery mildew (*Blumeria graminis* f.sp. *tritici*), head scab (*Fusarium graminearum)* and spot blotch (*Bipolaris sorokiniana*) are the diseases occur at Nilgiri and causes significant loss to the crop yield. Cultivation of resistant varieties and fungicides sprays are two major plant protection strategies followed to combat various diseases. However, exploration of beneficial microbes and utilizing them to develop management strategies is followed preferably from respective crop ecosystem. The interactions of microbes in plant system play a crucial role in protecting the plant against abiotic and biotic stresses and improve the plant health. Under this direction, present investigations were made on elucidation of microbial communities which harbour on the wheat. Presently, we collected the rhizosphere soil in addition to leaf and stem samples of wheat from different fields at Nilgiri hills and enumerated the fungal microbes from phyllosphere, rhizosphere and from seeds. It was recorded that these samples harbours of both pathogenic and biocontrol microbes. Twelve genera of fungi viz.,*Fusarium*, *Bipolaris*, *Chaetomium, Alternaria, Trichothecium Sphaerellopsis*, *Acremonium*, *Curvularia*, *Sarocladium*,*Cladosporium, Epicoccum,and Trichoderma*were isolated, purified and identified. *In vitro* techniques are proven as the best method for rapid screening of different biocontrol agents. So, we screened the effective isolates of different biocontrol agents and mycoparasite under *in vitro* screening technique and short listed the effective BCAs against wheat pathogens. The leaves infected with spot blotch pathogen was frequently associated with the species of *Cheatomium*. Ten *C. Globosum* isolates were tested for their efficacy against the pathogens *B.sorokiniana* and *F. graminearum* and the results showed that *C. Globosum* is effective in inhibiting the mycelial growth of *Bipolaris* but, not having direct effect on inhibiting the mycelial growth of *F. graminearum* by dual plate technique. *Acremonium* sp. colonizing on stem rust of wheat is tested by using the culture filtrate and spore suspension of *Acremonium* sp. which recorded to be effective on uredospore germination and reduction in germ tube elongation of stem rust (*Puccinia graminis* f.sp. *tritici-Pgt)* andleaf rust (*Puccinia triticina- Ptr)* of wheat.The *Sphaerellopsis* sp. mycoparasite on leaf rust was found to be associated with some leaf rust infected samples of wheat. Additionally, two isolates of *Trichoderma* sp.were also isolated from wheat which are inhibitory to *F. graminearum.* The culture filtrate of *Trichoderma* sp. showed 97% inhibition of leaf rust spore germination whereas only 51 % reduction in germination of stem rust of wheat. The genus *Cladosporium* sp., was isolated from most of the stem and leave samples of wheat infected by rusts and found to be predominant in the phyllosphere region of wheat. The culture filtrate *Cladosporium* sp., has direct effect on the germination of urediospores of stem and leave rust pathogens in *in vitro* conditions. All the above genera of fungi were molecularly characterized by ITS region analysis. Through these studies it is evident that the interaction between microbes and their mode of action differs in plant system. The interaction studies of other microbes are under progress to identify effective isolates of BCAs on wheat.

OP19(3C): Progress and prospects in the management of decline and wilt of guava

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The area and production of guava has registered regular increase during last one decade due to its ever increasing demand and introduction of improved varieties. NHB estimated 299 thousand hectare area under guava with the production of 4394 thousand MT in India during 2020-21. The wilt disease of guava caused by *Fusarium* spp. has been a major constraint and countrywide spread of the root-knot nematode, *Meloidogyne enterolobii* in recent years has made the problem extremely serious. Management of these soil borne pathogens has never been an easy task particularly when no resistant cultivar is available. Application of chemicals is not only expansive but also harmful to non target organisms including human beings. Therefore, adoption of an integrated management approach with the emphasis on avoidance, intercropping, and organic amendments and bio-control agents is necessary for maintaining an orchard healthy. The research work carried out during last five years indicated that application of *Trichoderma asperellum, T. harzianum, T. viride, Purpureocillium lilacinum, Pseudomonas aeruginosa*, *Bacillus* sp. and *B. amyloliquefaciens* alone and in combination with manures has potential to keep orchard healthy. Bacterial bio-agents have been found able to enhance the growth of inoculated plants as compared to uninoculated control and in minimizing the infection of both the pathogens under controlled conditions. However, avoidance is the most important, as if once the nematode is introduced in the orchard, regular care is necessary to keep it under control. The major emphasis is being given in guava nurseries to minimize the further spread of the nematode.

OP20(3C): Seed bio-priming with endophytes enhances antioxidative defense system in host and non-host crops

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Seed bio-priming is one of the very promising techniques in seed health improvement which enable the seed to overcome various biotic and abiotic stresses. In this study, the effect of bio-priming with cotton endophytes on antioxidative defense system in host and different non-host crops like wheat, sorghum, cowpea and chick pea was examined. The fungal endophytes isolated from two cultivated cotton species namely *Gossypium hirsutum* and *G. arboreum* were antagonistic to *Corynespora cassiicola*. The seeds of cotton and different non-host crops were bio-primed with fungal endophytes' spore suspension (1×107 spores/ml) for 4 h to estimate the catalase and peroxidase activity. The results revealed that in all the bio-primed crops an increase in catalase activity was noticed, when compared to control. Though, this increase was common to all treatments in all the crops, CFS-5 resulted in decline of catalase activity except in chickpea. Specific activity of catalase ranged from 0.42 to 1.90 µmole/min/mg protein in cotton, 0.96 to 3.96 µmole/min/mg protein in chickpea, 1.99 to 4.32 µmole/min/mg protein in wheat, 0.44 to 2.82 µmole/min/mg protein in cowpea and 0.19 to 3.41 µmole/min/mg protein in redgram. Moreover, Peroxidase activity was found to be comparable in host as well as non-host crops. In comparison to their respective controls, higher peroxidase activity was seen in bio-primed samples of all the crops, except CFL-34 treated wheat and redgram. Therefore, seed bio-priming with endophytes plays a potential role in enhancing the antioxidative defense system, and thus improves the plant health.

OP21(3C): Evaluation of effective modules for management of onion anthracnose in Maharashtra, India

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Onion (*Allium cepa* L.) is an important vege-spice crop grown in India. Several factors have been identified for the low productivity of onion. Fungal diseases are a major yield-limiting factor in all onion-growing areas of India. Among the diseases, anthracnose/twister disease is more severe in India because of its complex nature, caused by *Colletotrichum* spp. and/or *Fusarium* spp. At a high degree of disease intensity, yield loss reaches up to 80%. To achieve maximum efficiency in the management of this disease, efforts were made to evaluate the economically viable and ecologically safe four different Integrated disease Management modules *viz*., M1, M2, M3, M4 with existing practice (EP), farmers practice (FP) and absolute control (AC) at the Directorate of Onion - Garlic Research at Pune, Maharashtra. During *kharif* 2021 Bhima super variety used to evaluate these modules start from nursery to 90 DAT treatments were applied. It was noted that all the modules inhibited the Anthracnose disease ranging from 7-61% over FP and 33-51% over EP. The maximum (61%) inhibition was recorded with M1 (Intensive management) followed by M2 (46%) over FP. While comparing with EP, M1 and M2 inhibited 51% and 33% anthracnose, respectively. Further, M1 also supported 20% and 31% higher yield over FP (18 t/ha) and EP (17 t/ha), followed by M2 which supported 14% and 24% higher yield over FP and EP. These modules could be a better option for the management of anthracnose in onion after recommendations.

OP22(3C): Disease management in organic farming systems and its scope in sugarcane agriculture

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Organic agriculture is an eco-friendly approach for cultivation of crops, which combines traditional knowledge, innovations to suit to modern requirement and science to promote fair relationships with sustainable pest and disease management approaches. Since synthetic pesticides are not used in crop husbandry, the disease pressure may be more in organic agriculture as compared to conventional agriculture. Despite, there are no specific control measures for the management of any pests or disease in organic system; plants are made to withstand pests or diseases attack by manipulating environment and growing conditions of crop plants. Few mineral based fungicides such as, copper and sulphur etc. are permitted to use with some restrictions. Physical, biological based disease management methods are also used, however, chemical fungicides recommended in organic agriculture should be used as a last resort when all other crop management practices are failed to give effective protection. Sugarcane is one of the important cash crops in India and diseases are the major concern in sugarcane. More than 50 diseases have been reported from sugarcane in India, among them red rot, smut, wilt-Pokka boeng, sett rot, rust, grassy shoot, ratoon stunt and some viral diseases like YLD, mosaic etc. are important diseases. Due to vegetative propagation, most of the diseases are transmitted through planting materials (setts). Methods such as, use of resistant varieties, proper sanitation, heat treatment of seed canes, use of biocontrol agents, crop rotation, ratoon management, irrigation management *etc.* are the eco-friendly disease management options in sugarcane. To eliminate systemic viral, bacterial and phytoplasmal pathogens tissue culture derived planting materials are promoted and these diseases are successfully managed under Indian scenario. Although effective fungicides are available, dense canopy of sugarcane and impervious nature of hard rind in the stalk make the use of chemicals impractical. Previous studies demonstrated usefulness of bacterial and fungal bioagents against major fungal diseases like red rot, smut and wilt. Scope of utilizing pressmud based *Trichoderma* formulations was successful to manage wilt. Recent efforts of trash decomposition will further support organic agriculture and survival of antagonistic microflora in the rhizosphere. Hence, the crop becomes a natural choice for adoption of organic disease management practices for the successful cultivation of crop.

OP23(3C): Management of collar rot disease of groundnut (*Arachis hypogaea* L.) Caused by *Aspergillus niger* in Rajasthan

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Groundnut is an economic important edible oilseed crop. Groundnut suffers seed, soil and foliar diseases. Among the groundnut diseases, collar rot is one of the economic important diseases. Collar rot damaged regularly due to its seeds and soil borne nature. This disease has prevalent in almost all groundnut growing states. Field experiment was conducted for two years to find out effective control of collar rot of groundnut. Nine treatments including fungicides/bio-agents along with check were laid in randomized block design with three replications. Efficacy of deep summer ploughing with mould board plough + Seed treatment with Tebuconazole followed by PGPR + Soil application of *Trichoderma* enriched in 250 kg FYM/ha at 35 and 80 DAS along with farmer practices as well as control was tested at ARS, Bikaner in RBD design for management of soil borne diseases of groundnut. The result revealed that deep summer ploughing with mould board plough + Soil application of *Trichoderma* @ 4 kg/ ha enriched in 250 kg FYM/ha + Seed treatment with Tebuconazole 2DS@ 1.5 g/ kg of seed followed by Seed treatment with PGPR @625g/ ha of seed + Soil application of *Trichoderma* @ 4 kg/ ha enriched in 250 kg FYM/ha at 35 and 80 DAS (T4) gave minimum collar rot incidence 7.33%, highest pod yield of 4803 kg/ha, highest haulm yield 6438 kg/ha and maximum 89.00 per cent germination followed by deep summer ploughing with mould board plough + Seed treatment with Tebuconazole 2DS 1.5g/kg seed followed by PGPR @625g/ ha of seed + Soil application of *Trichoderma* @ 4 kg/ ha enriched in 250 kg FYM/ ha at 35 and 80 DAS (T1) where collar rot 7.67 %, 4620 kg/ha pod yield and haulm yield 6067 kg/ha with83.00 per cent germination. All the treatment significantly superior as compared to control, where 15.33 % collar rot incidence, 3027 kg/ha pod yield and haulm yield 4653 kg/ha and minimum 74.00 per cent germination were recorded.

OP24(3C): Growth, yield and disease incidence in soybean under different sowing methods in Vindhya Plateau of Madhya Pradesh

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Soybean [*Glycine max* (L.) Merrill] is a legume species belongs to the family Leguminosae and sub family Papilionideae, grown mainly in *Kharif* season in Madhya Pradesh. Soybean is classified more as an oilseed crop than as a pulse. It contains 40-42% of proteins and 18-20% of oil. Soybean accounts for 30 per cent and 21.3 per cent of total production and area under oilseeds in the country. Rhizoctonia root and stem rot, caused by the fungus *Rhizoctonia solani*, is an important disease of soybean. The disease causes heavy mortality of soybean in suitable climate. The root rot pathogenic fungi are major threat for this crop as these attacks on the root of the plant and destroy the proper functioning of the plant by disturbing the absorption of water and nutrients. Recently expansion of soybean area but their productivity was very poor against the yield potential of variety due to heavy infestation of insect and pest. Due to dominancy of mono cropping of soybean in the same field and non adoption of suitable integrated disease management modules cause heavy loss due to build up of many insect, pest and diseases, which become a foremost limiting factor in soybean productivity in recent years. An experiment was conducted at Agricultural Science Centre, Sagar, Madhya Pradesh in *kharif* season of 2016-17 to 2018-19 to evaluate the impact of the sowing methods and integrated disease management practices on yield and disease incidence in soybean. The results revealed that the broad bed furrow (BBF) sown soybean resulted remarkably higher plant height, no. of root nodules/plant, no. of branches/plant, no. of pods/plant, no. of seeds/pod, seed index, seed and straw yield (50.2 cm, 18.15, 3.24, 41.5, 3.35 12.34 g, 1510 kg/ha and 2.31 t/ ha) respectively in comparison to other sowing methods. Among the IDM practices, these parameters were highest in IDM-1 (summer ploughing, soil treatment with *Trichoderma viride* @ 2.5 kg/ha and seed treatment @ 10g/kg seed, spray of pre-mix fungicide carbendazim 12% + mancozeb 63% WP @ 750 g/ha) followed by IDM-2 (summer ploughing, soil treatment with *Trichoderma viride* @ 2.5 kg/ ha, seed treatment with pre-mix fungicide carboxin 37.5% + thiram 37.5% WS @ 2 g/kg seed, spray of thiophanate methyl 70% WP @ 600 g/ha) over control. Maximum (10.8 and 9.2%) and minimum (6.5 and 4.6%) foliar and root rot disease incidence was noted in flatbed planted soybean and BBF sown crop respectively. Minimum incidence of foliar and root rot disease was observed under the treatment IDM -2 as compared to control plot. Highest net return was recorded in BBF planted soybean and IPM-1 with the incremental net return of Rs. 13155 and 19250/ha respectively.

OP25(3C): Management of White Root Rot of Apple (*Dematophora necatrix*) in the Nursery and Orchard Through Fungicides

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Apple (*Malus* × *domestica* Borkh.) is one of the most popular species OF the Genus *Malus* cultivated in the temperate region around the globe. Due to favourable climatic conditions, north-western Himalayas in India comprising of Union territory of Jammu and Kashmir (J&K) and states like Uttarakhand (UK) and Himachal Pradesh (HP), is considered as the hub of apple cultivation. Productivity of apple orchards in India is very low in comparison to other apple-growing countries, mainly due to biotic and abiotic factors. Among the biotic factors, white root rot disease caused by a soil inhabiting fungus, *Dematophora necatrix* is a destructive disease in the nurseries as well as orchards of apple. Absence of resistant root stock and other management practices are either cumbersome or not sufficient for white root rot management; hence use of fungicides is an ideal option. Fifteen fungicides were evaluated against the mycelial growth of *D. necatrix* through poisoned food technique. Selected fungicides were tested for management of white root rot disease using seedling dip and drenching. The result of the poisoned food technique revealed that propineb, mancozeb, carbendazim, propiconazole and tricyclazole completely inhibited the mycelial growth of *D. necatrix*. In seedling dip treatment, only two fungicides *viz*., carbendazim and propiconazole were effective against *D. necatrix*. However, drenching with propineb, carbendazim and propiconazole were found to be effective in managing the white root rot of apple. Since carbendazim has been proposed to be banned by the Government of India and based on the cost-effectiveness of fungicides, for eradication of *D. necatrix* from infected nursery plants dip treatment for 30 min with propiconazole can be recommended to the farmers. Also, for the treatment of white root rot infected trees, soil drenching with propiconazole and propineb can be recommended.

OP26(3C): Innovative approach for control of Plant diseases through Phyllosphere microflora in maize

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The phyllosphere refers to the whole above-ground sections of plants that serve as microbial home. The caulosphere (stems), phylloplane (leaves), anthosphere (flowers), and carposphere (carposphere) are subsets of the phyllosphere. The influence of over use of chemical fungicides on the environment and food safety has become a serious problem with the rise of ecological agriculture. Phyllosphere microflora serves as a biocontrol agent as an alternative to chemical fungicides. The internal and exterior foliar microbiota serves a variety of purposes, including indirect pathogen protection via interactions between non-pathogenic bacteria and foliar plant pathogens. Antifungal action was discovered in volatile organic molecules generated by a *Bacillus subtilis* strain. They could potentially be important in carbon and nitrogen cycling. Microbial interactions in the phyllosphere provide pathogen protection as well as the release of phytohormones that encourage plant development and colonisation while also suppressing plant pathogen infection of tissues. Increase the disease resistance and productivity of agricultural crops by 30-37% on average. Bacillus spp. were isolated from the phyllosphere microflora and identified. This can be used as a foliar spray on plants to increase the beneficial microflora population and function as a primary defence.

OP27(3C): Developing a broad spectrum bioformulation against air, soil and seed borne diseases in commercial and horticultural crops

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Bioformulation refers to the as biologically active products which comprises of single or consortia of benign micro-organisms, that not only effectively control and eradicate diseases but also provides some essential nutrients that helps in combating the nutrient deficiencies in the crop. It accelerates the plant growth by developing a supportive rhizosphere and restores soil fertility by maintaining pH, moisture ,temperature etc.Amid growing population of the country it is really important to produce good yield and save crops from pathogen attack in order to meet the growing hunger demands. The aim of this study is to develop a broad spectrum bioformulation which can control air, soil and seed borne disease in some important and popular crops like chick pea ,lentil, mustard and mango.*Trichoderma harzianum* is a popular culturable fungi that compete with other harmful micro-organisms to obtain nutrition leading to their eradication. *Trichoderma harzianum* MZ407756, isolated from the fields of IARI, Pusa Campus ,New Delhi shows unimaginable potential to curb diseases such as wilt, *Aschochyta* Blight, white rust and mango malformation The in vitro and in vivo studies done in present investigation shows 98% reduction in malformation of mango, 92% decline in wilt in chickpea ,lentil ,90% decrease in blight of chick pea and 62% reduction in white rust of mustard. The SEM and GC-MS studies reveals that *Trichoderma harzianum* exploits other harmful micro-organisms to extract nutrients for its own survival which in turn kills them without causing any harm to the crop.

OP28(3C): Prevalence and management of blast of rice through fungicides

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Rice (*Oryza sativa L.*) is the most important cereal food crop grown in India. it occupies about 23.3% of gross cropped of the country. It plays vital role in the national food grain supply. Rice contributes 43% of total food grain production and 46% of total cereal production of the country. Total production of rice during 2020-21 is estimated at record 121.46 million tones. It is higher by 9.01 m. tones then the last five year's average production of 112.44 million tones. At present, change of climatic condition, cropping pattern, cropping intensity, crop management and change of spreading varieties of rice, blast disease caused by *Pyricularia oryzae*is Cav. (Syn. *Magnaporthe grisia* (Hebert) Barr. is becoming serious disease in all the rice ecosystem of India, particularly in Jharkhand State (Murlidharan, 2006, Barnwal *et al.,* 2012). Rice is prevalent in all survey areas of Jharkhand state. Lowest leaf blast disease severity of 8.0% was recorded when two spray of Tebuconazole (0.15%) was sprayed in rice plots, This treatment also recorded highest rice grain yield of 51.72 q/ha and neck blast disease incidence 6.0%. This treatment was followed by two spray of Kitazin @ 1 ml/lit. which recorded leaf blast disease severity of 13.4%, neck blast disease incidence of 9.4% and grain yield of 47.73 q/ha wheras, the control plots recorded rice leaf blast disease severity 34.9%, neck blast disease incidence 18.3 and grain yield of 41.89 q/ha.

OP29(3C): TrichoBARC, a novel *Trichoderma virens*(G2) formulation for the management of collar rot of chickpea

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Sclerotium rolfsii is a serious soil-borne pathogen infecting more than 500 crop plants. Being a broad host-range pathogen, it's very difficult to manage this pathogen through resistance breeding, and being soil-borne, fungicides are not very effective. Due to these reasons, *S. rolfsii* continues to cause serious losses several crops. Chickpea collar rot is such a disease for which there is no effective control measure available under field conditions. A novel formulation (named as TrichoBARC) based on amutant strain of *Trichoderma virens*has been developed and extensively field tested Simple seed treatment with this formulation significantly improved germination and plant growth, in addition to reducing collar rot incidence, and inducing early flowering. The efficacy of this formulation has been confirmed in repeated field trials in KVK and farmers' fields over more than five years.

OP30(3C): Encapsulated PGPR Bioactive loaded nano zinc formulation: A potential arsenal for the management of major foliar diseases of rice

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Two major diseases of rice viz. bacterial blight (BB) and brown spot (BS) have been reported to cause heavy losses in yield upto 70% and 90% respectively. Besides, in India, Zn is considered the 4th important yield limiting nutrient and accounts 10 Mha as Zn deficient in soil. In the recent study, Zinc oxide nanoparticles (ZnO NPs) and bioactives from PGPR were synthesized biologically to evaluate the antimicrobial efficacy against the pathogens of BB and BS of rice. As reported earlier, encapsulation of the nano ZnO provides better protection under harsh environmental conditions and also aids in target delivery of the synthesized products. Therefore, the nano Zn and the bioactives was encapsulated using a capping agent (Gum arabica). The effect of encapsulated nano ZnO loaded bioactive formulation (En-ZnO-B) at 100 percent concentration was tested against Bipolaris oryzae and Xanthomonas oryzae pv. oryzae causing brown spot and bacterial blight respectively.At 1000 ppm, encapsulated nano Zinc loaded PGPR bioactive formulation resulted satisfactory result for managing both the pathogens. After the satisfactory results in in vitro, a field experiment was conducted during the study and evaluated for other growth parameters.

OP31(3C): Post harvest management of banana anthracnose (*Colletotrichum musae* Berk. & Curt.) by integrating fungicides, plant-based products and biocontrol agents

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Banana (*Musa paradisiaca* L.) is an important commercial fruit crop in tropical and sub tropical regions which can be grown round the year. It is a staple food for millions of people. The fruits are used both for cooking and post harvest products like chips, flour, jam, jelly and drinks. The post-harvest loss is 25 to 30% due to its perishable nature, improper handling, lack of storage and post harvest diseases. Fruits suffer from many serious diseases such as anthracnose, crown rot, finger rot, white rot, cigar end rot etc. The fungus *Colletotrichum musae* can cause both crown rot and anthracnose. In this study, for its management different fungicides, essential oils, phytoextracts and biocontrol agents were tested by fruit dip method. Results revealed that fruit treatment with carbendazim 12% + mancozeb 63% WP tested at 0.05% concentration gave minimum disease intensity (11.54%) and it was significantly superior over control and remaining other treatments. For obtaining residue free organic banana fruits cinnamon oil at 0.1% and *T. harzianum* (106 cfu/ml) were found best which minimized 36.87 and 52.89 per cent disease, respectively. Minimum weight loss of 9.31% was recorded in carbendazim 12% + mancozeb 63% WP and shelf life of fruits treated with these was also more (10 days) as compared to the untreated control fruits (3 days). Therefore, by economical and eco-friendly disease management shelf life and storage time of banana fruits were increased and maintained the quality of fruits.

OP32(3C): Nematicidal activities of zno formulations including zno *nanoparticles* against root-knot nematode, *Meloidogyne incognita*

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Plant nematodes are a major problem in qualitative as well as quantitative crop production worldwide, causing about the US $125 billion loss per year worldwide. In India, the estimated annual crop yield loss due to plant nematodes is 21.3 percent, which is equivalent to about 102039.19 million or $ 1.58 billion, and losses in 19 most common horticultural crops are 23.03 percent amounting 50224.98 million. Among the plant nematodes, the root-knot nematode is a serious threat, which formed galls/knots and causes considerable yield losses. It has been estimated that global losses to the *Meloidogyne incognita* amount to $78 billion worldwide. Nematicides are widely used for control of this nematode pest all around the world. Due to alarming health concerns and repetitive application requirements problems, a possible alternative strategy as part of INM is the need of the day. Hence, present study on the nematicidal activities of the various formulations of ZnO including ZnO nano particles synthesized through chemical and biological methods on egg hatching and *M. incognita* (J2) mortality *in vitro* were evaluated. Among the tested formulations, T2 and T3 were found promising to inhibit the egg hatching as well as mortality of *M. incognita*. It is concluded that T2 and T3 have high antagonistic/nematicidal activities. These promising treatments can be considering for evaluation on *in planta* as well as larger scale in field.

OP33(3C): *In vitro* evaluation of potential homeopathic drugs against stem rot of groundnut *caused by Sclerotium rolfsii* Sacc.

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Stem rot caused by *Sclerotium rolfsii* is a common major disease of groundnut (*Arachys hypogea* L.) in India. The efficacy of 33 different homeopathic drugs at different potencies was evaluated for their anti-fungal activity against *Sclerotium rolfsii* causes stem rot in groundnut. The potential homeopathic drugs were screened based on their effect on mycelial inhibition, sclerotial reduction and other growth parameters based on *in vitro* studies. Among the tested homeopathic drugs, *Chelidonium*@30C (88.88%) and *Colchicum*@1000C (82.21%), *Thuja occidentalis*@200C (73.33%) were predominantly inhibiting the mycelial growth and sclerotial reduction over the control by agar well diffusion method. All the effective homeopathic drugs were inhibiting the mycelial growth, sclerotial germination, delayed the initiation of sclerotia and decreased the production of the number of sclerotia and also delayed the maturity of sclerotia when compare to control. It is widely recognised that homeopathic drugs use for plant pathogens is the most important alternative for the future and can be exploited within the frame work of integrated disease management. The present study is mainly focussed to study and identify the potential homeopathic drugs against *Sclerotium rolfsii*.

OP34(3C): Evaluation of fungicides and bioagents for management of anthracnose of greengram

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The present research paper work was carried out at Department of Plant Pathology, N. M. College of Agriculture, Navsari Agricultural University, Navsari (Gujarat) during the year 2020-2021. Green gram [*Vigna radiata* (L.) Wilczek] is often attacked by anthracnose caused by *Colletotrichum lindemuthianum* (Sacc. & Magnus) Briosi & Cavara. The efficacy of fungicides and bioagents, which found effective *in vitro* were evaluated in pot conditions. Eight treatments including fungicides and bioagents were evaluated in pot condition as a seed treatment and foliar spraying. Minimum per cent disease index was recorded in carbendazim 50 WP @ 1.0 g/l (10.70%) followed by propiconazole 25 EC @2.0 ml/l (13.34%) and captan 70% + hexaconazole 5% 75 WP @ 0.6 g/l (26.22%) for two foliar sprays at 15 days interval. While, in seed treatments minimum per cent disease index was recorded in seed treated with *T. viride* @ 10 g/kg seeds (14.44%) followed by seed treated with carbendazim 12% + mancozeb 63% 75 WP @ 3.0 g/kg seed (24.03%) and mancozeb 75 WP @ 3.0 g/kg seed (35.55%). Maximum disease index was recorded in control (69.86%).

OP35(3C): Development and adoption of modules for management of maydis blight of maize in India

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Maydis leaf blight (MLB), also called as southern corn leaf blight (SCLB) caused by necrotrophic plant pathogen *Cochliobolus heterostrophus* (Anamorph - *Bipolaris maydis*) is a major disease of maize worldwide. The disease is prevalent across maize growing regions of India, especially in northern parts of the country. Present investigation was carried out to manage MLB by designing and adopting three approaches/modules [organic, chemical, and integrated disease management (IDM)] in three locations, namely Ludhiana (Punjab), Karnal (Haryana) and New Delhi (Delhi) during *kharif* 2019 and 2020. In the first approach, seed treatment with *Trichoderma harzianum* formulation [@10g/kg seed] was done with foliar spray of *Pseudomonas flourescens* [@10g/l water at 45 days after sowing (DAS)] followed by foliar spray of cow urine (20%) at 60 DAS. In second approach, seed treatment was done with Thiram (3g/kg seed) followed by foliar spray with Mancozeb 75 WP (2.5g/l water) at 45 DAS and then foliar spray with Azoxystrobin 18.2% w/w +Difenoconazole 11.4% w/w SC @1 ml/ l water at 55 DAS. In third approach, seed treatment with *T. harzianum* formulation [@10g/kg seed] and foliar spray of *P. flourescens* [@10g/l water at 45 DAS] were done followed by foliar spray of Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC@1 ml/ l water at 50 DAS and also foliar spray of cow urine (20%) at 60 DAS. The treatments were compared with the standard control of foliar spray of with Mancozeb 75 WP (2.5g/l water) at 45 and 55 DAS. All the modules could reduce MLB disease significantly, and overall performance of the modules varied with the locations due to difference in environmental conditions. The chemical module was found most effective followed by IDM at Ludhiana and Karnal where as standard control was most effective at New Delhi.

OP36(3C): Plant endophytic *Firmicutes*: an unexplored antifungal prokaryotic communities for rice blast suppression

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Rice blast incited by *Magnaporthe oryzae* is a well known threat for global rice production. Endophytic microbes have proven to play a major role in promoting rice plant health by producing secondary active compounds against *Magnaporthe oryzae*. We have isolated nine isolates of endophytic *Bacillus* (Firmicutes) from rice cultivars Pusa Basmati 1, Pusa Basmati 6, BPT5204, HPR2143 planed in India, and two other *Bacillus* species from wild cactus (*Euphorbia trigonas*) from Cameroon. Based on morphological characters and 16S rRNA gene sequencing the isolates were identified as *Os*Enb-ALM-B18 (*Bacillus subtilis*), *Os*Enb-ALM-B34 (*B. altitudinus*), *Os*Enb-PLM-S4 (*B. subtilis*), *Os*Enb-PLM-S6 (*B. subtilis*), *Os*Enb-ALM-D28 (*B. flexus*), *Os*Enb-PLM-L10 (*B. licheniformis*), *Os*Enb-PLM-L12 (*B. velezensis*), *Os*Enb-PLM-L14 (*B. circulans*), *Os*Enb-PLM-L34 (*B. siamensis*), RA37 (*B. amyloliquefaciens*) and RR10 (*B. megaterium*). Seed priming with the endophytic *Bacillus* species in rice cv. Pusa Basmati-1 showed growth promotion ability with enhancement in root and shoot length. *In vitro* dual culture confrontation (secreted metabolites) and volatile mediated inhibition assays with endophytic *Bacillus* spp. against *Magnaporthe oryzae* revealed 20-75% and 9-34% inhibition of mycelial growth, respectively. An in-depth study to identify strain-level secondary active compounds secreted by the endophytes is also in progress. Our study indicates that endophytes for managing rice blast disease will pave the way for eco-safe agricultural production with minimal pesticide application.

OP37(3C): Genomic analysis of rice phyllosphere adapted antimicrobial bacterium, *Pantoea agglomerans*

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Pantoea, a Gram-negative bacterial genus belonging to the family*, Enterobacteriaceae* is among the ubiquitous prokaryotic organism in plant niches. One of the species, *Pantoea agglomerans* strain PPA_1b isolated from rice phyllosphere samples collected from Almora, Uttarakhand, India showed antimicrobial activity against *Magnaporthe* and *Xanthomonas oryzae* pv. *oryzae*. We sequenced the whole genome of *Pantoea agglomerans* PPA_1b by adopting short-read sequencing technology (Illumina HiSeq 150 X 2 bp chemistry). A total of 7.1 Gb data was generated with 52.5 million reads. The reads were *de novo* assembled into three scaffolds with an N50 value of 3.89 Mb. The genome size was estimated to be 4.44Mb with a GC content of 57.1%. The genome annotation revealed 4297 protein-coding sequences. With regards to biochemical pathways, the genome analysis revealed a total of 133 biochemical pathways among which seven were linked with the biosynthesis of polyketides (PKS) and nonribosomal peptides (NRPS). In particular, polyketide sugar unit biosynthesis, biosynthesis of siderophore group nonribosomal peptides, and biosynthesis of vancomycin group antibiotics were detected in the PPA_1A. Additionally, a total of 23 biosynthetic pathways for secondary metabolites such as Puromycin, Phenylpropanoids, and Diterpenoid were found. Further, the genome data generated along with the metabolome analysis would elucidate the biocontrol mechanism of epiphytic *Pantoea* strain against rice pathogens such as *Magnaporthe oryzae* and *Xanthomonas oryzae* pv. *oryzae*.

OP38(3C): Studies on Integrated disease management on growth components and seed quality parameters against Stemphylium blight of onion

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Onion (*Allium cepa* L.) is known to be affected by many biotic and abiotic stresses during seed production. Among them Stemphylium blight caused by *Stemphylium vesicarium* (Wallr.) is one of the important disease which causes considerable losses in seed crops as well as bulb crops. It is more prevalent in warm and humid conditions. In the present investigation, integrated disease management against stemphylium blight was undertaken using different chemicals, biocontrol agents and plant products for the quality seed production. Effect of biocontrol agents such as *Trichoderma harzianum, Pseudomonas fluorescens, Talaromyces and Bacillus subtilis* were studied against *Stemphylium vesicarium* using dual culture technique. Invitro fungicides test was conducted to study the efficacy of six different fungicides viz., Metiram+Pyraclostrobin, Mancozeb, Difenconazole, Zineb, Tebuconazole and Kitazine and three plant products *Lantana camara*, *Pongamia pinn*ata and *Azadirachta indica* under laboratory condition. The efficacy of same fungicides and botanicals were evaluated on bulb and seed crop of Punjab naroya and Pusa red cultivars during Rabi season (2019-2020 and 2020-2021). Among biocontrol agents, *Trichoderma harzianum* was found to be most effective. Studies on invitro fungicides test showed that, fungicides such as tebuconazole and difenoconazole were found better in growth inhibition of *Stemphylium vesicarium*. The same fungicides were found effective than others during foliar application under field condition in the management of stemphylium blight disease. Among the growth components and seed quality parameters studied, tebuconazole and difenoconazole applied plants/seeds showed better results compared to other treatments.

OP39(3C): Selection of wheat (*Triticum aestivum*) of wheat for (*Puccinia striiformis*) resistance

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The article presents experimental data of wheat *(tríticum aestívum)* varieties on *(puccinia striiformis)* resistance. The success of breeding soft wheat varieties with long-term protection from yellow rust *(puccinia striiformis)* depends entirely on the source material, which should be characterized by genetic diversity, a combination of different resistance genes that restrain the development of the pathogen; the correct choice of genotypes for crossing, the genetic markers used, favorable weather conditions for the development of diseases, the composition of an artificial infectious background for selection.

3D: Biosecurity, Quarantine & Biosafety

Keynote Lectures

KN01(3D): National plant quarantine system: India

Dr. Ravi Prakash
Ministry of Agriculture & Farmers Welfare, Directorate of Plant Protection, Quarantine & Storage, Faridabad, Haryana, India

KN02(3D): Plant protection and biosafety: strategies and challenges

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Plant protection is the science and practice of managing pests, plant diseases, weeds and other pest organisms that damage agricultural crops and forestry. Plant protection measures are carried out to reduce yield losses as well as for quarantine purposes. The major thrust areas of Plant Protection in India are promotion of integrated pest management, ensuring availability of safe and quality pesticides for sustaining crop production from the ravages of pests and diseases, streamlining the quarantine measures for accelerating the introduction of new high yielding crop varieties, besides eliminating the chances of entry of exotic pests and human resource development including empowerment of women in plant protection skills. A wide variety of individual measures - with varying ecological, economic and socio-economic impacts - are available for keeping diseases, pests and weeds below the economic threshold. Biosafety is usually defined as the discipline addressing the safe handling and containment of infectious microorganisms and hazardous biological materials. The practices of safe handling of pathogenic micro-organisms and their toxins in the biological laboratory are accomplished through the application of containment principles and the risk assessment. The biosafety is the prevention of large-scale loss of biological integrity, focusing both on ecology and human health. The international Cartagena Protocol on Biosafety, deals primarily with policies and procedures implemented to ensure the environmentally safe application of modern biotechnology in Agriculture with special reference to living modified organisms (LMOs). Biosafety concepts include Biosafety Containment Levels (BSL 1-4 & ABSL 1-4) and infectious agent Risk Groups (RG1-4). The Environment Protection Act (EPA), 1986 provides guidelines on the handling, research, application and technology transfer of GMOs. The overall biosafety concept needs to be updated under changing risk situation, especially if new working methods are adopted, new organisms are handled, new items of equipment which are relevant to biological safety are introduced and existing facilities replaced/ changed. Thus, the concepts of biosafety are guided by international regulations to be best fitted into national scenario. Appropriate stranguries are required as per existing conditions to address the challenges in Biosafety in plant protection at National level. The involvement of all the sectors responsible at National levels are required to harness the potential benefits to improve public health, enhanced international trade, improved agricultural production and environment protection.

KN03(3D): Plant biosecurity in the Asia-Pacific region

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After the recent emergence of Covid -19 and its impact on human life and economy the subject of Plant biosecurity assumed greater importance for also ensuring agricultural biosecurity worldwide. The Asia-Pacific comprising 46 countries is seeing frequent outbreaks and spread of devastating pests such as rice brown plant hopper, wheat rust, late blight of potato, fruit flies, etc. threatening food security and livelihood and also impacting the agricultural trade. Efforts are being made to apply control measures and to undertake surveillance programmes for important pests. The Regional Plant Protection Organization viz., Asia-Pacific Plant Protection Commission and Pacific Plant Protection Organization are playing important roles in conjunction with National Plant Protection Organizations to minimize the pest threat in the region, though new pests such as Tropical race 4 of *Fusarium oxysporum* f. sp. *cubense* on banana, *Tuta absoluta* on tomatoes, *Magnaporthe oryzae* pathotype *Triticum* on wheat, *Spodoptera frugiperda* (fall Armyworm) on corn etc., continue to emerge and spread in certain countries. Pests such as South American Leaf Blight, devastating on rubber in Latin America has high potential to be introduced and spread in the region. The challenges in managing transboundary pests in the Asia-pacific region stems from the very fact that the member countries fall under different categories of development i.e. developed, developing and the least developed. This has a direct bearing on their resources and capacity and hence the operational quality in dealing with the problem. This poses a huge challenge in harmonising the quarantine norms to combat the transboundary movement of pests in the Asia-pacific region. Monitoring of emerging pests through surveillance and implementation of Standards for compliance to Sanitary and Phytosanitary Agreement of WTO, stricter quarantine measures and capacity building on various aspects including emergency measures to tackle outbreaks are the key challenges for ensuring biosecurity in the region. The Regional Organizations like Asia Pacific Association of Agricultural Research Institutions and many national and international research, development and donor agencies are engaged in working towards various aspects of Plant Biosecurity in the region.

KN04(3D): Understanding Biosecurity challenges and opportunities for creativity

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KN05(3D): Plant Biosecurity in Sri Lanka

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Invited Lectures

IL01(3D): Role of plant biosecurity diagnostic networks and capacity development in biosecuring agriculture

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The rush to global market systems that connect countries with well-developed plant biosecurity infrastructure to countries with poorly developed and ineffective plant biosecurity infrastructure will continue to have consequences of spread of pests. The role of diagnostics for detection of pests which threaten biosecurity is well established, with increasing use of sophisticated high-throughput and potentially mobile systems. Early detection and rapid response are crucial in any effort to reduce the risk of new and emerging biological threats to crops. Accurate, timely and secure communications are essential for the effective response to plant health emergencies. Just as communication networks, diagnostic networks are available in different countries to ensure biosecurity of crops. The United States of America has established the National Plant Diagnostic Network (NPDN) and it works with state and federal agencies to ensure quick, accurate and secure conveyance of information about new detections. Through NPDN's communications system, diagnosticians have access to expertise wherever it exists. Among the deployed technologies underlying NPDN's capabilities are web-enabled microscopy and video conferencing to facilitate collaborative diagnostics. NPDN labs follow standardized protocols for data acquisition and storage and practice secure communications to ensure that information of potential regulatory concern is not released inappropriately. Australia has established the National Plant Biosecurity Diagnostic Network (NPBDN). The NPBDN is the nationally integrated network for plant diagnosticians in Australia and plant diagnosticians involved with this network are located in every state and territory. Diagnostic services are provided from cities and regional centres in most of Australia's major agricultural production areas. Similarly European Union (EU) has projects on crop biosecurity since 2004 and Network of Excellence on Plant and Food Biosecurity aims to establish a virtual Centre of Competence to prevent, respond to both intentional and unintentional biosecurity threats to EU agriculture, farming and agro-food industry. India also need to establish a strong network of interconnected accredited laboratories able to quickly diagnose new pests/ races/biotypes; provide effective tools and protocols for use by inspectors for quarantine and phytosanitary controls; enhance surveillance capacity already in place and develop improved surveillance models and early warning surveillance systems; identify and prioritise areas where more research is needed and suggest future investment needs; raise awareness of the issue of crop biosecurity, to enhance preparedness. Diagnostics for indigenous diseases in the context of biosecurity have been largely ignored to date and will require further development. The plant biosecurity diagnostic networks and capacity development is essential for global plant biosecurity.

IL02(3D): Equivalence in phytosanitary risk management strategies for effective seed trade

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Seed movement across territorial boundaries is the most important aspect of seed trade. Today, seeds are produced in one country, shipped to another for processing and then sown in another. This complex movement of seeds across country borders requires a globally equivalent system to safeguard against phytosanitary risks. India has an elaborate and detailed regulatory regimen to mitigate phytosanitary risks. However, these checks and balances need to be aligned with the recent International Standards for Phytosanitary Measures (ISPMs) adopted by the Commission on Phytosanitary Measures (CPM), which is the governing body of the International Plant Protection Convention (IPPC). The lecture/ presentation will focus on showcasing the present-day scenario of seed movement and will also address the gaps that exist in the Indian phytosanitary regulation regimen when compared to the guidelines provided under ISPMs. Concepts such as seed as a pathway, purpose of import, seed treatment, systems approach, equivalence of phytosanitary measures and utilization of equivalent testing protocols will be discussed. Specific examples will be provided to highlight the areas where regulatory reforms can be initiated utilizing the existing global resources such as the ISPM recommendations and International Seed Federation pest list and ISHI veg. protocols. Also, recommendations for adopting a collaborative approach towards disease evaluation for phytosanitary risks will also be discussed.

Oral Presentations

OP01(3D): Investigation of germination and conidial trap forming ability of a nematode-trapping fungus *Drechslerella brochopaga* in fungistatic and fungicidal soil environments

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Nematode-trapping fungi are a group microorganisms that form special adhesive and mechanical infection structures to capture and kill the nematodes. Heavy losses caused by plant parasitic nematodes resulted in an interest to use nematode - trapping fungi as bio control agents of plant pathogenic nematodes. *Drechslerella brochopaga* Drechsler, *a* strangulating nematode-trapping fungus was studied for their adoptability to soil fungistasis and its tolerance against some common fungicides. *D. brochopaga* was isolated from horticultural soil of Baberu, Banda. The fungus was found to effectively capture and kill the 96.4 per cent second stage juveniles of *Meloidogyne incognita* by its three celled constricting ring produced on hyphae within 3 days. The study of adaptability of *D. brochopaga in* various agricultural and horticulture soil of Banda revealed that this fungus is frequently formed conidial traps in vicinity to soil and parasitized the nematodes. The study of the tolerance and sensitivity of conidia of *D. brochopaga* with soil amended with different concentrated of common fungicide indicate that this fungus showed various range of tolerance/sensitivity with common fungicides. Conidia of *D. brochopaga* were found most sensitive to chlorothalonil and propineb at 10 µl ai kg-1 concentration followed by carbendazim, mancozeb, copper oxychloride, copper sulphate, thiram which inhibited the conidial trap formation at 25 mg/µl ai kg-1 ppm. Tebuconazole completely inhibited the fungus at 100 µl ai kg-1 whereas Metalaxyl and Sulphur completely inhibited the fungus at 300 µg ai kg-1. *D. brochopaga* showed tolerance to propiconazole up to 300 mg ai kg-1 but the fungus was completely inhibited at 400 mg ai kg-1. The result of the present study indicate that *D. brochopaga* is sensitive to most of the fungicides tested under the present study. The fungus showed tolerance to Metalaxyl, propiconazole and Sulphur below 200 mg/µl ai kg-1 concentration of in soil.

OP02(3D):Plant Quarantine: Significance in Plant Diseases Management

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Plant quarantine can be defined as legal restrictions promulgated by governments to regulate the movement of plants, planting materials, plant products, soil, living organisms, etc. with a view to prevent inadvertent introduction of exotic pests, weeds and pathogens harmful to the agriculture or the environment of a country/region, and if introduced, to prevent their establishment and further spread. Quarantine is accomplished through prohibition, interception, and elimination of pests, diseases and weeds at pre entry, entry and post entry points of consignment. The Destructive Insects and Pests Act, 1914 governs plant quarantine regulations in the country. The import of agricultural commodities is presently regulated through the Plant Quarantine (Regulation of Import into India) Order, 2003.The specified planting materials for propagation require growing under Post Entry Quarantine (PEQ) for a specified period. Pest Risk Analysis (PRA) is required as a defensive approach by internationally recognised standards. As per the PQ Order, 2003, all plants/plant material must undergo a pest risk analysis prior to being imported into India. Agricultural commodities intended for export require phytosanitary certificate, which is an official document indicate that the commodity is free from pest/diseases and meet specified phytosanitary import requirements of importing countries. Thus, quarantine not only helps to ward off the threats of exotic pests, but also aim to eliminate and prevent further spread of pests/pathogens with restricted distribution within the country. Plant quarantine is thus designed as a safeguard against harmful pests/pathogens exotic to a country or a region.

OP03(3D):Post-entry quarantine inspection of exotic crop germplasm for prevention of entry of pests of quarantine significance into India

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Post-entry quarantine (PEQ) is growing of plants in isolation for any specified period in a glass-house, a facility, area or nursery and /or holding of biological control agents and beneficial organisms under a contained facility. PEQ growing of crop germplasm and inspection is of paramount importance for the biosecurity of the country as some of the pests might escape laboratory detection during quarantine processing and spread. During 2017 to 2021, ICAR-NBPGR, Regional Station, Hyderabad conducted PEQ inspection of 27,782 accessions of exotic crop germplasm grown in private organizations (26,488), public organizations (97) and NBPGR greenhouse (1197) during active crop growth period. During the inspection, plant samples exhibiting suspected symptoms were collected and tested for pathogen detection using standard blotter test, serological and molecular techniques. Some important interceptions were leaf spot of okra (*Cercospora abelmoschi*) from USA, bean common mosaic virus on bambara groundnut from Ghana, arabis mosaic virus, bean pod mottle virus, soyabean mosaic virus and tomato ringspot virus on soybean from USA and loose smut (*Ustilago nuda*) on barley from Netherland. In addition, maize showing suspected viral symptoms in accessions imported from several countries; downy mildew (*Sclerophthora* sp.) from Philippines, South Africa and Thailand; Southern corn leaf blight (*Drechslera maydis*) from Italy, Mexico, Philippines, South Africa, Thailand and USA were uprooted and incinerated. Plant suspected with viral disease on barley (Netherlands), bitter gourd (Thailand and Taiwan), sponge guard (Vietnam), were rogued out and incinerated as several viruses are listed as regulated pests in Plant Quarantine (Regulation of Import into India) Order 2003. Thus, PEQ inspection facilitated in preventing the entry and spread of exotic pathogens in India.

Session 4:
Commercial plant pathology

4A. Entrepreneurship, industry and business incubation in plant pathology and
4B: Smart agriculture with precision plant protection

Keynote Lectures

KN01(4A&B): Automation in crop diagnostics – a case study from Industry

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Global Seed Molecular Analytics Scientist, Bayer Cropscience

India is the 6th largest seed market in the world and in the past two decades, it has emerged as a leading vegetable seed production hub. The Indian seed industry is backed by strong seed improvement programmes that gains from both the public and private sector initiatives. Parental seed quality improvement can significantly enhance export-oriented hybrids seed production. One of the quality parameters that is in focus is disease free seed/ plant for production as phytopathogens can be a significant quarantine barrier for seed trade globally. The rapid development of new molecular (nucleic acid-based) diagnostic methods such as real-time PCR with nested, multiplex, isothermal amplification, DNA and RNA based probes provides novel tools for detection of plant pathogens at various level of export-oriented seed production. Robust implementation of Molecular diagnosis for seed and tissue samples of high importance pest like Tomato Brown Rugose Virus and pospiviroid that has been quarantined by EU and USA provides a systematic approach towards producing clean seeds. The diagnostic aspect of disease testing has been prioritised by us using globally aligned sensitive real time PCR method. The methods reliability and reproducibility were enhanced by automation. The detailed aspects of sample processing for nucleic acid extraction, precise liquid handling during extraction and PCR by robotic liquid handling systems to obtain end to end automized molecular method to detect low pathogen titre with enhanced capacity (4X) using multiplexing will be discussed for both on-site s and off-site screening. The application of these technologies in plant pathology has greatly improved our ability to detect plant pathogens from symptomatic and asymptomatic samples which increases our understanding of their ecology and epidemiology and to produce best in class quality seeds. With adequate policy support, such expertise developed by companies engaged in export-oriented seed production can be utilized more effectively to mitigate phytosanitary risks.

KN02(4A&B): Tailored solutions for crop management – integrated approach towards disease management

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Agriculture in India is very diverse, and our varied Agro-climatic situations makes it furthermore challenging to manage the crop health. Management of plant diseases, especially, is always a big challenge under complex situations and tailored solution is the best approach to manage the crop health in a more sustainable way. Farmers have one of the most challenging jobs: feeding the world's growing population efficiently and sustainably. If they make one wrong choice, there is negative impact on productivity and profitability which leads to influence their livelihood for the entire year. There choices range from picking the right hybrid seeds, planting time, agronomic practices, right pesticides to manage the harvest for maximum benefit. In the years to come, we'll see increasingly tailored solutions that will integrate all available tools to help farmers, by simplifying tough choices, minimizing risks, and maximizing prospects for successful harvests. And ultimately, these tools will play a significant role in the world's efforts to ensure a stable food supply and healthy planet for future generations. While farmers will always have to battle against weeds, pests, plant diseases and unpredictable weather conditions, for each farmer and each region of the world. Threats to crop productivity are constantly evolving, that's exactly why farmers always need new modes of action and technology without exhausting the earth's natural resources. Bayer Crop Science has paved a new intersection by bringing together market-leading capabilities in biology, breeding, chemistry, biologics and data science. It offers a broad range of hybrids, chemicals and data-driven solutions to help farmers safely and responsibly protect their crops from pests such as weeds, economically important insects, and diseases. We also work collaboratively with farmers to offer tailored solutions – including agronomic recommendations - based on the specific needs of their fields, crops, and soil to defend against pests, help ensure productive harvests and improve soil health, all while protecting our natural resources.

KN03(4A&B): Entrepreneurial integrated approaches for healthy and safe food

M.S. Reddy*

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Agriculture is becoming more integrated in the Agro-food chain and the global market, while environmental, food safety and quality, and animal welfare regulations are also increasingly impacting on the sector. Plant pathologist needs an understanding of the organisms and agents that cause disease as well as an understanding of how plants grow and are affected by diseases. There are ventures in agricultural business such as farm to table ventures and mega-ventures such as investing in technology to enable more free-market opportunities for rural farmers. Today's agricultural entrepreneurs are developing innovative ways to revolutionize the entire food chain. They are at the forefront of reducing food loss and waste, increasing crop yields, improving market access, developing novel technologies, and increasing sustainable farming practices across the globe. In addition to the traditional goals of making a profit and taking care of the natural resources so that the business can continue, sustainable agriculture puts a special emphasis on the social aspects of agriculture. Consumers are becoming more concerned about where their product comes from, who raised it, and what production methods are used. Farmers are recognizing the benefits of raising a local product for their communities and in reinstating the consumer's connection to the land that has been lost in many cities and suburbs. Writing a business plan can uncover roadblocks to profitability, including start-up costs and marketability and explore opportunities and forge partnerships to contribute to the sustainable development goals of no poverty, no hunger and climate action to develop climate-smart villages, digital agriculture and the use of information technologies in agriculture. A critical and crosscutting theme in humanitarian aid and resilience programs in collaboration with other organizations is the key for successful entrepreneurship. My talk will focus on foundational production skills, business knowledge, and personal development to establish the next generation of resilient farm enterprises for healthy and safe food.

KN04(4A&B): Changing disease complex scenario & crop protection market in India

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Globally the Population & nutritional requirement is increasing, but per capita farm land availability is reducing year by year. Technological innovations in agriculture have played & further going to play key role to meet the Quantity & Quality of the agriculture produce. Technological advances like Mechanization , fertilizer, crop protection & breeding & Plant biotechnology are playing very important role in increasing the production and productivity of agricultural crops. Among them Crop protection also have key role to play under the challenging environment conditions of Agriculture. In last 50 years the Global cropped area has increased in some developed countries, but the overall increase was insignificant. Approximately threefold increase in agricultural production is attributed to increase in productivity through adoption of modern technologies in mechanization, fertilizers, agrochemicals-crop protection, and bio technology In India, the demand for food will continue to rise significantly in the future as the population grows. Overall demand for food grains to increase from 192 million MT (2010) to 345 million MT (2030).To meet this demand, production of food grains needs to increase by 5.5 million tons annually . Constant increasing yield is required to meet production demands.
Global CPC Industry has grown @ CAGR of 8.2% (2010-14) while growth over last year is 4.5% . Increasing awareness in Herbicides coupled with number of new introductions on Rice, Cotton & Soybean; Sucking pest segment of Insecticides make up larger share ; Strobilurins are the growing segment in fungicides Emerging trend is towards environmentally safer & user friendly formulations Ex WG,SC,EW,FS etc. The disease changing pattern and its complexity on various crops like Blast, sheath blight, Bakkane , false smut, sheath rot & grain discoloration on rice & Rust, leaf spots & boll/pod rot in Soybean and Cotton etc are emerging new segments.Various Game Changers like mobile networking & Banking, Micro Banking, Use of Apps, Progressive farmers communities, Internet etc are changing the Indian Agriculture as well as Agrochemical Industry.

Invited Lectures

IL01(4A&B): Synthesis and application of metallic nanoparticles for combating maize diseases

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Excessive and continuous use of conventional pesticides poses an adverse impact on the environment. Taking into account of numerous setbacks such as high toxicity, non-biodegradable nature, and residual activity of the chemicals, a novel method of disease management has been executed in maize using copper nanoparticles (CuNPs). Initially, CuNPs were synthesized by employing a chemical method where CuSO4 was used as precursor, NaBH4 and ascorbic acid as reducing agents, and polyethylene glycol 8000 (PEG-8000) as a capping agent. In another attempt, CuNPs were synthesized using fungi (*Trichoderma virens*, *Chaetomium globosum*, *Fusarium verticillioides*, *Bipolaris maydis*, *Macrophomina phaseolina*). CUNPs were characterized using Transmission Electron Microscope (TEM) and Fourier Infrared Transform Spectroscopy (FTIR) for particle size and the functional group associated with them, respectively. The synthesized CuNPs significantly inhibited three pathogenic fungi namely *Macrophomina phaseolina, Bipolaris maydis*, and *Fusarium verticillioides* at 20 ppm and *Rhizoctonia solani* at 80 ppm. Bactericidal property of CuNPs was also documented against *Erwinia carotovora* and *Ralstonia solanacearum*. *In vivo* evaluation of CuNPs against two diseases *viz.,* maydis leaf blight (MLB) and banded leaf and sheath blight (BLSB) resulted in a reduction of percent disease index (PDI). Seed treatment + foliar spray of CuNPs @ 300 ppm provided a significant reduction of MLB whereas BLSB disease was relatively less reduced. CuNPs were found counterproductive when tested against beneficial fungi and bacteria. However, a positive effect on soil enzyme activities *viz.,* dehydrogenase, urease, and alkaline phosphatase and maize seedling characters *viz.,* root number per seedling, root length, shoot length, fresh and dry weight.

IL02(4A&B): Nematode Problems in Agri-Horticultural Crops and their Management

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Phytonematodes are microscopic invertebrate animals often called as threadworms, eelworms or roundworms. They cause severe losses to economically important crops like vegetables, cereals, pulses, oilseeds, fruit crops, etc. They are distributed all over the world in different kinds of habitats and found in nearly every biological niche that supports life. Sasser and Freckman (1987) have indicated an annual crop loss due to nematodes on worldwide basis to the tune of $100 billion. The destructive plant- parasitic nematodes are one of the major limiting factor in crop production throughout India. Low production and productivity of vegetables are mainly because of biotic and abiotic stresses, among the biotic stresses nematodes also one of them. Large number of plant parasitic nematode is recorded from the rhizosphere of many crops like Root-knot Nematode (*Meloidogyne spp.*), Reniform nematode (*Rotylenchulus reniformis*), cyst nematode (*Heterodera spp.*), lesion (*Pratylenchus penetrans) etc.* They damage the crops not only by feeding on plants but also by interacting with various other organisms. These nematodes predispose the crops to fungal and bacterial pathogens, especially *Fusarium spp*., *Pythium*, *Rhizoctonia*, *Ralstonia solaneacearum*, etc. However, predisposition occurs due to mechanical wounding of the roots, rhizosphere modification and disruption of resistance mechanism caused by the nematodes. Such interactions aggravate the damage caused to the crop. Majority of the farmers remain unaware of nematodes as pests as no conspicuous aboveground symptoms are observed on the plants. There are many ways to identify nematodes by morphological and molecular tools. Hence nematode problems can be identified and various options of nematode management are available such as crop rotation, soil solarisation, use of bio-nematicides, botanicals and Integrated nematode management approach which can reduce nematode pest densities in the soil and increase crop yield. However, use of *Trichoderma viride, T. harzainum, Paecilomyces lilacinus, Calotropis procera*, marigold, neem has played a great role in controlling nematode population.

IL03(4A&B): A new era of biopesticide application in Agriculture

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Degeneration and deterioration of the quality, fertility, and efficiency of soil is continuously going day by day, with implications of soil erosion and climate change. The Indiscriminate use of chemicals causes resistance, resurgence, and residues. It also causes the elimination of natural enemies of pests. It disturbs the ecological balance, environmental degradation, and Pollution. Beyond the Economic, it enters the food chain. In order to overcome these challenges and meet the requirements for food and supplies, the productivity and sustainability of agricultural practices should be improved and novel and improved strategies must be needed. Enhanced agricultural productivity can be achieved in many ways, such as through increasing crop yield by providing manure and organic-based treatments, including the use of biofertilizers and biopesticides. The losses can be limited by the use of bioagents and bio growth promoters. Biopesticides, which are pest management agents based on living microorganisms or natural products, offer a great promise in controlling yield loss without compromising the quality of the product. Biopesticides are natural, biologically occurring compounds that are used to control various agricultural pests infesting plants in forests, gardens, farmlands, etc. There are different types of biopesticides that have been developed from various sources. This presentation underscores the utility of biocontrol agents composed of microorganisms including fungi, bacteria, viruses used for managing crop yield losses due to pest infestation. Biopesticides have several advantages over their chemical counterparts and are expected to occupy a large share of the market in the coming years.

Oral Presentations

OP01(4A&B): Digital technologies: Dramatically Changing Face of Plant Protection in India

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India has around 14 crores of farmers in more than six lakhs villages . Reaching out to them by any individual or institutions is impossible. This gloomy picture has been fortunately changing since 2015 due to modern technology. Digital tools are one of the most innovative crop protection tools of modern agriculture. Technologies like mobile application, artificial intelligence (AI) Internet of Things (IoT), big data, Robot, and predictive analysis among others have streamlined the crop protection system. Digitisation could help farmers in getting technology at their doorsteps eg- weather forecasting, prediction of diseases in advance, projection of insect attack, estimation of market prices etc. would be very helpful to the farmers. This has ensured holistic risk management of farmers and helped them to get the right price for their produce. With internet and mobile penetration at the level of 50% and 79% respectively, provide digitally enabled One Stop Solution to the farmers. Smart phone, Remote sensors, Satellites, Drones, and Artificial intelligence (AI) tools can monitor plant health 24/7. With the use of smart phones, one can take the technology to a large number of farmers inhabited in remote areas. Through the availability of smart phones, farmers can find the right solutions to their problems by downloading certain apps, or they can reach easily to companies and scientists like us by sending images regarding their problems to get the accurate solutions. Tools like artificial intelligence and object based recognition are being used to better assess soil life as well as detecting harmful microorganisms. Agrochemical spraying through Drone helped to fight highly mobile invasive pests such as Fall Armyworm and desert locusts efficiently and effectively. *F*armers can record pest and disease data, receive regional crop protection advice, and chat with knowledgeable experts. These digital tools help provide PEACE OF MIND to our farmers. It shifts mindsets to be PREVENTATIVE rather than CURATIVE

OP02(4A&B): Potential use of drought tolerant BCAs in arid agro ecosystem for plant disease management

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Organic farming not only ensures the health of the soil but also improves the quality of food. Release of nutrients from organic inputs is a result of mineralization process mediated by plant growth promoting microbes. Microbes stimulate the growth of the plants by increasing the nutrient availability, growth hormone production and disease suppression. Exploitation of these plant growth promoting microbes have supreme importance in organic agriculture. An experiment was conducted in the *Rabi* 2020-21 and *Kharif* 2021, before cultivation of cumin, mustard, mung bean and pearl millet field was prepared by mixing neem cake (@ 250 kg/ha) and *Trichoderma* (1kg/ha) as a preventive measure against soil borne plant pathogens. Seeds were also treated by consortium of biocontrol agents viz., *Trichoderma harzianum* and *B. tequlensis* (@4 g/kg) before sowing in both the seasons. Observations were recorded in cumin and mustard crops in a weekly interval for wilt, root rot and blight infestation following the standard scale of 0-9 score in Rabi season for both the crops. Prophylactic sprays of botanicals (extract of *Calotropis procera* 5%+neem oil 2%) with biocontrol agents alone or in different combinations were used for managing diseases in organic plots. In the *Kharif* season, mung bean was severely suffered by mixed infection of fungal and bacterial foliar diseases with the intensity of 25-55%. However, prophylactic spray schedules (in every fortnight) of neem oil and biocontrol agents alone or in combinations gave good results for managing diseases in organic plots. Native strains of beneficial microbes helps the crop plants to perform better specially under biotic and abiotic stress. Plant growth promoting microbes appeared to be the most exploited microbes than any other. Many case studies have shown that *Bacillus* and *Trichoderma* are the most commonly studied BCAs worldwide and are the most effective in controlling diseases caused by bacteria, fungi, and nematodes. The main problem in usage of these BCAs is development of suitable formulations and delivery systems. Further, the legal issues associated with production and sale of these bioagents add to this hurdle. It is these problems which have hindered the wide exploitation of these microbes as demonstrated by negligible number of plant growth promoting microbes registered in India. Thus, the proper production technology and identifying the suitable delivery method with easing of the legal issues for registration of the bioagents will help in long way in managing the diseases in organic cultivation.

OP03(4A&B): Investigation, exploration and utilization of phytobiomes for effective management of Rhizoctonia sp. infecting Zea mays L

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Investigations were carried to study the soil samples from maize fields under monoculture as well as under rotation practice with cucurbits-potato-wheat-maize during Kharif season viz., 2019-20. The culturable component of phytobiomes was examined to study the changes in microbial diversity with progress of crop cycle. Samples were collected at different stages of growth viz., V_0 (pre-sowing), V_E (post emergence), V_9 (pre-flowering), V_T (post-flowering) and R_6 (pre harvest). The soil samples from each phytobiome were grown on Potato dextrose Agar (PDA Plate) by serial dilution method. The fungal and bacterial colonies were microscopically examined to characterize the culturable component**.** At pre sowing stage the fungal community was mainly saprophytic, however under rotation, dominant bacterial community was *Actinobacteria, Streptomyces, Lysobacter* and *Cyphellophora*. The frequency of soil borne pathogenic fungi was comparatively higher in monoculture fields than the rotation fields. The post emergence microbial diversity was mixed; however, colonies of pathogenic genera *Rhizoctonia, Fusarium* and *Bipolaris* were observed more. At pre-flowering stage inoculum load of pathogenic fungi was on rise in monoculture phytobiomes in comparison to rotation phytobiome. Pathogenic fungi were observed in abundance; however, pathogenic potential was poor. Only two fungal genera viz., *Rhizoctonia* and *Bipolaris* were observed. The findings revealed that, inoculum load of pathogenic soil borne fungi develops during the pre-flowering stage to post flowering stage and effective management can be applied during these stages to manage the pathogen

OP04(4A&B): Compatibility of Trichoderma sp. and Pseudomons sp. with agro chemicals

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Fungicides/combination of fungicides, insecticides and herbicides were tested for their compatibility with *Trichoderma harzianum* and *Pseudomonas fluorescens* under *in vitro*. Carbendazim @ 50, 100, 250 and 500 ppm, and copper oxychloride @ 1000, 1500, 2000 and 2500 ppm concentrations, completely inhibited growth of *T. harzianum*. Methyl-o-demeton at all the four concentrations i.e. @ 250, 500, 1000 and 1500 ppm were found incompatible with 94.44% growth inhibition. However, chlorpyrifos and cartap hydrochloride @ 250 and 500 ppm were moderately compatible. Quizalofop-ethyl at 500, 100, 1500 and 2000 ppm produced incompatible reaction with 94.44% growth inhibition of fungal bioagent *T. harzianum*. At initial two lowest concentrations, pendimethalin @ 500 and 1000 ppm and fenoxyprop-p-ethyl @ 50 and 100 ppm found compatible with *T. harzianum*. All the fungicides/combination of fungicides, insecticides and herbicides tested at all their concentrations were completely compatible with *Pseudomonas fluorescens* isolate-1.

OP0354A&B): Compatability of different microbes and chemical inputs for multilayer seed coating in groundnut crop management

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The information on compatibility and synergistic benefits of inputs (chemicals and microbial bioagents) is critical to introduce multiple agents on to seed in a single or multi layers. In the present study, compatibility of different microbial agents viz., *Trichoderma* strains (*T. harzianum* Th4d, *T. harzianum* Th and *T. asperellum,* TaDOR7316), *Bradyrhizobium* (*B. arachidis*, *B. japonicum*) and *Bacillus subtilis* with seed treated fungicide (chlorothalonil, tebuconazole, mancozeb, carboxin + thiram and penflufen + trifolxystrobin), insecticides (thiamethoxam and imidacloprid) and biopolymers (chitosan and cellulose) was tested. *Bradyrhizobium* isolates and *B. subtilis* were found compatible with all insecticides, fungicides and biopolymers. All the three *Trichoderma* strains were compatible with biopolymers. Imidacloprid and thiamethoxam @1000ppm conc., inhibited mycelial growth of *Trichoderma* up to 16.2%. The fungicide penflufen + trifolxystrobin was found highly compatible with only 13% inhibition and all other fungicides were highly inhibitory to *Trichoderma* strains. All *Trichoderma* strains are compatible with *Bacillus subtilis* and *Bradyrhizobium* sp. *Trichoderma* strains (Th4d, Th, and TaDOR7316) have inhibited mycelial growth more than 60%. The compatible fungicides Penflufen + trifolxystrobin, insectcde, *T. harzianum* and *B. arachidis* whnintriduced n to seed as multilayer seed coating on groundnut seed gave >95% seed germination and very low (>1%) collar rot (*Aspergillus niger*) disease incidence.

OP06(4A&B): Commercialization of microbial pesticides, management strategies for organic farming: to create healthy system

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Growing demand for reducing chemical inputs in agriculture and increased resistance to insecticides has provided great impetus to the development of alternative forms of insect-pest management. Microbial control of crop pests offers environmentally acceptable strategies with lower cost and longer run effect. The bioagents i.e. *Bacillus subtilis, Psudomonas fluorescens, Trichoderma viride /harzianum* controlling plant disease and entomopathogenic fungus and that act as a parasite of insects and kills or seriously disables them, comprise a diverse group of over 90 genera with approximately 750 species, reported from different insects and these are potentially the most versatile biological control agents due to their wide host range. Entomopathogenic fungi and bio-control agents are naturally occurring organisms which are perceived as less damaging to the environment. Their occurrence and distribution are widely distributed in diverse habitats. An extensive survey was conducted during Kharif and Rabi season of 2017-18 and 2018-19 on different crops grown in different regions of Chhattisgarh and collected naturally infected insect cadavers and also soils samples from forest, non forest and cultivated lands. The purpose of this work was to isolate different entomopathogenic fungi and bioagents identify them and study the taxonomy & biodiversity of local isolates. Entomopathogenic fungi was isolated from insect cadavers and soil samples using Galleria bait method and identified as *Beauveria bassiana, Metarhizium anisopliae, Nomuraea rileyi* and *Aspergillus flavus* from

different insects of Soybean, Groundnut, Mustard and Pigeonpea. The favourable time for collection of EPF was 1st week of September to 2nd week of October for Soybean, Groundnut and Rice crops whereas 2nd week of September to last week of December from sugarcane crop, November to December was ideal for Pigeonpea crops insects which are infected by entomopathogenic fungi. Similarly different Bioagents was isolated from soil samples used for large scale production and commercialization of products, to safe the crops from diseases of different crops i.e. cereals, fruit and vegetables and oilseeds etc. Biopesticides including bio-control agents controlling plant disease and entomopathogenic fungi controlling insects are important which suppressed the biotic factors and helps the farmer's community for increasing their production and productivity and a sunrise sectors for developing Agri- entrepreneurship and can help in employment generation and uplift of socio-economic conditions of poor farmers for nation's prosperity. Their commercialization is important steps to available for large farmers community and get a opportunity to youth, create new startup in agriculture sectors.

OP07(4A&B): Sequencing and comparative genomic analysis of *Penicillium oxalicum* isolated from rice grain provides insight into the role of secretory proteins and CAZymes in decomposition of paddy straw

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Penicillium oxalicum fungus is highly popular for its cellulose degrading activity and was utilized in industries since many years. In many studies *Penicillium oxalicum* was reported as a biocontrol agent and potential candidate for paddy straw decomposition. *Penicillium oxalicum* UV4 was isolated from the false smut ball was observed promising for the cellulose decomposing activity in a solid state fermentation against rice straw and for the paddy straw decomposition under *in vitro* conditions. In order to understand the insight into the genome for the decomposition whole genome of *Penicillium oxalicum* isolate UV4 was sequenced using the Illumina and nanopore platforms. The high throughput hybrid assembly of short and long reads resulted in a total of 15 scaffolds with average scaffold length of 2019922 bp. A total of 7224 proteins were predicted in the genome and out of them 7206 proteins were annotated. A total of 15642 SNPs and 8612 SSRs were identified. Further, a total of 400 secretory proteins and 390 CAzymes were identified in the genome of *Penicillium oxalicum* (UV4). Glycoside Hydrolase (GH) group of CAzymes were most abundant (56.15%); followed by glycosyl transferases (20.77%). Maximum numbers of enzymes were observed for GH3, GH5 and GH16 families. Carbohydrate binding modules (CBM) 20 and CBM 24 families were predominant. Comparative analysis of different isolates of *Penicillium oxalicum* UV4 with other isolates revealed 13 gene clusters were unique to isolate UV4. Gene Ontology (GO) annotation suggested GO:0006863 (purine nucleobase transport); GO:0016709 (oxidoreductase activity); GO:0046300 (2,4-dichlorophenoxyacetic acid catabolic process), GO:0009636 (response to toxic substance) are uniquely present in *Penicillium oxalicum* UV4. Further, comparative and phylogenetic analysis revealed *Penicillium oxalicum* isolate UV4 is closely related to *Penicillium oxalicum* isolate 114-2. Real time PCR based analysis suggested increased expression of cazymes during solid state fermentation. Genetic information and

comparative analysis of *Penicillium oxalicum* UV4 is valuable for further comprehensive understanding the mechanism of the biomass-degradation at the genome level.

OP08(4A&B): Evaluating the efficacy of biosynthesized silver nanoparticle against *Rhizoctonia solani* Kuhn, the causal agent of sheath blight disease of rice

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Sheath blight caused by *Rhizoctonia solani* Kuhn is one among the most devastating diseases of rice. It is controlled by spraying of fungicides like validamycin, carbendazim, propiconazole, iprodioneetc. However, rampant use of these chemicals has led to development of resistance towards them. In this context, present study was carried out to evaluate efficacy of biosynthesized silver nanoparticle (AgNP) in inhibiting *Rhizoctonia solani.Silver* nanoparticle (AgNP) was synthesized using the culture extract of *Aspergillusniger* and was characterized using UV-Vis spectrometry. The inhibitory efficacy of the nanoparticle was tested *in vitro* by poisoned food technique at different concentrations viz. 5, 10, 15, 20, and 30 ppm. The AgNP was found to inhibit the growth of fungal pathogen by 13 to 28 % at different concentrations. *In vivo* efficacy was studied in pot culture by using cultivar Tapaswini, highly susceptible to sheath blight disease.The plants were inocoluted with mycelial plugs of *Rhizoctonia solani* at tillering stage and different concentrations of AgNP viz. 5, 10, 20 and 50 ppm of AgNP were sprayed twice after 96 and 144 hours of inoculation and percentage disease indices (PDI) were recorded. Highest PDI (44.23) was recorded in the control plants, in which no AgNP was sprayed. PDI decreased with increase in concentration of AgNP spraying. PDI was 22.75 in case of 50ppm AgNP spray, which was better than validamycin 3%L sprayed at its recommended dose. Findings suggest that AgNP could be used to control sheath blight disease of rice.

OP09(4A&B): Effect of Phospho Enriched Compost and Zinc on Productivity and Nutrient Uptake of Blackgram (*Vigna mungo* L.) in Subhumid Southern Hills and Aravalli Region of Rajasthan

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A field experiment was conducted during *Kharif* 2018 at Rajasthan College of Agriculture, Udaipur (Rajasthan). The treatments comprised of four levels of phospho enriched compost (PEC) i.e. control, PEC @ 2.0, 4.0 and 6.0 t ha-1 and four levels of zinc i.e. control, Zn @ 2.0, 4.0 and 6.0 kg ha-1. The experiment was laid out in a factorial randomized block design with three replications. The increasing levels of phospho enriched compost and zinc upto 4 t ha-1 and 4 kg ha-1, respectively increased significantly (P=0.05) the number of nodules per plant, number of pods per plant, number of seeds per pod, test weight, seed yield, stover yield, nutrient content (N, K and Zn) and uptake (N, P, K and Zn) in seed and stover of blackgram. Whereas, the application of zinc significantly decreased the phosphorus content in seed and stover as compared to control. However, the combined application of phospho enriched compost @ 6 t ha-1 along with zinc @ 6 kg ha-1 was found to record higher seed and stover yield. The application of phospho enriched compost @ 4 t ha-1 and zinc @ 4 kg ha-1 along with the recommended dose of fertilizer results in significantly higher productivity, nutrient content and uptake of blackgram under Typic Haplustepts soil.

OP10(4A&B): In vitro efficacy of different Phytoextract against *Colletotrichum orbiculare* (Berkely and Montage) von Arx causing Anthracnose of Cucumber

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Cucumber (*Cucumis sativus* L.), belonging to the family Cucurbitaceae. Cucumis sativus L. native to India, where it has been cultivated from over 3000 years. In cucumber (*Cucumis sativus* L.), Anthracnose, Cercospora leaf spot, Wilt, Rust and Powdery mildew etc. are important diseases but Anthracnose caused by *Colletotrichum orbiculare* is one of the most widely spread and destructive disease of cucumber (*Cucumis sativus* L). Anthracnose appears on leaves, stem, fruits, sometimes on the entire seedling and rarely on stem. All the eight plant extacts tested were found fungistatic against *Colletotrichum orbiculare*. However, At 15% concentration, maximum mycelial inhibition of 67.41% was seen with Neem leaves extract (*A. indica*) followed by Ginger rhizome extract (*Z. officinealis*) (66.96%) and Garlic bulb extract (*A. sativum*) (60.48%) while 20 per cent concentration, Garlic bulb extract (*Allium sativum*) showed 94.44% growth inhibition of *Colletotrichum orbiculare*. The next effective phytoextracts in order of inhibition were Neem leaves extract (*A. indica*) (75.48%), Turmeric rhizome extract (*C. longa*) (74.11%), Ginger rhizome extract (*Z. officinalis*) (67.41%).

4C: Advances in mushroom technology

Keynote Lecture

KN01(4C): Biodiversity of wild edible mushrooms of India for their nutritional, medicinal and industrial applications

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Diversity is the variation among living organisms in morphology, genera species, genes, biochemical and physiological aspects and in other related characters. Fungi are second species rich organisms group after insects. Fungi play key role in ecosystem as decomposers, mutualists and pathogens besides playing important role in industry, agriculture, medicine, biotechnology and others related to human welfare. The role of individual fungi in nature is still unknown. There may be 2.8 – 3.8 million of fungi as an estimate but Wu *et al* (2019) have made an estimate of 13 million of fungi which may be occurring in the world. Around 1,40,000 fungal species (6.7%) have been identified in the world and have been described mostly so far from temperate regions (Tonjock *et al*., 2017). However, the tropical region of the country has the highest fungal diversity which has yet not been fully exploited. India is blessed with a rich mushroom diversity as we have vast forest covers and varied agro climatic conditions from temperate to tropical. The diversity of climatic conditions prevalent in India made this country a natural habitat of a number of mushrooms species. Out of 2.5-3.8 million species of fungi in nature, 2000 species of edible fungi are known to man out of 10,000 species of macrofungi. Macrofungi are those that form large fructifications visible to the naked eye and include *Basidiomycota* and *Ascomycota* with large observable spore bearing structures. Ecologically, macrofungi can be classified into three groups: the saprophytes, the parasites, and the symbiotic (mycorrhizal) species. About 1,40,000 species of macrofungi are commonly called as mushrooms. Mushrooms are achlorophyllus macrofungi without leaves, stems and roots. Many of them are edible, non edible, medicinal, poisonous and miscellaneous species. The edible and medicinal mushrooms are now widely recognized, consumed and used as herbal medicine to boost the human immunity against biotic stresses, particularly viral infection including Covid-19. The most frequent mushrooms observed from different agro climatic zones of Chhattisgarh are *Volvariella volvacea, Cantherellus* spp*, Tuber* sp., *Russula* sp., *Termitomyces* spp., *Ganoderma lucidum Agaricus bisporus, Calocybe indica*, *Trametes versicolor*, *Schizophyllum commune*, *Lentinula edodes*, *Auricularia polytricha*, *Pleurotus* spp., *Astraeus hygrometricus*.Natural products play a very important role in the process of discovery and development of drugs, including the treatment of chronic diseases such as cancer. For hundreds of years, medicinal mushrooms are used as decoctions and essences, and are applied as alternative medicine in Korea, China, Japan and eastern Russia. A wide variety of compounds that occur naturally have proven active to protect against the development of tumors and inflammatory processes. The package of practices for commercial cultivation of edible/medicinal mushrooms have been standardized in India but its utilization as nutritious and medicinal health food is still to be explored in India. There is enormous scope of several mushrooms to be utilized for industrial applications too in making different enzymes and medicines and spent substrates are being used for preparing bricks.

Invited Lectures

IL01(4C): Microbial enhancer VL Bioagent 9 for shortening *Macrocybe gigantea* pinhead initiation and enhancing yield

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Commercial mushroom production is based on a series of solid fermentation stages under controlled conditions in which bacteria and fungi have major roles in processing raw materials, minimizing fungal competitors and inducing fructification. A wide variety of interactions between bacteria and cultivated mushrooms has been described leading to both positive and negative outcomes for the fungus, depending on the bacterial isolate and the developmental stage of the fungus. The casing is the coverage material placed onto the substrate colonized by the host mycelium. Some of the most commonly cultivated species of mushrooms i.e., *Agaricus bisporus* and *Macrocybe gigantea* require casing to fructify. The mycelium of these fungi secrete volatile organic compounds (VOCs) which act to suppress the initiation of fructification. A model of synergism between bacteria and fungi has been postulated to occur within the casing material, in which native bacteria consume VOCs, and therefore, stimulate fructification. Certain microbiota, including bacteria from the genera *Azotobacter*, *Bacillus, Paenibacillus* and *Pseudomonas*, described increasing the mycelial growth of cultivated species while showing antagonism against competitive molds, have been reported as candidates for the design of alternative nutritional supplements/biofertilizers. A good number of bacteria from the genera *Bacillus, Pseudomonas* or *Bradyrhizobium* appear to stimulate the mycelial growth of some cultivated species (*A. bisporus, A. bitorquis, A. subrufescens, P. ostreatus* or *P. eryngii*) in compost or *in-vitro*, and others have been described to favour and enhance mushroom fructification in casing, such as members from the genera *Pseudomonas*. Although there are increasing number of commercial bio-fertilizers based on bacterial and fungal plant growth promoters, to date there are no commercial supplements based on mushroom growth promoting microorganisms available in the market. No information is available for role of microbial inoculant in *Macrocybe gigantea*. Despite of plenty of reports on role of bacteria in supporting the fructification phenomenon in button mushroom, their commercial cultures for *A. bisporus* sporophores yield enhancement are still not available. Normally in mushroom *Macrocybe gigantea*, primodial/pinhead initiation takes ~12-14 days' time duration, which leads to fruiting and affects yield of final produce. The investigation addresses reduction in duration of primodial/pinhead initiation and early & enhanced pin head formation, which in turn enhanced the mushroom production. Since this bacterium produces siderophore (an iron chelating compound) helps in iron sequestration and enhanced proliferation of mushroom mycelium. This bacterium is able to shorten the primodial/pinhead initiation duration by approximately 40% in *Macrocybe gigantea*. During the investigation, a total of 09 siderophore producing Pseudomonad strains were applied at the time of casing along with untreated check during the years 2018 and 2019 at Experimental Farm, ICAR-VPKAS, Almora. Out of these, casing application of VL *Bioagent* 9 strain (*Pseudomonas* sp. NARs9) resulted in 116.08% and 104.43% higher yield of *Macrocybe* in comparison to untreated control, respectively. The pinhead initiation period was also found to be less (7.5 and 7.0 days) in comparison to control (13.5 and 12.0 days). The promising VL *Bioagent* 9 strain (*Pseudomonas* sp. NARs9) was demonstrated at farmer's field by applying in casing soil for enhanced yield of *Macrocybe gigantea*. The average yield recorded was 550g per bag (85% biological efficiency) against 305g of un-inoculated control.

IL02(4C): Evaluation of various Button Mushroom strains under Haryana conditions

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Agaricus bisporus commonly known as white button mushroom is most popular and commercially cultivated in India. The development of improved strains of *A. bisporus* is a continuous process to get better production. Selection of superior strains through evaluation among available germplasm appears to be one of the way of improving crop yield without increasing cost of production. Keeping this in view, ten strains of *A. bisporus* (IVTB-20-01, IVTB-20-02,IVTB-20-03, IVTB-20-04, IVTB-20-04, IVTB-20-05, IVTB-20-06, IVTB-20-07, IVTB-20-08, IVTB-20-09 and IVTB-20-10) were screened for their yield potential in Haryana conditions during 2020-2021. Cultivation was carried on short method compost using wheat straw as substrate. Basic data of ready Compost pH (7.7), Nitrogen (1.8), moisture 67% and colour (dark brown) was recorded during the course of study. Out of 10 button strains, IVTB-20-09 (13.25 kg/100 kg compost) gave maximum yield followed by IVTB-20-06 (11.75 kg/100kg compost) in four weeks cropping. Average fruit body weight was found maximum in IVTB-20-06 (25.55 gm) followed by IVTB-20-05 (23.87 gm). Time taken to first harvest (days post casing) was found early in IVTB-20-09 (27.80 days) followed by NBS 05-1084 (29.80 days).

Oral Presentations

OP01(4C): Evaluation of different fungicides, botanicals and bio-agents for the Integrated Disease Management of Curvularia leaf spot of Maize caused by *Curvularia lunata*

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This study was done in Udaipur in *In vitro* and *In vivo* conditions to explore the approaches of integrated management of curvularia leaf spot of maize caused by *Curvularia lunata. In vitro* evaluation of fungicides like Propiconazole, Tebuconazole and Hexaconazole + Zineb showed 100% growth inhibition among tested treatments. Among botanicals, NSKE and garlic showed maximum growth inhibition than others. *Trichoderma harzianum* (TH-3) and *Trichoderma viride* (TV-3) revealed better results among bio-agents. In field case, the lowest PDI (8.97%) was recorded with application of Hexaconazole 4% + Zineb 68% @0.2% + NSKE @15% giving yield of 1194.83 g/plot with a gain of 26.1% yield over control followed by the reduced concentrations (0.1% + 10%) of same combination with 13.37% PDI producing 1186 g/plot yield. After them, a combination of Hexaconazole 4% + Zineb 68% @0.1% & 0.2% + garlic @10% & 15%, respectively gave fair results with PDI 16.38% and 11.94%, respectively and yield of 1117 g/plot and 1138.17 g/plot, respectively with a gain of 21.1% yield over control. The least satisfying combination was *Trichoderma viride* TV-3 @1% and 2% concentrations with PDI 41.95% and 38.33%, respectively and 993 g/plot and 1015 g/plot yields, respectively followed by the treatment of Garlic @10% and 15% concentrations with PDI 41.38% and 32.99%, respectively and yield 1014 g/plot and 1021 g/plot, respectively. Thus, this disease can be efficiently managed by adopting the IDM approach through the combined application of Hexaconazole 4% + Zineb 68% @0..1% and 0.2% + NSKE @10% & 15%, respectively with the tested source of resistance to avoid yield losses.

OP02(4C): Exploiting the potential of lactobacillus species to produce mushroom hydrolysates and BAPs from matured edible mushrooms

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Edible mushrooms have excelled as a source of high proteins due to their low-fat content and absence of cholesterol. Mushroom bioactive proteins have drawn significant attention in medical applications due to their anti-inflammatory, antidiabetic, antioxidant, cardiovascular, hepatoprotective and anticancer potentials. Bioactive properties of mushroom proteins are significantly enhanced by enzymatic hydrolysis, playing a crucial role in physiological processes along with development of drugs and drug-related compounds. The present study focused on edible mushrooms viz *Agaricus bisporus* and *Pleurotus* species. The crude protein was extracted from matured fruit body which was further concentrated using using 10% TCA and was hydrolysed using lactobacillus species (*Lactobacillus acidophilus* and *lactobacillus brewis).* Optimization of degree of hydrolysis was done using a chemical orthopthalaldehyde (OPA) to screen effective bioactive peptides. Highest degree of hydrolysis (6.86%) was obtained in the sample *Agaricus bisporus* optimized with ph 6.0, temperature 37¿C and *Lactobacillus acidophilus* (6.84 CFUs / 500ul) and *Lactobacillus brewis* (44.5 CFUs/2.5ul). The bioactive peptides of these hydrolysed samples were profiled by running the SDS-PAGE with 12% resolving and 5% stacking gel.

OP03(4C): Scope and status of oyster mushroom cultivation in India

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Edible mushrooms are currently in high demand for their medical benefits and therapeutic attributes, in addition to their nutritional worth. *Pleurotus* sp. grows in temperate and tropical forests on dead and decaying organic debris, wooden logs, and occasionally on dying deciduous or coniferous tree trunks, and are easily artificially cultivated. It is the popular edible mushroom after button mushrooms at the global level. It is popularly known as 'Dhingri' in India. These mushrooms, unlike other mushroom species, are the easiest, quickest, and cheapest to grow. It has cheap capital expenditures, takes less time to prepare, and uses low-level production equipment, making it more profitable to cultivate than other mushrooms on a commercial scale. These mushrooms are appealing because they can use a wide range of agricultural waste products and convert the lignocellulose biomass into high-quality food, flavour, and nutritional value. The world production of all mushrooms is about 40 million tonnes contributed largely by countries like China, the USA, the Netherlands,

Poland, Spain, France, Italy, Ireland and Canada. India produces less than one per cent of mushrooms of total world mushroom production, with white button mushroom accounting for 73% of total mushroom production, and other tropical mushrooms such as oyster mushroom (16%), paddy straw mushroom(7%), and milky mushroom(3%) only of total mushroom production. Haryana is one of the leading states in white button mushroom production contributing about 15 per cent of total mushroom production in India. Among different mushrooms the world production of oyster mushrooms is estimated to be about a million tonnes, the third-highest among other mushrooms at the world level. China is responsible for about 85% of the total world production. In India, the cultivation of various species of oyster mushroom began in the early 1960s. India annually produces about 21,000 tonnes of this mushroom and is popularly grown in Madhya Pradesh, Andhra Pradesh, Orissa, Karnataka, West Bengal, Maharashtra and North Eastern states. In Haryana the total production of oyster mushroom is only 50 tonnes and but there is a great potential in Haryana to produce oyster mushrooms. Edible mushrooms are currently in high demand for their medical benefits and therapeutic attributes, in addition to their nutritional worth. Mushrooms are high in vitamin B, particularly niacin and riboflavin, and have the greatest protein level of any vegetable. Fresh mushrooms have an average moisture content of 85-90 per cent, 3.0 per cent protein, 4.0 per cent carbohydrates, 0.3-0.4 per cent lipids, and 1.0 per cent minerals and vitamins. Mushrooms have many medicinal properties such as antimicrobial, antiviral, anti-human immunodeficiency virus (HIV), antineoplastic, immunomodulatory, anti-aging properties.antitumor, antimutagenic,antioxidant, hyperglycaemic, hypotensive, anti-inflammatory, hepatoprotective and hypocholesterolemic, Inflammation and platelet aggregation are inhibited by methanol preparations of *P. florida*. *P. sajor-caju* has hypertensive effects through its active ingredients which affect the renin-angiotens in system. Oyster mushrooms are reported to have high nutritional values. It has protein (25-30%), fat (2.5%), sugar (17-44%), mycocellulose (7-38%) and mineral of about 8-12% (potassium, phosphorus, calcium and sodium). They also contain folic acid, which aids in the treatment of anaemia. It is rich in B complex and Vitamin C. The Niacin concentration is almost 10 times that of any other vegetable. The mushroom's economic value is mostly derived from its use as human food. Different species of temperate, tropical, and sub-tropical mushrooms are farmed throughout India due to the varying agro-climate and plenty of farm waste. Widespread malnutrition with the ever-increasing protein gap in our country has further necessitated the search and cultivation of an alternative source of protein. As the production of pulses has not kept pace with our needs, and there is an ever-increasing protein deficit and need for quality food, mushroom growing is now developing as an important industry in several sections of our country. Although *Pleurotus* is a popular mushroom in the country, most of the production relies on a few species only. Despite rising demand, there is a scarcity of oyster mushrooms throughout the year. As a result many oyster mushroom species which give production under different climates, may be the ideal year-round oyster mushroom alternative. Among all the cultivated mushrooms *Pleurotus* has the maximum number of commercially cultivated species suitable for round the year cultivation. All the varieties or species of oyster mushrooms are edible except *P. olearius* and *P. nidiformis* which are poisonous. *Pleurotus* Species commercially cultivated all over the world include *P.ostreatus, P. sajor-caju, P. florida, P. flabelltus, P. citrinopileatus, P. fossulatus, P. sapidus, P. membranaceous, P. eous, P. cornucopiae, P. eryngii, etc.* India produces about 600 million tonnes of crop residue each year, with the majority being permitted to degrade naturally or burned on the spot. This may be used to grow high-nutritive-value foods like oyster mushrooms, and the wasted mushroom substrate can be turned into organic manure. Haryana produces around 22 million tonnes of whea and paddy straw per year. In Haryana and neighbouring states, paddy straw burning in the fields is an issue and it's critical that efforts should be made for the best use of these straws in terms of both cost and environmental impact. Pasteurization of substrates is one of the most crucial factor to optimize the yield of oyster mushrooms. Different states have different crop residues and even within a state, the crops residues are different in different parts. Like in Haryana, in northern districts paddy and wheat straws are the major crops wastes which can be used in oyster mushroom cultivation whereas in southern Haryana, mustard, cotton wastes etc. are the major crop residues which may be used for oyster cultivation. Standardization of technology of substrates preparation from different crop residues has not been recommended in most states of India. Successful cultivation of mushroom often requires pasteurization of the substrate, before inoculation with spawn. In India, oyster mushroom producers typically utilise chemicals for substrate pasteurisation, which are both expensive and environmentally unfriendly. Other sources like solar energy, which is free and available throughout the year, may be a better option for pasteurization but it requires exhaustive studies before any recommendation. Similarly, hot water treatment provides a low-cost alternative to substrate pasteurisation, which is an important pasteurisation approach. Use of different pasteurisation methods of different substrates like steam pasteurisation, hot-water treatment, and chemical sterilisation with formalin are practised in different parts of India. Chemical sterilization is expensive and not eco-friendly practice to cultivate oyster mushrooms. Steam pasteurization is also not becoming popular because of high cost of establishment of structures or equipments. Hot water treatment or pasteurization in chambers are the two best options but establishment of pasteurization chamber is beyond reach of small farmer. Soaking of substrates in normal water (no hard water and neutral in pH) upto 12 hours (depends upon the substrate hardness) and then hot water treatment of substrates at 70 degree celcius for 20 minutes was found most effective for pasteurization of wheat and paddy straw. It yielded early and maximum yield of *P. florida* and *P. sajor-caju* on paddy straw followed by wheat straw. A profitable method of cultivation is not followed by oyster mushroom growers in India, generally due to lack of information on cultivation methods most suited to oyster mushrooms. In India, it is primarily grown using the rack method in which bags are placed on the racks, which has very low economic returns. Other methods of cultivation *i.e.* hanging rope system method was found to be comparatively less costly and accommodated more bags per unit area and produced more yield . Oyster mushroom farmers are now opting hanging method because there is no cost involved in racks formation as well as a conducive climate is met in mushroom house for optimum growth, maximum space for development of fruiting body which results in early spawn run, early pin head formation, early harvest and higher yield. A mushroom grower in a thatched hut of 30x60 ft. can accommodate about 1750 oyster mushroom bags in rack system but in hanging method about 2150 oyster mushroom bags can be accommodated which may give better returns to the oyster mushroom growers.Various value added products like pickle, biscuits, cakes, nuggets, curry, soups, pakoras, paranthas, rice pulav, fried oyster mushroom, mixed vegetables etc. can be prepared from the fresh/dry oyster mushroom.

OP04(4C): OP01(4C): Development of improved strains of *Calocybe* spp. through inter specific hybridization

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Milky mushroom (*Calocybe indica* P&C) is a widely, cultivated tropical edible mushroom in India after button and oyster mushrooms. The milky white robust sporophores with high nutritive value, enhanced shelf life and lucrative value have attracted the attention of mushroom consumers. It is a explicit source of protein (17.2%), fibre (3.4%), vitamins and minerals. The development of new strains of mushrooms can be achieved by introduction, selection, hybridisation and mutation etc. The present study was undertaken for development of improved strains by inter specific hybridisation between *C. indica* (parent1) and *C. gambosa* (parent2) by single spore crossing. Eleven single spores, each were isolated from parent A and B (A1 to A11 and B1 to B11). The single spore crossing was done by dual culture technique between A1 to A11 with B1 to B11 through hyphal anastomosis. 121 crosses were done with 42 compatible interactions indicated by barrage formation while 79 crosses were incompatible. Among the twenty-two compatible crosses, four crosses (A1 x B5, A2 x B4, A4 x B2 and A4 x B6) were selected based on the mycelial characters. *In vivo* experiments were done by preparing the beds of the selected four interspecific crosses along with their parents. The fruiting body production was observed only in hybrid A2B4. The parents A2 and B4 failed to produce any sporocarp. The number of days taken for spawn run, pin head formation and first harvest in hybrid A2B4 was comparable with *C.indica* and *C.gambosa*. The sporophores were attractive, initially light brownish later turning to creamish white colour similar to *C. gambosa*. The morphological characters of pileus and stipe showed similarity to *C. gambosa*. Hybrid A2B4 produced robust sporophores with an average sporophore weight of 84.75 g. The biological efficiency of A2B4 was 50.85 % compared to *C. indica* (61.59%) and *C. gambosa* (84.79). Molecular characterization of interspecific hybrids and parents revealed that the hybrid A2B4 had 69.6 per cent and 54.5 per cent similarity with B4 (*C. gambosa*) and A2 (*C. indica*) respectively.

OP05(4C): Influence of different organic and inorganic supplements on yield and biological efficiency of paddy straw mushroom (*Volvariella volvaceae*)

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Mushrooms are known as the “meat” of the vegetable world which offers greater potential in producing more proteins per unit area of land, which is not possible by another form of source. Paddy straw mushroom (*Volvariella volvacea*) is a fast-growing mushroom also known as “Warm Mushroom” because it grows at high temperature (20-35*!*) and the total crop cycle is completed within 3-4 weeks period. This mushroom can use a wide range of cellulosic materials and the required C: N ratio is 40-60, quite high in comparison to other cultivated mushrooms. The experiment was mainly focused on mushroom supplementation which is an agronomic process consisting of different organic and inorganic amendments to the substrates with a substantial impact on biological efficiency and yield. The addition of external nutrients increases the yield and biological efficiency. Various organic supplements i.e. Water hyacinth, Rice flour, Gram dhal flour, Mustard oil cake, and inorganic supplement (urea) were applied at 2% dry weight of substrate were applied to the substrate for evaluating their effect on the biological efficiency of paddy straw mushroom. The highest yield and biological efficiency (2452.2 g and 17.67%) were obtained from the substrate supplemented with 2% red gram flour where the spawn run period was minimum (8 days) with a maximum average weight of sporophore (29.7 g). Significant differences were observed among the treatments over control (1756.5g and 13.7%) where spawn run period was maximum (10 days) and the average weight of sporophore obtained is (15.6 g).

OP06(4C): Influence of casing thickness on yield and biological efficiency of milky white mushroom (*Calocybe indica* p&c)

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Mushrooms are also considered "White vegetables" and "Vegetable meat" because it contains a high amount of proteins, vitamins, minerals, essential amino acids, carbohydrates, fibers, and less amount of fat and absolutely free from cholesterol. Mushrooms help in the degradation and bioconversion of lignocellulosic and agricultural wastes. Milky white mushroom (*Calocybe indica*) is one of the fast-growing edible mushrooms and can cultivate easily by its simple cultivation methods. Commercial cultivation is very easy in the areas where plenty of agricultural wastes are available in the states like West Bengal, Orissa, Andhra Pradesh, Tamil Nadu, Kerala, and Karnataka. The temperature ranges of these areas are most suitable for the growing milky mushroom. The experiment was mainly focused on the influence of casing thickness in the production of milky mushrooms. Casing thicknesses of beds influenced the pinhead initiation, sporophore maturation period as well as yield and biological efficiency of *C.indica*. Among the different casing thicknesses, the early primordia initiation (11days) sporophore maturation (8.67 days) yield (717.5g), and biological efficiency (71.75%) were obtained from 1.0" casing thickness beds and the lowest yield (447.9g) and biological efficiency (44.79%) obtained from 0.5" thickness cased beds.

OP07(4C): Evaluation of strains of *Lentinula edodes* (Shiitake mushroom) under Haryana conditions

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Shiitake mushroom (*L. edodes*) is popular in the world because of its taste, nutrition, medicinal importance. China and Japan are the leading producers of this mushroom. It has copper, selenium, potassium, manganese, magnesium, iron, phosphorus, eritadenine, beta-glucans, lentinans, Vitamin D, thiamin, riboflavin, niacin, folate etc. This mushroom has large cap of 2 to 5 inches and vary in colour from light to chocolate brown. It is also available in market in dry form. In India, its cultivation is being done by a few mushroom growers only. The DMR Solan supplied four strains during 2017 and five strains during 2019 for testing their performance at AICRP (mushroom) centre, Hisar. During 2017, the saw dust was used as a substrate for its cultivation while in 2019 the wheat straw was used as a substrate for their cultivation. The substrates were thoroughly soaked in water overnight, then dried in shade so that it has is 55 per cent moisture and then supplemented with wheat bran @ 20% and CaCO3 @ 1% on dry weight basis. The supplemented wet substrate was filled @ 1.5 kg / polypropylene (PP) bag and autoclaved at 126o C for 2h. The autoclaved bags were cooled and spawned asceptically @ 5% on wet weight basis. The inoculated bags were kept in incubation room at 24oC till it turned to brown in colour. Then blocks from the bags were removed and dipped in chilled water (4-50C) for about 10 minutes. After chilled water treatment, these were kept at a temperature below 20oC. After fruits harvesting and giving rest period of 2 weeks, the blocks were again dipped in chilled water (4-50C) for about 10 minutes and kept in incubation room below 20 degree celcius till harvesting of fruit. There were five replications and 6 bags/replication and randomized properly as per RBD design. The observations on yield kg/100 kg dry straw, time taken for first harvest (days) and average fruit body weight (g) were recorded. In the year 2017, the significantly highest yield (17.5kg/100kg dry substrate) was obtained from strain LE17-01 followed by LE17-04 (17.3kg) which differed significantly as compared to other strains. The time taken for first harvest was significantly lowest (97 days) in LE 17-03 followed by LE17-04 (99 days). The average fruit body weight was maximum (10.7g) in LE17-01 followed by LE17-03 (10.2g). In the year 2019, among the five strains tested the highest yield of 37.3 kg/100 dry wheat straw was given by LE 19-02 and significantly lowest yield of 23.47 kg/100 kg dry straw by LE 19-05. The time taken for first harvest was significantly lowest (79.6 days) in LE 19-01 as compared to other strains and it was significantly high (85.5 days) in LE 19-03. The average fruit body weight was significantly lowest (18.3 g) in LE 19-05 and highest (22.6 g) in LE 19-02.

KN01(TG2022): Whole-genus ecological genomics of *Trichoderma*: understanding the origin of environmental opportunism

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Trichoderma (Hypocreales, Ascomycota) exhibits unique nutritional versatility forming biotrophic interactions with fungi, animals, plants, and efficiently degrading lignocellulose and other natural and synthetic polymers. The genus includes up to three hundred molecularly defined species, most of which are rare and ecologically restricted. However, there is also a group of phylogenetically unrelated species with a remarkable potential of environmental opportunism. Most of the commercial products for the biological control of fungal pests contain soil-competent *Trichoderma* spp. bioeffectors that either directly parasitizes plant pathogenic fungi or outrun them in the competition for the resources. Being aggressive mycoparasites, these species devastate mushroom farms worldwide. They are increasingly relevant for clinical microbiology as opportunistic pathogens of immunocompromised humans, causing nosocomial infections. To understand the biological and biochemical mechanisms underlying these characteristics of *Trichoderma* spp., we initiate the whole genus comparative genomic and transcriptomic analyses of at least 300 isolates from taxonomically defined clades, species and phylogenetic lone linages representing the broad spectrum of infrageneric ecological versatility and biogeographic distribution. Here we will present the first results obtained from the analysis of 60 newly sequenced and 15 previously available *Trichoderma* genomes, including species with different ecology and biogeography.

IL01(TG2022): *Trichoderma* species of temperate climate- their characteristics and ways of interaction with common wheat and its pathogens from the *Fusarium* genus

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Due to the lack of sufficient information on the biodiversity of *Trichoderma* / *Hypocrea* in Central Europe, research was undertaken to isolate, identify and collect *Trichoderma* strains from various biotopes and locations in this region of Europe with a temperate, warm, transitional climate. The studies led to the collection of over 1,000 strains and the identification of 25 *Trichoderma* species or species complexes. Bearing in mind the prospect of using *Trichoderma* in sustainable agriculture as an alternative strategy in cereal disease management, the collection of *Trichoderma* species has been thoroughly and comprehensively tested for their biological activity relative to common wheat and against phytopathogenic *Fusarium* species. Biochemical, microbiological and microscopic analyzes have led to the selection of strains with a different lifestyle and mode of nutrition, including effective antagonists of *Fusarium* species, as well as strains representing a saprophytic lifestyle.

Two of these *Trichoderma* strains / species with different modes of action were selected for further multi-omic studies to understand their interactions with wheat plants. Based on these studies, the ability of both *Trichoderma* species to colonize the surface and internal root tissues of wheat plants was documented. Changes in the morphology and anatomical structure of the roots were observed, including changes in the distribution of pectins and lignins in wheat plants treated with *Trichoderma* fungi. Moreover, significant changes in the metabolome, proteome and transcriptome of seedlings and adult wheat plants were detected as a result of interactions with *Trichoderma* fungi. However, it was noted that the nature of these changes depends both on the genotype / variety of the plant, its organ, developmental stage, growing conditions and the *Trichoderma* species. Knowledge and understanding of the mechanism that underlies wheat's response to treatment with non-pathogenic *Trichoderma* species, detecting the dependence of these reactions on environmental conditions, the genotypes of both communicating organisms, or the duration of this relationship, may be useful in designing a new generation of targeted and specific immune inducers and stimulants defense reactions of wheat plants, or bio-stimulants of development and yielding of this economically important cereal.

OP01(TG2022): *Trichoderma hamatum:* endophyte from kale roots (*Brassica oleracea* var. *acephala*) as a biotechnological tool in cruciferous plants

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Few studies have been carried out regarding the diversity of endophytic fungi in *Brassica* roots, no studies having been developed in the species *B. oleracea*. In previous work, we isolated and identified *Trichoderma hamatum* as a kale (*Brassica oleracea* var. *acephala*) roots endophyte. In this study, we reported as *T. hamatum* is implicated in the activation of a systemic resistance that caused kale plants to be significantly less affected by the phytopathogenic bacterium *Xanthomonas campestris*. Subsequently, *T. hamatum* was used as a possible agricultural biostimulant in different leafy *Brassica* crops. This work reported, for the first time, an increase in the productivity of kale, cabbage and turnip greens by *T. hamatum* root inoculation. Furthermore, fungal inoculation reported a significant increase in the content of total glucosinolates in cabbage and turnip greens (mainly sinigrin and gluconapin, respectively), along with an increase in their antioxidant capacity. Finally, we have raised the possible role of *T. hamatum* as an interplant communicator. Using the model plant *A. thaliana* and the plant pathogens *X. campestris* and *Sclerotinia sclerotiorum*, we have been able to report how *T. hamatum* acts as a communicator between neighboring plants by colonizing the rhizosphere and its roots. After the attack of necrotrophic pathogens, the plant activates its defenses and conditions root colonization by *T. hamatum*, implying a greater colonization of neighboring plants, activating their systemic resistance.

OP02(TG2022): Diversity of *Trichoderma* spp. in cultivated Agricultural fields of southern Rajasthan

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The southern part of Rajasthan was untouched to utilize the potential of its *Trichoderma* strains thus it was necessary to first isolate, identify and characterize the *Trichoderma* spp. The first crop rhizosphere based survey of *Trichoderma* species was conducted in 7 districts of Rajasthan state. The soil samples were collected from diverse crop rhizosphere of cereals, pulses, vegetables and fruit plants. Eight species belonging to rhizosphere of cultivated crops and orchards were identified based on molecular approach and morphological characteristics. A total of 74 isolates were identified as *Trichoderma.* Among these 60 isolates were classified into 8 species: *Trichoderma brevicompactum* (16), *T. erinaceum* (15), *T. asperellum* (12), *T.harzianum* (13), *T. atroviride* (01), *T. ghanense* (01), *T. longibrachiatum* (01), *T. hamatum* (01). Isolation rate of Trichoderma isolates from 273 varied soil samples was 27%. The relative dominance values calculated showed that genus Trichoderma is not dominant in the soil samples. The dominance value of *T. brevicompactum, T. erinaceum, T. harzianum, T. asperellum* was 0.016, 0.012, 0.01 and 0.008 respectively which was very low as compared to standard dominance value (>0.02). These species can be distinguished with other species by having species specific features viz. different colony growth characteristics, colony color, shape, size and arrangements of phialides, etc. Morphology and cultural characteristics were observed, described and illustrated in detail. Their phylogenetic positions were determined by sequence analyses of partial sequences of ITS region and Tef 1 á.

KN01(TG2022): *Trichoderma*-induced priming and heritable responses in plants

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Trichoderma is a common resident of the rhizosphere where it first evolved as a mycoparasite and then established symbiotic relationships with plants, becoming an endophyte. Beyond the production of cell wall degrading enzymes and antibiotic metabolites, main actors in biocontrol activity, a fine-tuned crosstalk with the plants has allowed many strains of *Trichoderma* to carve out an advantageous ecological niche while providing benefits to their hosts in terms of plant growth promotion and induction of faster and stronger immune responses. This defense mechanism is known as priming and is deployed to be effective against attack by pathogens and abiotic stresses. Priming of defenses is regulated by transcription factors which in turn modulate a complex phytohormonal network that provides defense or growth according to the needs of the moment. Therefore, results describing different types of phytohormone-dependent plant defense triggered by *Trichoderma* may seem contradictory as they tend to point to what happens at a fixed time, but the fact is that plant responses to *Trichoderma* signals follow undulating dynamics, and the extent of priming depends on the timing and conditions of each *Trichoderma*–plant interaction study. The molecular hubs that condition the beneficial action that *Trichoderma* has on plants regulate the immediate and long-lasting systemic responses and orchestrate the trade-off between plant growth and defense. In addition, the memory of the *Trichoderma* signature reaches the seeds and can be passed on to the offspring. Moran-Diez et al. (2021). *Trichoderma* and the plant heritable priming responses. *J. Fungi* **7**, 318.

IL01(TG2022): Success stories on transfer of Trichoderma based technology from lab to land in tribal belt of North East India for the plant health management

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Indigenous strains of *Trichoderma* species were isolated from the agro-ecological conditions of North East India. Through a series of *in vitro* and *in vivo* experiment, potential strains of *Trichoderma* spp. effective against six (6) soil borne fungal plant pathogens and root knot nematode were identified. Mode of action of *Trichoderma* spp. was studied against all these targeted pathogens. The potential *Trichoderma* strains showed compatible reaction with 6 other biocontrol agents, and this helps to develop a consortial bioformulation with multiple functions. Study on tolerance to Al and Fe toxicity, tolerance to different doses of fertilizers, Caseinase activity, alpha-amylase activity, chitinase activity, P and Zn solubilization ability etc. showed encouraging results. The potential strains showed positive results in siderophore production ability. Continuous effort in different agroecological conditions of NER, standardized a biointensive strategies and popularized among the farming communities. More than 2000 farmers, extension personals and tea garden managers etc. were trained on technical aspects of the technology and its field use. Technology adopter gained more profit due to the result of higher yield with nutritious farm produce which have high shelf life etc. The farmers could fetch more income compared to the non-adopters and bankability increases. Many adopters procured modern farm implements. This success opens a hope that the technology may create a revolution among the farming communities of the nearby areas. Moreover, 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.

IL02(TG2022): Green vaccination: future applications for plant health and food security

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In the absence of genetic resistance in crops, food production heavily depends on the use of chemicals to control pathogens. Despite their effectiveness, chemicals-based plant defence has detrimental environmental consequences and creates risks to the wider environment. Modern synthetic chemicals usually have reduced environmental toxicity; however, they are expensive and only available to advanced agricultural production systems. Moreover, as with antibiotics, the discovery of new chemicals to control plant disease is difficult and extensive use of current agents may result in the selection of pathogen strains tolerant to pesticides. Plants have evolved a sophisticated immune system to resist pests and diseases. Apart from their innate immune system controlling pre-programmed defence reactions, plants can also increase the responsiveness of their immune system in response to selected environmental signals. This phenomenon is known as “defence priming”. Priming is one of the most economical and effective modes of resistance because it prevents wasteful metabolic consumption in plants. The fitness costs of priming are lower than those of constitutively activated defences, suggesting that priming functions as an ecological adaptation of the plant to respond faster to a hostile environment. Although defence priming rarely provides full protection, its broad-spectrum effectiveness, long lasting durability and inherited to future generations make it attractive for integrated disease management. Plant defence priming and Transgenerational Immune Priming (TGIP) will be discussed in relation to wheat crop improvement and sustainability.

KN01(TG2022): Interactive proteomics among Sugarcane, Colletotrichum falcatum and Trichoderma harzianum – Platform for simultaneous identification of antifungal, defense and pathogenicity related proteins

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Molecular analyses on antagonistic suppression of *Colletotrichum falcatum* during ditrophic and tritrophic interactions revealed differential expression of defense, antifungal and pathogenicity related proteins. During tritrophic interaction, the growth and proliferation of *T. harzianum* over *C. falcatum* was confirmed by suppression of symptom production, duplex PCR, tissue bioassay, and microscopic observations. Results on proteomic analysis revealed that, most of the differentially expressed proteins involved during three way interaction were found to be of sugarcane origin and were categorized into defense and stress responsive proteins, metabolism, signaling etc. However, important finding in the study was the suppression of pathogenicity related proteins of *C. falcatum* viz., cytochrome p450 and Hsp20. Since these proteins could not be traced in standing canes, proteomic analyses on two-way interaction of *C. falcatum* and *T. harzianum* on sugarcane tissue was subsequently performed. Results from this study, showed expression of 17 unique protein spots which were found to be defence and stress responsive proteins *viz*., disulfide isomerase, pyruvate decarboxylase, peroxidase, Hex1, Cu/zn superoxide dismutase, hypothetical protein etc., of *T. harzianum*. Like antagonistic isolates, *C. falcatum* also expressed superoxide dismutase proteins and Hypothetical proteins during the two way interaction. Expression analysis of transcripts of the identified proteins revealed that, defence genes of sugarcane and candidate genes of *T. harzianum* were upregulated and correspondingly the pathogenicity related proteins were down regulated during tritrophic interaction. These results clearly established that the antagonistic fungus directly act on the pathogenicity genes/ proteins of its host, makes it less pathogenic on sugarcane and leading to the interaction as a suppressed phenotype of the disease.

KN01(TG2022): Multifunctional secondary metabolites from *Trichoderma* spp. and its applications

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Species of the genus *Trichoderma* are well known for their ability to inhabit diverse environmental conditions and are known to involve in mutual interactions with other organisms specially plants. *Trichoderma* spp. are also known filamentous ascomycetes due to their biological control activity and great adaptability to various ecological conditions. Secondary metabolites (SMs) from microorganisms may have an antifungal role against agriculturally important phytopathogenic fungi. *Trichoderma* spp. are prolific producers of secondary metabolites which enrich many associated genes in their genomes which are involved during interactions with pathogen and plant. There are diverse range of secondary metabolites produced by *Trichoderma* spp. are characterized in to following classes like, terpenes, pyrones, gliotoxin, gliovirin, Koninginins, Pyrones, Viridins, Butenolides, Hydroxy-Lactones, Peptaibols, etc and their responsible genes and their products plays an vital role in biocontrol activity through cell wall degradation of pathogens, abiotic and biotic stress tolerance to host plants. The metabolites produced by these fungi which interact with the plant defense mechanism and involved in induced systemic resistance in plants. Identification of novel metabolic biosynthetic genes/gene clusters from *Trichoderma* spp. will helps to the better elucidation of biosynthetic pathways in host system against major phytopathogens in future.

KN01(TG2022): *Trichoderma* spp. in the mitigation of stresses in plants, their commercialization for sustainable agriculture and rural prosperity

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Trichoderma spp. *viz., Trichoderma viride, T. harzianum, T. asperellum,* etc. have been found quite effective in mitigating biotic stresses viz. seed - and soil- borne diseases of crops viz. wilt (*Fusarium* spp.), root rot (*M. phaseolina*, *R. solani*), collar rot (*A. niger*), etc., which usually cause huge quantitative and qualitative yield losses in crops. These bio-agents are also efficient in mitigating the abiotic stresses of the plants viz. extreme temperatures, drought, salinity, allelopathic effects, oxidative stress, etc. These are efficient colonizers, promote plant growth & root development, induce systemic resistance (ISR); besides, managing farm and urban organic wastes by decomposing them with their efficient cell wall degrading enzymes and making the nutrients available for plant growth. The use of bio- agents to manage soil and plant health is the present day need for eco-friendly & sustainable crop production; reduction of cost of cultivation and remunerative return of agricultural produce; generation of employment through their commercialization, etc. Thus, it is the best sector for improving socio-economic status of farmers and nations to become prosperous and self-reliant. Mass production technologies of the bio-agents i.e. fermentation, formulations, delivery systems, etc. are now available. Commercial production of these has now emerged as a potential sector for employment generation, where millions of skilled persons will be required at different levels in coming decades, particularly in developing world, where unemployment among the youths are the emerging problem. ICAR, SAU's have introduced ELP's for the students to become entrepreneurs. The KVK's, NIPHM, etc. impart trainings to entrepreneurs/ farmers for establishing bio-agents production units. Being a Sun rise sector, the funding agencies viz. RKVY, DBT, DST, NHM, Banks, NFSM, Central & State Govt., etc. need to support farmers, entrepreneurs, NGO's, SHGs, etc. for hands on training in the production process and to establish bio-agents production units. The funding agencies should also establish 'Bio-resource complex' for production, training and guidance of needy HR. Besides, collaborative research groups should be established nation-wise as well as globally for innovative quality product development for the efficient use in the agriculture.

OP01(TG2022): Assessing the efficacy of *Trichoderma asperellum* against different pathogens of medicinal plants

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The present study was performed to assess the efficacy of the local *Trichoderma asperellum* strain against different isolated pathogens from important medicinal plants *in-vitro* and in field conditions against leaf spot disease of Tulsi. In vitro study, *Trichoderma asperellum* was evaluated against 10 different plant pathogens of medicinal plants namely Ashwagandha (*Alternaria* sp. and *Fusarium solani*), Sarpgandha (*Colletotrichum* sp. and *Alternaria* sp. Tulsi (*Colletotrichum* sp. and *Alternaria* sp, Mint (*Curvularia* sp. and *Alternaria* sp.), Mandukparni (*Cochliobolus* sp. and *Alternaria* sp.). After 144 hours, maximum inhibition was shown against Fusarium solani where the radial growth was recorded to be 15.10 mm with control having 35.10 mm growth, indicating the reduction in percent growth by 56.36 per cent. This was followed by inhibition of *Cochliobolus* sp. where the radial growth of the pathogen was recorded to be 14.13 mm with control having 31.67 mm growth, indicating the reduction in percent growth by 55.38 per cent. *T. asperellum* was also found effective against *Alternaria* sp. isolated from Ashwagandha (53.06%), *Alternaria* sp. from Sarpagandha (53.51%), and *Curvularia* sp. (52.12%). The FYM enriched with *Trichoderma*, seedling treatment with *Trichoderma* followed by foliar spray of neemoil and fungicide were tested in the field against Leaf spot of Tulsi caused by *Alternaria alternata*. The treatment (T5), Soil application of FYM (1.0 kg/m2) enriched with *Trichoderma asperellum* + *Pseudomonas fluorescence* talc based formulation each @ 2.0% at planting time+ three sprays of mancozeb @ 0.25% with 15 days interval on the onset of disease symptoms was found highly effective in minimising the per cent disease index (10.37%) followed by Treatment (6) Soil application of FYM (1.0 kg/m2) enriched with *Trichoderma asperellum* + *Pseudomonas fluorescence* talc based formulation each @ 2.0% at planting time +three sprays of with Bordeaux mixture@ 0.5% at 15 days interval on the onset of disease symptoms and both the treatment were at par with each other. Maximum per cent disease index recorded (41.48%) in control. Maximum fresh weight observed in treatment. The result may imply that FYM enriched with *Trichoderma asperellum* could be effective and can be incorporated in IDM programs for the eco-friendly disease management in tulsi.

OP02(TG2022): *Mitigation of drought stress by Trichoderma harzianum through seed biopriming*

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Wheat, the world's most important food crop in terms of production and consumption, serves as the prime item in the diet of millions of people. Production of wheat in India is limited by several biotic and abiotic stresses. The present study has been focused to investigate the effect of antagonist fungus *viz Trichoderma harzianum* for drought stress management, abiotic stress, in wheat. Wheat seed biopriming with *T. harzianum*, enhanced drought resistance by affecting stomatal conductance, net photosynthesis, proline content, chlorophyll content, catalase, and peroxidase activity. Out of several strains of *T. harzianum* collected from different locations of Uttar Pradesh and from various crop's rhizosphere, the most superior six strains (*viz.* IRRI-1, Th-3, Th-21, Th-26, Th-28, and Th-30), on the basis of their growth rate were selected. These selected strains were applied as seed bio-priming to test their efficacy to enhance drought tolerance in wheat at the stem elongation/jointing stage. With strains IRRI-1and Th-3, after 14 days of exposure to drought, maximum shoot length, root length, leaf area index, flag leaf area, relative water content, membrane stability index, chlorophyll content, proline content, catalase, and peroxidase activity were observed as 83.80 cm, 23.60 cm, 37.91, 31.76, 71.23, 66.36, 45.60, 11.50 µ mol g-1, 104.69 and 202.02 unit with IRRI-1 and 74.30 cm, 19.90 cm, 32.69, 30.82, 66.89, 63.83, 42.60, 12.40, 98.25 and 189.45 with Th-3, respectively. IRRI-1and TH-3 strains of *T. harzianum* have been found to be effective in providing drought tolerance in wheat plants by decreasing the proline content and by enhancing the total chlorophyll content, relative water content, membrane stability index, and biochemical properties *i.e.* catalase and peroxidase activity in wheat plants.

OP03(TG2022): *Trichoderma harzianum* – a potential bio control agent for management of stem and pod rot disease of Groundnut

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Trichoderma harzianum is a free living soil inhabiting fungus and is a potent biological control agent used successfully against various plant pathogenic fungi. Plant growth promoting capacities to plant substrates can help reduce the input of chemical pesticides and fertilizers in agriculture. *Trichoderma* strains solubilize phosphates and micronutrients. *Trichoderma* spp. grow in the rhizosphere and are capable of penetrating and internally colonizing plant roots. Groundnut is a major legume and important oil seed crop of Saurashtra region of Gujarat. Farmer's economy mostly depends on groundnut productivity. Major soil borne diseases of groundnut are stem and pod rot, root rot, aflarot and collar rot. Out of all, stem rot caused by *Sclerotium rolfsii* is of prime significance and is an economically important. This soil borne pathogen has a wider host range such as wheat, sunflower, mungbean, sugar beet, tomato, lentil, cabbage and cauliflower. A trial was conducted to test the biocontrol Efficacy of *T. harzianum* against *S. rolfsii* -stem and pod rot disease of groundnut, under field condition in cultivar GG-20 for four consecutive years 2017-2020. *Trichoderma* was applied in different ways: application with carriers and application by spray pumps or irrigation water. Application of *T. harzianum* lead to significant reduction in stem and pod rot disease with mean reduction of 69.84%, 73.67%, 60.63% and 84.57% during 2017, 2018, 2019 and 2020, respectively. The mean disease reduction recorded was 72.18%. The application of *T. harzianum* also increased pod yield with 25.48%, 28.92%, 12.37% and 34.48%, respectively for study period with an overall increase in pod yield of 25.31%.

OP04(TG2022): Seed Biopriming and soil application of *Trichoderma viride* enriched vermicompost for management of wilt and collar rot complex disease of Chickpea

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Chickpea (*Cicer arietinum* L.) of Family: Leguminosae is the premier legume crop grown widely in the Indian subcontinent. Chickpea suffers mainly with wilt (*Fusarium oxysporum* f. sp. *ciceri)* and collar rot (*Sclerotium rolfsii)* which are mainly soil and seed borne in nature. *In vitro* application of *T. viride, T. harzianum* and *T. virens* conidial suspension to chickpea seeds gave significant results with high plumule length and radical length. The seedling emergence and vigour index were significantly high in all treatments compared to pathogen check. Among the treatments, seed biopriming application of *T. viride* along with soil application of vermicompost enriched *T. viride* resulted in better seedling emergence and highest vigour index, followed by seed biopriming application of *T. viride* alone with seedling emergence and high vigour index.

OP05(TG2022): Rhizospheric Microbes in defense and PGP activities- A step towards Sustainable Agriculture

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Pulses are important food crops globally due to higher availability of protein content, occupying important group in India after cereals and oilseed, responsible for yielding large financial gains. Among a dozen of pulses grown in India, Chickpea and pigeonpea are the leading crops. However, the crop is encountered by several diseases among which *Fusarium* wilt is a prominent one and considered as a major biotic constraint in almost all the chickpea and pigeonpea growing areas. The injudicious use of chemicals for enhancing the plant growth and controlling the disease has caused a detrimental effect on soil, plant, environment and human health. The present study was carried out to check the effectiveness in plant growth promoting activities of three compatible rhizospheric microbes namely *Pseudomonas fluorescens* (OKC), *Ochrobacterum spp* (SBF, TKF 11), *Trichoderma spp.* (T-40, K1 and K2) in enhancing the plant growth and biosynthesizing phenolic compounds in chickpea and pigeonpea under the challenge condition of *Fusarium udum*. *In-vitro* assay was carried out for plant growth promotion attributes. It was observed that OKC expressed the positive result in phosphate solubilizing test by producing a clear halo zone around the bacterial colony. Also, OKC, SBF, TKF - 11 and T-40 was able to change the colour from light yellow to dark yellow in colour. The intensity of change in colour indicated the amount of production of ammonia. *Trichoderma spp.* (K1 and T-40) were able to synthesis HCN showing a positive indication of the experiment. The gelatin liquification test was carried out where OKC, SBF and TKF-11 had a positive result. All the isolates of *Trichoderma* spp. were able to show positive result for siderophore production test. Zinc solubilization was observed in case of OKC and two *Trichoderma* spp. (K1 and K2). The microbes were applied as seed treatment in two sets and pathogen was inoculated in one set after 21 days of sowing. The further experiment was carried out to analyze the presence of Phenylalanine Ammonia Lyase (PAL) enzyme, Total Phenolic Content

(TPC), Peroxidase (PO) and Catalase (CAT) enzyme from the leaf tissue and relative difference between primed + pathogen challenged and non-primed + pathogen challenged plants was observed.

OP06(TG2022): Management of tomato damping off disease in the nursery through biocontrol agent

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Among the biocontrol agents used in agriculture to protect the crops from various diseases, genus *Trichoderma* has been emerged as superstar. It is naturally occurring fungus which is well capable of managing various fungal phytopathogens especially soil borne such as species of *Fusarium*, *Pythium*, *Phytophthora* and many more. Looking in to its effectiveness, an experiment was planned and executed at research area of Department of Vegetable science, Chaudhary Charan Singh Haryana Agricultural University, Hisar during 2020-21 crop season. There were seven treatments i.e. T1-Soil application of *T. harzianum,* T2-Soil drenching of *T. harzianum,* T3-Seed treatment *T. harzianum,* T4-FYM + *T. harzianum,* T5- Carbendazim drenching, T6-Vermicompost+ *T. harzianum* andT7-Untreated control, each treatment was replicated thrice and plot size was 90 cm x 100 cm for each treatment. The enrichment of farmyard manure and vermicompost with *T. harzianum* was done 15 days before sowing and drenching was done at the appearance of the disease. Observations on seed germination and damping off disease were recorded after 20 and 40 days of sowing. Results revealed that *T. harzianum* when applied as soil application, seed treatment, drenching, and enrichment of farmyard manure as well as vermicompost could enhance the tomato seed germination and effectively reduced the damping off disease of tomato in comparison with control. The seed germination ranged from 68.0 to 82.7 per cent which was higher than control (64.7). Damping off incidence was recorded from 10.54 to 16.18 per cent against 24.74 per cent in control indicated that the antagonist is capable of managing disease in nursery when applied in various ways and it could be an alternate strategy for managing this disease.

OP07(TG2022): Myco-parasitic activity of *Trichoderma harzianum* against soil and seed-borne disease of lentil caused by *Fusarium oxysporum* f. sp. *lentis*

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Fusarium wilt caused by *Fusarium oxysporum* f. sp. *lentis* (Fol) has been considered a destructive soil-borne disease of lentil. The super-coiling structure of *Trichoderma* hyphae was observed over the hyphae of Fol under a scanning electron microscope, which proves its mycoparasitism activity. *T. harzianum* isolates were further studied for the production of phytohormones i.e. IAA and GA3, Th3, and ThL-4 isolates gave maximum production of phytohormones. Optimum production of chitinase and â-1,3 glucanase enzymes against Fol isolates were found at 96 h of incubation and maximum activity was shown by isolate Th3 i.e. 9.16 and 2.86 U/mg protein, respectively. *T. harzianum* isolates also induced defense enzymes (PO, PPO, and SOD) in lentil when exposed to Fol. It was found that *T. harzianum* (Th3 and ThL-4) induced higher levels of defense enzymes. The expression pattern of the chitinase gene, from *T. harzianum* strains Thl-4 and Th3 were analyzed using real-time PCR during interaction with Fol. The chitinase gene was upregulated 5 to 7 folds (Thl-4 and Th3, respectively) during the interaction. The maximum germination percentage of lentil seeds in 2017-18 and 2018-19 was observed by isolate Th3 (91.2 and 92.4%, respectively) followed by the isolate ThL-4 in both the years (90.0 and 91.6%, respectively). The maximum disease was controlled by isolate Th3 i.e. 57.28% in 2017-18 and 59.47% in 2018-19 followed by isolate ThL-4 i.e. 55.60% in 2017-18 and 53.15% in 2018-19 over the control. This study proposes the use of rhizospheric *T. harzianum* isolates for better and all-around protection of plants against soil and seed-borne phytopathogens. The isolates Th3 and ThL-4 can be utilized to formulate bio-fungicides which are the need of the hour as far as disease management is concerned.

OP08(TG2022): *In vitro* efficacy of bio-control agents on growth inhibition of *Fusarium oxysporum* f.sp. *lycopersici* and *Sclerotium rolfsii* Sacc. causing wilt and collar rot of tomato and brinjal, respectively

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A study was undertaken to investigate the efficacy of bio agents in the management of wilt of tomato and collar rot of brinjal. Growth inhibition of fungus *Fusarium oxysporum* f.sp. *lycopersici* and *Sclerotium rolfsii* Sacc. causing wilt and collar rot were studied *in vitro* for determining the efficacy of seven fungal bioagents. The maximum per cent inhibition of mycelial growth of *F. oxysporum* f. sp. *lycopersici* was observed in treatment of *T. harzianum* (54.33%) followed by *T. hamatum* (52.03%), *M. anisopliae* (50.03%), *T. virens* (32.07%), *T. asperellum* (27.55%) and *P. lilacinus* (19.03%). Among all bioagent tested least per cent inhibition of the pathogen was observed in treatment of *V. lecanii* (16.47%). Similarly, the maximum per cent inhibition of mycelial growth of *Sclerotium rolfsii* Sacc. was observed in treatment of *T. harzianum* (54.14%) followed by *T. virens* (52.03%), *T. asperellum*(42.99%), *T. hamatum* (40.99%), *M. anisopliae* (32.11%) and *P. lilacinus* (23.51%). Among all bioagent tested least per cent inhibition of the pathogen was observed in treatment of *V. lecanii* (15.62%).

OP09(TG2022): *In vitro* efficacy of bio-agents and essential oils against *C. musae* causing post harvest fruit rot of banana (*Musa paradisiaca* L)

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Banana fruit rot is a devastating post harvest disease causing economic loss. The present study was conducted to determine the antagonistic activity of nine bio-agents against *Colletotrichum musae*. Among the nine bio-agents tested, *Trichoderma asperellum* was found the most effective and recorded highest mycelial inhibition (77.29%) followed by *Trichoderma hamatum* (76.00%), *Trichoderma koningii* (75.81%), *Trichoderma harzianum* (68.47%), *Aspergillus niger* (66.25%), *Pseudomonas fluorescens* (48.51%), *Metarhizium anisopliae* (64.51%), *Bacillus subtilis* (45.77%) and *Verticillium lecani* (25.63%), respectively. Among the essential oils tested at 10% concentration, Eucalyptus oil, Citronella oil and Mint oil exhibited 100% mycelial growth inhibition followed by Neem oil (63.66%), Mustard oil (48.77%), Clove oil (42.92%), Sesame oil (35.66%), and Castor oil (33.81%), respectively and for essential oils tested at 20% concentration, Eucalyptus oil, Citronella oil and Mint oil exhibited 100% mycelial growth inhibition followed by Neem oil (66.81%), Sesame oil (58.55%), Mustard oil (56.47%), Clove oil (50.07%) and Castor oil (41.85%), respectively.

OP10(TG2022): Biocontrol action of *Trichoderma* spp. in reducing Fusarium wilt disease and promoting plant growth of Tomato

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Trichoderma spp. has long been used as biological control agents offer direct and indirect mechanisms to control various soil-borne pathogens including *Fusarium oxysporum*, which confers a better component in plant protection than fungicides. The aim of the study is to reduce the pathogen colonization rate (colony-forming unit (CFU) / g soil) that correlated with *Trichoderma* CFU/ g of soil tomato. Efficacy of the local isolates of *Trichoderma* species was assessed to promote the growth and yield parameters of tomato and to manage Fusarium wilt disease under field conditions. The pathogen that causes the Fusarium wilt of tomato, was isolated and identified as *Fusarium oxysporum* f. sp. *lycopersici* (FOL). Four native *Trichoderma* viz., *harzianum, viride, virens* and *koningii* were isolated from healthy tomato rhizosphere filed soil, Aligarh Muslim University, India. For field experiments, soil application of *T. harzianum* at 4g/m2 exhibited minimum Fusarium wilt disease severity of 22.17% in 2019 and 21.56% in 2020 followed by *T. viride* (25.41 and 24.39%), *T. virens* (28.51 and 29.65 %), and *T. koningii* (31.24 and 30.23 %) in both years of cropping respectively. Besides, *T. harzianum* showed good potential in controlling wilt disease severity, it promotes higher shoot length and yield I trial 58.26 cm and 456 g tomato per plant whereas in II trial were recorded as 60.23 cm and 475 g tomato per plant respectively than other species of *Trichoderma* over control. Thus, *T. harzianum* was found most promising with biocontrol action. This study concludes that the biocontrol agents particularly local isolate of *Trichoderma* species might be exploited for sustainable disease management programs to prevent the environmental risk of agrochemical toxic residues.

OP11(TG2022): Effect of pre and early post emergence application of herbicides in cumin on Trichoderma applied in soil

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The wilt caused *by Fusarium oxysporum* f.sp. *cumini* is a serious disease of cumin (*Cuminum cyminum* L.) in India and has been reported as a problem limiting cumin production worldwide. Hence, we have tested *Trichoderma* under *in vitro* and further it requires to be studied under field condition. Highest *Trichoderma* population (104.67 x 104 cfug1), maximum seed yield (1127 kg/ha) and maximum net return (Rs. 54233/ha) was recorded in the soil application of *T. harzianum* @ 5 kg in 500 kg of castor cake/ha and application of *T. harzianum* @ 5 kg/ha in 100 kg sand one month after germination of crop followed by pre-emergence spray of pendimethalin @ 0.9 kg a.i./ha at 2DAS + soil application of *T. harzianum* @ 5 kg in 500 kg of castor cake/ha and application of *T. harzianum* @ 5 kg/ha in 100 kg sand one month after germination of crop (89.50 x 104 cfug1, 1005 kg/ha and Rs. 40,695/ ha, respectively).

OP12(TG2022): Assessment of antagonistic potential and plant growth promoting traits of native *Trichoderma* species against groundnut stem rot caused by *Sclerotium rolfsii*

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Trichoderma spp. are known for their biocontrol properties *viz.,* space competition, production of antibiotics, growth inhibition, coiling of pathogen hyphae and secretion of cell wall degrading enzymes. Thirty-five isolates of *Trichoderma* spp. collected from groundnut rhizosphere of Jaipur district (Rajasthan), India were evaluated for biocontrol potential against stem rot caused by *Sclerotium rolfsii* and growth promoting traits in groundnut. The morphological studies of the 35 isolates based on colony appearance, shape, and size of conidia, phialides structures and branching pattern of conidiophores were further supported molecularly by amplification of ITS 1 and ITS4 rDNA region and classified into four species namely *Trichoderma harzianum, T. asperellum*, *T. longibrachiatum* and *T. citrinoviride* which were further subjected to antagonistic potential for biocontrol efficiency. The highly efficient representative strains namely, *Trichoderma harzianum* Thar23, *T. asperellum* Tasp49, *T. longibrachiatum* Tlongi5 and *T. citrinoviride* Tcitri2 were evaluated for production of cell wall degrading enzymes and growth promoting traits. The comparative study of these strains revealed that, *T. harzianum* Thar23 was highest producer of lytic enzymes viz., chitinase (31.36 U/ml), â 1, 3 glucanase (4.1 U/ml) and protease (2.76 U/ml). Plant growth promoting traits namely germination efficacy (85.2%), increase in shoot (26.03 cm) and root length (16.33 cm), vigour index (3598.2) and relative water content (79.79%) studied under glasshouse conditions. Based on results, bioformulation of the promising native strain *T. harzianum* Thar23 could be developed and evaluated at field level to study the biocontrol efficacy against groundnut stem rot.

OP13(TG2022): Nutrient rich Bioformulations to enhance growth of tomato plant

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A Nutrient rich bioformulation(s) were prepared by inoculating the bio-inoculants viz., Trichoderma isolate (TRT-9), *Pseudomonas fluorescens* and *Azotobacter chroococcum*, in vermicompost supplemented with minimal inorganic fertilizers i.e. Diammonium phosphate (DAP) and Muriate of potash (MoP). Based on various tests viz., compatibility test, biochemical test and bio efficacy test, three formulations were constituted and evaluated for growth of tomato under pot and field both conditions. Under pot condition, the formulation comprised DAP (10% w/w) and MoP (3% w/w) supplemented vermicompost enriched with three bioinoculants was found most effective and significantly improved growth of tomato, whereas in field conditions nutri-rich bioformulation showed best result in terms of increased plant growth attributing parameters.

OP14(TG2022): Effect of selected bioagents on host defense related biochemical parameters viz., peroxidase (PO), polyphenol oxidase(PPO) and Phenylalanine ammonia lyase(PAL)

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Two sets of experiments were carried out to study the effect of four bioagents *viz*., *T. viride* (Tv-BKN), *T. harzianum* (Th-BKN), *P. fluorescens* (Pf-18) *and B. subtilis* (Bs-15) on defence related enzymes i.e. PO , PPO and PAL content in two *clusterbean* genotypes i.e. RGC-1033 and RGC-936 under green house condition. In this study, individual antagonists were used as seed treatment. The antagonist Tv-BKN proved to be most effective in inducing the PO activity in both the clusterbean genotypes at two stages of sampling i.e. 30 and 40 days after sowing (DAS) under M. phaseolina inoculated condition. Induction of PPO was more pronounced in Tv-BKN and Th-BKN treatments as compared to Pf-18 or Bs-15 treatments. PAL activity was higher in Tv-BKN and Pf-18 treatments. While, the response of this enzyme with respect to another two antagonists i.e. Th-BKN and Bs-15 was relatively less.

OP15(TG2022): Trichoderma -a sustainable component of indigenous farmer' friendly IPM techno-packages for combating soil borne root knot nematode and fungal disease complexes causing serious losses to field crops. A true friend of farmers

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In the era of changing scenario targeting towards ecofriendly and non-chemical based research for reclaiming the soil and crop health which has completely destroyed by indiscriminate and overuse of toxic chemical pesticides, the Plant Protectionist are diverting towards safe and cost effective means. With this mission in mind a section of researchers is sincerely attempting to switch on to utilize indigenous strains in IPM packages for management of soil borne maladies. In the present investigation which is based on field to lab and vice-versal research a indigenous strain of *Trichoderma* particularly *T. harzianum* collected from rice growing areas of G.B nagar tested separately against the major soil borne pathogenic root knot nematode *Meloidogyne graminicola* and *Rhizoctonia* through *in vitro* dual culture test separately exhibited distinct variation in their potentiality against the pathogens ties in inhibiting both the pathogenic root knot nematode and rot causing fungus followed by the strain from Haryana. All other strains under investigation also showed remarkable performance. In the present study, the locally isolated strain, in general, proved variability in its mycoparasitic and egg parasitic nature much potent than the others collected from different regions of Western U.P and Haryana. The strain was thereafter selected and maintained on starch rich sorghum grains for both, nursery and field application referred as core component of the evolved indigenous IPM techno-packages for combating hidden enemies of farmers.

OP16(TG2022): Biointensive management of *Meloidogyne enterolobii* in tomato under glasshouse conditions

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Meloidogyne enterolobii is a tropical or subtropical nematode and has a broad host range, including cultivated plants and weeds. For decades, the control of sedentary nematodes has relied heavily on chemical nematicides. The present investigations were carried out to study bio-intensive management of *Meloidogyne enterolobii* causing root-knot disease in tomato. The experiments were laid out using different treatments of biocontrol agents (*Trichoderma asperellum* (Ta-14), *Pseudomonas flourescens* (Psf-173), PBAT 3 (consortium of Ta14 & Psf173) and *Paecilomyces lilacinus* (commercial) with the combination of Biofumigation (*Brassica juncea* & *Raphanus sativus*). Nematicide carbofuran was used as chemical check. All the treatments showed positive effect on the growth parameters of tomato plants. Combination of PBAT3+Biofumigation(M) resulted in maximum fresh root (7.38g) and shoot weight (36.07g) with minimum number of root galls (18.33 galls per root system) as compared to the combination of other treatments.

OP17(TG2022): Evaluation of a novel biopolymer based *Trichoderma harzianum*, Th4d formulations against seed and soil borne disease of oilseed crops under field conditions

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Delivery of *Trichoderma* a potential bio control agent to the target point in the form of formulations with suitable carriers is adopted by many researchers and industries for commercial use. Chitin or chitosan supplemented formulations proved to be effective in proper adherence to treated surfaces, reducing the wastage of bio control agent, besides providing antimicrobial activity, physiologic protection to seed and promoting plant growth. Natural polysacharides viz., chitosan and cellulose were converted to film forming seed coating polymers and used for developing Trichoderma liquid formulations. These novel biopolymer liquid chitosan and cellulose based *T. harzianum*, Th4d seed coating formulations were evaluated against soil borne pathogens of soybean and groundnut under field conditions. Seed treatment with chitosan + *T. harzianum*, Th4d formulation in soybean has resulted in seed germination of 74.3% germination, low Macrophomina root rot incidence (2%) and recorded high seed yield (830 kg/ha) compared to 63.3% seed germination, root rot incidence of 8% and yield of 620 kg/ha in control. In groundnut, germination of 92.4%, low incidence of Aspergillus collar rot (4.3%) and high seed yield of 1900kg /ha was obtained in chitosan+ *T. harzianum*, Th4d seed treatment compared to a germination of 74% and collar rot incidence of 13.5% and yield of 1500kg/ha obtained in control.

OP18(TG2022): Management of Collar Rot of Groundnut by using Biocontrol Agents

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Groundnut (*Arachis hypogaea* L.) is to be out of the most important oilseed in the world. It belongs to the family leguminaceae and originated from in South America. The disease is prevalent in sandy soil of Rajasthan where climatic conditions are dry and temperature remains high and is a major constraint in increasing yield, which may attack plants at any stage of growth from seedling to maturity. Therefore, it was very important to undertake the studies to find out the causes for disease development and its suitable control measures. A field experiment was conducted at the Instructional Farm, College of Agriculture, Swami Keswanand Rajasthan Agriculture University, Bikaner during *kharif* season of 2015. The seeds of groundnut variety HNG-10 were sown in the field with three replications following randomized block design (RBD). In this experiment three bioagents *viz., Trichoderma harzianum, T. viride* and *Pseudomonas fluorescens were* used individually and combined for soil application and seed treatment both. In case of control, seeds were sown in pathogen inoculated soil without any bioagents. Observation on disease incidence were recorded. In field conditions, During *kharif* 2015, Biocontrol agents minimized the collar rot incidence in groundnut as compared to control. *P. fluorescens* in combination with *T. viride* as seed and soil application (11.39%) was most effective in minimizing the collar rot incidence followed by *P. fluorescens* in combination with *T. viride* as combination seed treatment (12.41%) and sole application of *T. viride* as seed and soil treatment (12.85%) as compared to other treatments. *Trichoderma viride* as seed treatment (13.58%) also effective in minimizing the disease incidence followed by *P. fluorescens* as seed and soil application in combination (14.23%). Conclusively, the bioagents in combination reduced the disease incidence effectively as compared to sole application of bioagents.

OP19(TG2022): Role of *Trichoderma* spp. in mitigating moisture stress in black pepper (*Piper nigrum* L.) through antioxidative defence system

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Major factors limiting growth and yield in crops are biotic and abiotic stresses. Amongst the abiotic stresses, drought causes significant reduction in yield. Several species of Trichoderma have the innate ability to induce tolerance in plants against abiotic stresses especially drought and moisture stress. The present study was conducted to understand the mitigation of moisture stress by Trichoderma isolates viz., T. asperellum (NAIMCC 0049), T. erinaceum (APT1), T. atroviridae (APT 2), T. harzianum (KL3), T. lixii (KA15), and T. asperellum (TN3) in black pepper plants. Single node stem cuttings of black pepper (variety: - IISR Sreekara) raised in polybags were subjected to four levels of moisture viz., field capacity (FC), 75 percent FC, 50 percent FC and 25 percent FC. After imposing moisture stress the plants were inoculated with different Trichoderma isolates. The biochemical parameters viz., proline, protein, phenol, lipid peroxidation, chlorophyll, relative water content (RWC), and growth parameters were recorded at the time of inoculation, 10, 20, 30, 40, 50, and 60 days after inoculation (DAI). Under moisture stress, the proline content of plants increased, whereas the plants inoculated with Trichoderma showed an additional increase in proline. The plants inoculated with the isolate T. atroviridae (APT2) showed the highest protein content, while in uninoculated plants, there was a significant reduction. The plants inoculated with the isolates NAIMCC 0049 and APT2 showed the lower rate of reduction in RWC, even at 25 percent moisture stress. Among the six isolates tested, the isolates T. asperellum (NAIMCC 0049), and T. atroviridae (APT2) have the potential to induce tolerance to drought stress by enhancing the root and shoot growth and also by triggering protective mechanisms, which in turn prevented oxidative damage. The study showed that the Trichoderma isolates hold great promise in mitigating moisture stress in black pepper.

PP01(TG2022): Morphology and Molecular based characterization of *Trichoderma* spp. collected from different geographical locations of Chhattisgarh

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Morphological descriptors of *Trichoderma* are often confusing therefore molecular tools are employed for identification. For ten *Trichoderma* isolates intergenic spacer region of the nuclear ribosomal DNA repeat, portions of the translation elongation factor 1 alpha intron sequence of the EF1-á gene was amplified using the primers EF1-728F and EF1-986R (Carbone & Kohn 1999) and 5.8 rRNA gene intervening sequence specific primers for the ITS region of the ribosomal DNA was targeted using the primers ITS4 and ITS5 (White *et al*. 1990) for 2 *Trichoderma* isolates (isolate T37 and T80). The Maximum likelihood analysis of the intergenic spacer region of the nuclear ribosomal DNA repeat, portions of the translation elongation factor 1 alpha and Chromosomal 18S-28S rRNA intervening DNA sequences with all the selected (Best hit) retrieved from *Trichoderma* genome database using the dialogue (Nucleotide BLAST: Search nucleotide databases using a nucleotide query (nih.gov)) and the species identity was resolved based on the phylogenetic affinities of intergenic spacer region of the nuclear ribosomal DNA repeat, portions of the translation elongation factor 1 alpha intron sequence of the EF1-á gene and ITS (18S-28S rRNA intervening DNA sequence) sequences. Out of 14 isolate, DNA sequence analysis of 12 isolates through NCBI, Blast corresponds to *Trichoderma harzianum.*

PP02(TG2022): Biological Control of Root rot of Cotton incited by *Rhizoctonia* spp.

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Root rot caused by *Rhizoctonia* spp. is the most destructive soil borne disease of cotton (*Gossypium*) which appears every year in cotton fields and causes heavy losses in yield. Among various types of biocontrol agents, *Trichoderma* is widely used species. *Trichoderma* species are asexual fungi that are present in all types of agricultural soils and is parasitic on many foliar and soil borne plant pathogens, as it stimulates plant resistance, plant growth that leads to increase in crop production. Hence, the present investigation was carried to study the eco-friendly management of the pathogen through bio-agents under *in vitro* conditions of Department of Plant Pathology, CCSHAU, Hisar. Total fourteen isolates of *Trichoderma* were tested against the pathogen to evaluate their biocontrol activities against the pathogen. Among them, T-10 which was isolated from Sirsa district was found to be most effective, as it showed positive results for HCN production, IAA production, Cellulase production and Ammonia production followed by T-3 isolate which was isolated from Charkhi Dadri district. The biocontrol activities showed by *Trichoderma* help in inhibiting the growth of the pathogen and promote the plant growth. Currently *Trichoderma* spp. is being used to control plant diseases in sustainable diseases management system.

PP03(TG2022): *Growth promoting effects of Trichoderma virens G2 formulation on different vegetable crops*

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Worldwide acceptance of Trichoderma spp. (accounting for 90% of all antagonistic fungi utilized in plant protection (Benítez et al. 2004)) as bioagent in agriculture (Mukherjee et al. 2013) was due to its ability to produce large number of secondary metabolites, mycoparasitism, ability to induce SAR in plants against invading pests and pathogens, plant growth promoting ability, inducing NUE and ability to impart tolerance to abiotic stresses (Lorito et al., 2010). Trichoderma species produce many small metabolites with medical and agricultural significance, exhibiting a range of unique properties and bioactivity. Mukherjee et al. 2019 reported extensive field evaluation of Trichoderma virens G2 (BARC G2 mutant / TrichoBARC) for management of collar rot (S. rolfsii) in chickpea and lentil (Lens culinaris) and also noticed that the bioagent also improved plant growth and yield. In the present investigation we report the plant growth promoting effect of Trichoderma virens G2 formulation under small plot experiments on different vegetables (Spinech, red amaranthus, fenugreek, chickpea, safflower, bottle gourd, and cowpea). We observe 20 to 40% increase in leafy vegetables.

PP04(TG2022): Compatibility of *Trichoderma asperellum* TR4 with chemical fungicides

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Trichoderma asperellum TR4 is a soil inhabitant fungus with an ability of inhibiting plant pathogens especially soil borne pathogens, immunity and growth enhancer in plants. In integrated disease management approach the use of different components in which the compatibility of all the components is must and economical. Hence, the compatibility of *T. asperellum* TR4, isolated from chickpea rhizosphere showing antagonistic potential against *Fusarium oxysporum* f. sp. *ciceris* causing wilt of chickpea was tested for its compatibility with systemic, non-systemic and combi- fungicides at three different concentrations by using poisoned food technique. The compatibility results were estimated based on mycelial growth inhibition of the fungus in different treatments. Among, systemic fungicides tested, azoxystrobin alone was compatible with *T. asprellum* TR4 with less inhibition of growth of fungus (2.22%) and hexaconazole, thiophanate methyl, carbendazim, tebuconazole and benomyl were found highly incompatible with *T. asprellum* showing 100 per cent inhibition at 0.05, 0.1 and 0.15 per cent concentrations. Among different non-systemic fungicides tested at 0.1, 0.2 and 0.3

per cent concentrations, *T. asperellum* TR4 was found compatible with propineb, copper hydroxide, copper oxychloride and mancozeb and incompatible with captan (80.62%) and thiram (51.61%). Among different combi-fungicides tested at 0.1, 0.2 and 0.3 per cent concentrations, *T. asperellum* TR4 was found compatible with copper oxychloride + copper hydroxide and cymoxanil + mancozeb, supporting growth of fungus, whereas incompatible with thiophanate methyl + pyraclostrobin, carboxin + thiram, carbendazim + mancozeb and tebuconazole + trifloxystrobin, showing 100 per cent inhibition of the fungus.

PP05(TG2022): *In vitro* mycoparasitic activity of *Trichoderma harzianum* against plant pathogens including biochemical characterization promoting indirect plant growth

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We evaluated the production of potential growth-promoting metabolites (IAA, phosphate, siderophore) for 14 isolates of *Trichoderma* collected from different geographical locations of Chhattisgarh. All the *Trichoderma* isolates were able to solubilize and also released inorganic phosphorus and Zn from tri-calcium phosphate and zinc sulphate. All the *Trichoderma* isolates had consistent ability to produce siderophores and only one isolate (T84) produced IAA. The production of these metabolites varied greatly within species. Using the same set of isolates we evaluated the production of potential cell wall degrading enzymes. Confrontation assays of *Trichoderma* isolates against two soilborne plant pathogens (*Scelrotium rolfsii* and *Rhizoctonia solani*) expressed varying degrees of antagonistic responses, *in-vitro* antagonism being effective against both *R. solani* & *S. rolfsii*.

PP06(TG2022): Antagonistic effects of different soil isolate bio-agents against *Fusarium oxysporum* f. sp. *cubense* TR4 *in vitro* and molecular characterizations

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Bananas are the earliest fruit crop cultivated by humans from ancient times in India and have great social-economic importance, merged with the country's cultural heritage. Different bio-agents were isolated from the rhizosphere of wilt affected banana plants cultivar Grand naine on *Fusarium oxysporum* f. sp. *cubense* TR4 areas of Bihar. All isolated bio-agents were tested against FOC TR4 *in vitro* condition by dual culture technique. The maximum inhibition over control at 10 days of inoculation was recorded in *Trichoderma asperellum* 1(Tr1) (64.82%), followed by *Trichoderma asperellum* 2(Tr2) (62.70%), *Aspergillus flavus* (35.00%) and minimum in *Penicillium chrysogenum* (22.62%). The result clearly showed that *in vitro Trichoderma asperellum* 1 was highly effective while *Penicillium chrysogenum* was found least effective antagonistic against *Fusarium oxysporum* f. sp. *cubense* TR4 *in vitro.* Molecular characterizations of two morphologically different *Trichoderma spp.* were identified as two different strains of *Trichoderma asperellum* 1 and *Trichoderma asperellum* 2.

PP07(TG2022): Evaluation of 6PP producing and non-producing mutant progenies of *Trichoderma atroviride* (T14) affecting root and shoot morphogenesis of different crops.

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The pyrone, 6-pentyl-2H-pyran-2-one (6 PP) is a secondary metabolite commonly produced by various *Trichoderma* species and is responsible for the characteristic coconut odor produced in axenic cultures. In this study, one hundred and seventy putative variants derived from Gamma-ray irradiation of wild type *Trichoderma atroviride* (T14) formed the basis of our present investigation. Sensory evaluation of characteristic aromatic odor resembling coconut odor produced by volatile, 6-pentyl-2*H*-pyran-2-one (6PP) helped us to select six putative variants M70, M95, and M111 (6PP producing) and M5, M126, and M164 (non-producing). This prompted us to compare the aromatic odor (coconut odor) producing and non-producing putative variants on growth promotion of Bottle gourd, Tomato and Rice plants. In majority of the observations, 6PP strong producers induced larger difference in different plant growth parameters. Negative effects by some negatively impacting putative variants may be because of factors such as concentration of individual compounds and varying volatile profile over time.

PP08(TG2022): Large scale application of Lignocellulosic *Trichoderma lexii* (T-94a) formulation for the management of paddy straw

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Farmers usually dispose of the rice straw through open ûeld burning because of its slow degradation, disease prominent infestation, instability in nutrients, and negative effects of nitrogen immobilization reduces yield. Microbial composting is an effective way of decomposition of straws present in the field. Field demonstrations laid out at farmer's fields and the tedious process of large-scale application prompted us to look for a strategy for large-scale application technology. Water suspension of *Trichoderma lexii* formulation was sprayed in the field using a boom sprayer which uniformly covered and distributed the spores all over the field and was the most suitable method as compared to broadcasting. A random sampling of straws from the sprayed field (6 times at an interval of 7-10 days) recovered *Trichoderma* on TSM media. Identity was confirmed using light microscopy originally (*Trichoderma lexii* (94a)).

Satellite Workshop on Trichoderma and Gliocladium

PP09(TG2022): Efficacy of *Trichoderma* spp. against different fungal pathogens of potato

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Potato (*Solanum tuberosum* L.) is one of the most important vegetable crop in the world. India holds 2nd rank in potato production and 3rd in area under cultivation. In India the major potato producing state is Uttar Pradesh. It is affected by many diseases like fungal, bacterial, viral, and also parasitic nematode. Early Blight of potato is one of the most serious diseases of potato. Efficacy of bio-agents was studied and revealed the all three *Trichoderma* species significantly reduced the mycelial growth of the pathogen over the control by dual culture method. In present study *Trichoderma* spp. (*Trichoderma asperellum, Trichoderma harzianum* and *Trichoderma viride)* were found maximum inhibition on growth of *Alternaria* and *Fusarium* spp. by *Trichoderma harzianum* and least by *Trichoderma asperellum.* In *in vivo* condition maximum plant height, Number of branches and crop canopy were found in *Trichoderma harzianum* treated field plot. Minimum disease incidence was found in *Trichoderma harzianum* treated field plot.

PP10(TG2022): Identification of bio-active compounds from *Trichoderma asperellum* TR4 for the management of wilt of chickpea caused by *Fusarium oxysporum* f. sp. *ciceris*

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Secondary metabolites (SMs) from microorganisms have an antifungal role against agriculturally important phytopathogenic fungi. *Trichoderma asperellum* TR4 which is a versatile fungal bio-control agent having ability to produce a variety of secondary metabolites and these secondary metabolites utilized by fungus as the primary means of antagonism against plant pathogens. The study was conducted to identify different volatile secondary metabolites from *T. asperellum* TR4, isolated from chickpea rhizosphere having bio-activity against *Fusarium oxysporum* f. sp. *ciceris* causing wilt of chickpea, using GC-MS/MS. The GC-MS/MS analysis showed that the chromatogram showing the presence of 29 compounds at different peaks with retention time ranging from 4.910 to 21.868 min. The mass to charge (m/z) ratio of compounds ranged from 43 to 190. The compound 2-Imidazol-1-ylmethyl-pyridine 1-oxide (C9H9N3O) was found with maximum area of 14375440 and retention time of 19.842 as compared to other compounds and 7-Isopropylidene-5-methyl-2, 3-diazabicyclo (2.2.1) hept-5-ene-2,3 dicarboxylic acid, diethyl ester was present at highest peak with retention time of 20. Further, the methanolic crude extract containing bio-active compounds was tested against pathogen at 5, 10 and 15 per cent concentrations through poisoned food technique, where maximum inhibition of pathogen (75.93%) was observed at 15 per cent concentration showing the bio-activity of volatile compounds.

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PP11(TG2022): Selection of secondary metabolite producing superior putative mutants from gamma radiation of *Trichoderma atroviridae* (T-14)

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In this study putative variants (single spore isolates) derived from Gamma-ray irradiation of wild type *Trichoderma atroviride* (T14) formed the basis of our present investigation. Gamma radiation (1000 Gray per min) induced secondary metabolite producing superior putative mutants, and a subset of selected putative mutants produced plant growth promoting effects similar to hormonal application. *Trichoderma atroviridae* isolate T14 in the present study had a characteristic aromatic odour resembling coconut odour (identified as 6-PP) reported to be produced commonly by strains of *Trichoderma viride*, and sometimes also by *T. atroviride* (Kubicek and Harman 1998). Sensory evaluation for characteristic aromatic odour resembling coconut odor volatile, 6-pentyl-2*H*-pyran-2-one (6PP) helped us to selected 6pp producing and non-producing putative variants. Confirmation of 6pp producing and non-producing putative variants with TLC and GCMS is underway.

PP12(TG2022): Improvement of bio-control potential of *Trichoderma asperellum* through mutagenesis and its biochemical & molecular characterization

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In present investigation chemical and physical mutagenesis were applied for genetic improvement of the *Trichoderma asperellum* to enhance its bio-control efficiency. Sixteen mutants were tested for its stability up to seven generation. All mutants and mother culture of *T. asperellum* were differentiated by cultural, morphological and molecular characteristics. The mutants showed strong antagonistic activities against major soil borne pathogens. The highest per cent growth inhibition of *Sclerotium rolfsii* was recorded in mutant TaH_2 88.89 per cent. In case of *R. bataticola* and *Fusarium oxysporum* f. sp. *ciceri* highest per cent growth inhibition was recorded in mutants TaU_3 and TaG_1 i.e., 62.82 and 75.38 per cent respectively. All the mutants recorded higher chitinase enzyme content than mother culture. Mutant TaH_2 recorded highest i.e., 0.98 chitinase enzyme units/ mg of protein whereas mother culture has only 0.62 chitinase enzyme units/ mg of protein. The genetic relatedness among the mutants of *T. asperellum* were analyzed by RAPD and ISSR markers.

PP13(TG2022): Biocapsulation of *Trichoderma asperellum* and its shelf life

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In present investigation shelf life of *Trichoderma asperellum* in bio-capsule formulations was evaluated. Gelatin capsule formulation was prepared by mass multiplication of *Trichoderma asperellum* on sterilized grains of sorghum, maize, wheat, soybean and psyllium husk. After 15 days of incubation these substrates were dried under shade for 7 days and ground to fine powder in mixer grinder separately. The ground substrate was mixed with carboxymethyl cellulose @ 0.5 g and dextrose @ 1.0 g for 100 g of mixture. Talc based formulation of *Trichoderma asperellum* with 1:2 proportion was prepared and used as control for comparison. The highest initial population in capsule i.e. 21.9 x 10^8 cfu/g was recorded in sorghum grain substrate. The shelf life of capsulated *Trichoderma asperellum* was evaluated up to 180 days with an interval of 30 days. At 180 days of storage, highest population of *T . asperellum* was recorded in sorghum, maize, wheat grain substrate capsules i.e. 18.6 x 10^8, 18.3 ×10^8, 18.0×10^8 cfu /g, which was at par with each other and lowest population i.e. 7.4×10^8 cfu/g was recorded in psyllium husk capsule. The result of the present study indicated that the sorghum, maize and wheat grain substrate were found suitable for the commercial preparation of *Trichoderma asperellum* capsules.

PP14(TG2022): Relative antagonistic efficacy of *Trichoderma* spp. against *Sclerotium rolfsii* (Sacc.) causing collar rot of chickpea (*Cicer arietinum* L.)

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The present study was undertaken in order to find out the relative antagonistic efficacy of four Trichoderma species viz., Trichoderma viride, Trichoderma harzianum, Trichoderma virens and Trichoderma azospirillum against Sclerotium rolfsii incited collar rot in chickpea. Under in-vitro condition four species of Trichoderma were tested against S. rolfsii, minimum radial growth of the S. rolfsii was recorded in the T. viride 20.40 mm, 4 days after inoculation with maximum growth inhibition 54.67%, statistically superior among all Trichoderma spp. tested, followed by T. harzianum radial growth and inhibition were recorded respectively 22.20 mm and 50.67% inhibition, by dual culture technique. After 20 days of incubation maximum percent reduction of sclerotia formation recorded in T. virens 73.56%. Efficacy Trichoderma viride and T. harzianum evaluate against collar rot disease of chickpea in pot experiment and also impact of treatment application method viz., soil application, seed treatment and integration of both soil application & seed treatment of bioagents. All the treatments proved significantly superior when compared with pathogen inoculated control. Maximum percent reduction in Pre-Emergence Seed Rot (90.91%) and Post Emergence Seedling Mortality (43.75%) were recorded in Trichoderma viride applied through integration of soil application & seed treatment, followed by Trichoderma harzianum recorded 81.82% reduction in Pre-Emergence Seed Rot and 37.50% Post Emergence Seedling Mortality respectively. Maximum percent final plant population (66.67%) were observed in Trichoderma viride applied through integration of soil application & seed treatment, followed by Trichoderma harzianum with 61.54% final plant population. Trichoderma spp. had synergistic impact on plant vigour and grain yield.

Offline/Online Poster Presentations

SESSION 2:
Basic research in plant pathology

2A: Taxonomy and systematics of plant pathogens

PP01(Off)-2A: Morphological and molecular characterization of *Fusarium oxysporum* infecting scented geranium [*Pelargonium graveolens* (L.) Herit] in southern Karnataka

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Scented geranium is an important, perennial aromatic herb affected by several biotic stresses includes viral, fungal and bacterial diseases. Among them, wilt caused by *Fusarium oxysporum* is becoming a major constraint in cultivation. Wilt symptoms such as yellowing, drooping of plants and vascular discolouration were observed in the infected stems. Maximum wilt incidence recorded in Tumakuru district (36.73 %) of southern Karnataka. The pathogen was isolated from infected samples and pathogenicity was proved under controlled conditions. The re-isolated pathogen was identified as *F. oxysporum* based on its morphological characters by comparing with standard descriptions of *Fusarium* species. Cultural morphological studies of all *Fusarium* isolates revealed variability. The colony colour varied from pale white to red on PDA. Micro-morphological characters *viz.,* size, shapes of conidia and arrangements of chlamydospores varied significantly, these isolates produce sickle shape to elliptical macroconidia, oval to ellipsoid microconidia and thick walled chlamydospores. For molecular identification, the genomic DNA was extracted, and the internal transcribed spacer region (ITS) was amplified using the pairs of fungal universal primers ITS1/ITS4 which yielded PCR amplicon at 550 bp. *F. oxysporum* isolate GFO 1, GFO 2 and GFO 3 sequences were analysed and submitted to GenBank (accession numbers: MT740398, MT740399 and MT740400, respectively). These sequences show 100 % homology with [MN055701.1] *F. oxysporum* Ginrarsnl 1 reference strain. Phylogenetic analysis using maximum likelihood approach showed the sequences of all isolates matched with *F. oxysporum.* So, ITS gene region confirmed that *F. oxysporum* as the causal organism for wilt disease in scented geranium.

PP02(Off)-2A: Interpreting Variability among *Macrophomina phaseolina* isolates causing dry root rot of clusterbean

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Macrophomina phaseolina is a serious pathogen of many crops. In the present investigation, twelve isolates of *M. phaseolina* collected from different agro climatic zone of Rajasthan during survey were studied for their cultural, morphological, and pathological variability. Regardless of their geographic origins, all the isolates showed considerable variation in colony colour, type, aerial mycelial, branching pattern, radial growth, shape, size, colour and number of sclerotia and virulence. Mp-BKN also found highly pathogenic on all tested five varieties with 69.95 per cent mean disease incidence and Mp-UDZ isolate was least virulent on all tested five varieties with minimum mean disease incidence (31.61%). Among the tested culture media all the isolates attained maximum mycelial growth of 85.20 mm on Potato Dextrose Agar (PDA). These morphological, cultural and pathogenic variations in various isolates of *M. phaseolina* may be considered important in disease management systems and will be useful in breeding programmes of cultivars resistant to dry root rot.

2B: Genetics and ecology of plant pathogens

PP03(Off)-2B: Characterization of *Lecanicillium* spp and its efficacy against sucking pest of cotton

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The test fungus was isolated from soil, from serial dilution method and from infected sucking pest. Detailed morphological studies of effective isolate (VI2) show that the fungus grew well in SDAY medium. Four different semi synthetic media namely PDA, SDAY, CMA and MEA were evaluated for better growth of *Lecanicillium spp.* and it was observed that SDAY medium (53.00 mm) showed highest growth of isolates. Temperature 25ºC, humidity 95 per cent and pH 6.0 were observed as optimum for growth and sporulation of *Lecanicillium spp.* Molecular detection by polymerase chain reaction with specific primers ITS1 and ITS4 was performed on three isolates. The pattern showed by PCR analysis was identical for all the isolates tested confirming their identity as *Lecanicillium spp*. Highest insect mortality due to *Lecanicillium spp.* of *A. gossypii* was recorded at 0.25×107 conidia per ml followed by 0.20×107 conidia per ml, least mortality recorded at 0.100×107 conidia per ml after 2, 4, 6, and 8 days after treatment. Similarly, in case of insect mortality of *B. tabaci* , 109 spores per ml was recorded highest mortality followed by 108 spores per ml, least larval mortality was observed at 105 spores per ml after 3, 5, 7 and 10 days after treatment.

PP04(Off)-2B: Genetic variability of yield and yield related traits in mungbean [Vigna radiata (L.) Wilczek] genotypes

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A field experiment was conducted to study the genetic variability and diversity involving 38 genotypes for seed yield and component traits in mungbean at Agricultural Research Station (Agriculture University, Jodhpur), Mandor, Jodhpur during Kharif 2019. Under this study eleven characters were analysed and significant differences were observed among genotypes for all the characters. The magnitudes of phenotypic coefficients of variation were slightly higher over genotypic values showing smaller effect of environment in the expression of all the studied characters including seed yield. The highest magnitudes of PCV and GCV were observed for seed yield per plant followed by pods per plant, harvest Index, plant height, branches per plant. High heritability coupled with high genetic advance as 5 per cent of mean were altogether at a glance and observed for the traits like plant height (98.5, 45.9), pods per plant (94.9, 56.0), 100 seed weight (93.0, 27.2), seed yield per plant (89.8, 54.4), branches per plant (85.4, 40.7) and harvest index (88.3, 43.4) suggesting additive gene action in the expression of these characters, hence these characters may be proved as effective criteria for selection to improve the seed yield in mungbean.

PP05(Off)-2B: Genetic variability in *Bipolaris maydis* isolates inciting maydis leaf blight of maize

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Maize is one of the most important cereal crops in the world and also known as queen of cereals. Among various diseases of maize, maydis leaf blight incited by the fungus *Bipolaris maydis* has attained the status of the economically important disease. Twnety six isolates of *Biploaris maydis* (*viz*. BM-1, BM-2, BM-3, BM-4, BM-5, BM-6, BM-7, BM-8, BM-9, BM-10, BM-11 to BM-26) were collected from different locations of India and their genetic variability was studied by using random amplified polymorphic DNA (RAPD) and internal transcribed spacer (ITS). Data generated from 18 RAPD and 2 ITS polymorphic primers from six *B. maydis* isolates was analysed with UPGMA by using NTSYS and dendrogram was constructed. The cluster analysis of *B. maydis* isolates using combined data of RAPD and ITS primers depicted wide range of genetic relatedness, which ranged from 0.66 to 0.97, i.e., 66 to 97 per cent among the isolates of *B. maydis*. All primers showed 100% polymorphism with fragment size varying from 0.25-3 kb. The UPGMA analysis differentiated the twenty six *B. maydis* isolates into four groups i.e. group A, B, C and D at similarity coefficient of 0.76. The group A consisted of 13 isolates of *B. maydis*, in this isolates BM-15 and BM-19 showed 85 per cent genetic similarity whereas Isolate BM-17 and BM-20 showed 82 per cent genetic similarity. On the other hand group B consisted of 8 isolates of *B. maydis,* group C consisted of 2 isolates of *B. maydis* and group D also two isolates (BM-16 and BM-23) with 75 per cent genetic similarity. Analysis of *B. maydis* isolates from maize by phylogenetic tree revealed distinct clusters showing genetic variation.

PP06(Off)-2B: Effect of cultural conditions on the production of pectolytic enzyme by *Rhizoctonia bataticola*

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Pectin substances are major structural constituents of plant cells middle lamella and primary cell wall. The polysaccharides are degraded by pectolytic enzymes produced by phytopathogenic micro-organisms. The fungal pathogens attack plant cell wall, secreting the enzymes pectinases, which also facilitates entry of plant pathogens intra and inter cellularly into the host tissues. Pectic enzymes that degrade pectic substances of primary cell walls and middle lamellae are of major importance in the invasion of plant tissues by pathogenic fungi. All five carbon and nitrogen sources incorporated separately in the culture medium for pectolytic enzyme production. In carbon sources; all the twenty test pathogen isolates showed wide variability in pectolytic enzyme activity ranging from 0.299 to 0.238 µg of D-glucose/ml (CMC); 0.884 to 0.435 µg of D-glucose/ml (pectin); 0.415 to 0.238 µg of D-glucose/ml (glucose); 0.376 to 0.241 µg of D-glucose/ml (starch); 0.424 to 0.330 µg of D-glucose/ml (sucrose) and 0.164 to 0.115 µg of D-glucose/ml in control. However in nitrogen sources; all twenty isolates showed wide variability in pectolytic enzyme activity ranging from 0.662 to 0.424 µg of D-glucose/ml (urea); 0.694 to 0.402 µg of D-glucose/ml {potassium nitrate (KNO3)}; 0.659 to 0.434 µg of D-glucose/ml {ammonium chloride (NH4Cl)}; 0.855 to 0.627 µg of D-glucose/ml (glutamine); 0.790 to 0.525 µg of D-glucose/ml (glutamic acid) and 0.257 to 0.148 µg of D-glucose/ml in control. The growth of the pathogen and production of pectolytic enzymes were optimum at 300C in all isolates. As the temperature increased, above 150C, the growth and production of pectolytic enzyme was increased. Not a single isolate produced growth and pectolytic enzyme at 5, 10 and 400C temperature. The growth and synthesize of pectolytic activity varied at different pH levels (pH 3.0 to 8.0). At pH 2.0, the pathogen could not grow, hence there was no pectolytic enzyme activity. Whereas the activity was increased with an increase in pH of medium upto pH 6.0 and further, the activity was decreased at pH above 6.0 to 8.0.

2D: Mechanism of disease development

PP07(Off)-2D: Pathogenicity test and symptoms developed by *Colletotrichum capsici* on tomato fruits by various *in vitro* techniques

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Tomato (*Lycopersicon esculentum*) belongs to family solanaceae, is most important vegetable crop in India. Tomato causes different diseases such as fungal, bacterial and phytoplasmal which of that fungal fruit rot of tomato caused by *Colletotrichum capsici,* which is most destructive seedborne fungus, survive for longer duration in seed. The pathogen attacks on leaves, branches and fruits. Pathogenicity of *C. capsici* was attempted by applying fruit inoculation techniques, Pin-prick method and Cotton Plug inoculation method by using detached, healthy, semi-ripe and fully ripe tomato fruits. The test isolate was pathogenic to tomato fruits on artificially inoculated partially ripe and fully riped tomato fruits, the test isolates induced typical symptoms. Pathogenicity test were carried out during 2020-21, at Department of Plant Pathology, College of Agriculture, Latur (M. S.). Results revealed that symptoms induced by *C. capsici*, on fully ripe tomato fruits by using pin prick method were produced large, irregular, water-soaked lesions appeared on upper surface of fruits which were dark brown to black in coloured. Whereas, the symptoms induced by cotton plug inoculation method were small, irregular, water-soaked lesions appeared on fruits which were greyish brown in coloured. On fully ripe tomato fruits, the lesion diameter induced by *C. capsici* by using pin prick method was 22.9 mm and 11.4 mm on partially ripe tomato fruits, average lesion frequency on fully ripe tomato fruits was 7 % and 4.3 % on partially ripe tomato fruits, percent fruit area affected on fully ripe tomato fruits was 80 % and 50 % on partially ripe tomato fruits, under 22 hrs. of incubation period.By using plug inoculation method on fully ripe tomato fruits, the lesion diameter induced by *C. capsica* was 17 mm and 7 mm on partially ripe tomato fruits, average lesion frequency on fully ripe tomato fruits was 4 % and 2.3 % on partially ripe tomato fruits, percent fruit area affected on fully ripe tomato fruits was 40% and 10 % on partially ripe tomato fruits, under 22 hrs. of incubation period. Thus, virulence potential of *C. capsici* was highest on fully ripe tomato fruits as compared to partially ripe tomato fruits.

PP08(Off)-2D: Efficacy of oil-cakes against root- knot nematode (*Meloidogyne javanica*) in brinjal

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Brinjal (*Solanum melongena*) belongs to the family Solanaceae, it is an important vegetable crop and grown all around the world. It is one of the most important host for plant parasitic nematodes, mainly root-knot nematode *Meloidogyne javanica*. The nematicides are proven to be hazardous to the environment. A promising alternative is the use of microorganisms antagonistic to plant-parasitic nematode. The experiment was conducted in pots with four replications to test the efficacy of oil-cakes *viz.,* castor, mahua, karanj, mustard and neem cakeagainst the root-knot nematode, *M.javanica* on brinjal. Oil-cakes were used as root dip treatment at the time of transplanting @ 10 per cent concentration. The experiment was harvested after 60 days of transplanting and observation was recorded on plant growth parameter (shoot length, shoot weight, root length and root weight) and nematode reproduction (no. of galls per plant, no. of egg masses per plant, no. of eggs per egg mass and nematode juvenile per 200gm soil). As results showed that the neem cake @ 10 per cent concentration was found best treatment in improving plant growth characters and significantly reduced reproduction of root-knot nematode on brinjal, closely followed castor and karanj cake which also had almost similar impact in plant growth and nematode reproduction parameters.

PP09(Off)-2D: Study on pathogenicity factor of Early Blight of Tomato *(Solanum lycopersicum* Mill.) Incited by *Alternaria solani*

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Tomato (*Solanum lycopersicum* L., syn. = *lycopersicon esculentum* Mill.) is a regular kitchen component of Indian diet which comes under the family *Solanaceae*. The most important fungal disease of tomato prevalent in tomato growing areas of India including Rajasthan is early blight of tomato caused by *Alternaria solani* it is regarded as one of the limiting factors for victorious cultivation of tomato. The diseased leaves were collected from farmer's field of nearby Jobner, Kaladera (Jaipur) and fungus associated was isolated and multiplied on Potato Dextrose Agar medium. Purification of the fungus was done by single spore technique and fungus was identified as *Alternaria solani* on the basis of its phylogenic, morphological and colony characters. Pathogenicity was proved on healthy leaves of tomato. The characteristic symptoms of the disease appeared after 10 days of inoculation. Initially, the symptoms of this disease comprised minute yellow dot like circular, bright yellow colored spots on leaves. After that, spots enlarged, transformed into brown to dark brown, necrotic spots having bright yellow halo and less prominent concentric rings. Spots intermingled and surrounded larger area of leaf. The fungus was found to be pathogenic to tomato producing typical symptoms and results showed that the fungus was pathogenic with 66.45% disease intensity.

PP10(Off)-2D: Interactive effect of Meloidogyne javanica and Fusarium solani in causing root rot of fennel

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Fennel *(Foeniculum vulgare* Mill.) popularly known as *"Saunf"* is one of the important and highly valued spice crops grown in India. *Fusarium solani* is the most common pathogen in causing root rot of fennel with qualitatively and quantitatively losses. Development of disease in cultivated crops depends on the complex interaction between host, pathogen and prevailing environmental conditions. The significant role of nematodes in aggravating fungal diseases is well known in many crops throughout the world. In lieu of this, present study was planned to know the interactive effect of *Meloidogyne javanica* in enhancing the incidence of root rot by *Fusarium solani*. The experiment was laid out in a completely randomized design with four replications in pot conditions. Total 6 six treatments were taken *i.e.,* T1 - nematode alone (N), T2 - fungus alone (F), T3 - simultaneous inoculation of nematode and fungus (N+F) at the time of sowing, T4 - nematode at the time of sowing and fungus one week after (N1+F2), T5 - fungus at the time of sowing and nematode after one week (F1+N2) and T6 - control without fungus and nematode. Prior crop sowing, pots were inoculated with 2000 second stage juveniles of nematode while fungus was added @ 20 g per pot (multiplied on sorghum grains). The results showed that inoculation of nematode at the time of sowing and fungus one week after sowing caused maximum reduction in plant growth parameters and increased disease incidence followed by simultaneous inoculation of nematode and fungus in comparison to check. Conclusively, presence of root damaging nematodes in rhizospheric zone of plants plays an important role in enhancing incidence of root rot diseases.

PP11(Off)-2D: Variable association of mycoflora with blighted pods of soybean

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Valued for high quality protein and oil, the crop soybean (*Glycine max* (L.) *Merril*) is an important oilseed legume crop of India. Pod blight is an emerging threat for profitable cultivation under agro conditions of Jabalpur, Madhya Pradesh. Unpredicted precipitation during pod development is the key factor that develops disease. Pod blight disease is being observed during mid October to November. Association of *Colletotrichum dematium*, *Rhizoctonia solani*, *Alternaria alternata*, *Curvularia lunata*, *Aspergillus flavus*, *Aspergillus niger*, *Myrothecium roridum*, *Fusarium oxysporum* and *Rhizopus* spp. has been observed. Pathogenic ability investigations revealed that *Colletotrichum dematium* is primarily responsible for the development of disease, however, the remaining mycoflora develop faster on the affected portions. Stem blackening and leaf spots were also recorded that were induced by *Colletotrichum dematium.* The spore and mycelial suspension (12 day old) prepared in 10ml sterile water applied with the help of micro-sprayer, resulted in the necrosis and symptoms on pods of 5 commonly grown soybean varieties. The detached pod technique confirmed the pathogenic factor.

2E. Host plant resistance

PP12(Off)-2E: Reaction of chilli germplasm to *Chilli leaf curl virus* under natural field conditions

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Chilli (*Capsicum annuum* L.,) is an important vegetable and spice crop belong to *Solanaceae* family. It is highly susceptible to biotic and abiotic stresses and among these, Begomoviruses (family *Geminiviridae*) are the most destructive plant viruses that cause leaf curl disease in the tropical and subtropical world. This virus is efficiently transmitted by whiteûy (*Bemisia tabaci)* in persistent manner. Present investigation was carried out to know the reaction of chilli germplasm against leaf curl virus for two cropping seasons under natural field conditions. The per cent disease intensity (PDI) was recorded as per disease severity grade of 0-5 scale at 30, 60 and 90 days after transplanting (DAT). Out of 32 germplasm, none was found immune or free from viral infection, while 13 germplasm (EC- 928983, EC-759977, EC-692281, EC-920855, EC-927381, EC-692286, EC-773729, EC-769427, EC-915030, EC-928987, EC-772738, EC-769388, EC-927382) were categorized as resistant (PDI 6-25), eight (EC-771550, EC-759960, EC-759985, EC-771559, EC-769434, EC-755696, EC-769396, EC-692283) were categorized as moderately resistance (PDI 26-50), eight (EC-927381, EC-692287, EC-769406, EC-769386, EC-755694, EC-769430, EC-769399, EC- 769376) were categorized as susceptible (PDI 51-75) and three (EC-772732, EC-779985, EC-771549) were categorized as highly susceptible (PDI >75) up to 90 DAT under natural field conditions. A significant difference among genotypes implies sufficient variation among genotype screened, that can be deployed in chilli breeding programs.

PP13(Off)-2E: Activation of disease resistance in early blight of tomato through salicylic acid

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Tomato (Solanum lycopersicum L., syn. = lycopersicon esculentum Mill.) is a regular kitchen component of Indian diet which comes under the family Solanaceae and it is native of Tropical America. In the era of 16th century it spread throughout the world from the center of origin. After potato, it is second most important vegetable whereas processing point of view it ranks first among vegetables. The pathogen of early blight disease of tomato i.e. Alternaria solani is a soil inhabiting and air borne in nature. Study of Salicylic acid under in vitro condition resulted that SA at 200 ppm (68.45%) concentration was most effective in inhibiting mycelial growth followed by 150 ppm (46.98%) concentration. For activation of defense mechanism of plants, salicylic acid was evaluated through interaction between root dipping and foliar spray. Salicylic acid was proved to be most effective in treatment combination (root dip of 200 ppm and foliar spray of

150 ppm) against Alternaria solani and recorded minimum per cent disease intensity i.e., 17.41%, 20.43% at 45 DAS and 60 DAS, respectively.

PP14(Off)-2E: Screening of castor genotypes for *Fusarium* wilt disease resistance source

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Fusarium wilt disease of castor is widely distributed and severe yield losses were recorded in many cultivated castor hybrids. The release and adoption of wilt resistance castor hybrids has managed wilt disease effectively. Renowned wilt resistant castor hybrid, GCH-4 eventually turned out to become wilt susceptible. Similarly, wilt resistant variety, DCS-9 exhibited up to 60 % wilt incidence which indicated gradual breakdown of resistance. It is necessary to identify the newer potential wilt resistance sources. Hence, this study was undertaken to find out *Fusarium* wilt disease resistance sources. Promising castor inbred and pistillate lines were screened in wilt sick plot at Castor Mustard Research Station. The inbred and pistillate lines were grown as augmented trial with spacing 90 × 45 cm and 9.0 m row length. Susceptible (JI-35) and resistant (48-1) indicator lines were planted after five test lines. Wilt incidence (%) was recorded at 180 days after sowing and disease reaction was categorized as resistant (0.0 - d” 20.0% incidence), moderately resistant (> 20.0 - 40.0 % incidence), moderately susceptible (> 40.0 - 60 % incidence) and susceptible (> 60.0% incidence). Castor inbred lines *viz.*, SKI-399, SKI-401, SKI-403, SKI-405, SKI-406, SKI-408, SKI-411, SKI-412, SKI-415, SKI-416, SKI-417, SKI-419 and SKI-420 were resistant and SKI-404, SKI-407, SKI-413 and SKI-414 were moderately resistant to wilt disease. Castor pistillate lines *viz.*, Geeta, JP-96, SKP-106, SKP-121, SKP-123 and SKP-84 were resistant to wilt disease. These lines could be used as wilt resistance source(s) in breeding program to develop wilt resistant hybrid/variety.

PP15(Off)-2E: Plant Virus Control by Chemicals and a Plant Protein

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Eco-friendly approaches to confer disease resistance in plants are being universally addressed. We have explored the efficacy of antiviral resistance inducers Salicylic acid (SA) and/or Benzothiadiazole (BTH), and CIP-29, the *Clerodendrum inerme* antiviral protein, in controlling TMV infection on tobacco cv. Xanthi-nc and tomato. Foliar treatment with CIP-29 (20 μg/ml) on tobacco led to a 98% reduction in lesion number on remote leaves, with resistance lasting a week, while SA (2.5 mM) and BTH (2 mM) induced resistance declined sharply after the 3rd and 1st day of treatment, respectively. Expression of pathogenesis-related genes, glucanase and chitinase, were monitored in treated tobacco, employing a semi-quantitative RT-PCR. Glucanase gene-specific amplicon (444 bp) was expressed in all treated sets, including the DW control, while the chitinase gene-specific amplicon (410 bp) was observed in SA and BTH-treated sets only, as well as in the TMV inoculated set included as a positive control. Despite the chitinase gene expression in SA or BTH treated plants, the induced resistance was of a lower magnitude when compared to the CIP-29 treatment. Progression of mosaic and detection of TMV coat protein (CP) through SDS-PAGE and Dot blot analysis at 48 dpi supported a 20% and 90%

disease incidence in tomato plants treated with CIP-29 and SA, respectively. No amplification of the TMV CP-RNA was observed in the resistant tomato plants of both sets. CIP-29 treatments scored over SA with respect to growth promotion in tomato. Hence, under glass house conditions, CIP-29 was more efficacious than SA, both at controlling TMV infection on tomato and its growth promotion.

PP16(Off)-2E: Screening of urdbean genotypes against mungbean yellow mosaic virus under South-Eastern Rajasthan

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Urdbean is an important legume crop of the family leguminaceae and it is grown mainly in Indian subcontinent. On comparison with other pulse crop, urdbean is highly priced. Urdbean also known as blackgram and the yield potential of urdbean is shallow due to lack of genetic variability and biotic stress susceptibility. Among various diseases infecting and reducing yield of urdbean, yellow mosaic disease caused by mung bean yellow mosaic virus is the crucial one. MYMV belonging to Geminiviridae family and begomovirus group can affect crop yield upto 100 percent under higher incidence (Nene, 1972). The present investigation was to identify resistant urdbean genotypes against MYMV at natural condition through field screening. Out of fifty five urdbean genotypes, 41 genotypes viz., IPU 11-02, IPU 18-2, IPU 18-3, IPU 18-8, IPU 19-10, IPU 19-6, KPU 111-233, KPU 175-2, KPU 18-1, KPU 18-2, KPU 405, KUG 479, LBG 932, OBG 101, OBG 44, OBG 45, PANT U 1519, PANT U 1537, PANT U 19, PANT U 31, PANT U 35, PANT U 13-05, PUSA B-26, PUSA B-27, PUSA B-28, PUSA B-29, PUSA B-30, PUSA B-41, PUSA B-54, PUSA B-55, SHEKHAR-2, SUG 1190, SUG 1191, TU 1-11, VBG 12-034, VBG 14-016, VBG 17-026, VBG 18-085, VBG 18-099, VBG 18-124 and VBN 9 were found resistant. However, five genotypes *i.e.* LBG 787, LBG 904, VBG 18-111, VBN 6 and VBN 8 exhibited moderately resistant, Whereas, four genotypes GBG 133, GBG 140, LBG 623 and LBG 752 as moderately susceptible. While, DBGV 19 as susceptible and ADT 6, DBGV 28, DBGV 33 and GBG 109 were found highly susceptible. The promising genotypes having yellow mosaic virus resistance in urdbean may be utilized for breeding programme to develop high yielding varieties coupled with disease resistance.

PP17(Off)-2E: Induction of Systemic Resistance in Chickpea against Dry Root Rot Caused by Macrophomina phaseolina

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In the present study, *Trichoderma asperellum* and *Pseudomonas fluorescence* were appraised as potential biocontrol agents that induce resistance in Chickpea (Cicer arietinum) against the destructive pathogen *Macrophomina phaseolina*, which causes dry root rot in chickpea. Under greenhouse conditions, chickpea seeds pre-treated with *Trichoderma asperellum* and *Pseudomonas fluorescence* by soil soak method inflicted an induced systemic resistance (ISR) in chickpea against *Macrophomina phaseolina* under challenged conditions. The plants have defence genes that need appropriate stimuli or signals to activate them. Inducing the plants for their own defence mechanisms by prior application of abiotic or biotic inducers is a novel technique of plant protection. These inducers are known to accumulate signalling molecules mediating SAR, leading to increased expression of defence genes encoding chitinase, peroxidase, Polyphenol oxidase(PPO) and other enzymes involved in synthesis of phytoalexins. The seed treatment with biocontrol agents induces systemic resistance leading to plant defence mechanisms.

PP18(Off)-2E: Study On Host resistance against bacterial blight disease of clusterbean Caused by (*Xanthomonas axonopodis* pv. *cyamopsidis*).

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Host plant resistance is an ultimate tool to keep away the disease from the crop. It is a simple, cheap and ecofriendly approach for the management of disease. Therefore, one hundred clusterbean germplasm were screened against bacterial blight disease (*Xanthomonas axonopodis* pv. *cyamopsidis*) under artifical epiphytotic condition to find out the source of resistance. Per cent disease index (PDI) of each genotype was recorded at pre-flowering and maturity stage by visual scoring as per the standard continuous rating 0-5 scale (Rathore, 2006). On the basis of pooled data of 2018 and 2019, among the total one hundred germplasm, only two germplasm namely RGr-16-2 (RGC-936×RGC-1055) and RGr-16-11-5 (RGC-1025×RGC-197) were found resistant with minimum PDI 7.17 & 9.44 and 9.44 & 10.00 at pre flowering and maturity stages respectively, thirty germplasm showed moderate resistant (MR), sixty seven germplasm found moderately susceptible (MS), one germplasm namely RGr-17-16-2 (GG-1×RGC-936) found susceptible (S) with maximum PDI 51.11 & 52.22 at pre flowering and maturity stage, respectively. None of the germplasm was found completely free from the disease and highly susceptible (HS) against bacterial blight disease.

PP19(Off)-2E: Aggressiveness of Rhizoctonia bataticola isolates causing dry root rot of chickpea in Rajasthan

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Dry root rot (DRR) of chickpea (*Cicer arietinum* L.) caused by *Rhizoctonia bataticola* is an important disease affecting chickpea production especially in tropical and sub-tropical ecologies of world. The root necrosis gradually increases with time without any apparent symptoms on the parts of the above ground till flowering and podding growth stages. *Rhizoctonia bataticola* is mainly a soil-borne pathogen with wide host range and can survive under soil as a saprophyte up to 15 year. It causes high yield losses in the oilseed, pulses and vegetable crops and producing the different symptoms like charcoal rot, stem and root rot, dry root rot, seedling blight and ashy stem blight. The present investigation was planned to evaluate the aggressiveness of *Rhizoctonia bataticola* isolates with susceptible variety L-550. Five isolates collected from major chickpea growing areas of Rajasthan were found significantly pathogenic on susceptible variety L-550 and produced typical symptoms. Among all the isolates, RBjd was found highly aggressive with minimum seed germination (80.00 %) and higher disease incidence (37.50 %) followed by RBr isolate (33.33 %). Initial symptoms due to highly aggressive isolate occurred within 26 days of sowing and caused highest pre emergence mortality.

PP20(Off)-2E: Biochemical changes in mothbean leaves infected with Cercospora leaf spot pathogen *Cercospora canescens*

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The maximum phenol content (6.69 mg g-1fr.wt.) was recorded in the diseased leaves of RMO-40 variety compared to healthy leaves. Similarly, highest total sugar (14.29 mg g-1fr.wt.), non-reducing sugar (5.54 mg g-1fr.wt.) and reducing sugar (8.75 mg g-1fr.wt.) content was determined in healthy leaves of RMO-40 variety compared to diseased leaves. Besides highest protein content (15.70 mg g-1fr.wt.) was estimated in diseased leaves of same variety. Based on physiological changes, highest total chlorophyll content (1.55 mg g-1fr.wt.) was observed in healthy leaves of RMO-40 variety as compared to diseased leaves or other susceptible varieties. Highest proline content (1.16 mg g-1fr.wt.) was recorded in the diseased leaves of RMO-40 variety compared to healthy leaves.

PP21(Off)-2E: Biochemical changes induced in the maize leaf sheath upon inoculation with *Rhizoctonia solani* incitant of banded leaf and sheath blight

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Banded leaf and sheath blight (BLSB) caused by *Rhizoctonia solani*, a soil-borne fungal pathogen of maize is an emerging disease in the northwest region of India. The disease has become economically important in several hot and humid tropical areas around the world In order to plan long-term strategies for sustainable disease control, it is therefore necessary to understand the biochemical mechanisms involved in the interactions between host and pathogen. However, changes in the activities of defense related enzymes in maize hybrids/inbreds and their associated BLSB resistance are unknown. The present study was planned to investigate the potential role of defense related enzymes in imparting resistance against *R. solani* in seven inbreds *viz.,* LMDR-2, CM-143, CM-600, LM-11, LM-12, LM-13 and LM-14, and four maize hybrids viz., PMH1, PMH2, PMH4 and JH3459. The enzyme activites were determined from the leaf sheaths collected at 0, 24, 48, 72, 96, 120 and 144 hrs post inoculation. Results indicated a spike in the expression of phenylalanine ammonia-lyase (PAL), polyphenol oxidase (PPO), peroxidase (POX) and catalase (CAT) at 72 hrs post inoculation following pathogen challenge in different maize inbreds/hybrids. The moderately resistant group (LMDR-2 and JH3459) showed significantly higher activities than the susceptible group (LM-11, LM-12, CM-600, PMH4 and PMH2). A strong positive correlation was observed between different enzymes at 72 and 96 hrs after inoculation. Lesion length showed negative correlation with the activities of enzymes studied. Our results indicated that PAL, PPO, POX and CAT played key roles in providing BLSB resistance in maize cultivars.Banded leaf and sheath blight (BLSB) caused by *Rhizoctonia solani*, a soil-borne fungal pathogen of maize is an emerging disease in the northwest region of India. The disease has become economically important in several hot and humid tropical areas around the world In order to plan long-term strategies for sustainable disease control, it is therefore necessary to understand the biochemical mechanisms involved in the interactions between host and pathogen. However, changes in the activities of defense related enzymes in maize hybrids/inbreds and their associated BLSB resistance are unknown. The present study was planned to investigate the potential role of defense related enzymes in imparting resistance against *R. solani* in seven inbreds *viz.,* LMDR-2, CM-143, CM-600, LM-11, LM-12, LM-13 and LM-14, and four maize hybrids viz., PMH1, PMH2, PMH4 and JH3459. The enzyme activites were determined from the leaf sheaths collected at 0, 24, 48, 72, 96, 120 and 144 hrs post inoculation. Results indicated a spike in the expression of phenylalanine ammonia-lyase (PAL), polyphenol oxidase (PPO), peroxidase (POX) and catalase (CAT) at 72 hrs post inoculation following pathogen challenge in different maize inbreds/hybrids. The moderately resistant group (LMDR-2 and JH3459) showed significantly higher activities than the susceptible group (LM-11, LM-12, CM-600, PMH4 and PMH2). A strong positive correlation was observed between different enzymes at 72 and 96 hrs after inoculation. Lesion length showed negative correlation with the activities of enzymes studied. Our results indicated that PAL, PPO, POX and CAT played key roles in providing BLSB resistance in maize cultivars.

PP22(Off)-2E: Pathogen Mediated Plant's Programmed Cell Death

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Microbial pathogens are among the many threats that plants face. Plants have developed defensive tactics to combat possible invaders in order to protect themselves. Plants are capable of selectively triggering inducible, broad or narrow spectrum defense systems depending on what type of invader encountered. Biotrophic pathogens need only living hosts to complete their life cycles, whereas necrotrophic grow and establish themselves on dead cells. In comparison to other microorganisms, hemibiotrophic microbe associate with plants in two phases; early with biotrophic phase and later as a necrotrophic phase. Plants and pathogens communicate through receptors present on the surface of host cells and elicitors which generated by microorganisms. When plants and pathogens interact, either a compatible or incompatible reaction occurs. Plants show programmed cell death in response to diverse biotic and abiotic stress factors, which limits the growth of biotrophs and hemibiotrophic, whereas necrotrophs, as an opportunist and grow on dead tissue for their own advantage. Programmed cell death regulation is the result of plant-pathogen crosstalk, which is entirely reliant on biochemical events such as the production of nitric oxide, reactive oxygen species, ionic efflux/influx, phytohormone biosynthesis, phytoalexin biosynthesis and pathogenesis-related proteins. During the invasion of harmful microorganisms, this phenomenon mainly happens in resistant and non-host plants.

PP23(Off)-2E: Biochemical changes in groundnut cultivars against early leaf spot disease (*Cercospora arachidicola*)

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Groundnut (*Arachis hypogaea* L.) is an important oilseed and supplementary food crop of the world which belongs to the family *Leguminosae.* The crop is suffered from several biotic factors that limit its production and productivity. However, only a few are economically important in Rajasthan, such as fungal diseases like early leaf spot. Early leaf spot caused by *Cercospora arachidicola* Hori. is most destructive disease in all the groundnut growing areas of Rajasthan which drastically change the composition of infected leaves. Three most popular groundnut varieties of cultivators *viz;* HNG-10, HNG-123 and HNG-69 were used in this experiment to determine the changes of biochemical composition with respect to phenol, total sugar, protein, proline and chlorophyll in infected leaves caused by early leaf spot pathogen and compared with healthy leaves. Total phenol, soluble protein and proline were increased due to infection of *Cercospora arachidicola* in all the three varieties with maximum in HNG-10 followed by HNG-123 and HNG-69. Total chlorophyll and total sugar content were decreased due to infection with maximum in HNG-69 followed by HNG-123 and HNG-10.

PP24(Off)-2E: Response of Defence Related Enzymes in Cucumber Treated with Oil-Cakes against Root-knot Nematode, *Meloidogyne* spp. and *Fusarium oxysporum*

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Cucumber (*Cucumis sativus*) popularly known as khira is one of the important cucurbitaceous vegetables from nutritional as well as economic point of view. It is grown for its tender fruits for fresh consumption as salad or as pickling cucumber for preservation, marinated with vinegar, salt, dill or other spices. Plants produce a spacious range of biologically active molecules which have antagonistic properties against plant parasitic nematodes and wilt disease. The peroxidase (PO), polyphenol oxidase (PPO), Phenol is the most defense enzymes produce by plants during nematode and fungus infection. An experiment was conducted to assess the effect of oil-cakes (Neem, castor, karanj, mahua and mustard @ 2 g/per plant) on accumulation of polyphenol oxidase (PPO), peroxidase (PO) and phenol in cucumber roots infected with wilt complex disease and management of disease complex. The observations on enzymatic activity were assayed after 14 days of sowing using spectrophotometer while observation on plant growth parameters, disease incidence and nematode reproduction were recorded 60 days after sowing. The results showed increased level of PPO, PO and phenol activity in cucumber roots treated with oil-cakes. Results showed that maximum PPO, PO and phenol activity was recorded after with neem followed by castor and mahua. while, minimum PPO, PO and phenol activity was observed in nematode + fungus infected control plant roots. The data also indicated that all oil-cakes significantly increased cucumber plant growth parameters compared to control plant. Maximum plant growth parameters were recorded with neem followed by castor and mahua oil-cake. However, minimum plant growth parameters were recorded with untreated control (nematode + fungus). Data on nematode

reproduction showed that all the oil-cakes significantly reduced the nematode reproduction as compared to untreated check. Among the oil-cakes the neem was recorded most effective treatment with minimum nematode reproduction followed by castor and mahua oil-cake. However, untreated check nematode alone was observed least effective with maximum nematode reproduction. While, maximum per cent disease incidence was recorded with untreated check nematode + fungus.

PP25(Off)-2E: Studies on field and molecular marker based screening of promising taro (*Colocasia esculenta var antiquorum*) cultivars for resistant to *Phytophthora* blight

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Taro [*Colocasiaesculenta L*. (schott)] var. *antiquorum* is one of the most important tropical tuber crop worldwide. It has been prone to attack by several pathogens and one of the major devastating pathogen is a fungus causing Taro blight. In our present study, our main objective was to do field and molecular based screening of the Taro plants in West Bengal in order to identify resistance to *Phytophthora colocasiae* using molecular based marker.Total 9 entries of upland taro (TTr 17-1, TTr 17-2, TTr17-3, TTr17-5, TTr17-8, Tr17-12, TTr17-13, Muktakeshi, and Teila) were field evaluated for the incidence of *Phytophthora* blight disease where variety Muktakeshi and Telia were taken as positive and negative control respectively. The significant positive correlation of economic traits like number of cormels per plants, weight of the cormels per plant (grams), total cormel yield (t^{-1}ha), weight of the corm per plant , total yield (corm + cormerls) in t^{-1}ha, was recorded, suggesting that inspite of the pathogen damage, TTr entries have tolerant capacity and gives significant yield. Molecular based screening was conducted using resistant gene primers *Prg* 1 *Prg* 2, Primers showed 100% polymorphism and the number of bands ranged from 3 to 5 (Muktakeshi, TTr 17-12, TTr 17-8 & TTr 17-5). These were the entries which have resistant gene which helps to overcome the pathogen damage.

2F: Epidemiology and crop loss assessment

PP26(Off)-2F: Prevalence of postharvest diseases of khasi mandarin fruit in siang Region of Arunachal Pradesh (India)

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The postharvest losses are often by fungi may appear during the growth period, harvesting, handling, transportation and post-harvest stockpile and marketing conditions and after procuring by the consumer. Short shelf-life period provoked by pathogens is one of the important factors that impact the economic value of mandarin fruits. Khasi mandarin fruits purchased from local market of Siang regions of Arunachal Pradesh to study the biodiversity of fungal post-harvest decay of Khasi mandarin. A total of 200 infected fruits samples were collected from different local market, small pieces of decay part were inoculated on prepared plates of PDA media, after 7 days of incubation, pure isolated fungi were identified according to the recommended references. Common decay fungi are isolated and identified as *Penicillium*, *Aspergillus*, *Geotrichum, Colletotrichum*, *Alternaria, Botrytis*, and Mucor. Several fungal species (25) belonging to 7 fungal genera could be regarded as post-harvest decay of fruits in Siang regions of local market. Proper measures should be adopted to protect fruits from fungal decay in local market facilities. In recent years, storing mandarin fruit in local market facilities has become *Penicillium sp.* (32.25%) was most prevalent followed by *Aspergillus sp.* (25.50%) and *Geotrichum sp.* in both grower lots of the fruit season of the year 2020-21 and 2021-22 respectively. Although, maximum fruit decay incidence (38.46%) recorded in both the fruit season of the year 2020-21 and 2021-22. The fruit decay diseases is threat to mandarin growers because there is no cost effective fruit decay disease management method to the growers of Khasi mandarin losses in Siang regions of Arunachal Pradesh.

PP27(Off)-2F: Survey and Assessment the Disease Incidence of Alternaria Leaf Blight of Carrot

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Carrot (*Daucus carota* L.), is most important vegetables root crop with huge medicinal, nutritional and health value. The carrot suffers from several diseases among those Alternaria leaf blight is one of the most horrible diseases are causing considerable quantities and qualitative losses in carrot. A roving survey was conducted in different farmer's fields of Jodhpur district during *Rabi,* 2020-21 in the month of December and January. The data revealed that the disease incidence of Alternaria leaf blight of carrot in Jodhpur district, tehsil's varied from 11.74% to 24.02%. In Tinwari, the maximum disease incidence was recorded 24.02% followed by Osian (22.66%), Lohawat (18.17%), Bawadi (13.84%). However, minimum disease incidence was recorded in

Balesar (11.74%). The data recorded confirms that the overall mean incidence of Alternaria leaf blight of carrot in Jodhpur district was (18.08%) Based on 125 fields of Jodhpur district during R*abi,* 2020-21. Alternaria leaf blight disease of carrot is one of the major yield limiting factors in Jodhpur district of Rajasthan.

PP28(Off)-2F: Incidence and severity of wheat powdery mildew (*Blumeria graminis* f. sp. *tritici*) in the different wheat growing districts of Himachal Pradesh, India

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Powdery mildew caused by *Blumeria graminis* (DC.) E.O. Speer f. sp. *tritici* E'm. Marchal (syn. *Erysiphe graminis* f. sp. *tritici*) is one of the major diseases of wheat across the globe. This disease is favoured by moderate temperature, reduced light, humidity and succulent plant growth. The weather conditions in the northern hills of India are favourable for the development of this disease and therefore, it is drawing more attention along with other important diseases of wheat. In order to ascertain the severity, recurrent surveys were carried out and the distribution of powdery mildew was assessed in the wheat grown in the different districts of Himachal Pradesh. Total of 75 wheat fields located in 10 districts *viz*., Shimla, Kinnaur, Lahaul-Spiti, Sirmour, Mandi, Bilaspur, Chamba, Kangra, Kullu and Solan were frequently visited during the year 2019 and 2021and assessed the PM incidences and severity in wheat growing areas of Himachal Pradesh. Survey was carried out in farmer's field, research farms and stations. Surveillance was carried out during heading to grain filling stage of wheat crop. Powdery mildew was recorded based on foliar infection. Data on latitude, longitude and altitude was recorded along with incidence and severity of powdery mildew. Modified Cobb scale (0-9 scale) was used to estimate disease severity and percentage of infected tissue of plant in a field. Comprehensive analysis of PM severity on the basis of pooled data resulted that the maximum disease severity was recorded from Dalang maidan, (Lahaul-Spiti), Tutikandi, Dhanda in Shimla, Kala Amb (Sirmour) and Dhaula Kuan (Sirmour). These locations have favourable weather conditions for development of this disease. Also locations such as Dalang maidan, (Lahaul-Spiti), Tutikandi (Shimla) and Dhaula Kuan (Sirmour) are research stations. Keeping in view, severity of powdery mildew it can be ideal locations for screening wheat germplasm at field conditions and also to identify durable resistant types to contain the pathogen in long-term.

PP29(Off)-2F: Use of Botanical for the management of Pulse Beetle, callosobruchus chinensis (Linn.) iensis (Linn.) on cowpea under storage condition

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The different plant products viz,neem oil, castor oil, mustard oil, groundnut oil, karanj oil(0.1&0.5 ml or g/ 100 g of seeds) and neem leaf powder, karanj leaf powder, aak leaf powder and datura leaf powder (1.0 and 2.5 g/ 100 g seeds) when admixed with cowpea grains proved to be causing

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adverse effect on adult emergence of C.chinensis and reduces grain damage and weight l oss by this pest.The neem oil was the best treatment to enhance the developmental period and reducing the adult emergence and ovipositional potential, while datura leaf powder was least effective treatment.The per cent grain damage and weight loss were minimum in neem oil and maximum in datura leaf powder.No adverse effect of tested plat products was observed on the germination of cowpea seeds up to 90 days of treatment.

PP30(Off)-2F: Influence of environment factor and their interaction on ovipositional potential of *Callosobruchus chinensis*

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The growth and development of C. Chinensis was studied under stored conditions on different temperature (20, 25 and 30 !) and humidity (60, 70, and 80%) .The temperature and humidity have been shown to play a vital role in the growth and development of various stages of this pest. The ovipositional potential increased with the increase in temperature.The developmental periods decreased with the increase of temperature and vice -versa. The adult emergence, grain damage and loss in weight were maximum at 30 ! and 70 % relative humidity and less at 20 ! and 80 % relative humidity .On the basis of various parameters, it can be concluded that for development of this pest ,the optimum conditions were 30 ! temperature and 70 % relative humidity.

PP31(Off)-2F: Effect of temperature and humidity levels on growth and development of *Callosobruchus chinensis*

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The growth and development of *C. chinensis* was studied under stored conditions on different temperature (20, 25, 30 and 35 0C) and humidity (60, 70, 80 and 90 %). The temperature and humidity have been shown to play a vital role in the growth and development of various stages of this pest. The ovipositional potential increased with the increase in temperature from 200 to 300 C and decreased at 350 C. the ovipositional incubation and developmental periods decreased with the increase of temperature and *vice-versa*. The adult emergence, grain damage and loss in weight increased up to 300C and maximum at 300C and 70 per cent relative humidity and less at 200C and 90 per cent relative humidity. On the basis of various parameters, it can be concluded that for development of this pest, the optimum conditions were 30+10C temperature and 70+5 per cent relative humidity.

PP32(Off)-2F: Estimate losses in different varieties of lentil caused by Callosobruchus chinensis

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Pulses the “wonderful gift of nature” play an important role both in Indian economy and diet. Lentil is one of the important Rabi pulses. The assessment of losses at storage has been an intricate problem since long. Though various estimates and sporadic surveys have been made by various workers from time to time, the actual losses occurring in the villages in respect of grain damage caused by various pest species still remains unanswered. The genus *Callosobruchus* attack grain legumes during both pre and post harvest stages all over the world, but in India, *C. maculatus, C. analis* and C*. chinensis* are the predominant pest species of the genera. Investigations were carried out on Eco-friendly management of pulse beetle *Callosobruchus chinensis* (Linnaeus) on Lentil (*Lens esculenta* Moench)" during 2014-15 at S.K.N. College of Agriculture, Jobner. Out of 10 varieties screened on the basis of biological parameters and physico- chemical characters against this insect, Asha and PL-01 were less susceptible and Spana, IPL-81and L-4076 were highly susceptible. However, PBW-343, L-147, RKL-60701, JL-3, RKL-607, and RKL6118 were moderately susceptible.

PP33(Off)-2F: Importance of survey and surveillance in Plant Diseases Management

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Assessment of presence, distribution and abundance of plant disease are essential pre requisites to plant diseases management. Modern diseases management cannot operate without accurate estimates of diseases or plant damage and its effect on yield. This is made possible by undertaking surveys. Survey is the planned procedure to determine the characteristics of pathogen population over a defined time period while surveillance is the regular monitoring of pathogen population dynamics, its incidence and damage on crop at fixed intervals. The basic principle of surveys to manage plant diseases is that no management strategy is to be undertaken unless it is known that pathogen population has reached economic threshold. The survey can be qualitative or quantitative. Generally two types of surveys are employed in field of plant pathology: Intensive and extensive surveys. Roving survey and fixed plot survey are the two basic techniques employed in surveillance of plant diseases. The former technique involves the assessment of pathogen population or damage from randomly selected spots representing larger area while the latter involves assessment from the fixed plots selected from field at periodic intervals. Every year there is significant loss to agricultural yield and productivity owing to no proper and centralised database for analysis and forecasting of diseases and also due lack of timely advisory service and early warning to farmers to implement necessary disease-prevention measures. Hence it is the need of hour that different agencies should work together on pest surveillance and present convergent good quality data on actual diseases problems.

PP34(Off)-2F: Pathometry – historical development, current era and future challenges

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Pathometery is the discipline of phytopathology that deals with estimation or measurement of the extent of plant diseases as expressed by symptoms of disease or the signs of a pathogen on the host. Knowledge of the quantity of disease is fundamental to i) ascertain crop losses; ii) conduct disease surveys; iii) establish thresholds for decision making; iv) improve knowledge of disease epidemiology, v) evaluate the effect of treatments and vi) breeding for diseases resistance. In general, diseases offer three parameters for measurement – incidence, severity and yield loss. Visual estimation is the method of allocating value to severity of symptoms perceived by the human eye. Visual estimates of disease severity rely on scales typical to measurement science: nominal scale, ordinal rating scale, interval scale and ratio scale. Standard Area Diagrams are elementary and widely used tool to enhance the accuracy of estimates by accessor as they also allow estimation of intermediate levels of diseases severity. With the advancement in field of science and technology, a sensor or instrument can directly or indirectly measures the amount of disease or stress signal based on remote sensing. Visible spectrum image analysis is based on the measurement of number of pixels that comply with pre-defined properties of pixels characterising a diseased state contra healthy state, which are identified using a range of statistical programmes. New tools based on artificial intelligence have demonstrated competence and the potential to conquer many of the barriers associated with visual and sensor based methods.

PP35(Off)-2F: Survey of rice diseases in major rice growing areas of Haryana

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Roving surveys in paddy growing area of Haryana were conducted during *Kharif* 2020 by a team of scientists. A total of 80 villages (10 villages per district) were surveyed in the districts of Kaithal, Kurukshetra, Karnal, Jind, Yamuna Nagar, Ambala, Panipat and Sonepat. None of the rice diseases appeared in devastating form and the farmers were managed these biotic stresses with recommended/other effective pesticides. None of the diseases was recorded at 20, 20, 10, 20, 10, 20, 10 and 20% sites in Kaithal, Kurukshetra, Karnal, Jind, Yamunanagar, Ambala, Panipat and Sonepat districts, respectively. Among diseases, sheath blight was observed in low to moderate form at 60, 70, 70, 60, 80, 60, 80 and 70% locations in the districts of Kaithal, Kurukshetra, Karnal, Jind, Yamunanagar, Ambala, Panipat and Sonepat, respectively both in scented and non-scented inbreds and hybrids. The disease was recorded in rice varieties Pusa Basmati 1121, Pusa Basmati 1509, CSR 30, Pusa Basmati 1, Pusa Basmati 1718, HKR 147, PR 114, PR 118, PR 126, Sawa 127, Sawa 134, Bayer 28P64, Bayer 28P67, 25P35,357, 2222 and 2111. Leaf blast appeared in traces to moderate intensity at 50, 20, 10, 20 and 10% locations in the districts of Kaithal, Jind, Yamunanagar, Panipat and Sonepat, respectively in rice varieties Pusa Basmati 1121, Pusa Basmati 1509, CSR 30 and Pusa Basmati 1718. While Neck blast incidence ranged from 1-5% at 30, 10, 10, 20 and 20% location in Kaithal, Karnal, Jind, Panipat and Sonepat districts, respectively in CSR-30, Pusa Basmati 1121, Pusa Basmati 1509and Pusa Basmati 1718. Bakanae incidence ranged from traces to 7.0% at 40, 20, 20, 40, 10, 10, 80 and 60% locations in the districts of Kaithal, Kurukshetra, Karnal, Jind, Yamunanagar, Ambala, Panipat and Sonepat, respectively in CSR-30, Pusa Basmati-1121, Pusa Basmati 1509 and Pusa Basmati 1718. The maximum bakanae incidence of 7.0 % was observed in village Rasina (Kaithal) in Pusa Basmati 1121 where the farmer uprooted paddy nursery from dry nursery beds leading to root injury.

PP36(Off)-2F: False smut: a threat for grain yield and quality of rice

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False smut is the most important grain disease of rice worldwide. False smut was previously recorded as a minor disease but in recent, increasing occurrence of false smut has been reported in most major rice growing regions such as China, India and USA. Their epidemics not only lead to yield loss but also reduce grain quality because of multiple mycotoxins generated by the causative pathogen *Ustilaginoidea virens*. Which specifically infects rice flowers and transforms the latter into smut balls? Smut balls are small at first growing slowly and enclosing the floral parts. The early balls were found to be slightly flattened, smooth and covered by a thin membrane. As the pathogen growth intensifies, the smut ball bursts with chlamydospores and becomes orange then yellowish-green or greenish-black. The smut balls generate sclerotia when the temperature difference between day and night is large in autumn. Smut ball is the only visible symptom of false smut disease. The disease induces considerable losses both in yield and quality due to the occurrence of smut balls and increased sterility of kernels adjacent to the balls. Moreover, smut balls produce two types of mycotoxins, i.e., ustiloxin and ustilaginoidin, which are poisonous to both humans and animals and impose significant health hazards by contaminating rice grains and straws. The disease spread varies within a field or between fields and more severe in the proximity of drainage channels. Epidemics of false smut disease tend to occur when rice booting and heading stages meet with rainfall periods.

PP37(Off)-2F: Prevalence and incidence of dry root rot of chickpea (*Rhizoctonia bataticola*) in Rajasthan

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Chickpea (*Cicer arietinum* L.) also known as Bengal gram is one of the most important winter season pulse crops grown in India. This crop is prone to several fungal diseases, among them dry root rot caused by *Rhizoctonia bataticola* is economical disease. The disease generally appears around ûowering and podding time in the form of scattered dried plants. Drooping of petioles and leaûets, lower portion of the tap root usually remains in the soil when plants are uprooted, taproot is dark and is devoid of most of its lateral and ûner roots. A roving survey was conducted in major chickpea cultivating districts of Rajasthan like Jaipur, Tonk, Ajmer and Jodhpur during *Rabi* season of 2021 during peak of disease development at around 90 days after sowing. A total thirty fields from ten villages of these four aforesaid districts were surveyed and isolates were collected along with information like cultivar, soil type, irrigation facility (rainfed or irrigated), disease prevalence. The results of field survey revealed that incidence of root rot were varied from 27.45 – 58.00 per cent in surveyed districts of Rajasthan. The highest mean disease incidence was observed in Jodhpur district (58.00%) followed by Ajmer (47.05%) and it was lowest in Jaipur district (27.45 %).

PP38(Off)-2F: Effect of Weather on Alternaria Blight Disease of Tomato caused by *Alternaria Alternata*

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Alternaria blight incurring loss both at pre and post-harvest stages in tomato caused by *Alternaria alternata* become an important constraint for tomato producers in Rajasthan. The severity of this disease generating significant economic losses in crops has been increasing daily for the last few years in Rajasthan due to environmental changes. Field experiments were carried out to examine the development of Alternaria blight in tomato relevant to weather conditions during *zaid* 2017 and 2018 at SKNAU Jobner (Jaipur). Results showed that maximum temperature (r= 0.9032 Unit in 2017 and 0.8893 in 2018), minimum temperature (r=-0.8590 in 2017 and 0.8512 in 2018), relative humidity maximum (r=-0.6184 in 2017 and -0.8562 in 2017), relative humidity minimum (r=-0.6840 in 2017 and -0.5477 in 2018) and rainfall (r=-0.6161 in 2017) had shown significant negative correlation with disease severity index (DSI). The mean value of the minimum and maximum temperature during this period ranged from 15.630C to 35.740C and 15.750C to 36.240C during 2017 and 2018, respectively. Development of disease observed in favourable mean relative humidity ranging from 25.33 to 63.00 and 16.66 to 58.00 per cent. The coefficient of multiple determinations (R2) was 74.50 and 92.40 per cent during 2017 and 2018, respectively.

PP39(Off)-2F: Epidemiology of bacterial blight of cluster bean caused by *Xanthomonas axonopodis* in relation to weather parameters during *kharif* 2020

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Clusterbean (*Cyamopsis tetragonoloba* L.Taub.), commonly known as guar, has come to be recognized as one of the most important commercial crop of arid and semi-arid region. It is a drought hardy leguminous crop because of its deep tap rooting system and has high capacity to recover from water stress. Traditionally, pods of the clusterbean are used for vegetable purpose. Clusterbean is also raised as a green manure and cover crop. Being a leguminous crop, it enriches the soil fertility by fixing the atmospheric nitrogen. Out of cluster bean diseases, bacterial blight of cluster bean caused by *Xanthomonas axonopodis* is considered as one of the most serious disease. The disease is widely distributed in India during *kharif* season. Bacterial blight appears every year with great incidence in Haryana. Disease development and progression of bacterial blight on three different genotypes of cluster bean sown on three different dates *viz*., first fortnight of June, second fortnight of June and first fortnight of July during *kharif* 2020 was recorded. Disease severity in all cluster bean genotypes was observed maximum in IIIrd date of sowing ranging followed by IInd date of sowing; however in Ist date of sowing the disease intensity was lower. The correlation coefficients were calculated for all the cluster bean genotypes and date of sowing with weather parameters. Results showed that the disease development was positively correlated with maximum temperature, RH morning for all the three varieties at all dates of sowing, These finding will be helpful in developing integrated disease management strategies for the control of bacterial blight of cluster bean.

PP40(Off)-2F: Survey and Epidemiological studies on Sesame Phyllody disease development

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Sesame (Sesamum indicum L.) belongs to family pedaliaceae, which have basic chromosome number 2n =26 and originated in India. It is oldest oilseed crop. High yield and quality of oil, sesame is often called as the “Queen of oil seeds”. The crop is affected by sesame phyllody disease and transmitted by leaf hopper (Orosius albicinctus Dist.). By conducting survey for incidence of sesame phyllody disease at 10 different villages of Jaipur district the maximum disease incidence was recorded at Bhutera (26.05%) followed by Pachkodiya (25.23%) Malikpur (24.91%), Jobner (22.15%), Bhojpura (21.90%), Kaladera (21.10%), Bobas (20.76%), Jagmalpura (19.98%), Khejrawas (18.46%) and Dhani Boraj (17.90%), respectively and the severity of sesame phyllody in surveyed areas was from 17.90 to 26.05%. Among the environmental factors effecting sesame phyllody were minimum temperature, relative humidity and rainfall that increase both leaf hopper population and per cent disease incidence except maximum temperature which show non-significant negative correlation with disease incidence and leaf hopper population. A multiple correlation between the disease incidence and a group four independent variables (weather parameters) was responsible for the disease in cropping season under study. The coefficient of multiple determinations (R2) was 0.989 per cent.

PP41(Off)-2F: Survey and epidemiological aspect of early blight of tomato (Lycopersicon esculentum Mill.) incited by alternaria solani (Ellis and Martin) Jones and Grout

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Tomato scientifically known as Solanum lycopersicum L.,(syn. = Lycopersicon esculentum Mill.) is originated in Peru of South America and its area and production spread throughout the world Survey on the disease in the field gives information about the extent of early blight disease affecting the crop and quality of the fruits in different locations. The epidemiological studies on Alternaria leaf blight of tomato will give an idea the relationship of weather parameters for disease occurrence, survival and dissemination of the pathogen in nature. In Gwalior district the maximum percent disease index was recorded in Shyawari (49.30 %) while minimum incidence was recorded in Duhiya (11.50 %). The maximum disease intensity was recorded in Shyawari followed by

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Ganeshpura village of Morar Block in Gwalior district. In present studies, the cumulative per cent disease intensity was found higher in the month of second week of March. Correlation coefficient of cumulative per cent disease intensity showed that the disease was greatly favoured by temperature with maximum temperature (21.3 to 37.7 0C) and minimum temperature (5.5 to 18.2 0C).

PP42(Off)-2F: Survey of powdery mildew and anthracnose diseases in different mango growing area in Pune district

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The survey study was conducted at Krishi Vigyan Kendra, Pune M.S. Eleven village viz; Belsar, Wadaj, Yenere, Kale, Kasur, Tambe, Nirgude, Katede, Botharde, Ralegan and Shinde were selected from Junnar Tehsil and Five villages viz; Pokharkarwadi, Shinoli, Pimpalgaon tarf Ghode, Gangapur and Aamondi from Ambegaon Tehsil of Pune district for the survey.. In each village ten mango plants has been selected for observation. The observation were conducted in the February to June months 2021. The powdery mildew caused by *Pseudoidium anacardii* (Formerly known as *Oidium mangiferae* Berthet) and Anthracnose caused by *Colletotrichum gloeosporioides* are the most common diseases, widespread and serious diseases allover India causing significant yield losses. The disease, powdery mildew reported yield losses up to 90 % . About 25 to 30% loses of total mango production has been reported due to anthracnose. The per cent disease index (PDI) of powdery mildew and anthracnose diseases varies between 17.50 to 27.50 (Av. 23.64) and 12.00 to 26.00 (Av. 17.82) in Junnar thasil whereas in Ambegaon tahasil it is 17.50 to 25.00 (Av. 20.50) and 12.00 to 16.00 (Av. 14.40) respectively. The highest PDI was recorded in the village of Shinde and Yenere (27.50) of powdery mildew and in village Ralegan (26.00) of anthracnose respectively. The lowest PDI was recorded in the village Shinoli, Gangapur and Tambe (17.50) of powdery mildew and in the village of Wadaj and Aamondi (12.00) of anthracnose respectively.

PP43(Off)-2F: Role of weather parameters on development of pea diseases of Central India

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Weather parameters have a significant role in the development of diseases in any crop. Therefore, a present study was conducted to know the effect of different weather parameters on development of diseases in pea. The favorable weather parameters *viz.,* (temperature, relative humidity and rainfall) were observed and correlated against intensity of various diseases of pea. Maximum wilt disease incidence of 9.66 percent was observed at 50th *SMW and their related temperature (Maximum temp. 24.40c), (Minimum temp. 7.90c) and relative humidity (43.3 to 83.3%). Powdery mildew disease incidence was observed as 21.43% at 1st *SMW and related temperature was Maximum temp. 25.00C, Minimum temp. 6.60C along with relative humidity between 37.42 and 77.28%. Downy mildew disease incidence was observed as 16.21 per cent

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at 49th *SMW and their related temperature were (Maximum temp. 25.60c), (Minimum temp. 9.00c) and relative humidity (33.9 to 85.9%).

PP44(Off)-2F: Population dynamics of of leaf gall midge, *Asphondylia phyllanthi* on aonla

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The euphorbiaceous tree Phyllanthus emblica (Emblica officinalis) is valued in India for it fruits. Numerous galls caused by *Asphondylia phyllanthi* Felt. were observed on the leaves and shoots in orchards in Rajasthan and Haryana. It was found that galls were formed between February and May were oval or barrel-shaped, scaly, hollow, soft, dehiscent and sessile. Population dynamics of leaf gall midge, *Asphondylia phyllanthi* on aonla crop was conducted in unprotected crop during 2010 to 2016 at Asalpur Farm, SKN College of Agriculture, Jobner. Temperature, Relative Humidity and Rainfall were analyzed with respect to population fluctuation of leaf gall midge. The observation revealed that the initiation of Aonla leaf gall midge, *Asphondylia phyllanthi* damage was started in the month of February and it was reached at its maximum level in the month of September in all the years. The pest population increasing with the increasing in temperature and pest population decreasing with the increasing of relative humidity and rainfall. The meteorological study showed that pest population positively correlated with the minimum and maximum temperature and negatively correlated with the relative humidity and rainfall.

SESSION 3:
Applied research in plant pathology

3A. Diagnosis of plant pathogens

PP45(Off)-3A: Effect of different temperatures & pH on growth and sclerotial formation of various isolates of *Rhizoctonia solani* caused by root rot in Ajwain (*Trachyspermum ammi* L.)

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Ajwain (*Trachyspermum ammi* L.) is also known as Bishops weed and Carom seed, is one of the most important seed spices crops it's belonged to family *Apiaceae*, is a native of Egypt. The seeds are small yellowish brown in colour. It is a popular seed spice crop in India. The major ajwain producing countries are India, Persia, Iran, Egypt, Afghanistan, Pakistan and North Africa. In India it is widely distributed and its production is concentrated mainly in Rajasthan followed by Gujarat, Madhya Pradesh, Bihar, Uttar Pradesh, Punjab, Tamil Nadu, Andhra Pradesh and West Bengal, respectively. Since ancient time the state of Rajasthan and Gujarat has emerged as "Seed spices bowl". Whose dried fruit of seeds are used as spices. In Rajasthan, it is cultivated in the districts of Chittorgarh, Udaipur, Jhalawar, Baran, Rajsamand, Bhilwara and Kota covering an area of 11658 hectares. In this present investigation was conducted at Department of Plant Pathology, Rajasthan College of Agriculture, Udaipur and results revealed that the different isolates of *R. solani* exhibited considerable variations in growth, colony character and sclerotial size. The *in vitro* physiological studies revealed that the maximum mycelium growth and sclerotia of the isolates of *R. solani* were recorded at 300C temperatures and pH 7 though considerable variations were recorded among isolates of *R. solani*.

PP46(Off)-3A: Seed borne mycoflora associated with mustard (Brassica juncea L.) seed under different storage conditions

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To detect the presence of internal and external mycoflora in stored mustard seed variety Giriraj. Seeds were kept under observation for 6 months at room tempterature in various storage containers like earthen pot, Raw earthen pot, china clay pot, steel pot, glass pot, cloth bag, gunny bag, paper bag, and polythene bag. Under various storage conditions different fungi such as *Aspergillus flavus, A.niger, A.candidus, A.fumigatus, A. terrious, Penicillium spp., Cladosporium spp* and *Rhizopus* were recorded; from which *Aspergillus* spp was more prominent. Seed germination rate was maximum in glass container which establishes less mycoflora, whereas more seed mycoflora were recorded in earthen pot and vis- a- vis less seed germination.

PP47(Off)-3A: Survey of foliar diseases of mustard from different geographical locations of Chhattisgarh

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Mustard is grown in various climates and is prone to biotic and abiotic stress. *Alternaria* blight, powdery mildew, white rust, and downy mildew are the most common diseases that cause major yield losses. In light of the diseases, a detailed survey for the occurrence of disease incidence of mustard in important mustard-growing areas in Chhattisgarh was conducted. Survey was carried out at *rabi*, 2020- 21 in the major mustard growing areas of Chhattisgarh. Three fungal diseases, *Alternaria* blight, powdery mildew, and white rust, were discovered in association with mustard cultivars at an advanced stage throughout the survey. For *Alternaria* blight, the mean highest disease incidence 62% was recorded in Bastar district and mean lowest disease incidence 22% was recorded in Janjgir-Champa district. For powdery mildew, the mean highest disease incidence 82.72% was recorded in Kabirdham district and mean lowest disease incidence of 52.73% was recorded in Raipur district. For white rust disease incidence highest 47.46% in Bastar district and mean lowest disease incidence 25.31% was recorded in Raigarh district. Disease incidence (DI) of powdery mildew (82.72%) is relatively higher than *Alternaria* blight (62%) and white rust (47.46%) respectively. The lowest disease incidence (DI) among the foliar fungal diseases were found in white rust (25.31%).

PP48(Off)-3A: Identification of Novel Allexiviruses Infecting Garlic using Targeted High-Throughput Sequencing

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In mid-January 2021, mild mosaic-related symptoms were observed on the leaves of garlic cultivar Yamuna Safed-3 (G-282). The electron microscopy observations reveal the presence of filamentous shaped virus particles ranging 700 to 800 nm size. To reveal the identity of the observed virus particles, total RNA was extracted from the symptomatic leaf samples, RT PCR was performed with *Allexivirus* genus degenerate primers. cDNA library for target sequence metagenomics was prepared using an amplified PCR product at Illumina Novaseq 6000 platform. 19,442,868 reads were generated, low-quality reads were removed, and de novo assembly of generated contigs was performed. Searching the protein databases using BLASTX resulted in the identification of novel (*Garlic mite-borne filamentous virus*; GarMbFV, *Blackberry virus E*; BVE and *Alfalfa virus S*; AVS) and other contigs belonging to other allexiviruses (*Garlic virus A, Garlic virus B, Garlic virus C, Garlic virus D, Garlic virus E* and *Garlic virus X*). The presence of novel viruses was confirmed with RT PCR using coat protein-specific primers. To the best of our knowledge, this is the first evidence of BVE and AVS infecting garlic worldwide. The evidence concerning the incidence of garlic viruses is significant for virus indexing for virus-free propagative material as well as breeding for virus resistance of the new garlic cultivars to the investigated viruses.

PP49(Off)-3A: Molecular diagnostic techniques for detection of plant pathogenic bacteria and their future challenges

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“Diagnosis” means identifying the nature and cause of problem responsible for disease occurrence. Conventional microbiological approaches used for recognizing phytobacteria are rely on visual signs and symptoms. But it is time consuming and difficult to discriminate a bacterial species on the basis of morphological features. The main aim to discuss our most recent art of molecular diagnostic techniques is to enable fast and accurate identification of plant pathogens based on well-developed genotyping techniques- polymerase chain reaction, Multiplex PCR, RT PCR, LAMP, BIO-PCR, ITS-PCR, LSSP PCR, SSCP PCR and Molecular markers. Polymerase chain reaction (PCR) and real-time PCR have revolutionized the popularity of molecular diagnostics techniques. Enriching bacterial pathogen in growth medium can increase the population of bacterial cells before performing PCR; this method is called BIO-PCR. The 16 S rRNA gene contains variable regions that are used for the discrimination between the species and genera. Phytobacteria, including *Pseudomonas, Erwinia* and *Xanthomonas* have been identified on the basis of ITS-PCR. Several primer pairs for diagnosing *Xanthomonas, Pseudomonas, Ralstonia, Clavibacter, Agrobacterium, Erwinia, Xylella, Candidatus liberibacter, Burkholderia, Streptomyces*. Single-strand conformation polymorphism (SSCP) and low-stringency single specific primer (LSSP-PCR) are the key techniques which differentiate bacterial pathogens into species and isolate level. But these methods cannot provide real-time detection which makes them less suitable for on-field testing, latent infection, pathogen reservoirs and early warning systems. The future will bring more novel tools to detect plant bacteria, probably based on the new sequences, novel linkers and molecular technologies.

PP50(Off)-3A: Survey of diagnosis and detection of major pathogen of mustard in Banda district of Bundelkhand

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Banda district of Uttar Pradesh is known as a distinct agro climatic area of Bundelkhand which is scarce by hot climate during the late growth stage of the crop is present in resignation severity of different diseases occurring on the mustard crop during the different growth period and their associated pathogens where studied village of Banda. The first symptom was noted as black rot of mustard V-shaped symptom on the lower leaves of plants followed by white rust and powdery mildew. The pathogen associated with the black rot of mustard and Alternaria blight isolated from pure culture on nutrient media and cornmeal agar media. The was black rot identifying as *Xanthomonas* and other *Alternaria brassicae, brassicola,where* identify as causes of Alternaria leaf spot. Combined infection of white rust pathogen *Albugo candida* and *Hyalopernospora brassicae* was identified and in the white pustule hypertrophy floral parts of the mustard plant.

Powdery mildew incited by *Erysiphe polygoni* was identified from the powdery mildew affected areas leaf, pods, the stem of the mustard crop. Observation of the severity of different disease indicate that powdery mildew of mustard is most predominant followed by Alternaria leaf spot, white rust and downy mildew of mustard. Black rot of mustard was found in low disease intensity at the early growth stage of the crop only. Sclerotinia rot observed in many surveyed field during 2020-2021. Five diseases and 6 pathogens where recorded during the surveyed area of which powdery mildew incited by *Erysiphe polygoni* was noted as most aggressive pathogen which cover the whole period of the plant during the whole session cover of the crop.

PP51(Off)-3A: *Pestalotiopsis* leaf spot disease in coffee and bio-efficacy of fungicides for management

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Coffee is a perennial plantation crop belongs to the family Rubiaceae and the genus *Coffea*. Arabica (*Coffea arabica* L.) and robusta (*Coffea canephora* Pierre Ex. Froehner) are two cultivated coffee species growing on a commercial scale in most of the countries. In India, coffee is cultivated mainly in the hilly tracts of Western and Eastern Ghats under agro-forestry ecosystem. The final produce of coffee is consumed as a non-alcoholic beverage worldwide. Coffee is susceptible to fungal diseases *viz.,* leaf rust, black rot, stalk rot, anthracnose, berry blotch and root diseases in field conditions and collar rot, stem necrosis & *Myrothecium* leaf spot and brown eye spot under nursery conditions. These diseases are of economic importance which is one of the limiting factors for production and productivity of coffee. Coffee leaf spot caused by *Pestalotiopsis* sp. was recorded during 1977 in robusta coffee. But in the recent past this is being noticed in nursery as well as in field conditions both in arabica and robusta. Coffee leaf samples which were found different from brown eye spot & *Myrothecium* leaf spot symptoms collected from nursery and field were subjected for isolation. Further, purified fungal cultures were observed for spore morphology under microscope and were identified as *Pestalotiopsis* sp. both from field and nursery. Bio-efficacy of thirteen fungicides *viz.,* hexaconazole 5 EC, propiconazole 25 EC, difenconazole 25 EC, tebuconazole 25.9 EC, azoxystrobin 23 SC,pyraclostrobin 133 g/L + epoxyconazole 50 g/L, azoxystrobin 18.2% + difenconazole 22.4% SC, propiconazole 13.9% + difenoconazole 13.9% EC, fluxapyroxad 167g/l + pyraclostrobin 333g/l SC, tebuconazole 25% + trifloxystrobin 50% WG, copper oxychloride 50 WP, carbendazim 50 WP at 500 and 1000 ppm concentrations and Bordeaux mixture (1%) were evaluated under laboratory conditions. Observations on inhibition of mycelial growth of pathogen were recorded seven days after inoculation. Data indicated cent per cent mycelia growth inhibition in hexaconazole 5 EC, propiconazole 25 EC, tebuconazole 25.9 EC, pyraclostrobin 133 g/L + epoxyconazole 50 g/L, propiconazole 13.9% + difenoconazole 13.9% EC, fluxapyroxad 167g/l + pyraclostrobin 333g/l SC, tebuconazole 25% + trifloxystrobin 50% WG, carbendazim 50 WP in both 500 and 1000 ppm concentrations. Least (50.40%) mycelial growth inhibition was recorded in 1 % Bordeaux mixture. These effective fungicides will be evaluated in nursery and field conditions for management of *Pestalotiopsis* leaf spot disease in coffee.

3B: Resistant cultivar development

PP52(Off)-3B: Screening of chickpea genotypes for resistance to dry root rot

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Dry root rot (DRR) is an important emerging disease of chickpea caused by a necrotic fungus *Rhizoctonia bataticola (Taub.) Butler* (Pycnidal stage; *Macrophomia phaseolina (Tassi) Goid*). *R. bataticola* is a soil-inhabiting organism proficient in infecting chickpea at any crop stage, but most frequently infects at post-reproductive stage of chickpea in the dry and warm regions. Considering the significance of this disease the present study was conducted at seed farm JNKVV Jabalpur during 2020-21. Forty two advanced breeding lines of chickpea were screened against *Rhizoctonia bataticola* using the paper towel method to find out the source of resistance. Among these 42 genotypes, 10 were found resistance in experiment, with disease scoring ranged from 1.9 to 3.0. The resistance genotypes depicting minimum disease score namely, JG-2020-45, JG-2020-604, JG-2020-78 and JG-2020-56. These resistance genotypes were further screening using sick plot method to confirm their resistance towards DRR. Among these four genotypes, JG-2020-604 depicted highest plant stand and survival rate followed by JG-2020-56, JG-2020-45 and JG-2020-78 as compared to susceptible check (BG 212, JG 74). These chickpea genotype might be useful in breeding programs to develop resistance against verities against DRR.

PP53(Off)-3B: Genetic variability and character association studies in clusterbean (*Cyamopsis tetragonoloba* L.) Taub.

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Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] (2n = 14) is a multipurpose arid legume crop belonging to the family *Fabaceae*. It is grown in kharif season in arid and semi arid regions of India as it is drought hardy, insect-pests and disease tolerant in nature. Assessment of genotypes for existing variability is considered as pre-requisite step in any crop improvement programmes. An experiment was conducted to know the genetic variability and character association in 10 genotypes of clusterbean during *Kharif* 2019. Genetic analysis of variance revealed highly significant differences for all the characters, showing considerable amount of variability among the genotypes. Out of 10 genotypes, four genotypes (RGC-1066, RGC-986, RGC-936 and RGC-1033) considerably exhibited higher mean values for seed yield per plant. High phenotypic coefficient of variance (PCV) was recorded for number of branches per plant, biological yield, harvest index and number of clusters per plant while higher genetic coefficient of variance (GCV) observed for number of branches per plant. High heritability estimates found for number of branches per plant, plant height and moderate for days to maturity, days to 50 per cent flowering, number of clusters per plant, biological yield per plant, number of seeds per pod and number of clusters per plant. The number of clusters per plant and biological yield were exhibited high genetic advance. The seed yield showed strong significant positive correlation with branches per plant and biological yield per plant, thus these traits may be given importance while selection. Therefore, it can be concluded that seed yield has strong positive correlation with

number of branches per plant and biological yield per plant. Hence, simultaneously selection for these traits would result better in genetic improvement of seed yield in clusterbean for the betterment of farmers.

PP54(Off)-3B: Screening of castor genotypes for resistance to *Macrophomina phaseolina* causing root rot of castor by different two methods

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Macrophomina phaseolina is a soil borne fungus and possess greater problem in managing the disease. Variation in fungal habitats and excellent sclerotial survival make its chemical control difficult and uneconomical. As the most suitable method to avoid root rot diseases is the use of resistant cultivars, seems to be relatively cheaper and appropriate to control the disease because it requires no special equipment or extra capital investment. Twenty-one castor genotypes were screened for resistance to *M. phaseolina* causing root rot of castor by two artificial inoculation methods *viz.*, soil inoculation and root dip inoculation. Among them, nine genotypes *viz.,* 48-1, EC 103746, JI 35, Kranti, SKI 341, SKI 388, SKI 393, SKI 404 and JI-357 showed susceptible reaction, whereas ten genotypes *viz.*, JP 117, PCS 124, SH 42, SKI 333, SKI 373, SKI 381, SKI 390, SKI 401, SPS 23-6 and VH-71-1-4 showed moderately susceptible reaction. Only two genotypes *viz.*, SKI 406 and TMV 5 showed moderately resistant reaction to root rot of castor in both soil inoculation and root dip inoculation methods, which can be used in breeding program for the development of root rot resistant castor varieties/hybrids.

PP55(Off)-3B: *Tracing the presence of blast resistance gene(s) Pi1 K and Pi2 in progenies derived from Safri-17 x PR-122 x Safri-17 x Aganni; Safri-17 x PR-122; Dubraj x PR-122*

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Among the biotic stresses afflicting rice, blast is an important disease that causes significant yield reduction worldwide. The disease, in its severe form, is known to cause yield losses of 74 to 81 %. Host plant resistance is considered the most economical and ecofriendly strategy for achieving disease resistance and yield stability. The ability to quickly and reliably select desirable material, and to eliminate individuals that contain deleterious alleles is critical to the success of a plant breeding program. We therefore used known linked molecular markers that facilitated the identification of favorable (or deleterious) alleles in the progenies derived from Safri-17 x PR-122 x Safri-17 x Aganni; Safri-17 x PR-122; Dubraj x PR-122. Through bioinformatics analysis we were able to generate molecular marker near to the already linked molecular markers, we were able to validate three molecular markers which co-segregated with the resistance phenotype amongst the derived progenies.

PP56(Off)-3B: Screening of cumin germplasms/varieties against blight disease incited by *Alternaria burnsii*

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Cumin (*Cuminum cyminum* L.) is an important seed spice and one of the earliest known major spices used by mankind and indispensable condiment consumed in every Indian home. Blight caused by *Alternaria burnsii* (Uppal, Patel and Kamat) is a serious disease of cumin. This disease is quite prevalent and destructive as it affects all above ground plant parts including seed, thus causing direct yield loss. Though high degree of host resistance against Alternaria blight has not been found in any genotype of cumin in India, however some degree of resistance has been reported by various workers. In a view to consider this situations, field trials on screening of germplasms/varieties were carried out during two consecutive *Rabi* seasons 2019-20 and 2020-21 at Institutional Farm, Collage of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner. These lines were collected from Agricultural Research Station, Mandor (Jodhpur) and except a variety *i.e.* GC-4, there is no research is available for screening of other germplasm lines against Alternaria blight disease in cumin to the best of our knowledge. Data of two years shows that no line was totally resistant against cumin blight also the variety GC-4 was found highly susceptible to Alternaria blight.

PP57(Off)-3B: Identification of Citrus tristeza virus disease free and immune mother plant of Khasi mandarin (*Citrus reticulata*) tree from different orchards of Northeast India

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Citrus tristiza virus (CTV), a phloem limited closterovirus, is one of the most important agents causing citrus decline worldwide. CTV contain flexuous filamentous particle, 2000 x11 nm in size. The genome contains positive ssRNA, 19.3kb in length comprising 12 ORFs encoding 19 putative proteins. It is predominantly transmitted by brown citrus aphid (*Toxoptera citricida*) in a semipersistent manner. Khasi mandarin (KM)(*Citrus reticulata*) is the most economically and widely cultivated citrus fruit in Northeast (NE) India, which is tremendously affected by decline caused by CTV. The production and supply of CTV free and immune grafted KM planting materials are the important control measures. Thus, effort has been made to identify disease free/immune KM mother plants as source of scion. A survey was made and KM twig samples from healthy looking-best fruit quality trees from seven orchards of Assam were collected. Total 31 twigs were collected and grafted on rough lemon root stock and maintained in nursery. CTV infection was detected by direct antigen coated enzyme-linked immuno-sorbent assay (DAC-ELISA) using CTV specific antisera and PCR using specific primes targeting coat protein and 5’ORF1a gene.

Most of the samples showed CTV infection in ELISA with considerable virus titre. The ELISA positive samples were confirmed by PCR. Of the KM trees tested, three; Solomon F-2, SolomonF-4 and Mohan-MP-2 did not show CTV infection and confirmed by PCR. These plants were considered as disease free/immune mother plant and will be used further for production grafted plating materials to manage the KM decline NE India.

PP58(Off)-3B: Exploration of Chickpea Germplasm against *Fusarium oxysporum* f. sp. *ciceri*

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Chickpea (*Cicer arietinum* L.) is an important cool season grain legume of Asia grown in several countries worldwide being a rich and cheap food source of protein can help people to improve the nutritional quality of their diets particularly vegetarian population. In India, it is cultivated in *rabi* season and prone to several insect pest and drought or cold stresses. The wilt caused by *Fusarium oxysporum* f. sp. *ciceris* is an important soil borne disease in which plants get infected at an early stage, symptoms however, appear at different growth stages depending on the severity of infection. Generally, wilt symptoms appear 4-6 weeks after sowing but become common and pronounced at reproductive stage. Chickpea wilt is an economically significant disease causing losses to the tune of 25 to 65 per cent. A total of 500 accessions screened against *Fusarium oxysporum* f. sp. *ciceris*, grown in Augmented Block Design during 2021-22 along with three checks JG 62 (susceptible), JG 12 and JG 315 (resistant) in Seed Breeding Farm, JNKVV, Jabalpur, MP. Total plants counted after 20 days (Emergence count) and wilted plants were recorded at 30, 45 and 60 days interval after sowing and finally averaged. Phenotypic screening showed 72 accessions very less infected against *Fusarium* wilt and categorized as resistant. Ninety-eight accessions revealed moderate resistant reaction with disease incidence ranged from 10.81 to 20.0 per cent. One hundred two accessions exhibited moderately susceptible reactions with disease incidence in the range of 20.83 to 30.0 per cent. Eighty-six accessions showed susceptible reaction with disease incidence in the ranged from 31.04 to 50.0 per cent. Rest of the accessions showed vascular wilting symptoms >50 % categorized as highly susceptible.

3C. Success stories in plant diseases management

PP59(Off)-3C: Green engineered silver and silica nanocomposite: A potential arsenal for managing *Rhizoctonia solani* Kuhn causing sheath blight disease of Rice

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The increasing interest in exploring potent non-toxic drugs in medicine is widening the opportunities for studying the usage of nanostructures in the management of various diseases in agriculture. A green synthesis route was undertaken in the present study where, silver (Ag) and silica (SiO_2) nanocomposite (Ag-SiO_2 NC) were synthesized using leaf extract of *Litsea salicifolia* acting as a reductant cum stabilizer. Ag nanoparticles (NP) have antimicrobial property & SiO_2-NP is a good enhancer of plant defense mechanism, the NC was found to be a great source for management of *R. solani*. Subsequently, measurement of zeta potential (ZP), zeta size (ZS), UV- Vis Spectrophotometry, nanoparticle tracking analysis (NTA), scanning electron microscopy (SEM) were employed to characterise the synthesised nanoparticles. AgNPs were found to have spherical morphology with SPR band at 420 nm with size and zeta potential of 69 nm and -18.1 mV respectively and NTA showed that the size of the AgNP lied between the range of 19-394 nm. For SiO_2 NP size and zeta potential of 50.29 nm and -11.0 mV respectively, spherical in shape, with NTA size range from 95-518 nm. *In vitro* efficacy test of the NC at different doses showed that, the effect was strikingly dependant on the concentration of the NC. The highest inhibition against both sclerotia and mycelia being at a concentration of 200 ppm with inhibition of 75.11% and 73.55% respectively. An encapsulated product of Ag-SiO_2 was prepared and its efficacy was tested at two different concentration and compared its performance with the unencapsulated NC and recommended chemical. Result showed 100% mycelial growth inhibition at 200 ppm of encapsulated product.

PP60(Off)-3C: *In vitro* and *In vivo* Antifungal Activities of Mentha spicata and Cymbopogon citratus Volatilomes against Tomato Fusarial Wilt Pathogens

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The soil-borne fungus *Fusarium oxysporum* is a complex species especially infecting in tomato, varies considerably in morphological and pathological characteristics and known to cause severe crop losses. The volatilomes produced by the leaves of *M. spicata* showed production of antifungal compounds such as carvone, geraniol, bourbonene *etc.,* involved in the suppression of pathogens. Vaporous action of carvone completely suppressed the mycelial growth of F. *oxysporum* f. sp. *lycopersici* when used at 500 ppm. Similarly, the volatilomes diffused from the leaf extract of *M. spicata* completey inhibited the mycelial growth of *F. oxysporum* f. sp. *lycopersici;* followed by the volatilomes produced by the leaves of *C. citratus.* The efficacy of volatilomes produced by the leaves of *M. spicata* were tested *in vitro* by olfactory chamber. The results revealed the volatilomes of *M. spicata* could completely suppress the mycelial growth of *F. oxysporum* f. sp. *lycopersici.* Tripartite interaction of *M. spicata* volatilomes on *Fusarium oxysporum* f. sp. *lycopersici* inoculated tomato plants could induce diverse VOCs. Plants inoculated with *Fusarium oxysporum* f. sp. *lycopersici* produced large quantities of phenol lipids, carboxylic acids, hydrocarbons, fatty acid, organo nitrogen and organo oxygen compounds. Carvone, bourbonene, caryophyllene and naphthalene were the major compounds produced by *M. spicata* immobilized vermiculite balls on exposure to *Fusarium oxysporum* f. sp. *lycopersici* inoculated tomato plants. The compound, carvone was up regulated in pathogen inoculated tomato plants on exposure to the volatilomes of *M. spicata*. In conclusion, the VOCs induced by the leaves of *M.spciata* has great potential for exploitation in suppression of Fusarial Wilt Pathogens in Tomato.

PP61(Off)-3C: Integrated management of root-rot (*Fusarium solani*) and root Borer *(Emmalocera depressella)* in Bael (*Aegle marmelos* L.)

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Drying of bael (*Aegle marmelos*) plants was observed in the orchard of the Regional Research Station, Bawal, Haryana, India. The initial symptoms on dried plants appeared as yellowing and drooping of leaves which proceeds downward resulted in drying of the plant. A wide spread incidence of root rot incited by *Fusarium solani* resulted in extensive damage and reduction in acreage of bael. An experiment was conducted to find out the effective management practices to control the fungus inciting root rot disease in bael at research farm, RRS Bawal from 2018-21. In the present investigation, eight treatments *viz*; Carbendazim, Copper oxychloride, *Trichoderma viride*, Chlorpyriphos, Phorate 10 G, Carbendazim + Chlorpyriphos, Copper oxychloride + Chlorpyriphos were taken as soil drenching. Pooled result of three years data revealed that two applications of carbendazim 50 WP (20 g/tree) + chlorpyriphos 20 % EC (50 ml/tree) at the time of manuring and repeated after 15-20 days interval used for the control of root rot and root borer in bael was found significantly superior which was followed by carbendazim (20 g/tree) as compared to control. Pooled yield with carbendazim (20 g/tree) + chlorpyriphos (50 ml/tree) was also maximum (84.2 q/ha) and minimum under control (34.7 q/ha). Carbendazim (20 g/tree) + chlorpyriphos (50 ml/tree) was also found cost effective in managing disease with highest BC ratio (6.2).

PP62(Off)-3C: Management of dry root rot of chickpea incited by *Macrophomina phaseolina* (Tassi) Goid. in Rajasthan

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Dry root rot of chickpea caused by *Macrophomina phaseolina* (Tassi) Goid is emerging as a serious biotic constraint for chickpea production in Rajasthan. For the management of soil borne disease like dry root rot of chickpea, by using fungicides alone is not feasible due to environmental and health hazards. Hence integrated management of the disease by using bio-agents and

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fungicides is the best alternative.Therefore, in the present investigation, our main emphasis was to identify best fungicide and bio-agent for management of dry root rot in chickpea.Eight fungicides (captan 70% WP, thiophanate methyl 70% WP, chlorothalonil 75% WP, carbendazim 12%+ mancozeb 63%, tebuconazole 50%+ trifloxystrobin 25%, carboxin 37.5%+ thiram 37.5%, copper oxychloride 50% WP, carbendazim 50% WP) and four bio-agents (*Trichodermaviride*, *T. harzianum, Pseudomonas fluorescens* and *Bacillus subtilis*) were evaluated against dry root rotpathogen (*M. phaseolina*) in labas well as in field condition.The experiment was conducted at instructional farm, COA, SKRAU, Bikaner during *Rabi*-2019 on most popular cv. GNG-1581in RBD design with the application of seed treatment and soil application of different bio-agents and fungicides at different concentrations against dry root rot disease and compared with an untreated control.Among all the fungicides used in the present investigation, tebuconazole 50% + trifloxystrobin 25% was found most effective in inhibiting the mycelial growth of the pathogen. Among all the bio-agents, *T. harzianum* was found most effective in inhibiting the mycelial growth of the pathogen.Under field condition, tebuconazole 50%+ trifloxystrobin 25% WG as seed treatment @ 1.5 g/kg along with *T. harzianum* @ 10 kg/ha as soil application gave maximum (83.76 %) disease control with highest pod yield (19.5q/ha) and net return (Rs 39,826/ha). These treatments can provide an effective and economical management of dry root rotdisease for chickpea cultivators.

PP63(Off)-3C: Efficacy of AM fungi and pre-sowing treatment of drupes on physiological parameters of *Melia azedarach* seedlings

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Melia azedarach belongs to the family of *Meliaceae* a fast-growing, drought-resistant tree native to the Southeast Asia and northern Australia. It has dense shade, dark green foliage and medicinal properties. The study is required for better germination and faster growth of its seedlings. The poor germination of its drupes and late nursery establishment is a main constraint in its extensive cultivation. To overcome this problem, experiment was designed with pre-sowing treatment of drupes with different substances and sowing of drupes in *Glomus mossae* incorporated soil on the seedlings growth and biomass. Soil application of AM fungi were applied at the rate of 400-500 sporocarp/kg of soil at the time of sowing of drupes of *Melia azedarach* during 2019 and was evaluated for its effect on the survival and growth of *Melia azedarach* seedlings. Observations on physiological parameters such as chlorophyll, carotenoid, photosynthesis, transpiration rate and stomatal conductance were recorded after 90 and 180 days after sowing (DAS). Total chlorophyll and carotenoid content were maximum *i.e.* 30.3 μg/ml and 5.7 μg/ml, respectively in pre-sowing treatment of drupes of *M. azedarach* with GA_3 @ 200 ppm for 24 hrs and sown in soil incorporated with *G. mosseae.* Similarly other physiological parameters such as photosynthesis, transpiration and stomatal conductance were maximum in pre-sowing treatment of drupes of *M. azedarach* with GA_3 @ 200 ppm for 24 hrs and sown in soil incorporated with *G. mosseae i.e.,*9.99 μ mol CO_2 $m^{-2}s^{-1}$, 5.88 m mol H_2O $m^{-2}s^{-1}$ and 0.312 m mol $m^{-2}s^{-1}$respectively.

PP64(Off)-3C: Management of Stem Rot of Brinjal caused by Sclerotinia sclerotiorum de Bary

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Brinjal is one of the important tropical vegetable crops in India. Brinjal is infected by a number of diseases caused by fungi, bacteria, nematodes, virus and phytoplasma which adversely effect the yield and the quality. Of these diseases, stem rot caused by *Sclerotinia sclerotiorum* de Bary is considered as one of the devastating diseases in almost all the brinjal growing areas of country. *Sclerotinia* rot or stem rot of brinjal was found to be a serious disease of brinjal that causes partial or complete wilting of the plant. The present investigation was under taken to study behaviour of the disease and to provide necessary information for suitable management practices to minimize crop losses. In the field experiment, maximum disease inhibition was found in tebuconazole 50%+ trifloxystrobin 25% WG (86.21%) used as seedling treatment and soil drenching which is most effective treatment followed by carbendazim 12%+ mancozeb 63% WP (78.93%) used as seedling treatment and soil drenching as compared to other treatments. The least effective treatment was soil application of Pseudomonas fluorescens (49.07%) (@ 10 kg ha^{-1} with 100 Kg FYM) which exhibited higher disease incidence and minimum disease inhibition (20.21%).

PP65(Off)-3C: Induced systemic protection in ber against powdery mildew disease through systemic acquired resistance activators

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Jujube or ber (Ziziphus mauritiana Lamk.) is a nutritionally important fruit of arid region of India. Powdery mildew of ber incited by Oidium erysiphoides f.sp. ziziphi, Yan and Wang is the most important disease that causes maximum reduction in yield and quality of ber fruits grown under semi-arid and arid regions of India. The exogenous application of synthetic elicitors to activate systemic acquired resistance (SAR) for powdery mildew management is still untouched area of evaluating their orchard performance. To assess the efficacy of SAR inducers, four different inducers (salicylic acid, isonicotinic acid, fosetyl-Al and ethylene) were applied before disease initiation to activate resistance to reduce disease intensity under natural conditions in orchard. Result indicated that all SAR inducers were found significantly superior over control. However, the highest disease control (58.75%) was recorded with salicylic acid (@ 200ppm) followed by isonicotinic acid (48.04%) and fosetyl-Al (46.30%). In conclusion, additionally exogenous application of systemic resistance elicitor (SA) in orchard can be held potential for managing pathogen resistance as well as also provide opportunity for organic production of edible fruits for consumers. This is the first report of SA application on ber for protecting it against powdery mildew by acting as systemic acquired resistance inducer under orchard conditions.

PP66(Off)-3C: Field evaluation of systemic fungicides against *Alternaria* blight of linseed

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Linseed or Flax (*Linum usitatissimum* L.) a member of family Linaceae is considered the most important oilseed crop of India. *Alternaria* blight caused by *Alternaria lini* Dey and *A. linicola* Grooves and Skolko, is a major biotic stress limiting crop yield in hot and humid environment. India ranks third in the world in respect to area and production of linseed. Linseed is the principal oilseed crop grown in Chhattisgarh under utera in rainfed conditions. It occupies 34 % share in total oilseeds production in the state and 17% in India. Fungicides have ability to provide protection against disease and therefore is an attractive option for the farmers. Systemic fungicides Azoxystrobin 23%SC, Hexaconazole 5%SC, and Tebuconazole25.9%EC was found effective under following curative spray. Systemic fungicides reduced the rate of disease development when it applied as curative spray.

PP67(Off)-3C: Management of collar rot of lentil caused by Sclerotium rolfsii through use of biopesticide in In-vitro and natural field conditions

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Lentil (Lens culinaris Medik.) is an important pulse crop in semiarid regions of Iran, India, Turkey and Canada and originated in the fertile crescent of the Near East and dates back to the beginning of agriculture itself. In searching for botanicals and natural farm products (biopesticide) that can be used as important sources for the control of plant diseases. The effect of phyto extracts of nine plant species were tested in vitro by poisoned food technique to know their inhibitory effect on the growth of Sclerotium rolfsii. Significantly minimum mycelium growth was recorded in Curcuma longa (39.25 mm) while maximum mycelium growth was sobserved in Ricinus communis (90.00 mm). Six animal products viz; compost tea, jiwamrit, vermiwash, cow urine, cow dung extract and butter milk were evaluated @ 5 % concentration against Sclerotium roffsii in vitro. Maximum mycelium inhibition was recorded in cow urine (12.25 mm) followed by Jiwamrit (22.00 mm), while maximum mycelial growth was recorded in vermivash (85.75 mm). Nine botanicals and six animal products were selected for field experiment after In vitro screening and evaluated against collar rot caused by S. rolfsii. Minimum collar rot severity was recorded in cow urine (34.26 %) which was at par with Michellia champaca(34.72 %) and Azadirachta indica leaf (27.96 %), while among treatments maximum severity was recorded in Ricinus communis (75.19 %).

PP68(Off)-3C: To study the importance of novel technology, antagonistic microorganisms and application of soil base potash against the management of charcoal rot disease of soybean with cost benefit ratio

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Charcoal rot (*Macrophomina phaseollina*) of soybean is a destructive disease of soybean caused significance economic losses throughout the world. Survival major released soybean verities hampered due to uncertain change of climate in favour of dreaded charcoal rot pathogen. Availability of saprophytic beneficial microorganism in soil goes down due to continuous indiscriminate application of chemical fertilizers and fungicides. Level of major soil nutrients such as nitrogen ,phosphorus and potash also decreased in soil due to multiple cropping system. Technological gap among the farmers also a factor for survival of the disease causing agent. Combined effect of novel technology, bio-pesticides and soil application of potash utilized during the present studied. Analysis of soil of experimental plot has been completed to known the availability of nitrogen, phosphorus and potash in experimental plot and found that soil was rich with phosphorus whereas nitrogen and potash were in medium. Total fifty farmers were selected and screened their technological knowledge before plotted the experiment and found that only 38% farmers known the proper seed and soil treatment practices. Nearly 62% farmer had knowledge about the application of electronic media in crop production of soybean. An experiment was conducted under field condition to find out the use of bio pesticides such as *Trichoderma harzianum* and *Pseudomonas fluorescens* as (seed and soil treatment) along with two dosed of potash(20kg/ha and 40kg/ha) against *Macrophomina phaseollina* pathogen during 2019-20 and 2020-21. Results of pooled data indicated that combined application of both bio pesticides and potash significantly reduced the incidence of disease in comparison to untreated control. *T. harzianum* used as soil (5kg/ha) and Seed (5g/kg seed) treatment with additional dose of basal potash (40kg/ha) in soil before sowing gave 64% disease control followed by soil treated with *P. fluroscens* plus potash (40kg/ha) 46%. Application of *T*. *harzianum* as seed and soil treatment with recommended dose of fertilizers (RDF) found 34% disease control which was significantly higher than T2 treatment (*P.fluroscens*+20kg/haK2O). Soil treatment with T. harzianum+K2O found more effective for promoting plant growth parameters and reduced charcoal rot disease of soybean. Yield in each treatment increased with bold seed and shin in compression to untreated control whereas 40kg potash with *T. harzianum* gave best performance in plant height, yield and cost benefit ratio in comparison to others treatments. Treatment 4 Yielded 32% more average yield than T2.However effect of trichoderma with 40kg/ha K2O was more effective than Pseudomonas plus K2O. In control plot, there was only 08q/ha yield with minimum net profit. Overall it might be seen that *T. harzianum*+K2O supplied plot produced significantly greater yield than *P. fluorescens +K2O* in both the years2019-20 and 2020-21. On average nearly 42-87% more yield recovered in treatments plot in comparison to control.

PP69(Off)-3C: Management of collar rot disease of groundnut incited by *Aspergillus niger* through seed treatment

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Groundnut (*Arachis hypogaea* L.) is an economically important edible oil seed crop of the world. Collar rot disease incited by *Aspergillus niger* is the major constraints in groundnut crop in Rajasthan and almost all groundnut growing states. Field experiment was conducted to find out effective seed treatment fungicides and bioagents (Mancozeb, Carbendazim, Tebuconazole, Hexaconazole seed treat with *Trichoderma, viride* alone and soil application with *T. viride* and seed treated with tebuconazole) for control of collar rot of groundnut. All the treatments except seed treatment with mancozeb recorded significantly more seedling emergence (81.59 - 95.29%) in comparison to control (65.24%). The highest seedling emergence (95.29%) was recorded where soil was treated with *T. viride* and seeds treated with tebuconazole. The seedling mortality by collar rot disease was significantly reduced (2.20 - 15.23%) in all the treatments in comparison to control (20.90%). The lowest seedling mortality (2.20%) and maximum pod yield (2170 kg/ha) were recorded in field where soil was treated with *T. viride* and seed treated with tebuconazole followed by Seed treatment with tebuconazole seedling mortality (3.82%) and pod yield (2074 kg/ha) in comparison to other treatments.

PP70(Off)-3C: Integrated management of early blight of tomato caused by *Alternaria solani* [Elli. and Martin] Jones and Grout

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Early blight caused by *A. solani* [Ell. and Martin] Jones and Grout is one of the most widely spread and destructive diseases of tomato (*Lycopersicon esculantum* Mill.). The pathogen induces damping-off, leaf blight, stem canker and fruit rot, which accounts for about 48-80 per cent fruit yield losses. Therefore, present investigations on *A. solani* were undertaken with the objectives to study *in vitro* efficacy of fungicides, bioagents, plant extract and, organic amendment in pot culture against *A. solani.* The disease incidence recorded at 30 days after third transplanting was found to be decreased slightly over that of observed after second treatment and it was ranged from 13.42 to 27.34 per cent, as against 26.42 per cent in control. The least disease incidence was observed in the plots treated with Propiconazole 25% EC @ 1.5/1lit of water + *T. harzianum* @10gm/kg + neem leaf extract (@ 20%) (13.42%) followed by *T. harzianum* @10gm/kg + neem leaf extract (@ 20%) + poultry manure (14.91), Propiconazole 25% EC @ 1.5/1lit of water + *T. harzianum* @10gm/kg (17.67%), *T. harzianum* @10gm/kg + neem leaf extract (@ 20%) (17.90%), Propiconazole 25% EC @1.5/1lit of water (18.33%). The maximum disease incidence was observed in pots treated with *T. harzianum* @10gm/kg(20.66%), neem leaf extract 20% @ 20ml/lit. of water (24.84%), poultry manure 25gm/pot (27.34%).

PP71(Off)-3C: *In vitro* Bioefficacy of the Phytoextracts Against *Phomopsis vexans* and *Alternaria alternata,* Causing Post Harvest Fruit Rots of Brinjal

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Microbial fruit rots of brinjal are caused by many fungal species, amongst which *Phomopsis vexans* and *Alternaria alternata* are major one deteriorating the fruit quality as well as their marketable value and thereby putting the farmers to economical loss. Though, there are several fungicides available to manage such fruit rot causing fungi, but due to their deleterious effect on consumers health, eco-friendly, safer options to combat post-harvest fruit rots, biological management strategies need to be explored. Therefore, present *in vitro* study was attempted to evaluate the bioefficacy of about nine solvent phytoextracts were evaluated (each @10 and 20%) by applying CRD and all the treatments replicated thrice, during 2020-21, at the Department of Plant Pathology, College of Agriculture, Latur (M. S.). The results revealed that all the test phytoextracts exhibited antifungal activity against *P. vexans* and *A. alternata* significantly inhibited their mycelial growth, over untreated control. At 10% concentration, in *P. vexans*, *Lawsonia inermis* resulted with significantly highest mycelial growth inhibition (63.81%), followed by *A. cepa* (46.47%), *A. indica* (43.25%), *Z. officinale* (42.18%), *A. barbadensis* and *L. camara* (each 41.59%), *E. globulus* (40.88%), *A. sativum* (40.81%) and *P. pinnata* (40.07%). Except, *L. inermis*, *A. cepa* and *A. indica*, rest of the test phytoextracts were on par to each other. At 20% concentration, mycelial growth inhibition of *P. vexans* was significantly highest with *A. sativum* (71.67%), followed by *L. inermis* (68.41%), *A. cepa* (50.77%), *Z. officinale* (49.66%), *A. indica* (47.55%), *E. globulus* (47.48%), *A. barbadensis* (46.26%), *L. camara* (43.85%) and *P. pinnata* (43.25%). Except, *A. sativum, L. inermis, A. cepa* and *Z. officinale*, rest of the test phytoextracts were on par to each other. At 10% concentration, in *A. alternata* mycelial growth inhibition of *A. altrenata* was significantly highest with *L. inermis* (77.51%), followed by *A. sativum* (72.10%), *Z. officinale* (68.55%), *A. cepa* (64.65%), *E. globulus* (64.36%), *L. camara* (63.22%), *P. pinnata* (62.85%), *A. indica* (61.81%) and *A. barbadensis* (53.99%). Except, *L. inermis*, *A. sativum* and *Z. officinale* rest of the test phytoextracts were on par to each other. At 20% concentration, mycelial growth inhibition of *A. alternata* was significantly highest with *A. sativum* (82.36%), followed by *L. inermis* (78.81%), *Z. officinale* (73.10%), *P. pinnata* (69.36%), *E. globulus* (68.88%), *A. indica* (66.47%), *A. cepa* (65.29%), *A. barbadensis* (65.10%) and *L. camara* (57.36%). *A. indica, A. cepa* and *A. barbadensis* were on par to each other. Thus, phytoextracts possessing antimicrobial ingredients such *L. inermis, A. sativum, Z. Officinale* etc can be used to combat fungal fruit rots of brinjal.

PP72(Off)-3C: Efficacy of root exudates and their different concentrations on growth of *Sclerotium rolfsii*

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Sclerotium rolfsii is a well-known soilborne fungus causes root rot, stem rot, collar rot, wilt and foot rot in several plants. The objective of this research was to assess the antifungal potency of several plant root extracts and their different concentrations against the significant phytopathogenic fungus *Sclerotium rolfsii*, which is known to cause substantial crop loss in the field. Twenty plants were selected as per their reported antimicrobial properties in previous research articles and harvested their root exudates to study their antifungal potency. The results of the study showed that root exudates had marked influence on mycelial growth, colony diameter and sclerotia formation of *S. rolfsii*. Neem root exudate had maximum inhibitory effect on mycelial growth of *S. rolfsii* (58.82 %). This was followed by mango and *shatavari* root exudates which showed 54.89 per cent inhibition in each. There were no sclerotia formation on neem, mango, *shatavari*, sorghum, coconut, periwinkle and parthenium root exudates even after 15 days of inoculation. However, datura and tamarind root exudates showed minimum per cent inhibition over control with profuse amount of sclerotia formation. It means datura and tamarind root exudates stimulate growth of *S. rolfsii.* Among the total samples, five promising plant root exudates *viz.* neem, sorghum, mango, coconut, *shatavari* were selected for evaluating effect on sclerotia germination in different concentrations (at 10, 20 and 50 %). At 10 per cent neem root exudate (21.32 %) was found effective against *S. rolfsii* followed by mango root exudate (16.91%). At 20 per cent, treatment of neem root exudates (33.08% inhibition) significantly superior to other treatment. After neem, *shatavari* root exudate (30.80 % inhibition) found effective while coconut found with least inhibitory over control. At 50 per cent conc., treatment of mango root exudate (53.67%) was found statistically significant against *S. rolfsii*.

PP73(Off)-3C: Evaluation of different essential oils against *Sclerotium rolfsii* Sacc. and *Fusarium oxysporum* f.sp. *lycopersici* causing collar rot and wilt diseases in brinjal and tomato

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Tomato (*Lycopersicon esculentum* Mill) and Brinjal (*Solanum melongena* L.) are the most widely cultivated food crops. *In vitro* efficacy of essential oils against *Fusarium oxysporum* f.sp. *lycopersici* and *Sclerotium rolfsii* Sacc. were tested @2500 and 3000 ppm. At 2500 Rose oil and Lavender oil was found best effective which inhibited 94.44 per cent mycelial growth, whereas at 3000 ppm Rose oil, Clove oil and Lavender oil were found best which inhibited 94.44 per cent mycelial growth of *Fusarium oxysporum* f.sp. *lycopersici*. Similarly in the case of brinjal, At 2500 ppm, Clove oil and Lavender oil were found most effective which inhibited 94.44 per cent mycelial growth, whereas, at 3000 ppm, Rose oil, Clove oil, Citronella oil and Lavender oil were found best which inhibited 94.44 per cent mycelial growth of *Sclerotium rolfsii* Sacc.

PP74(Off)-3C: Biological Management of root & Stem rot (*Macrophomina phaseolina* (Tasi) Goid) of Sesame

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Sesame (*Sesamum indicum* L.) is one of the world's oldest oilseed crops and has been cultivated in Asia since ancient times and largely produced for its oil and is also used as a flavoring agent. The seeds of sesame contains 40 to 63 percent oil, which contains significant amount of oleic and linoleic acids. In the country, it is grown in 15.62 lakh hectares area with production of 7.84 lakh tones. A field experiment was conducted on sesame during three years *Kharif* 2015 to 2017 at JNKVV farm, with seven treatments and three replications using susceptible variety of Sesame (*Sesamum indicum* L.),VRI-1, to find out the effect of *Trichoderma viride* and *Pseudomonas florescence* (either alone or in combination) on incidence of charcoal rot disease caused by *Macrophomina phaseolina* (Tasi) Goid. Treatments$T_4$and T_5were found to be effective in reducing disease intensity to11% in comparison to 38% in control. This interaction suggested that a single isolate of antagonist can be highly effective against *M. phaseolina*. reduced stem and root rot of sesame and increased seed yield. It was concluded that the, Seed treatment with *Trichoderma viride* (5g/kg seed*)+Pseudomonas florescence* (10g/kg seed)+ soil application of *T. viride* or *P. florescence* before sowing @ 2.5 kg/ha was effective for the Biological management root and stem rot *(Macrophomina phaseolina)* of sesame.

PP75(Off)-3C: Evaluation of neem produdcts and Biocontrol-agents against *Alternaria* leaf spot disease of Brinjal (*Solanum melongena* L.)

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Brinjal (*Solanum melongena* L.) is a major solanaceous vegetable crop of India after tomato and potato. In India the total area under brinjal cultivation is 7.22 lac hectares with an annual production of 134.44 lac tonnes (IVRI, Varanasi 2012-13). According to its nutritional value as a vegetable crop it is very valuable economical crop but several diseases like, *Alternaria* leaf spot, *Fusarium* wilt, *Anthracnose*, Damping off, Downy mildew, *Phomopsis* blight*,* Ripe rot of brinjal, *Sclerotinia* collar rot etc. are constraints to the yield. A field trial was conducted in *Rabi* season of 2015 to test the effect of botanicals and bio-agents viz Neem leaf extract 6%, Neem oil 6%, *Trichoderma viride* 6%, *Pseudomonas fluorescens* 6%, *T. viride* + Neem oil 3+3%, *T. viride* + Neem leaf extract 3+3%, *T. viride* + Neem oil + *P. fluroscence* 2+2+2% as foliar spray at 15 day interval for twice for eco-friendly management or minimize the disease intensity of *Alternaria* leaf spot disease of brinjal. Results shows that all the treatments are statistically significant over control and *Trichoderma viride* was the most superior in reduction % of *Alternaria* leaf spot disease of brinjal as compared to control.

PP76(Off)-3C: Ecofriendly management of Tuber Rot of Sweet potato by using Agrochemicals

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Sensitivity of Sclerotium rolfsii Sacc. To carbendazim tested by food poisoning test. MIC on agar plates ranged from 10ug/ml to 500ug/ml. Out of these isolate SR 10 was highly resistance. The agrochemical such as Fungicides, Herbicides, Insecticides ,Antibiotics and Micro-nutrients tested for their efficiency against Sclerotium rolfsii causing to Tuber Rot of sweet potato. Use of Carbendazim in mixture with agrochemical like Fungicides (Alite, Nagcopar, Benofit, Kocide), Herbicides (Andhi, Mat in, 2-4 D, Senchor) , Insecticides (Dantotsu, Actara, Armour, Admire) ,Antibiotics (Amoxycillon, Ciproflaxon, Erythromycin, Ofloxain) controlled growth of pathogen on agar plates and completely inhibited the growth of pathogen use of fungicides along with insecticides and herbicides gave promising control against tuber rot help to avoid resistance in pathogen Causing to tuber rot of sweet potato. Use of in mixture with agrochemical like fungicides.Controlled growth of pathogen on agar plates and completely inhibited the growth of pathogen use of fungicides along with insecticides and herbicides gave promising control against tuber rot help to avoid resistance in pathogen.

PP77(Off)-3C: Effect of Microalgae and Organic Manure on Leaf Spot of (Alternaria sp.) of Quinoa

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A Randomized Block Design (RBD) field experiment was conducted in Central Research Farm (CRF) at Department of Plant Pathology, SHUATS, Prayagraj, U.P. during the Rabi season of 2019-2020 to evaluate the effect of microalgae and organic manure on leaf spot disease of Quinoa. The organic amendments used as treatment were cow dung, goat manure and microalgae. The treatment cow dung @ 6 ton/ha + microalgae @ 2.5 kg/ha + goat manure @ 3 ton/ha was found to be the most effective against Alternaria spp. causing leaf spot of Quinoa. The minimum disease intensity (%) was recorded in T6- Cow dung @ 6 ton/ha + micro algae @ 2.5 kg/ha + goat manure @ 3 ton/ha (5.66 %, 12.67 % and 23.50 %, respectively) at 40, 80 and 120 days, respectively. The same treatment recorded maximum plant height (cm) (62.29, 90.48 and 117.31, respectively) at 40, 80 and 120 DAS, respectively. The same treatment recorded maximum yield (q/ha) recorded (23.45q/ha) at 120 DAS. The same treatment recorded maximum gross return, net return and cost: benefit ratio (Rs.70350/ha, 41326/ha and 1:1.42, respectively). Based on the result obtained, it was concluded that Cow dung @ 6 ton/ha + microalgae @ 2.5 kg/ha + goat manure @ 3 ton/ha was proved to be most effective against Alternaria spp. of Quinoa under Prayagraj condition.

PP78(Off)-3C: Simple germinated paddy seed roll technique for sheath blight infection development *in vitro* a basis to drive the component of fungicides evaluation

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Sheath blight (ShB) disease, caused by *Rhizoctonia solani*, is an economically important rice disease worldwide, and causes 5 to 10% yield losses in the lowland rice of tropical Asia 5-20% in Chhattisgarh. Resistance inducing chemicals that are able to induce broad disease resistance offer an additional option for the farmer to complement genetic disease resistance and the use of fungicides. In this article, we describe a simple germinated paddy seed roll technique for sheath blight infection development which formed the basis to drive the component of fungicide evaluation in moist chamber. Curative effects of fungicides (azoles, strobilurins and antibiotics) at two spray intervals on sheath blight development varied and was significantly reduced after second spray.

PP79(Off)-3C: Management of powdery mildew of mustard incited by *Erysiphe cruciferarum* through novel combined formulations of fungicides

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Indian mustard [*Brassica juncea (L.) Czern & Coss*] is an important oilseed crop. Mustard crop suffers from various diseases caused by fungi and other microorganism. The problem of diseases is the most important factor causing yield instability in rapeseed and mustard. Among these, diseases caused by fungi take heavy toll of the crop. Powdery mildew of mustard incited by *Erysiphe cruciferarum* (Opiz ex Junell) is the most important disease that causes maximum reduction in yield and quality of mustard seed. In india, powdery mildew disease affects yield losses from 10-90 per cent with reduction in 6.47 per cent oil content have been estimated from different Brassicas. Field experiment was carried out to know the effect of different fungicides (Tebuconazole 50% + Trifloxystrobin 25% WG, Metiram 55% + Pyraclostrobin 5% WG, Fluxapyroxad 250 g/l + Pyraclostrobin 250 g/l SC, Myclobutanil, Azoxystrobin 23% SC, Triadimefon and Control) against powdery mildew of mustard during *Rabi* season. Among the seven treatments, Tebuconazole 50 % + Trifloxystrobin 25% WG (0.1%), was observed highly superior over other fungicides and recorded minimum 8.33 per cent disease intensity (PDI) by decreasing 85.37 per cent disease intensity and maximum 13.62 q/ha yield. Myclobutanil (0.1%) was observed second best and recorded 12.73 per cent disease intensity and yield 12.32 q/ha.

PP80(Off)-3C: Effect of fungicides on conidial germination of powdery mildew (*Erysiphe heraclei* D.C.) Dillseed *in vitro*

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India is the leading country in the world for cultivation, production and consumption of seed spices and India has always been recognized as a land of spices. Dillseed (botanically known as *Anethum graveolens*) is an annual herb in the celery family Apiaceae. India is the leading producer of dillseed and its derivatives. The exports of the essential oil and seeds have grown over since last five years. India supplies whole and powdered spice to various European countries. It is also known as Suvaa, Sabbasige, Soppu, Soa-Kura, Pakhon, Soa, Suva and Shevies. powdery mildew (*Erysiphe heraclei* D.C.) disease is predominant in Gujarat in the dillseed cropping areas and causing huge loss quantitatively and qualitatively. A experiment was laid out during *rabi* 2016-17 at Dept. of Plant Pathology, Sardarkrushinagar Dantiwada Agricultural University. All fungicides (penconazole, difenoconazole, hexaconazole, metriam + pyraclostrobin, kresoxym methyl and wettable sulphur) at 100 to 750 ppm concentrations were found significantly effective in reduction of conidial germination of powdery mildew pathogen. The fungicide wettable sulphur recorded the least mean conidial germination (0.67 %) followed by hexaconazole (2.26 %) and penconazole (2.88 %). Wettable sulphur found effective as all the concentrations tested *i.e.,* 100, 250, 500 and 750 ppm. Although, hexaconazole (0.30 %), difenoconazole (0.56 %) and kresoxym methyl (0.62 %) found effective at 750 ppm concentrations for inhibiting conidial germination. The conidia entirely not germinated at the concentration of 1500 ppm by wettable sulphur.

PP81(Off)-3C: Eco friendly Management of foot rot papaya

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Papaya (Carica papaya L.) is an important fruit crop, which belongs to family Caricaceae. In India, papaya is mostly cultivated in the states of Andhra Pradesh, Gujarat, Karnataka, Orissa, West Bengal, Assam, Kerala, Madhya Pradesh and Maharashtra. In Gujarat, it is cultivated nearly on 18127 ha with the production of 11.15 lakh M.T. with the productivity of 61.52 M.T./ha of fruits. Papaya is a powerhouse of nutrients and is available throughout the year.It is a rich source of threes powerful antioxidant vitamins 'C,' 'A' and 'E' the minerals, magnesium and potassium; the B vitamin which pantothenic acid and folate and fiber. Cultivated papaya is prone to many diseases incited by fungi, bacteria, nematodes and viruses leading to heavy losses. Especially fungal pathogens gregariously attack various parts of plant from roots to fruits. Foot rot is caused by *phytophthora palmivora*, is considered one of the main diseases of papaya. An experiment was conducted at College of Horticulture, S.D. Agricultural University, Jagaudan (Mehsana) Gujarat during 2017-18, 1018-19 and 2019-20 under field condition. The experiment was conducted in Randomized Block Design in factorial concept with four replication. Twelve treatment using two factors, factor A was seed treatment and in this total three treatments was there and factor B was field application in this total four treatment was there It can be concluded that the seed treatment of *Trichoderma harzianum* @ 10g/kg seed or metalaxyl + mancozeb (ridomil MZ-72) @ 3g/kg seed and apply *T. harzianum* enrich with FYM (2.5 kg *T. harzianum* + 100 kg FYM at the time of transplanting + soil drenching of *T. harzianum* @ 50gm/10 lit water at initiation of the disease and second drenching after one month of first drenching for economically viable and effective foot rot management of papaya.

PP82(Off)-3C: Integrated disease management of yellow vein mosaic of okra

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Yellow vein mosaic is a devastating disease of okra, caused by monopartite and bipartite begomovirus and associate satellites. Yield loss due to this virus is quite high, up to 80-94 percent is reported under heavy infection. The okra crop is very much susceptible to white fly transmitted YVMV causing heavy losses by infecting all the stages of plant growth. Hence, an integrated management module of nine treatments by growing Poorvi variety for this disease was evaluated on Research farm at RARI, Durgapura during *kharif* 2019, 2020 and 2021. The module consists of use of seed treatment, agrimulching or spray of sea weed extract, neem oil, pyriproxifen, fenpropathrin, spiromesifen and buprofezin. It was observed that the disease incidence and yield showed significant variations as compare to control. Treatment T7 *i. e* mulching with agrimulch silver polythene sheet + seed treatment with Thaimethoxam 30% FS@ 4g/kg of seed + sequential spray of pyriproxifen (5% EC) + fenpropathrin (15% EC), spiromesifen 2.9 % SC, buprofezin 25% SC and neem oil at 10 days interval found most promising in reduction of yellow vein mosaic incidence and increasing yield of the crop.

PP83(Off)-3C: Management of tomato anthracnose through biopesticides

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The causal organisms of anthracnose fruit rot of tomato was isolated and identified as *Colletotrichum truncatum* on the basis of morphological characters and sequencing of DNA coding for internal transcribed spacer (ITS) region. The effectiveness of aqueous, ethanol based and cow urine based biopesticides of six native plants were evaluated for the management of the tomato anthracnose. Aqueous extract of *Cannabis sativus (*at 40%) resulted in inhibition of 36.56 per cent in mycelial growth of the pathogen. Cow urine based extract of *Eucalyptus citriodora* (at 20 % concentration) resulted in 76.29 per cent inhibition in mycelial growth followed by *C. sativus* (63.20 %) and *A. indica* with 56.67 % inhibition. Spray of tomato fruits with cow urine based biopesticide of *E. citriodora* (at 30 %) were found to be effective to manage anthracnose disease in tomato with disease reduction of 69.23 per cent compared to control. Among ethanol based biopesticides evaluated at four different concentration *viz.,* 1,2,3 and 4 per cent using poisoned food technique, extract of *E. citriodora* (at 4%) resulted in maximum mycelial growth inhibition (77.31%) while least mycelial growth inhibition of 63.14 per cent was recorded in crude extract of *Tagetes erecta.* Spray of tomato fruits with ethanol biopesticide of *E. citriodora* (at 4%) resulted in anthracnose disease reduction compared to control.

PP84(Off)-3C: Abiotic inducers of resistance for the management of purple blotch of onion

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Purple blotch, caused by *Alternaria porri* (Ellis) Cifferi, is one of the major disease in onion. In search for management of disease, various disease-free seeds, resistant cultivars and fungicidal applications are successful but they have some drawbacks which include short commercial life of resistant cultivars or development of fungicide resistance. Due to these disadvantages, there is a continuous requirement for inducing resistance to plants against the disease. Induced resistance is a new technology for crop protection that assumed to be much more ecologically solid than conventional practices for the management of purple blotch of onion. The present study was undertaken to assess the efficacy of abiotic resistance inducers by foliar sprays under pot conditions in the management against *A. porri* revealed that minimum incidence of 15.66 per cent and minimum disease index 7.77 per cent was observed with foliar spray of salicylic acid at 20 mM concentration with maximum plant weight and shoot length. It was followed by salicylic acid 10 mM concentration with disease incidence 25.55 per cent and disease index 11.10 per cent with increased in plant weight and shoot length. However, potassium oxalate and oxalic acid at 20 mM concentration were least effective against the purple blotch of onion disease with 87.50 and 86.67 per cent incidence and 79.17 and 73.33 per cent disease index, respectively with minimum plant weight and shoot length compared to un-treated control. From the present investigation it is concluded that efficient inducers of resistance could be used for management of purple blotch of onion.

PP85(Off)-3C: Effect of nutrients and plant extracts on Alternaria blight of tomato caused by *Alternaria Alternata*

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Studies with nutrients and phyto-extracts were performed in vitro and in vivo to assess their potential in controlling Alternaria blight of tomato (*Solanum lycopersicum* L.) caused by *Alternaria alternata.* It has become a severe menace to the growers of Rajasthan in India and in general causes economic losses under changing climatic scenario. In the present study, seven nutritional elements (copper, calcium, zinc, magnesium, potassium, iron and boron) at 100, 300 and 500 ppm concentration and seven botanicals (*Calotropis gigantea, Alstonia scholaris, Gingiber officinale, Allium sativum, Azadirachta indica, Datura stramonium* and *Aloe barbadensis)* at 5, 10 and 15% concentrations were evaluated in vitro by poisoned food technique. In field experiments, further these nutrients (at 0.5% conc.) and plant extracts (at 10% conc.) were assessed by two foliar applications to control the disease. The results of in vitro studies with copper and zinc showed the most significant antifungal activity at all tested concentrations. In botanicals, the 100% inhibition

of mycelial growth was obtained with garlic extract at 10% concentration. In field conditions, two foliar applications of copper sulphate (0.5%) were proved the most effective in reducing disease intensity (46.94%) and in increasing fruit yield (43.75%) followed by zinc sulphate. In plant extracts, garlic extract (10%) proved superior in reducing disease intensity (58.16%) and in increasing fruit yield (49.47%) followed by neem leaf extract. The results of this study indicate that foliar application garlic extract has great potential to be used to manage disease effectively and eco-friendly for the betterment of the end users. In lieu of consumer health, present findings may be helpful for growers to get extra benefits by producing organic tomato.

PP86(Off)-3C: Management of Sesame Phyllody disease through the insecticide in Madhya Pradesh

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Sesame (*Sesamum indicum* L.) is one of the important annual oldest oil seed crop grown in tropical to temperate zones in India. It belongs to family Pedaliaceae is native of India and plays an important role in the oilseed economy throughout the world. The sesame crop suffers from phyllody disease caused by phytoplasma. Phyllody disease transmitted through the insect vector, cuscuta and grafting in the form of phytoplasma and phytoplasma move within plants through the phloem from source to sink and they are able to pass through sieve tube elements.Plants infected by phytoplasmas exhibit a wide range of specific and non-specific symptoms. Symptoms of diseased plants may vary with the phytoplasma, host plant, stage of the disease, age of the plant at the time of infection and environmental conditions. The result indicated that, all the treatments were superior over the control. The effect of different treatments on per cent disease incidence and yield was recorded. The results obtained revealed that all the treatments reduced the disease significantly compared to unsprayed control. Seed treatment with imidacloprid 17.8 SL @ 5 ml/kg + spray of acetamiprid 20 % SP @ 0.3 g/L recorded the least disease incidence (7.05 %) and highest seed yield of 5.21 q/ha and while seed treatment with imidacloprid 17.8 SL @ 5 ml/kg + spray of azadirachtin 0.03% @ 3ml/L was least effective in which disease incidence of 11.43 per cent was recorded. The disease incidence in untreated check was 14.94 per cent and lowest seed yield of 3.04q/ha was recorded.

PP87(Off)-3C: Management of Blight, Powdery mildew and Aphid infestation in cumin (*Cuminum Cyminum* L.)

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Cumin is one of the most valuable crop specially for the arid region farmers. Cumin seeds have a typical pleasant aroma due to an aromatic alcohol, amino and spicy taste. It is largely used as condiment and an essential ingredient in all mixed spices and carries powers. Cumin faced many challenges in production is affected by diseases and pest which are responsible for heavy yield losses. Among this blight caused by *Alternaria burnsii*, powdery mildew incited by *Erysiphe* *polygoni* and aphid infestations by *Myzus persicae* (Sulzer) and *Hydaphis coriandri* (Das) are important and serious diseases and pest observed to be cause significant losses in grain quantity as well as quality. Management strategy both controlling both the disease and pest, an experiment was taken up involving integrated application of biocontrol agent, fungicides and insecticides at different stage of crop growth. The experiment consisted of fourteen treatments and each treatment the foliar application of biocontrol agent of *Lecanicillium lecanii, B. bassiana* and fungicides namely Hexaconazole, Kresoxym methyl, Carbendazim and insecticides i.e Dimethoate 30% EC, thiamethoxam 25 WG. This experiment was carried out at All India Coordinated Research Project on Spices, SKN College of Agriculture, SKN Agriculture University, Jobner, Rajasthan, India during *rabi* season of 2018-2021.The treatments were taken in R.B.D design with three replications. The crop variety RZ-19 was sown in plot 3 x 2.4 meter square in second fortnight of November every year at a distance of 30 cm row spacing by using seed rate 12-15 kg ha-1. The treatment combination of three foliar sprays of Kresoxym methyl 44.3 SC (0.044%) 10 ml/ 10 lit. water + two foliar sprays of Thiamethoxam 25WG (0.0084%) were recorded significantly minimum incidence of powdery mildew (10.59%), blight (14.81%) and lowest aphid index (0.46) at 3 and 7 days both sprays along with highest B:C ratio (3.0). The integrated use of fungicides and insecticides offer an effective management against the powdery mildew, blight disease and aphid infestations of cumin.

PP88(Off)-3C: *In vitro* Effect of custard apple leaf extract on seed mycoflora of Indian bean

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Indian bean has been reported to suffer from various types of disease and the majority of them are known to be caused by fungi that are seed-borne in nature. Amongst them, anthracnose caused by *Colletotrichum* sp, blight caused by *Alternaria* sp, vascular wilt caused by *Fusarium* sp., and other molds like *Rhizopus* sp. and *Mucor* sp. are major seed-borne mycoflora observed in Indian bean. Seed-borne fungi are the most important plant pathogens that cause direct and indirect losses of the bean crop throughout the world. The phyto extracts are new organics that are widely used for treating seed-borne diseases. Here, the effect of a total of seven phytoextracts namely, leaves of Castor, Custard apple, Neem, Datura, turmeric rhizome, and Neem oil on Indian bean seed mycoflora has been tested. Amongst them, effect of custard apple (leaves) @ 1.5ml revealed minimum (48.15%) seeds mycoflora and Turmeric (rhizome) extract @ 1.5ml (48.46%).was found highly significant against seed mycoflora.

PP89(Off)-3C: Management of soybean pod blight by fungicide application under agro-conditions of Jabalpur, Madhya Pradesh

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Soybean (*Glycine max* (L.) *Merril*) is an important oilseed crop grown in India. It is valued due to high quality protein (40-42%) and oil content (18-20%). On account of unique ability to fix biological nitrogen 270 kg/ha, the crop has exhibited distinct significance. Crop is grown on 55.5 lakh ha with a production of 54.0 lakh MT in India. Stem blackening and pod blight disease was noticed at R5 (Bean beginning to develop) and R7 (pod yellowing, 50% leaves yellow) stages. The disease was noticed in all the 23 soybean varieties. None of the variety was free from the infection. Incidence ranged from 11.0 to 32.0%. The disease was higher during 2nd week of November, when the average temperature was 19.5 C and relative humidity 66.57. Predominant association of *Colletotrichum dematium* (*C. truncatum*) was recorded. Association of fungus adversely affects the yield and seed quality characters. Fungicide application made at R3, R5 and R7 stage of the crop have resulted in significant reduction in the incidence of pod blight of soybean, under field condition. Three application of Pyraclostrobin + Metiram (0.2%) one at each R3, R5 and R7 stage resulted in incidence of 7.13% as compared to 30.9% in untreated control plots with no basic seed treatment and no foliar application. Application of Carbendazim + Mancozeb (0.2%) and Pyraclostrobin + Thiophanate M (0.2%) were promising.These fungicides are being widely used by farmers and soybean growers under large scale.

PP90(Off)-3C: Effect of antifungal activity of Seaweed extract (*Ascophyllum nodosum*) against soil borne pathogens of soybean

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The effect of different level of seaweed extract *(Ascophyllum nodosum)* on *Fusarium oxysporum* and *Rhizoctonia* spp. infecting soybean crop was tested in vitro at concentrations of 250, 500, 750, 1000, 1500 and 2000 ppm which showed considerable inhibition on mycelial growth of *F. oxysporum* and *Rhizoctonia* spp. But, the increased concentrations of 1500 and 2000 ppm showed maximum inhibition even sixth day after incubation. The effect of this seaweed extract inoculation on seed and soil was assessed by evaluating different growth parameters of soybean**,** where significant increase in emergence percentage was observed due to inoculation of seaweed extract at various concentrations. The treatment combination (T6) of seed treatment (5 ml/ kg) + soil application (100gm per kg of soil) recorded highest emergence i.e. 95.56 per cent at 10 days after sowing, highest root length *i.e.* 7.1, 8.66 and 9.36 cm, respectively at 30, 60 and 90 days after sowing. It also recorded highest shoot length *i.e.* 28, 36.33 and 41.2 cm, respectively at 30, 60 and 90 days after sowing a**s** well as highest vigour index *i.e.* 3354.15, 4319.31 and 4835.33, respectively at 30, 60 and 90 days after sowing.

PP91(Off)-3C: Population dynamics and viability of *Trichoderma harzianum* TS004 on different formulations across time intervals of storage

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In the present investigation Trichoderma based formulations were prepared using formulating materials viz. talc, gypsum, and paraffin oil. To study shelf life of formulations, it was tested up to

6 months at room temperature (15-380C) and 11 months at refrigerator (40C). The formulations were prepared and initial CFU of each formulation was measured. The colony forming unit (cfu) count was highest initially but gradually decline was recorded with the increases in storage time. The results revealed that all the formulations contained initial CFU count in the range of 18.20 to 45.1x107 CFU/g or /ml. At room temperature (15-380C) there was a gradual decline in the CFU of *Trichoderma* in all the formulations up to 3 months and thereafter sudden decline was observed after 6 month of storage. Among different formulations, maximum viability was observed in Paraffin oil based liquid formulation (21.15% 9.54x107 cfu/ml) followed by (9.02% 3.67 x107 cfu/gm) in talc based after 6 month of storage at room temperature (15-380C). The formulations stored at 40C revealed that there was a gradual decline in the CFU of *Trichoderma* in all the formulations up to 9 months and thereafter sudden decline was observed after 11 month of storage. Maximum viability was observed in (8.40% 3.83 x107cfu/ml) in Paraffin oil based liquid formulation followed by (7.31% 2.67 x107 cfu/gm) in talc based after 11 month of storage at 4oC (Refrigerator). This research showed that above Trichoderma formulations have the potential to improve shelf life as well as bio-control efficacy.

PP92(Off)-3C: Evaluations of organic soil amendment and bio-agents against cumin wilt caused by *F. oxysporum* f.sp. *cumini*

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Application of organic amendments and bio agents considered an eco-friendly practice to promote soil fertility and suppressiveness against wide range pathogens and now a day's trend shifting towards healthy, safe and sound eco-friendly control of plant disease. In this study, the suppressiveness of seven different organic amendments and four bio agents were determined against the cumin wilt disease in the year 2020-21. Among them, the lowest incidence per cent was recorded in mustard cake (27.11%) which is at par with neem cake (29.37%) and groundnut cake (29.96%) followed by sesamum cake (31.81%). The maximum per cent disease incidence was observed in castor cake (33.21%) followed by cotton cake (33.14%) whereas, 64.11% disease incidence was recorded in control pot. In bio-agent, *in vitro T. harzianum* (78.25%) and *T. viride* (72.69%) were found most effective in inhibiting mycelial growth of *F. oxysporum* f.sp. *cumini* and least mycelial growth inhibition by *Bacillus subtilis* (55.34%).

PP93(Off)-3C: Bio-efficacy of EcoLaid Freedom Microbicide against major grape diseases

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Downy mildew (*Plasmopara viticola)* and Powdery mildew (*Erysiphe necator*) are the most devastating diseases causing 60-70% of crop loss affecting the grape economy. Constant application of fungicides leads to the development of resistance in pathogen necessitates search towards new biological fungicide with an alternative mode of action. In this perspective, *in vitro* and field evaluation of different formulations of EcoLaid Freedom Microbicide were carried out to analyse its bio-efficacy against these diseases at Tamilnadu and ICAR-NRCG, Pune respectively. Four to five sprays of fungicides were given based on the favourable weather conditions. For downy mildew, spray applications of EcoLaid Freedom Microbicide @. 1.25 ml/L, 2.50 ml/L, 3.75 ml/L, Ecolaid freedom Microbicide V2 @1.25 ml/L, 2.50 ml/L, Dormulin Combi (2 sprays) /EcoLaid freedom Microbicide (3 sprays), Dormulin Combi / EcoLaid freedom Microbicide (2nd and 3rd spray) / EcoLaid freedom Microbicide (4th & 5th spray) were assessed. Dimethomorph @ 0.50g/L was used as standard check fungicides. For powdery mildew, EcoLaid Freedom Microbicide @ 2.50 ml/L, 0.50 ml/L, 0.75 ml/L, Ecolaid freedom Microbicide V2 @0.25 ml/L, 0.50 ml/L, Dormulin – flowering & fruiting twice @ 5g/L + Ecolaid Freedom Microbicide twice @ 5ml/L, Dormulin-Flowering & fruiting 5g/L and Sulphur @ 2g/L (standard check) were analysed. All the treatments were significantly superior over untreated control at *in vitro* and field conditions Dormulin Combi (2 sprays) @ 5g/L + EcoLaid freedom Microbicide (3 sprays) @ 5ml/L were effective against downy mildew with 26.14 PDI and Dormulin Combi (2 sprays) @ 5g/ L + EcoLaid freedom Microbicide (2 sprays) @ 5ml/L were effective against powdery mildew with 25.86 and showed highest yield of 23.79 t/ha and 21.58 t/ha at both locations.

PP94(Off)-3C: Integrated Management of Collar rot of Chickpea

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Chickpea (*Cicer arietinum* L.) is an important pulse crop of India. Collar rot of chickpea caused by *Sclerotium rolfsii* is an important disease of chickpea. An experiment was conducted with integration of potential indigenous isolate of *Trichoderma harzianum*, organic amendments viz., vermicompost, Farm yard manure (FYM) and a fungicide Taquat (captan 70% + hexaconazole 5% WP) in various combinations under pot conditions during *Rabi* 2019-20. The treatment in which seeds treated with captan 70% + hexaconazole 5% WP + soil application with *Trichoderma harzianum* enriched vermicompost found most effective and provided maximum seed germination (100%) and reduction (77.13%) in the incidence of collar rot over control followed by the treatment in which seeds treated with Taquat (captan 70% WP + hexaconazole 5% EC) seed@2g/kg of seed + soil application with *T. harzianum* enriched FYM found next in order to provide highest seed germination and reduction in collar rot incidence. However, soil application with *Trichoderma harzianum* enriched FYM alone was found least effective treatment in respective of seed germination and reduction in collar rot incidence respectively.

PP95(Off)-3C: Biochemical based Environmental Safe Practice for Management of Root-Knot Nematode, Meloidogyne incognita on Cluster bean (Cyamopsis tetragonoloba L.)

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Cluster bean, *Cyamopsis tetragonoloba* (L.) is a drought and high temperature tolerant deep rooted summer legume of high social and economic significance in Rajasthan. India is the largest producer of cluster bean and contributes 80 percent of total cluster bean production in the world. It occupies about three-fourth of the global cluster bean cultivation. Being deep rooted and drought hardiness, this crop has occupied tremendous areas in arid and semi-arid regions encompassing Rajasthan, Gujarat and Haryana state. Rajasthan ranks first with respect to area and production. The crop of such an immense economic value is prone to attacked by several pests and diseases (aphid, white fly, jassids, blight, powdery mildew etc.) including plant parasitic nematode. In recent years root-knot nematode, *Meloidogyne incognita* emerge as highly destructive pest of the field crops. Cluster bean is growing all over the Rajasthan and very much affected by this nematode. Many nematicides were tested on this nematode and are very effective but due to health hazards, residual toxicity, environmental pollution and high cost, their adoption at farmer’s level has been limited. Therefore, three biochemicals *viz*., salicylic acid, ascorbic acid and L-arginine at 1, 2 and 4 per cent w/w as seed treatment were tested for the management of root-knot nematode, *M. incognita* on cluster bean in pot. All biochemicals shows significant response in growth parameters with corresponding reduction in the number of galls, egg masses per plant, eggs per egg mass and larvae per 100 cc soil over control. The highest growth of cluster bean and maximum reduction in root-knot nematode population were recorded with ascorbic acid at 4 per cent followed by salicylic acid at 4 per cent and L-arginine at 4 per cent.

PP96(Off)-3C: Molecular identification of Actinomycetes using 16S rDNA and estimating population dynamics through -Diversity and GIS in Gangetic Plains of Bihar

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Actinomycetes are ubiquitous ray fungus also refer as powerhouse of biomolecules. Therefore, evaluation of their distribution is important to explore their role in field of agriculture. Aiming to this, total 1132 Actinomycetes colonies were observed from the analysis of 27 soil samples using agar plating method in the three different ecotones *viz.,* irrigated crop fields (ICF), diara land (DL) and barren lands (BL) of Bhagalpur. The numbers of Actinomycetes colonies were varied with fluctuation in pH, organic carbon (OC) and electrical conductivity (EC) of soil samples with significant differences. On the basis of morphological and biochemical examinations Actinomycetes colonies were divided into 25 groups belonging to three genera *Streptomycetes*, *Frankia* and *Nocardia*. Out of 25 isolated Actinomycetes, highest 19 from DL followed by 18 from ICF and least 4 isolates from BL were observed. On the basis of their phosphate solubilizing efficacy, some potent strains named AKR-1, 12, 14, 18 and 25 were confirmed through 16S rDNA sequencing. Diversity indices like Shannon's diversity index (H) was maximum (2.85) were recorded in case of DL and lowest (1.70) in BL. Simpson's index was recorded equally high in case of DL and ICF (0.94) and lowest (0.69) in BL, while highest evenness (J) was found (0.95) in ICF followed by DL (0.94) and least in BL (0.86). The diversity of Actinomycetes was plotted on GIS based map which clearly indicates that the diara lands are the natural depositories which may be explored further for discovery of more potent strains.

PP97(Off)-3C: Response of cow urine against soil borne plant pathogens of chickpea (*Cicer arietinum* L.)

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Chickpea (*Cicer arietinum* L.), also known as Bengal Gram is one of the major pulses cultivated and consumed in India. It is a cheap source of protein (about 17-20 %) compared to animal protein. Due to increasing environmental concern and health hazard the old management practices of the diseases in the form of fungicides, need to be replaced with safe and eco-friendly management approach. The present study was carried out to know the response of cow urine on soil borne plant pathogens of chickpea under invitro conditions. Effect of cow urine at different concentration viz. 5 %, 10 %, 15 % was tested against *Fusarium oxysporum f.sp. ciceris, Sclerotium rolfsii* and *Sclerotinia sclerotiorum* causing vascular wilt, collar rot and stem rot disease in chickpea, respectively. Observations were recorded on inhibition of mycelial growth of the pathogens at different concentrations of cow urine. Under the study 100 % inhibition of mycelial growth of *Sclerotium rolfsii* and *Sclerotinia sclerotiorum* was recorded in all the tested concentration after 144 hours of inoculation. While, in case of *Fusarium oxysporum f.sp. ciceris* maximum 48.52 per cent inhibition of mycelium growth at 15% concentration after 192 hours of inoculation was recorded.

PP98(Off)-3C: Evaluation of different bio-agents against root knot nematode of basmati rice

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Root knot nematode (*Meloidogyne graminicola*) is emerging as a serious threat to the basmati rice production. In the present study different bioagents were tested against rice root knot nematode under pot condition during 2019 and 2020 for the management of this nematode. In this study, five bio-agents *viz., Trichoderma* isolate S13, *Trichoderma* isolate S7, *Bacillus subtilis, Pseudomonas fluorescens, Paecilomyces lilacinus* and one chemical (Carbofuran) were taken to test the efficacy against the root knot nematode in pot conditions. Observations on number of galls per plant and plant growth parameters were recorded. On the basis of two years of

observations, among all the tested bio agents *Trichoderma* S13 (native isolate) was found most effective in the management of rice root knot nematode. In case of *Trichoderma* (isolate 13) when applied @ 5g/kg of soil, 7.89 and 6.00 galls/plant were recorded, whereas shoot length 71.78 cm and 65.00 cm was recorded at 60 days after sowing during both the year (2019 &2020) respectively. While in case of positive check (carbofuran@ 0.3g/kg soil) 8.11 and 6.44 galls/plant and 67.22 cm and 51.00 cm shoot length were recorded. In case of negative check (control) 14.44 and 16.44 galls/ plant was recorded at 60 days after sowing during 2019 &2020 respectively.

PP99(Off)-3C: *In vitro* assessment of fungicides against *Fusarium oxysporum* f. sp. *pisi* causing Fusarium wilt of pea

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Pea (Pisum sativum L.) is one of the most important legume crops in India. The major states growing pea are Maharashtra, Karnataka, Andhra Pradesh, Odisha, Tamilnadu and Madhya Pradesh. Various factors responsible for low production and productivity of pea, diseases caused by abiotic and biotic agents, wilt incited by F. oxysporum f. sp. pisi is one of the most important and destructive diseases of pea, inflicting heavy yield losses. In order to identify an effective control measure, seven fungicides viz., Azoxystrobin, Hexaconazole, Thiram, Tebuconazole, Pyraclostrobin, Carbendazim, Mancozebalong with control was evaluated against Fusarium oxysporum f. sp. pisi causal agent of wilt of pea. Tebuconazole and Pyraclostrobin were found best fungicides which completely inhibited the radial growth of F. oxysporum f. sp. pisi. Based on damage to nature and survival capability of the fungus, the use of chemicals for management of pea wilt was considered to be the only economical and practical solution.

PP100(Off)-3C: In vitro evaluation of different fungicides against *Fusarium* spp. casing pokkah boeng of sugarcane

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Pokkah boeng disease caused by *Fusarium* spp. complex is one of the economically important diseases in sugarcane growing states. The experiment was carried out to know the efficacy of different fungicides against *Fusarium* spp. The fungicides were tested by using poisoned food technique. The per cent inhibition of radial mycelial growth was of the pathogen over control was calculated by using the formula of Vincent (1947). Among the different fungicides, carbendazim, copper oxychloride, carbendazim + mancozeb and propiconazole found most effective in inhibition of mycelial growth of the pathogen. Carbendazim, copper oxychloride, carbendazim + mancozeb and propiconazole showed 100 per cent inhibition at 100 mg/ml and 200 mg/ml concentrations, respectively. Fungicide chlorothalonil was found least effective in inhibition of mycelial growth of *Fusarium.*

PP101(Off)-3C: Morphological characterization, ITS based identification and variability in *Fusarium oxysporum* f. sp. *lentis* causing wilt of lentil

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Lentil (*Lens culinaris Medik*) is a major edible legume crop after chickpea and it is commonly known as masoor or poor man's meat. Lentil is recognized as one of the most nutritious pulse crops among cool-season food legumes crop. It is also a rich source of carbohydrates, protein and minerals like calcium, phosphorus and Iron. Among the different biotic stresses, wilt is one of the most widespread and major constraint in production and productivity of lentil. The wilt affects both seedling and flowering stages of crop and appears as spots/ patches in the field. *Fusarium oxysporum* f. sp. *lentis* infection is considered by a sudden drooping of the lentil leaves, followed by dull green leaves with drying and the ultimate death of the seedling plants. The present investigation focused on identification of prevalence of wilt of lentil in Central India followed by cultural characterization and identification of variability among the collected isolates of *Fusarium oxysporum* f. sp. *lentis*. The wilt incidence recorded among eight different districts of Madhya Pradesh revealed disease incidence in the range of 5.04 to 20.47% during 2020-21. In total 23 isolates were isolated representing eight districts of Madhya Pradesh. All the isolates were identified microscopically as well as internal transcribed spacer (ITS) amplification and sequencing. The blast X analysis revealed the isolates as *Fusarium oxysporum*. Further cultural and morphological characterization based on colony characteristics, conidial size, septation revealed significant variability among the isolates.

PP102(Off)-3C: Isabgol – a crop of dollar earner and challenges to grow

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Isabgol (*Plantago ovate* Forsk.) is a short-stemmed medicinal annual herb. Isabgol belongs to *Plantaginacae* family. Psyllium is a source of natural and concentrated soluble fiber derived from the husk of blonde psyllium seed. Psyllium husk is the main product of Isabgol. Psyllium husk is used for the treatment of constipation, diabetes, ulcerative colitis, obesity and high cholesterol. India ranks first in isabgol production (98%) and the sole supplier of seeds and husk in the international market. In Rajasthan state, Isabgol growing districts are Jodhpur, Jalore, Barmer, Chittorgarh and Udaipur. Isabgol crop has acreage of 333954 ha with annual production of 170646 tonnes. A number of fungal pathogens were involved causing severe yield losses and seed quality of Isabgol. Fusarium wilt is the most important and widespread disease of Isabgol in Rajasthan which causes extensive damage to the crop. Mehta *et al*., 1985 reported *Fusarium oxysporum* Schlecht and *F. solani* from Haryana. Adverse effect of chemicals on soil, plant health and crop products have compelled plant pathologist to look for eco-friendly strategies for plant disease management. Various disease management methods have been implemented to combat and eradicate pathogen. These include cultural, regulatory, physical, chemical and biological methods. So integrated management strategy is the better solution to maintain plant health.

PP103(Off)-3C: Integrated Disease Management of Isabgol (*Plantago ovata* Forsk) wilt caused by '*Fusarium oxysporum* Schlecht'

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sabgol (*Plantago ovate* Forsk.) is a medicinal annual herb that grows up to a height of 35 to 40 cm. Field experimental trails was conducted during *Rabi* 2017-18 and 2018-19 to evaluate efficacy of bio-agents, de-oiled cakes and fungicides against *Fusarium oxysporum* Schlecht. Total seven treatments and three replications were taken up in randomized block design. The module consisting of soil application with neem cake mixture @100 gm/m^2 plus treatment with Bavistin-50WP @2 gm/kg seed plus Talc-based formulation of *Trichoderma viride* @10 gm/kg seed was found best effective during *Rabi* 2017-18 with minimum per cent disease incidence, maximum seed and husk yield 25.47, 1150.23 kg/ha and 230.54 kg/ha, respectively. Whereas in *Rabi* 2018-19 the module consisting of soil application with neem cake mixture @100 gm/m^2 plus treatment with Bavistin-50WP @2 gm/kg seed plus Talc-based formulation of *Trichoderma viride* @10 gm/kg seed was found best effective with minimum per cent disease incidence, maximum seed and husk yield 25.84, 1165.54 kg/ha and 233.33 kg/ha, respectively. The present study stated that use of bio-agents, de oiled cakes and use of resistant varieties may replace to fungicides without affecting seed and husk yield.

PP104(Off)-3C: Vascular wilt or Fusarium wilt of tomato

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Tomato (*Lycopersicon esculentum* Mill.) belongs to the family *Solanaceae* and it is viewed as one of the world's most mainstream vegetables. Tomato is also known as "poor man's apple" and "protective food. Juice of tomato considered as easily digestible, a good appetizer and known to function as blood purifier. India contains second position in the area and production of tomato. In Rajasthan, it is grown on 18.12 hectare area with an annual production of 88.73 metric tons. A number of biotic and abiotic factors affect the quality and productivity of tomato in which diseases caused by fungi, bacteria, viruses are most important. In India Fusarium wilt or vascular wilt disease of tomato, caused by *Fusarium oxysporum* f.sp. *lycopersici*, was first reported by Butler, 1918 from Pusa, Bihar. Browning of vascular system in infected stems and leaf petioles with larger size are strong evidence of *Fusarium* wilt. This disease is soil borne in nature and prolonged survival of pathogen in soil as a saprophyte cause difficulty to control the disease through conventional methods. The uses of chemical control methods create risk of residual effect of fungicides in soil and are not environment friendly and considered as risk factors for human health. To adopt a suitable integrated management strategy involving of bio-control agents and organic amendments in combinations with fungicides is paramount importance to control wilt disease of tomato.

PP105(Off)-3C: Bio-control *Fusarium* wilt of Tomato by Trichoderma species under in-vitro conditions

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Tomato is an important dietary component and is an essential vegetable. It is an important source of carbohydrate, vitamin, nutrients and minerals such as calcium, phosphorus, potassium and magnesium. Fusarium wilt of tomato, caused by *Fusarium oxysporum* f.sp. *lycopersici* (Sacc.) W.C. Snyder and H.N. Hans, is one of the major constraints in tomato production and causes serious economic losses. According to Singh *et al.* tomato wilt disease causes 70 to 60 percent losses in fruit yield with wilted plants having yellowed leaves. Biological control has emerged has one of the most promising alternatives to the chemical control. They not only control the disease but also beneficial for the vegetative growth of the plants. A study was undertaken to evaluate the efficacy of five bio-control agents *viz. Trichoderma viride* (IIHR-T.V.-5) five procured from Indian Institute of Horticulture Research, Bengaluru, *Trichoderma viride* procured from PCI: Pest Control India Pvt. Ltd., Bengaluru, *Trichoderma aureoviride* (DG. A. 91-5), Dungarpur, *Trichoderma harzianum* (J.H.H.89-2) and *Trichoderma harzianum* (ITCC- 7922/10) procured from Udaipur, in *in-vitro* conditions by using dual culture technique. *In-vitro* test showed that all the bio-control agents were antagonistic to the *Fusarium oxysporum* f.sp. *lycopersici*. Among all the bio-control agents *Trichoderma viride* (IIHR-T.V.-5) was found effective in inhibiting the fungal colony growth of the pathogen in the laboratory followed by *Trichoderma viride* (T.V. PCI).

PP106(Off)-3C: Exploration of different strategies in integrated sheath blight disease management for rice mat nursery

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Rice is a very Crop of India as well as west Bengal. In rice mat nursery farmers are facing the problem of sheath blight disease in a huge extent as the humidity is increased here because the trays where seedlings are prepared has to be covered by polythene for 14 days. Our findings provided ,The pathogen *Rhizoctonia solani* is the the causal agent we proved Koch's postulates and under humid conditions this pathogen found to be escaping from soil to canopy And we found canopeo based automated disease quantification methodology found to be accurate and effective and it was found that 100 gram seed density found to be less effected by *Rhizctonia solani* lowest disease severity 29.72% corresponding to 534.95 cm2 of affected area of 1800cm2 ,in search for best agent to control this pathogen we secerned variety of biotic and abiotic agents and their combinations to to found best one in inoculated treatments highest FGCC and 69.81% and lowest canopy temperature (26.63%) found in cucl2 treatment (T5) biochemical defence enzyme expression shown peroxidase (54%) and polyphenol oxidase (52%) and super oxide dismutase has (67%) negative correlation with disease incidence and they(defence enzymes) also had very high positive correlation with each other ,in root system reconstruction analysis studies revealed most of the root system characteristics found to be best in *Trichoderma viridae* treated seedlings 56% negative corelation found between second order root length and disease severity, in histopathological study some amount of infection cushions found on most of the treatments however in *pseudomonas fluorescens* and riboflavin treated seedling no infection development observed ,87% corelation found between disease scoring by FGCC and IMAGEJ methodology so CANOPEO based methodology was adopted for disease scoring and treatment screening as this is quick and accurate and it was found PF+TRICHO+PSB combination is the best as it produced lowest (7.4%)disease severity this treatment is followed by SSP+MOP+CUCL2 +PF+TRICHO+PSB (9.86%).

3D. Biosecurity, Quarantine & Biosafety

PP107(Off)-3D: Demarcation of brown rot (*R. solanacearum)* disease free area of potato in Meerut U.P.

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India contributes approximately 7.5 percent of the world's total potato production. The export performance of Indian potato is quite dismal as we have rarely been able to export near about 0.7% of our domestic production. The situation is further worsening as Indian potato exports have fallen during current half decade due to brown rot disease and potato tuber moth. The ISPMs provide guidance to member countries in implementing national programmes and fulfilling requirement of the IPPC and NSPM provide guidelines for declaration of disease free areas in India. In the present investigation, survey was conducted during September to April 2019-2020 and 2020-2021 in 35 village of Daurala block, Meerut to find out the presence of brown rot in potato. The samples were collected from pre cropping (soil), cropping (stem) and post-harvest (tuber). A total of 338 samples were collected from different farmer's field and cold storage for isolation and confirmation of. *R. solanacearum.* Out of 283 samples, 263 were processed for isolation of *R. solanacearum* on specific TZC media. Based on cultural Morphological, biochemical and molecular confirmation *R. solanacearum* was not detected in all collected samples. The study suggested Daurala block free from infection of brown rot disease. Therefore, potatoes of these areas can be recommended for export in international market. Considering the limitation of time and financial constraints, the present study was conducted in a very specific area for academic purpose. However, it may be required up to state or national level for the identification of the Pest Free Area (PFA) in a broader way. These finding can also help the farmer's to improve their financial performance. Data generated in the present study might be used for declaring disease free area (*R. solanacearum*) by the competent authority for export of potato to international market.

SESSION 4:
Commercial plant pathology

4B. Smart agriculture with precision plant protection

PP108(Off)-4B: Management of sclerotinia rot of indian mustard through fungicides

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Indian mustard [*Brassica juncea* (L.) Czern&Coss] is an important oilseed crop and attack of diseases and pests is the most important factor causing yield instability in the crop. Sclerotinia rot of Indian mustard is considered to be an economically important yield reducing disease in recent years. Therefore, the present investigations were carried out with the objective to test seven fungicides under *in vitro* (By poisoned food technique) and *in vivo* conditions. Carbendazim and carbendazim 12 % + mancozeb 63 % WP inhibited completely the mycelial growth of *Sclerotinia sclerotiorum* at all concentrations (50,100 and 150 ppm) followed by captan 70% + hexaconazole5 % WP with inhibition of 94.44, 100 and100 % at 50,100 and 150 ppm respectively. *In vivo* efficacy of six fungicides tested by applying as seed treatment, foliar application (30 DAS) and seed – cum – foliar application against Sclerotinia rot of Indian mustard under soil inoculation pot house conditions with cultivar Varuna (T-59). Carbendazim was found most effective in reducing the disease intensity followed by carbendazim 12 % + mancozeb 63 % WP.

PP109(Off)-4B: Management of Pomegranate leaf and fruit spot (Colletotrichum gloeosporioides (Penz.) Penz. & Sacc. and Alternaria alternata (Fr.) Keissler)

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Pomegranate (*Punica granatum* L.) is an ancient and commercially important fruit crop of both tropical and subtropical countries. The cultivation of pomegranate is going to be increase due to high remuneration from its fruits. Now a day's its cultivation is expanded to Saurashtra region of Gujarat. Leaf and fruit spot caused by *Colletotrichum gloeosporioides* and *Alternaria alternata* are contributing factors for the low productivity as well as huge economic losses among the farmers. Experiment was conducted to find out effective fungicides for the management of leaf and fruit spot of pomegranate. Seven different fungicide formulations were evaluated at farmer's field near Junagadh city during Mrigbahar (November-December) 2018 and 2019. Effect of fungicides on leaf spot and fruit spot was separately recorded at 15 days after last spray. Among seven fungicides tested ready mix fungicide tebuconazole 50% + trifloxystrobin 25% WG at 0.025% concentration was found significantly effective to reduce disease index for leaf spot as well as fruit spot. Mancozeb 75% WP (0.2%) was found least effective in reduction of leaf spot while, propineb 70% WP (0.2%) was found least effective to reduce fruit spots among all fungicides tested for both years. Yield loss due to leaf and fruit spot complex was also simultaneously recorded in this experiment. Maximum yield loss of was recorded in untreated plots as compared to plot treated with three sprays of tebuconazole 50% + trifloxystrobin 25% WG at 0.025 per cent concentration.

PP110(Off)-4B: Compatibility of Trichoderma sp. and Pseudomons sp. with agro chemicals

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Fungicides/combination of fungicides, insecticides and herbicides were tested for their compatibility with *Trichoderma harzianum* and *Pseudomonas fluorescens* under *in vitro*. Carbendazim @ 50, 100, 250 and 500 ppm, and copper oxychloride @ 1000, 1500, 2000 and 2500 ppm concentrations, completely inhibited growth of *T. harzianum*. Methyl-o-demeton at all the four concentrations i.e. @ 250, 500, 1000 and 1500 ppm were found incompatible with 94.44% growth inhibition. However, chlorpyrifos and cartap hydrochloride @ 250 and 500 ppm were moderately compatible. Quizalofop-ethyl at 500, 100, 1500 and 2000 ppm produced incompatible reaction with 94.44% growth inhibition of fungal bioagent *T. harzianum*. At initial two lowest concentrations, pendimethalin @ 500 and 1000 ppm and fenoxyprop-p-ethyl @ 50 and 100 ppm found compatible with *T. harzianum*. All the fungicides/ combination of fungicides, insecticides and herbicides tested at all their concentrations were completely compatible with *Pseudomonas fluorescens* isolate-1.

PP111(Off)-4B: Effect of spent mushroom substrate, Farm yard manure amended with *Trichoderma harzianum* on damping off of tomato

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Tomato is an important vegetable crop grown globally and consumed as salad, sauce, soup, pickle etc. Prevalence of high humidity and warm temperature not only favours the luxuriant growth of the crop but also favours the development of various diseases. The crop is affected by various diseases which reduce the potential yields drastically. Among the tomato diseases damping off is one of the most important disease. The experiment was conducted in Research farm Department of Plant Pathology CCS Haryana Agriculture University Hisar during 2020-21. The percent disease control in different treatments varied from 6.41 to 20.85 per cent. The spent mushroom substrate alongwith *Trichoderma harzianum* inoculated nurseries reduces the damping off of tomato by 20.85 per cent followed by FYM +*Trichoderma harzianum* (18.18%), Spent mushroom substrate (11.76%) and Farm Yard manure (6.41%) as compared to control.

PP112(Off)-4B: Molecular characterization of metarhizium anisopliae and Its efficacy against lepidopteran pest of cotton

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Metarhizium anisopliae is a fungus causing green muscardine disease was isolated from naturally infected lepidopteran larvae, from soil by *Galleria* bait method and serial dilution. Effect of different media, temperature, humidity and pH were assessed on the basis of radial growth of NGP-Ma5. SDYB medium (1577.33 mg) supported highest mycelial growth of isolates. The mycelium on this medium was appeared white colour later it turn green exhibited olive green colony colour on front side. The temperature 25°C, pH 5.5 and humidity 95 per cent were considered as optimum for growth and sporulation of NGP-Ma5. Four pathogenic *Metarhizium* isolates to *Helicoverma armigera and Spodoptera litura* larvae were characterize molecularly through rDNA-ITS sequencing. All the isolates after PCR reaction produced 500-600 bp expected amplicon with universal primer ITS1 and ITS4. The clustal w alignments and phylogenetic analysis confirmed the taxonomic identity. It showed that *Metarhizium anisopliae* was positively identified by PCR. *Metarhizium anisopliae* isolates grouped in the same clusters with more than 99% sequence similarity of NCBI GeneBank database. The PCR product of isolate NGP- Ma5 showed more than 99% similarity with *Metarhizium anisopliae.* The phylogenetic tree generated by using (MEGA X). The highest larval mortality of *H. armigera* (89%) was recorded at 0.50x 108 spore per ml and *Spodoptera litura* (93%), 109 spores per ml after 3, 5, 7 and 10 days after treatment.

4C. Advances in mushroom technology

PP113(Off)-4C: Extraordinary mushrooms: commercial Agri-Entrepreneurship

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Mushrooms are part of the fungal kingdom. In recent years, traditional plant-based medicines are gaining more and more attention with medical practitioners. Mushrooms are being at the top of the list for their many amazing health benefits. Many forms of mushrooms have been used throughout the centuries in Ancient Chinese herbal medicine, with well over 200 different species used in therapeutic capacities throughout the years. There is a great deal of recent research surrounding mushrooms and their potential therapeutic benefits for a variety of conditions such as cancer, digestive health conditions and autoimmune issues. The compounds that medicinal mushrooms produce, give the mushrooms an advantage in the microorganism community. Medicinal mushrooms are antibacterial, antifungal, and antiviral in nature. Humans and animals have evolved alongside these fungal communities and this benefits our immune system regulation. Polysaccharides are the main compound found in these mushrooms. These polysaccharides help to down regulate the pro-inflammatory immune response for individuals with compromised immune systems. Therefore, there is a reduction of overall inflammation in the body, and a modulation of the immune system. Some immunological changes triggered by mushroom polysaccharides include: Activation of immune macrophages, neutrophils, and monocytes, Increased antibody production, Increased interferon production, Increased immune activity against many different cancers and Inhibition of tumors. The button (*Agaricus bisporus*), oyster (*Pleurotus* spp.), milky (*Calocybe indica*) and paddy straw mushroom (*Volvariella volvacea*) are commonly cultivated throughout India and profitable business for livelihood because it required less expenses and more profit.

PP114(Off)-4C: Morphological characterization, DNA barcoding and commercialization of novel edible mushroom - *Tricholoma giganteum* (MGSLM01)

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During the year 2019, the novel edible mushroom strain *Tricholoma giganteum* (MGSLM01) were collected from Yercaud hills, Tamil Nadu. It resembles *Calocybe indica,* were mostly found and seen in Hooghly, West Bengal and some other parts of South India. To standardize the cultivation technology for this new edible mushroom various experiments were conducted. Comparative morphological characterization on *T. giganteum* (MGSLM01) were correlated with previous reports and confirmed. Physiochemical studies of the fungus recorded, significantly higher growth (90mm/ 90mm) and biomass yield (229.32g/ 100ml) on PDA medium which contain xylose (89.12mm/ 90mm) and yeast (88.66mm/ 90mm) extract as best Carbon: Nitrogen (12: 01) source. Production technology, among different grain based spawn substrates, sorghum grain based substrate was found to be the best spawn substrate statistically (21.46 - total spawn run days) and paddy straw based bed substrate recorded the superior result (169.81 % - bio efficiency) on different agrocellulosic wastes were tested. Among different casing mixtures tested, red soil + sand (1: 2) recorded minimum days (13.11

days) with maximum fruiting body formation (31.29) and higher yield (1698.82g/ bed). Proximate analysis such as protein, carbohydrates, fibre, macro and micronutrients were tested for nutritional status of this fresh edible mushroom. Protein and sugar profiling were also done to estimate the presence of protein and major sugar content. Eventually strain was deposited in Genbank Accession number MK764963.1.

PP115(Off)-4C: Evaluation of the best time for spawning of *Pleurotus eryngii* mushroom to standardize the cultivation technology in Rajasthan, India

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The aim behind this experiment was to know the suitability of months that gives better Biological efficiency and its sustainability with respect to yield. This research work was accomplished at the project of AICRP on medicinal mushroom unit in Department of Plant Pathology, Rajasthan College of Agriculture, Udaipur during the months of November to April in the natural climatic conditions, where the temperature and the relative humidity of cropping room ranged between 9-24°C and 60-80%, respectively. This work tells you about the best time for spawning to standardize the cultivation technology of *Pleurotus eryngii* in Zone IV a (Udaipur region) as well as in Rajasthan. Out of four different months (November, December, January and February) tested for spawning, the fastest mycelial run and pinhead initiation occurred in December and January months when the average temperature mean of maximum and minimum remains well under 20±1°C as per meteorological data whereas, maximum B.E.% was observed in the month of December followed by November. Hence, it clearly indicates that the best suited time for cultivating King Oyster (*Pleurotus eryngii*) Mushroom is during winter months of the year.

PP116(Off)-4C: Quantitative and qualitative parameters of Kabul Dhingri (*Pleurotus eryngii*) mushroom harvested from different substrates and supplements

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This study was conducted in Udaipur to explore the yield and yield attributing characters as well as nutritional and health benefits of *Pleurotus eryngii* harvested from different substrates and

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supplements. Qualitative parameters included moisture, protein, carbohydrate, crude fiber and phenol contents. Quantitative parameters were studied to find the best substrate giving the highest yield and Biological efficiency. Paddy straw gave the best results with highest biological efficiency and maximum number of fruiting bodies. While, maize straw showed the fastest spawn run and pin head emergence out of six tested substrates and supplements. Moisture contents of fruit bodies of mushroom ranged from 82-90%. Fruit bodies harvested from wheat straw and wheat straw + 5% wheat bran had the highest (90%) and the lowest (82%) moisture contents, respectively. Percentages of total protein on dry weight of mushrooms were found to be the highest (33%) on maize straw and the lowest (15%) being recorded on wheat straw + 5% wheat bran. The highest (67%) and the lowest (44%) total carbohydrate contents were obtained with the wheat straw + 5% wheat bran and sorghum straw, respectively. Crude fiber content was the highest (31%) and the lowest (11%) with wheat straw and wheat straw + 5% wheat bran, respectively. Total phenol contents of *Pleurotus eryngii* was in the range of 5.3-7 mg/g of dry weight, which was the highest on wheat straw + 5% wheat bran, followed by sorghum straw and wheat straw + 5% rice bran and the lowest was recorded with maize straw.

PP117(Off)-4C: Identification of resistance germplasm in sesame (*Sesamum indicum*) against dry root rot disease through different screening techniques

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Dry root rot (DRR), caused by *Macrophomina phaseolina*, is a prevalent disease of sesamum in India. The pathogen is a polyphagous necrotroph, survives in the soil for many years that results disease mitigation difficult. Managing DRR in sesame through an integrated approach has been suggested, and the use of resistant varieties is one of the economical methods. A study was conducted in the experimental Research Farm of ICAR-NBPGR Regional Station Jodhpur, during *Kharif* 2021 in order to screen 3700 accessions of sesame germplasm for resistance against dry root rot disease. Resistance response of Sesame germplasms was determined initially in field under natural conditions. Resistance level in germplasm lines and test lines was determined initially under natural condition in fields infested with *M. phaseolina* isolate (MPJ 1) at the rate 40g/m2 on the upper soil layer before sowing. Observation regarding resistance reaction of test germplasms was recorded by observing occurrence of charcoal rot incidence thrice during different crop growth stages using 0-6 visual rating scale. Results shows that, most of the accessions were highly susceptible to DRR and only 450 accessions gave resistance disease reaction with d"30% disease incidence. These accessions were selected for further evaluation using *M. phaseolina* infested tooth pick inoculation of stem in field condition. Control inoculations were performed with non-infested toothpicks and they gave healthy reaction. Total 400 toothpick inoculated accessions gave internal and external symptoms of dry root rot disease observed in split opened stem. During the screening 50 germplasm accessions gave d"1% disease incidence and found completely resistance to disease. These selected germplasm accessions with better levels of resistance can serve as additional sources of charcoal rot resistance in future breeding programs.

SESSION 2:
Basic research in plant pathology

2B. Genetics and ecology of plant pathogens

PP01(On)2B: Current genetic status of Cotton leaf curl begomovirus complex in Cotton growing areas of Northwest India

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Cotton leaf curl disease (CLCuD) is a major constraint in cultivation of cotton (*G. hirsutum*) in cotton growing states, Haryana, Punjab, and Rajasthan in Northwest (NW) India. CLCuD is caused by whitefly transmitted monopartite begomovirus of circular ssDNA genome (~2.7 kb), belonging to the genus, *Begomovirus* (Family: *Geminiviridae*) in association with betasatellite (~1.3 kb) and alphasatellite (~1.3 kb) molecules. The CLCuD outbreak has been changing constantly in year to year and area in NW India and in the present situation the CLCuD incidence is lower comparatively with previous years. Thus, the present study was focused on genetic variability CLCuD-begomoviruses those results in lower CLCuD incidence in NW India. A survey was made to study the CLCuD in cotton fields of NW India and collect samples to determine the variations in CLCuD-begomovirus species in the present condition. Several twigs from the cotton plant showing typical symptoms were collected and brought to laboratory. Complete CP genes (of ~750 nt) of 15 isolates were amplified and the nucleotide (nt) sequences were analysed. Pair wise sequence analysis showed that the present isolates shared 94-100% nt identity among themselves and 77-99.8% nt identity among other CLCuD begomoviruses. Based on phylogenetic analysis, five isolates, SGNR 8, HAU 12, ABR 41, ABR 21 and ABR 31 were members of *Cotton leaf curl Multan virus*-Rajasthan (CLCuMuV-Ra) strain and rest were *Cotton leaf curl Multan virus* (CLCuMuV). Recombination events were observed in the genome of CLCuMuV-Ra strain. With this observation it is conclude that the recombinant CLCuD-begomovirus, particularly recombinant CLCuMuV-Ra is predominant causing lower outbreak of CLCuD in NW India in present condition.

PP02(On)2B: Haplotype analysis indicates genetic diversity in *Phytophthora* species infecting black pepper

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Black pepper is an important commercial crop of India. Kerala, Karnataka and Tamil Nadu are the major black pepper growing states among which Karnataka is the leading producer (36,000 metric tons as of 2021). One of the main constraints faced in black pepper cultivation is the foot rot caused by *Phytophthora capsici* and *Phytophthora tropicalis*, which completely destroys the plant. Genetic variation caused by mechanisms such as mutation, recombination, duplication and uptake of novel DNA upon horizontal gene transfer (HGT) allows organisms to adapt to environmental changes. The population structure of *P. capsici* and *P. tropicalis* has to be disclosed in order to develop the management strategies to control foot rot disease of black pepper. In the present study, we have analyzed the mitochondrial gene region (Cox1, Cox2, Nad1 and Nad5) and Nuclear genes (²-tubulin, EF1±, HSP90 Tig A, Ura 3) of *P. capsici* and *P. tropicalis* isolates to identify haplotypes. The polymorphisms within the mitochondrial and nuclear genes were studied using DnaSP version 6.0 software, haplotype analysis was performed using TCS 1.21 software and Splits Tree version 4.14.2. The TCS cladogram showed 3 haplotypes with 02-20, 05-06, 06-12 as possible ancestors, and similar clusters were obtained for splits tree graph. Sequence data from 4 mitochondrial and 4 nuclear loci revealed 82 polymorphisms, 74 of which were parsimony informative. Greater number of haplotypes and polymorphism was identified for Tig A gene. Haplotype Diversity estimates also shows that Tig A gene is more diverse. This study provides an insight about the existence of diversity in *P. capsici* and *P. tropicalis* isolates infecting black pepper.

PP03(On)2B: Foldscope inexpensive tool for farmers to understand plant pathogens

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Foldscope is an origami-based paper microscope which is easy to use and extremely portable. This new paper microscope doesn't require any special laboratory facilities or high-cost chemicals. The present study is how foldscope can be used as an efficient and easy tool for farmers to understand plant pathogens by seeing symptoms on plant parts. For optical visibility of pathogen glass slides were used along with small diseased plant part and for staining methylene blue or lactophenol have been taken. Various samples were analyzed under foldscope in which various plant pathogens were visible i.e., *Alternaria, Fusarium, Helminthosporium* and *Curvularia* from class *Deuteromycetes*; *Aspergillus* from class *Eurotiomycetes*; *Mucor* from class *Zygomycetes* which causes spots, rotting or blights.

PP04(On)2B: Molecular Characterization of *Begomovirus* inciting Yellow Mosaic Disease of Soybean (*Glycine max* (L.) Merrill) in Tarai Region of Uttarakhand, India

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The yellow mosaic disease of soybean is a serious constrain for soybean cultivation in India and other South East Asian countries. The disease is incited by two distinct species of *Begomovirus* viz., *Mungbean yellow mosaic virus* and *Mungbean yellow mosaic India virus* and is transmitted by the whitefly, *Bemisia tabaci,* in persistent circulative manner. The present study was under taken to characterize the *Begomovirus* inciting the yellow mosaic disease of soybean in the Tarai region of Uttarakhand, India. The total genomic DNA was isolated from the infected leaf samples and the polymerase chain reaction was carried out using specific primers targeting the coat protein and movement protein coding region in DNA A ad DNA B, respectively. The BLAST analysis of partial coat protein gene revealed highest sequence identity (>96%) with MYMIV isolates reported earlier and 79.401, 80.001-80.501 and 72.501-74.701 percent identity with selected isolates of MYMV, *Horsegram yellow mosaic virus* (HgYMV) and *Dolichos yellow mosaic virus* (DoYMV), respectively. In phylogenetic analysis of partial coat protein gene of the selected legume infecting begomoviruses, the isolate under study formed clad with MYMIV group which showed closest relationship. The BLAST analysis of partial movement protein gene also revealed highest sequence identity (96.48%) with an Indian isolate of MYMIV infecting soybean. It shared 80.3 to 93.1, 77.0 to 78.8, 67.5-67.9 percent similarity with DNA B of MYMV, HgYMV and DoYMV, respectively. Based on high sequence identities and phylogenetic relationships of partial DNA-A (in particular) and DNA-B genome with MYMIV isolates, the *Begomovirus* isolate under study was identified as an isolate of MYMIV and designated as MYMIV_SB [Pant].

PP05(On)2B: Morpho-cultural variability of *fusarium* species causing bakanae disease of rice in western uttar pradesh

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Bakanae is the emerging disease threatening the rice cultivation globally and is one of the most important diseases of rice (especially aromatic rice). The major symptoms include seedling rot and abnormal elongation of infected rice seedlings/plants. A study was conducted with a total of 12 *Fusarium* isolates (Fm 1- Fm 12) were collected from bakanae infected rice plants from different geographical locations of western Uttar Pradesh. The isolates were evaluated for morphological and cultural variability. The isolates were cultured and multiplied on potato dextrose

agar media and fungal growth, colony diameter, pigmentation, radial growth, colony texture, growth pattern, spore characters in all the isolates were recorded after 10th day of inoculation. The isolates showed a considerable variation in morphological characters and were divided into two different groups based on morphology. Group I (GRP 1) with isolates Fm (1-6) and Fm 12 comprised of white coloured cottony colony producing isolates with the size of micro-conidia ranging between (7.4 – 8.8) X (2.8 – 3.7) µm and macro-conidia size between (24.24 – 35.70) X (3.2 – 3.87) µm, with no chlamydospores. Group II (GRP 2) with the isolates Fm (7- 11) comprised of creamy white colored colony producing isolates with the size of micro-conidia ranging between(7.3 – 9.1) X (3.2 – 3.9) µm and macro-conidia size between (29.54 - 35.73) X (2.92 – 4.8) µm, with no chlamydospores. On the basis of the morphological data, it was confirmed from "The *Fusarium* laboratory Manual" by Leslie and Summerell (2006) and from the standard culture obtained from ITCC, New Delhi used for comparison and confirmation, the isolates were identified and confirmed as *F. moniliforme*.

PP06(On)2B: Characterization of Phytophthora colocasiae Raci. isolates inciting blight of colocasia in North-Western Himalayas

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Leaf blight and corm rot incited by *Phytophthora colocasiae* is the most devastating disease of colocasia. Twenty isolates of *P. colocasiae* were isolated from the disease samples collected from five districts of Himachal Pradesh and characterized based on morpho-cultural variability, pathogenic variability, chlamydospore formation and mating type. On the basis of morpho-cultural characters and pathogenic variability, twenty isolates were categorised into six and five groups, respectively. Only four isolates formed chlamydospores and these were formed abundantly under dark condition at pH 6.0 in carrot broth incubated at 18°C. Out of twenty isolates 18 were of A1 mating type whereas, 2 were of mating type A2. Maximum oospore formation frequency was on carrot agar media at 25°C and was favored by dark conditions.

PP07(On)2B: Cultural, marphological and molecular charactarization of the pedencle bligh and anthracnose of tuberose

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Tuberose (*Polianthes tuberosa* L.) is the most important plant for the cultivation of long term spikes under tropical and subtropical ornamental bulbous flowers. It is entitled to be "king of flowers". It is usually referred to as Rajanigandha or Nishigandha. Tuberose is an important commercial cut flowers as well as loose flower crop having winder adaptability to varied climate and soil. Many fungal foliar diseases as tuberose specially peduncle blight (*Lasiotiplodia theobromae*) and anthracnose (*Colletotrichum gloeosporioides*) are two major pathogens involved to cause huge loss to know the etiolagy and to study the cultural, morphological and molecular characterization of the pathogen is very much necessary in the present situation. Among different media tested for L. Theobromae. PDA and oat meal agar showed maximum radial growth with good sporulation. Among the morphological charactera, cottony texture, regular margins ans aerial growth were predominant.Among madia tested for C. Gloeosporioides. V8 juice agar and Richard's agar showed maximum radial growth. Colour of colony varied with media used. Among different morphological characters, cottony texture, regular margins and aerial growth were predominant. Molecular identification of pathogen revealed that L. Theobromae amplified at 510 bp with 99.61 per cent similarity with L. Thebromae isolated FK14K03, whereas C. Gloeosporioides isolate cymbidium.

PP08(On)2B: First report of dsRNA uptake study of *Venturia inequalis* Apple scab causing fungus by using *in vitro* synthesised GFP dsRNA

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Venturia inaequalis, inflicting monetary losses in terms of fruit quality and fruit yield in many apple-producing provinces. The apple scab affects apple production by decreasing the yield by up to 70%. In this study, the major objective was to isolate the Himachal Pradesh strain of *V. inaequalis* and validation of dsRNA uptake by the fungus. Microscopic observation of *V. inaequalis* showed conidia with acute ovoid shape, and form mat-like septate mycelia. Molecular characterization of fungus using specific internal transcribed spacer (ITS) region of the nuclear ribosomal RNA gene showed 99.6% sequence identity, with the reference *V. inaequalis* with query coverage of 98%. For the validation of dsRNA uptake, the fungus was treated with Green Florescent Protein (GFP) dsRNA (150ng/µl) and observation revealed fluorescent conidia and mycelia compare to untreated *V.inequalis*. This study of uptake of dsRNA would help us to target the fungus virulence and life stage regulatory genes and GFP dsRNA results would become the base for dsRNA formulation development programme for apple scab disease management.

PP09(On)2B: The surviving of *Bipolaris sorokiniana* in cereals in southeastern Kazakhstan

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Spring barley is an important high-value crop globally, however, it is highly susceptible to soil-borne diseases in Kazakhstan and in the world. *Bipolaris sorokiniana* (Sacc.) Shoemaker can cause spot blotch diseases in barley, and the yield of grain decreases by 10-50%. The fungus was isolated from spring barley leaves from "Zholbarys agro" farm of Kerbylak district of Almaty, southeastern Kazakhstan, in the third decade of June 2021 (44.376726, 78.573329). We have established that the optimal nutrient media for the cultivation of *B. sorokiniana* were V4 medium, potato agar, and Czapek's medium at 22-30°C. The laboratory experiment was being conducted on 10-days seedlings of cereal, legume, and oilseed crops. We have established that seedlings of spring barley, spring wheat, and oat can save the infection of *B. sorokiniana*. Also interestingly, the isolated from leaves of spring barley the infection of *B. sorokiniana* had statistically significantly increased symptoms of spot blotch on spring wheat and spring barley seedlings, on oat - decreased. (P-value *Bipolaris sorokiniana* infection in spring wheat and spring barley.

PP10(On)2B: Identification and multilocus gene characterization of phytoplasmas associated with sweet cherry in India

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Symptoms of leaf roll, swollen nodes, flat branch and witches' broom were observed in sweet cherry orchards from Srinagar, Jammu and Kashmir province of India during 2019–2021. Phytoplasmas association were confirmed by amplifying 16S rRNA, *sec*A, *rp, tuf* and *sec*Y gene with phytoplasma specific primers in five symptomatic sweet cherry cultivars in nested PCR assays. Pair wise sequence comparison (all genes), phylogenetic (all genes) and virtual RFLP (16S rRNA gene) analyses confirmed the presence of '*Candidatus* Phytoplasma asteris' and '*Candidatus* Phytoplasma trifolii' strains in the sweet cherry samples. Both these phytoplasma strains were recorded randomly distributed in sweet cherry orchards with disease incidence of 5.8 to 25%. The multigene characterization of sweet cherry phytoplasma strains confirmed the validity of these molecular markers for identification of 16SrI and 16SrVI groups. The presence of phytoplasmas strains association with sweet cherry is the first report from India.

PP11(On)2B: Status of Boll Rot Complex of Bt Cotton in northern Karnataka

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Karnataka ranks sixth in area with 5.65 lakh hectares and fourth in production with 19.0 lakh bales of lint with the productivity of 572 kg/ha . Cotton is vulnerable to many biotic and abiotic stresses which accounts for its low yield potential and in turn the high cost of production. *Fusarium* wilt, *Verticillium* wilt, *Alternaria* blight, angular leaf spot, boll rot and leaf curl are the major diseases which are responsible for loss of yield and quality parameters in cotton. Cotton boll rot complex is a disease condition where the associations of many pathogens influence the appearance and quality of matured cotton bolls. To know the status of boll rot of cotton a roving survey was undertaken in five districts of northern parts of Karnataka *viz*., Belagavi, Dharwad, Gadag, Haveri and Uttara Kannada. Maximum disease severity was observed in Uttara Kannada district with 10.16 Percent Disease Index (PDI) at boll initiation stage and 30.94 PDI at boll maturity stage which was followed by Dharwad district. However, minimum disease incidence i.e., 7.71 PDI at boll initiation stage and 24.70 PDI at boll maturity stage was recorded in Gadag district. Observations regarding geographical coordinates indicated that the disease complex showed an increasing trend with the increase in latitude from 14° N to 17° N and showed a declining trend with the increase in distance from 74° E to 76° E with maximum disease severity at the elevation of 500 m to 600 m at both the growth stages of boll. Maximum disease incidence was noticed on bolls at lower part of the plant compared to those of mid and upper parts. Regions under Hilly zone (Zone 9) recorded maximum average disease incidence i.e., 10.75 PDI at boll initiation stage and 30.77 PDI at boll maturity stage.

PP12(On)2B: Identification and characterization of *fusarium fujikuroi* pathotypes responsible for an emerging bakanae disease of rice in India

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The bakanae disease of rice or foolish seedling disease is a well-known pathogen infecting rice host. Several studies characterized the *Fusarium fujikuroi* isolates collected from distant geographical regions and also within similar geographical areas for secondary metabolite production, population structure, diversity analysis but isolates characterization for virulence in a set of rice genotypes are lacking. A set of five rice genotypes were selected by screening the genotypes for bakanae disease. Ninety-four *Fusarium fujikuroi* isolates collected from different rice growing areas of the country during the years 2011 to 2020 were characterized and evaluated for bakanae disease of rice. The disease reaction varied significantly in these genotypes in response to *Fusarium fujikuroi* infection. Disease reaction observed was classified into highly susceptible, susceptible, moderately susceptible, highly resistant, resistant and moderately resistant in all possible combinations using a set of rice genotypes. Rice genotypes PB1509 and C101A51 were found to be highly susceptible and highly resistant respectively. Further, based on disease reaction isolates were grouped into 15 pathotypes. Group 1 with maximum isolates (19) observed to be more prevalent followed by group 2 and 3. Pathotype 4 was classified as highly virulent as it produced a resistant reaction (R) in C101A51 and susceptible (S) reaction in remaining genotypes. When we compared the pathotype distribution in different states, pathotype 5, 7 and 11 were found to be originated from Punjab and pathotype 1 is distributed in all states. Present study provided the distribution profile of different pathotypes in basmati growing states of India which will be further helpful for the development of breeding strategies and bakanae disease management in future.

PP13(On)2B: Morphological, cultural and pathogenic variability among the isolates of *Sclerotium rolfsii* Sacc. causing collar rot of lentil in Madhya Pradesh and their interactions with chemical fungicides

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Lentil (*Lens culinaris*) is a high value cool season, edible pulse crop; it is the oldest crop in the world as it has been grown since 8000 years ago. Lentil occupies a unique position in the world of agriculture, as a food crop the majority of world production from Canada (68%), followed by

India (33%). it is cultivated in India, with a 1.59 million ha of harvest area, producing 0.94 million tonnes with an average yield of 591kg per ha. In India, major lentil producing states are Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal and Uttrakhand. Madhya Pradesh ranks first with area of about 6.13 lakh ha and an annual production of 4.16 thousand tones. Crop contains about 25percent of protein which makes them an excellent meat alternative. They are also great source of iron, magnesium, zinc, potassium and vitamin B. Collar rot of lentil disease caused by *Sclerotium rolfsii* Sacc. is very important and a polyphagus pathogenic fungus causing substantial losses in quality and productivity of yield. This pathogen is very fast spreading and nonspecialized soil borne fungus having worldwide importance and has a host range of over 500 species, includes ornamental plants. The present experiment was carried out in the Department of Plant Pathology, JNKVV Jabalpur, Madhya Pradesh. The study reveals that the there was morphological, cultural and pathogenic variability among the six isolates of *Sclerotium rolfsii* Sacc. collected from different lentil growing regions of Madhya Pradesh. It was also observed that all the six isolates from different regions were showing variations in their growth rate, colony colour, mycelial dispersion appearance and; sclerotium formation, its colour, weight and number of sclerotia, arrangement, maturity days of sclerotia and pathogenicity. Significant variability with reference to mycelia, sclerotial and pathogenic characters across isolates of *S. rolfsii*, from different locations of central zone of Madhya Pradesh was observed. *In vitro* evaluation of five fungicide mixtures revealed that, Azoxystobulin + Difenconozole, Hexaconozole and Azoxystobulin was found most effective against the *Sclerotium rolfsii* Sacc. at all the tested concentrations (250ppm, 500ppm, 750ppm and 1000ppm).

2C. Genomics of plant pathogens

PP14(On)2C: De novo Genome sequencing analysis of Tilletia caries TC_MSG_1 causing common bunt of wheat

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Tilletia caries is a basidiomycete fungus that causes the common bunt of wheat. It is an economically important disease because it reduces yield and grain quality. The whole genome of T. caries was sequenced using Illumina HiSeq 2500 and Nanopore platform. The genome assembly size of T. caries was 38.18 MB with a GC content of 56.10 %. 46 contigs were obtained with N50 of 1798756 bp. The assembly was performed with the ONT data using Flye assembler and the resulting assembly was polished with Illumina data using the POLCA polishing tool. BUSCO group showed 99.23% completion of assembly. Masked the repeat sequences were about 8.49 % of the genome. 6,214 genes were predicted in the assembled genome using the Augustus tool. Out of 6,214 genes, significant BLASTX hits were 5,812 genes. Gene ontology analysis revealed significant GO terms like cellular component (298), biological process (677), molecular functions (725). Further, comparative genome and identification of virulence genes in T. caries are in progress. The whole genome of T. caries will help to understand the pathogenesis mechanism and devise newer management strategies against the common bunt disease of wheat.

2D: Mechanism of disease development

PP15(On)2D: Pathogenicity and virulence of entomopathogenic fungi *Beauveria bassiana* and *Metarhizium anisopliae* against laboratory rearing and field insects

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In the recent time intensive use of chemicals in agriculture leads to improve yields of crops but side by side development of pests resistance, contaminate ground water, slow or non- degradable thereby great losses to environments, harmful for beneficial microorganism, dangerous to human health by entering food chain and some are extremely carcinogenic. On the view of above side effects it is necessary to produce crops in sustainable manners through eco friendly management system. Microbial control of crop pests offers environmentally acceptable strategies with lower cost and longer run effect. In recent years, more emphasis has been given to the integrated approach for managing the pest. Biointensive IPM is most relevant approach in agricultural production system. Among the several component of integrated pest management, biological control gained increasing acceptance because of public awareness for environmental quality and consumer consciousness to health risk associated with use of synthetic chemical insecticides. Entomopathogens are naturally occurring organisms, such as bacteria, viruses and fungi for the control of crop pests, which can act as a parasite of insects and kills or seriously disables them. In recent years, microbial pathogens like viruses, bacteria, fungi and protozoa have been recognized for the biological suppression of many insect pests. About 1.5 million species of fungi alone are known to occur worldwide out of which nearly half of the species have been identified. Amongst these, several asexual stages of fungi are associated with insect infection. Pathogenicity and virulence of entomopathogenic fungi valuated at BTC, College of Agriculture & Research Station, (IGKV) Bilaspur in 2018-19 to obtain pathogenic and most virulent isolates and concentration of spore load of *B. bassiana and M. anisopliae* for effective control of insect pests. Pathogenicity of indigenous isolates of *B. bassiana* (Bb1 to Bb16) was tested against the larvae of insect's *viz*., *Galleria melongella*, *Corcyra cephalonia* and *Spodoptera litura* ($1x10^9$ cfu g^{-1}). Among all three tested larvae, isolates were more pathogenic against *Corcyra cephalonica* (73.33%) followed by *Spodoptera litura* and *Galleria mellonella* (72.50%).The two isolates Ma1and Ma2 showed 100% mortality against all three tested insects after 72 HAT. Pathogenicity was determined also by all isolates of *B. bassiana* against BPH of rice & mustard aphid and recorded maximum mortality showed by the isolate Bb3 (55.65%) and 63.25% against mustard aphid. Determination of virulence of all isolates of *B. bassiana* (16 isolates) and *M. anisopliae* (two isolates) at three different concentrations (10^7,10^8 and 10^9) against two larval instar of three lepidopteron insects (*G. mellonella*, *Corcyra cephalonica* and *Spodoptera litura*) revealed that local *B. bassiana* isolates Bb3, B16 and Bb1 and *Metarhizium* isolates Ma1 and Ma2 were highly virulent isolates compared to other isolates.

PP16(On)2D: Overwintering of French bean rust (*Uromyces appendiculatus*) pathogen as urediniospore in North Western Himalayas

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French bean (*Phaseolus vulgaris* L.) rust caused by (*Uromyces appendiculatus* (Pers.) Unger) is one of the most destructive diseases which can cause considerable economic losses. This rust is macrocyclic and autoecious in nature but only uridinial stage has been encountered in commercial French bean fields of Himachal Pradesh. The source of primary inoculum is not clearly known. The survival potential of urediniospores of *U. appendiculatus* was carried out both under polyhouse and field conditions during the off-seasons of 2016-17 and 2017 -18. Rust infected branches and stem pieces were buried in earthen pots filled with soil and kept in the open field as well as in polyhouse conditions. When these spores were retrieved from the samples stored, and inoculated on highly susceptible cvs. “Falguni”, produced regular symptoms. Other than urediniospores, no other spores (teleutospores) were recorded in both years. This study revealed that the pathogen overwintered as urediniospores up to one year under polyhouse conditions and up to 2 months under open field conditions. Overwinter survival of urediniospores under polyhouse conditions indicate that these spores might be functioning as the primary inoculum of this disease in the mid-hills of Himachal Pradesh.

PP17(On)2D: Isolation, Pathogenicity tests, Characterization and Identification of Endophytic Fungi of Soybean (*Glycine max* (L.) Merril)

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Endophytes are the microbes that’s residing in plant tissues without causing harmful effects to the host plants. A total of 14 endophytic fungi isolated from soybean plant samples (leaves, stems and roots), i.e. five isolates from leaves, five isolates from stems and four isolates from roots were obtained. Amongst them, isolated from the leaves were *Curvularia lunata*, *Cladosporium cladosporioides*, *Nigrospora sphaerica*, *Penicillium* sp. and *Paecilomyces lilacinus* and isolated from stems were *Alternaria alternata*, *Phomopsis* sp. 1, *Rhizoctonia* sp., *Phomopsis* sp. 2 and *Macrophomina phaseolina*. Whereas, isolated from roots were *Fusarium oxysporum*, *Aspergillus niger*, *Aspergillus* sp. and *Chaetomium* sp. Fungi isolated as endophytes from Soybean (*Glycine max* (L.) Merril) Cv. JS-335 were tested in order to ascertain whether they are capable of causing disease symptoms in healthy soybean’s stem, root and leaves. The pathogenicity test of fourteen fungal endophytes was carried out by pin prick method (for stem endophytes), spore suspension method (for leaf endophytes), root or soil drenching method (for root endophytes). No any fungal species of endophytic fungi able to cause any diseased symptoms on soybean plant and remained healthy.

PP18(On)2D: Studies on Modes of Action of Antagonists Against *Fusarium oxysporum* f. sp. *ciceri* (Padwick) Synd. and Hans. Incitant of Wilt in Chickpea

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The mechanism of action of antagonists in suppression of *F. oxysporum* f. sp. *ciceri* was studied under both *in vitro* and *in vivo.* The induction of defense related enzymes i.e. POD, PPO, PAL, chitinase, b-1, 3-glucanase and protease and total soluble protein content in two chickpea genotypes by four antagonists was also investigated under green house condition. The culture filtrate of Th-8, Tv-1 and Pf-I proved to be inhibitory to the pathogen. Volatile substances produced by the four selected antagonist i.e. Tv-1, Th-8, Pf-I and Bs 4-6 also checked the mycelial growth of FOC. The antagonists Th-8 and Tv-1 proved to be most effective in inducing the POD activity in both the chickpea genotypes i.e. RSG-44 and RSG-902 at 37 and 45 DAS. The induction PPO activity was more pronounced in Th-8 and Tv-1 treatment as compared to Pf-I and Bs 4-6. The overall PPO activity was less in both the genotypes at 45 DAS as compared to 37 DAS. The PAL activity was higher in Th-8 and Pf-I treatments. While, the response of this enzyme with respect to another two antagonists i.e. Bs 4-6 and Tv-1 was relatively less. The increase in chitinase activity was comparatively higher in response to Th-8 treatment closely followed by Tv-1 and Pf-I treatments under both FOC inoculated and uninoculated conditions. The antagonist Tv-1 and Th-8 were highly effective in inducing the activity of ²-1, 3- glucanase in both the genotypes under FOC inoculated and uninoculated condition. The overall enzyme activity in antagonist treated plants was comparatively less at 45 DAS as compared to 37 DAS. The activity of protease was highest in Tv-1 followed by Th-8 treatment in genotype RSG-44 under uninoculated condition at 37 and 45 DAS. While, in genotype RSG-902 the activity was highest in Pf-I followed by Th-8 treatment. At 37 DAS in FOC inoculated condition, the activity of this enzyme was highest in Tv-1 followed byTh-8 and Pf-I treatments in RSG-44 as well as in RSG-902. The Pf-I treatment was most effective in enhancing the soluble protein content under both inoculated and uninoculated conditions in two chickpea genotypes.

PP19(On)2D: Cultural and morphological characterization of isolates of *Alternaria alternata* (Fr.) Keissler, causing chrysanthemum leaf blight

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Fungal blights are among the major concern for limiting the cultivation and production of many flowering plants. Chrysanthemum is an important cut flower with great export potential. Diseased chrysanthemum samples were collected from chrysanthemum gardens, nurseries and farmers orchards in the Latur district for cultural and morphological characterization of *Alternaria alternata*.

The collected isolates of *A. alternata*, from various varieties / hybrids of chrysanthemum were characterized, based on their mycelial growth, growth rate, colony appearance, colony shape and margin, sporulation and concentric zonation and morphological characters (mycelial width, conidia dimensions, beak length and numbers of vertical and horizontal septa). The highest colony growth was found in Ac-1, Ac-3 and Ac-4 followed by Ac-5. Excellent sporulation was found in isolates such as Ac-1, Ac-3, Ac-5 and Ac-9. Four isolates Ac- 10, Ac-9, Ac-8 and Ac-7 showed large sized mycelial width ranged from 7.15-9.48 µm. Ac-9 and Ac-10 isolates was showed large sized conidia (42.17-60.29 L X 9.40-11.77 W). Three isolates Ac-5, Ac-9 and Ac-8 showed large sized beak length ranged from 13.52- 15.29 µm, whereas horizontal septation ranged from 1-9 and vertical septation from 1-5.

PP20(On)2D: Cultural variability of the isolates of *Phyllosticta zingiberi,* causing *Phyllosticta* leaf spot of ginger

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Phyllosticta zingiberi is an important and widely distributed pathogen that caused *Phyllosticta* leaf spot of ginger. Isolates of the *P. zingiberi* were isolated from naturally infected disease samples collected from various districts of Maharashtra. Therefore present investigation was undertaken, during *Rabi*, 2020-21, at the Department of Plant Pathology, College of Agriculture, Latur to demonstrate cultural variation among the isolates of the pathogen.Cultural characteristics/ variability among the ten test isolates of *P. zingiberi* were studied in respect of growth rate, colony colour, colony shape, colony margin, elevation, topography and zonation. The result indicated that the growth rate of test isolates varied from slow to fast. However, it was fast in the isolates *viz*., Pz-Ls, Pz-Br, Pz-Nk, Pz-Kh, Pz-Mj and Pz-Pb; moderate in Pz-Jl, Pz-Kj and Pz-Pr and slow in Pz-St and Colony diameter of the test isolates varied from 78.00 to 90.00 mm. However, it was highest in the isolates *viz*., Pz-Kh (90.00 mm), followed by the isolates *viz*., Pz-Br, Pz-Nk and Pz-Pb (each 88.00 mm). Colony colour of the test isolates varied from greyish, greyish white, dark greyish, cottony white, whitish grey and dark greyish with regular to irregular margin. Colony appearance was mostly fluffy (Pz-Ls, Pz-Jl, Pz-St, Pz-Kj, Pz-Pr), cottony (Pz-Br, Pz-Kh, Pz-Mj) and feathery (Pz-Nk, Pz-Pb). Colony topography of the isolates *viz*., Pz-Ls, Pz-Nk, Pz-Pb and Pz-Kj was smooth; in the isolates *viz*., Pz-Br, Pz-Jl and Pz-Pr was rough. Colony elevation was mostly raised in the isolates *viz*., Pz-Jl, Pz-Kh, Pz-Mj and Pz-Kj ; whereas, it was flat and slightly raised (Pz-Br), slightly raised (Pz-St, Pz-Pr), umbonate (Pz-Nk) and crateriform (Pz-Ls). In majority of the isolates (Pz-Br, Pz-Kh, Pz-Mj, Pz-St, Pz-Kj, Pz-Pr), the zonation was absent; whereas, it was indistinct in the isolates *viz*., Pz-Ls, Pz-Nk, Pz-Jl and Pz-Pb.

PP21(On)2D: Early interactions of rust pathogen *Puccinia arachidis* (Speg.) with groundnut genotypes varying in resistance

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Rust disease caused by *Puccinia arachidis* (Speg.) is an important foliar disease causing significant yield losses in groundnut (*Arachis hypogaea* L.). Resistance to rust has been well characterized in groundnut. However, there is a limited understanding of the histological differences among the groundnut genotypes varying in resistance which consequently led to visual differences in signs and symptoms. The study was conducted to understand the histopathological mechanisms of initial interaction of *P. arachidis* with six groundnut genotypes *viz.,* ICG 11426, GPBD 4, ICGV 13229, ICGV 171015, TMV 2, and K 6. Germination of urediniospores was detected during 6-8 hours after inoculation (hai) and continued until 24 hai. There were no differences in pre-penetration and penetration among all the six genotypes. Differences in post-penetration were observed among the genotypes during 3-5 days after inoculation (dai). In genotypes TMV 2 and K 6, extensive hyphal colonization was observed in the intercellular spaces of mesophyll cells by 4-5 dai indicating compatible interaction with *P. arachidis* and susceptibility to rust disease. Sparse hyphal growth and corresponding mesophyll cell death at 3-5 dai in genotypes ICGV 171015 and ICGV 13229 indicated defense response by the host and moderate resistance to rust. In genotypes ICG 11426 and GPBD 4, complete arrest of hyphal growth by 4–5 dai due to extensive mesophyll necrosis suggested incompatible interaction of *P. arachidis* and resistance to rust disease. This is the first histopathological description of the initial infection strategies encompassing pre-penetration, penetration, post-penetration of *P. arachidis* in these six genotypes with varying resistance.

PP22(On)2D:Biochemical alterations associated with sudden wilt syndrome in the Chilli pepper (*Capsicum annuum* L.)

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An evolving malady, sudden wilt of chilli pepper is characterized by an abrupt appearance during water stagnation for prolonged period under the field conditions leading to excessive losses. Three chilli organs, specifically the roots, leaves and fruits were evaluated for the effects of sudden wilt on a range of biochemical parameters in healthy and stressed plants. In healthy plants, the content of total phenols (1.15,1.54,1.97 mg/g GAE), o-dihydroxyphenols (0.19,0.26,0.33 mg/g), flavonoids (0.73,0.93,0.96 mg/g RE), ascorbic acid (0.24,0.27,0.51 µg/g), peroxidase (0.28,0.36,0.90 unit/g), catalase (0.86,2.35,1.94 unit/g), H_2O_2 (112.90,127.21,104.89 µmole/g), MDA (4.59,7.10,6.30 µmole/g), polyphenol oxidase (0.24,0.37,0.47 unit/g), PAL (7.72,11.72,9.24 µg/min/g), TAL (22.88,65.10,32.49 µg/min/g), lignin (3.57,5.15,7.93 µg/g) and proline (1.97,2.70,1.39 mg/g) was present in roots, leaves and fruits, respectively. In stressed plants, the content of total phenols (0.85,0.97,1.11 mg/g GAE), o-dihydroxyphenols (0.06,0.09,0.12 mg/g), flavonoids (0.67,0.84,0.89 mg/g RE), ascorbic acid (0.12,0.13,0.45 µg/g), peroxidase (0.12,0.20,0.27 unit/g), catalase (0.53,1.74,0.95 unit/g), H_2O_2 (120.76,142.12,114.43 µmole/g), MDA (5.64,9.99, 8.46 µmole/g), polyphenol oxidase (0.05,0.18,0.26 unit/g), PAL (7.42,8.32,5.50 µg/min/g), TAL (20.56,33.60,27.59 µg/min/g), lignin (1.46,3.39,5.13 µg/g) and proline (3.38,4.34,1.79 mg/g) was present in roots, leaves and fruits, respectively. The content of total phenols, o-dihydroxyphenols, flavonoids, ascorbic acid, peroxidase, polyphenol oxidase, catalase, PAL, TAL, PPO and lignin decreased in the stressed plants in comparison to the healthy plants. On the contrary, there was increase in the content of H_2O_2, MDA and proline in the stressed plants. It was concluded that sudden wilt of chilli not only induced deviations in plant morphology but also altered biochemical characteristics.

PP23(On)2D:Effects of plant age on disease development of stripe rust *Puccinia striiformis* f. sp. *hordei* on barley

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Barley (*Hordeum vulagere* L.) is one of the most important fourth cereals crop of the world after rice, wheat and maize. Stripe rust of barley caused by *Puccinia striiformis* f. sp. *hordei* (Psh), is an important disease in barley growing regions of India and worldwide. Barley plant tissues often show different levels of resistance to pathogens depending on their age. Age related resistance on the development of stripe rust in barley was studied on cultivar RD2035 under artificial disease inoculation condition in cage house. For identifying plant age susceptible to stripe rust, five staggered sowing at 10 days interval. The present finding showed that the per cent rust severity decreased with increased plant age. The youngest plant groups showed more vulnerability to rust infection with highest percent rust severity, minimum incubation period and latent period as compare to older one.

PP24(On)2D:Studies on effect of various soil factors on population dynamics of *Fusarium oxysporum* f. sp. *cumini* and incidence of cumin wilt

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The present investigations were carried out to study the effect of soil temperature, moisture, nutritional factors and organic amendments on wilt incidence due to *Fusarium oxysporum* f. sp. *cumini* (FOC) in cumin and survival of *F. oxysporum* f. sp. *cumini* under green house/controlled conditions. Soil temperature and moisture significantly (p°C, while, it was minimum at 35 °C. Maximum population of FOC was recorded at 25 ºC followed by 20 and 30 °C. The recovery of the pathogen was comparatively less at 35 °C. Wilt incidence and population of pathogen was highest at 40 per cent followed by 60 per cent moisture holding capacity The *F. oxysporum* f. sp. *cumini* was influenced by nutrients and organic amendments. The lowest wilt incidence and pathogen population were recorded in neem cake + NPK + $ZnSO_4$ treatment. The treatment vermicompost + NPK + $ZnSO_4$ also significantly (p*Fusarium* population were also reduced in response to addition of $ZnSO_4$ alone or in combination with NPK. With the increase in mycelial inocula of the pathogen from 5 to 10 g kg^{-1} soil, the wilt incidence increased irrespective of soil variables and treatments. Higher population of *Fusarium* was recorded at 30 days after application (DAA).

PP25(On)2D: Isolation, purification and pathogenicity of *Fusarium oxysporum* f. sp. *radicis-cucumerinum* incited root and stem rot of cucumber

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The studies were aimed; Isolation, Purification and Pathogenicity of *Fusarium oxysporum* f. sp. *radicis-cucumerinum.* The present study was undertaken in cucumber root and stem rot disease caused by *Fusarium oxysporum* f. sp. *radicis-cucumerinum* leading to rotting of roots, lower stems, crowns and rotting of seeds and seedlings. The pure culture of pathogen was obtained by hyphal tip method. On the basis of morphological and cultural studies, the pathogen was identified as *F. oxysporum* f. sp. *radicis-cucumerinum* and further its pathogencity was confirmed. Pathogenicity test of the culture of *Fusarium oxysporum* f. sp. *radicis-cucumerinum* was confirmed on young plants of susceptible variety (Cucumber Long Desi) of cucumber in the pot condition. The same symptoms were initiated after 10-12 days of inoculation as rotting and yellowing, sunken stems and wilting. Re-isolation of the pathogen was made on PDA plates and identified it on the basis of culture characteristics of the parent culture.

PP26(On)2D: Evaluation of inoculation techniques for identification of brown rust resistance sugarcane cultivar

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Two inoculation techniques *viz.*, clip inoculation in leaf whorl with rusted leaf clips and inoculation of rust urediniospores suspension in leaf whorl were evaluated during 2013-14 and 2017-18 for identification of brown rust resistance sugarcane cultivars. The results showed that most severe brown rust symptoms were observed using leaf whorl inoculation method containing inoculum suspension of 104-105 urediniospores/ml. In the leaf whorl inoculation method, higher average no. of rust pustules (16.16 /inch2) and higher no. of leaves bearing rust pustules (9.7) was recorded as compared to the clip inoculation method (14.05 /inch2 and 9.1 respectively). This indicates that the leaf whorl inoculation method is better for screening sugarcane genotypes against brown rust than the clip inoculation method. The leaf whorl inoculation technique enabled rapid screening of a large number of cultivars in field using a small amount of inoculums.

PP27(On)2D: *In vitro* compatibility of *Pseudomonas fluorescens* with systemic fungicides

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Bioagents are beneficial for plant and soil health and are proved to be compatible with different fungicides till the threshold level is achieved. An *in vitro* experiment was conducted with the objective to find out the suitability of different systemic fungicides with antagonists like *Pseudomonas fluorescens* used as a seed biopriming in the wheat farming at western Uttar Pradesh. Application of chemical pesticides for the control of soil borne diseases causes environment and health hazards to humans and adversely affects the beneficial microorganisms in soil. Therefore, the present investigation was proposed for observing the compatibility of systemic fungicides with *Pseudomonas fluorescens*. A previously characterized drought tolerant isolates of *P. fluorescens* strain (PfMB4) was selected on the basis of their growth performance. The effect of compatibility of *P. fluorescens* (PfMB4) with four fungicides *viz*., Hexaconazole, Nativo (Tebuconazole50%+ Trifloxystobin25%), Propiconazole and Tebuconazole was observed. Each fungicide was tested for four concentrations *viz*., 10ppm, 15ppm, 20ppm and 25ppm and their inhibition on growth of *Pseudomonas fluorescens* was recorded. It was found that the systemic fungicides *i.e*. Hexaconazole and Tebuconazole were found to be comparatively more toxic than other fungicides. However it was observed that Tebuconazole was comparatively more toxic than Hexaconazole, with respect to the level of percent inhibition of *Pseudomonas fluorescens* at 10ppm, 15ppm, 20ppm and 25ppm concentration respectively. It was therefore concluded that the possibilities of compatible fungicide could be incorporated along with bioagents for effective and sustainable disease management causing less disturbance to agro-ecosystem. Thus, the study was undertaken to determine the threshold level of different fungicides at suitable concentrations for effective growth of bioagents.

PP28(On)2D: Isolation and characterization of cutinolytic enzymes from *Amphobotrys ricini* causing gray mold disease of castor

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Castor (*Ricinus communis* L.), a non-edible oil seed crop has immense industrial and medicinal value. Gray mold is one of the most destructive diseases of castor caused by the fungus *Amphobotrys ricini*. The pathogen infects inflorescence/raceme resulting in severe yield losses up to 100 per cent. The mycelium of fungus first degrades the waxy cuticle and later penetrates the host tissue. At early stage of infection, pathogenic fungi can synthesize hydrolytic enzymes such as cutinases, esterases and lipases, which directly target cuticle and there by play key roles in pathogenic infection. The pathogen was screened for ability to produce cutinolytic enzymes capable of hydrolyzing the insoluble plant wax/ cuticle layer. Extracellular esterase were detected in saprophytic and parasitic phases during the fungal germination. The epicuticular waxes of castor serve as recognition factors efficient to induce the secretion of cutinolytic enzymes from the fungus. The enzyme activity was determined by a spectrophotometric assay utilizing the model substrate p-nitrophenyl butyrate as 3.32 µmoles/ml/min which was maximum after three days of incubation in broth supplemented with wax. The molecular weight of the enzyme was estimated to be 40 K.Da by polyacrylamide gel electrophoresis in the presence of sodium dodecyl sulfate.(SDS-PAGE). It was also observed that temperature of 30°C and pH of 8.0 was found optimum for esterase production. The seceretion of cutinolytic enzymes in the suspceptible and resistant cultivars indicated that the maximum enzyme secreted was 4.75 µmoles/min/gm after third day of infection in the susceptible cultivar DCH-519. Where as maximum enzyme produced was 2.47 µmoles/min/gm on sixth day of infection in resistant cultivar ICS-324 indicating that the epicuticular waxes of castor are playing a role in eliciting the disease acting as recognition factors inducing the secretion of cutinolytic enzymes in entries with wax where as in non waxy type specially ICS-324 delay in onset of disease due to absence of wax on pericarp of capsules.

PP29(On)2D: Characterisation and elucidation of the role of cytokinin-O-glucosyltransferase (CGT) genes of rice in biotic stress

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Cytokinin glucosyltransferases (CGTs) are key enzymes of plants for regulating the level and function of cytokinins. In a genome identification of rice CGTs, 41 genes with the PSPG motif of 44-amino acid consensus sequence, a characteristic feature of plant Uridine Diphosphate (UDP)-Glycosyltransferases, UGTs were identified. On *in silico* physicochemical characterisation, though the CGTs belong to the same sub-family, they displayed varying molecular weights ranging from 19.6 kDa through 59.7 kDa. The proteins were mostly acidic (87.8%) and hydrophilic (58.6%), and observed to be distributed in the plastids (16), plasma membrane (13), mitochondria (5), and cytosol (4). The phylogenetic analysis of the CGTs revelaed that their evolutionary relatedness ranged from 70-100% and aligned themselves into two major clusters. In a comprehensive analysis of the available transcriptomics data of rice samples representing different growth stages and with inoculation of Xoo and Mor, only the CGT, *Os04g25440.1* was significantly expressing (above 2-fold) at the vegetative stage, whereas 16 other genes were highly expressed at the reproductive growth stage. On the contrary, 6 genes, *LOC_Os07g30610.1, LOC_Os04g25440.1, LOC_Os07g30620.1, LOC_Os04g25490.1, LOC_Os04g37820.1,* and *LOC_Os04g25800.1* were specifically upregulated. In a qPCR analysis of rice sheath tissues susceptible to *Rhizoctonia solani*, *Magnaporthe oryzae* and *Xanthomonas oryzae* pv. *oryzae* pathogens, in comparison to the sterile distilled water control, at 24 h post-infection, only two genes, *LOC_Os07g30620.1* and *LOC_Os04g25820.1* displayed significant upregulations in response to all the three pathogens. On the contrary, the expressions of the genes, *LOC_Os07g30610.1, LOC_Os04g25440, LOC_Os04g25490* and *LOC_Os04g25800* were observed to be pathogen-specific. These genes were identified as the candidate ones and therefore could serve as potential susceptibility genes for facilitating pathogen infection.

PP30(On)2D: Deciphering the *Magnaporthe oryzae* infection process and innate defense genes expression in resistant and susceptible rice cultivars

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Rice blast caused by fungus *Magnaporthe oryzae* is one of most devastating rice diseases, affects grain quality and causes huge crop loss range from 50 to 80% depends on the severity and timing of infection. Currently the blast disease was managed by deploying dominant resistance *'R'* genes. In order to understand the infection process of *M. oryzae* on resistant line (Pusa Samba 1850 which possesses blast resistance genes namely, *Pi54, Pi1* and *Pita*) and susceptible lines (Pusa Basmati 1and BPT 5204 or Samba Mahsuri), we used green fluorescent protein (*gfp*) tagged *M. oryzae* isolate *RMg_Plm* for tracking via confocal laser scanning microscopy (CLSM). Visualized the conidial germination, germ tube and, appressorium formation followed by successful penetration which ultimately leads to disease establishment in case of blast susceptible lines (BPT 5204 & Pusa Basamati 1). In contrast to that, in case of resistant line (Pusa Samba 1850) we could observe the conidial germination and germ tube formation but failed to form appressorium and further penetration process which lead failure in disease establishment. These results coincide well with blast phenotypic screening and percent disease incidence calculated to 96.0 and 64.0 % in Pusa Basamati 1 & BPT 5204 lines whereas no symptoms were observed in the PS-1850 cv. and mock control. Real Time PCR analysis suggested that the defense genes *viz.,OsPAD4, OsEDS1, OsPR1.1, OsPDF2.2, OsFMO1, OsCERK1,* and *OsNPR1* activated mainly at the initial time-point of *M. oryzae* infection, and thereafter drastically declined indicating that no sustained defense mechanisms was enforced which resulted in severe blast disease recorded on PB1 and BPT-5204. Whereas in resistant cultivar Pusa Samba-1850 these genes were highly expressed approximately upto 6.5 to 22.0 folds particularly at 24 hpi, which provides the resistance against *M. oryzae* infection. Current study marks the way to utilize the technological advancements on pathogen visualization tools which helps to develop disease resistance rice varieties.

PP31(On)2D: Effect of different media, pH and temperature on the growth of *Rhizoctonia solani causing web blight of urd bean* under *in vitro* condititions

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Rhizoctonia solani is a multiphagous widely distributed plant pathogen. Web blight caused by *Rhizoctonia solani* causes huge yield loses in urdbean (*Vignamungo*). All the commercially grown varieties are susceptible. Being a typical soil borne fungus,. It was carried out to know the efficacy of different among the four tested media for colony growth of *R. solani* from urd bean, Richard's Agar medium was found most suitable and supported the growth of *R. solani*. However, Czapek'sDox Agar medium least supported the growth of *R. solani*. Further, it was observed that *R. solani* showed maximum radial growth at 25^{0}C. The maximum radial growth of *R. solani* was recorded a pH 7.0 after different incubation period. Further, it was observed that neutral pH 7.0 and slightly alkaline pH favours the colony growth of *R. solani*in comparision to acidic pH. However, neutral pH 7.0 found most suitable for growth of *R. solani*

E. Host plant resistance

PP32(On)2E: Arbuscular mycorrhizal diversity and their effect on growth of *Mesua ferrea* seedlings under greenhouse condition

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Mesua ferrea Linn. is a moderate to large-sized evergreen tree. Its timber is rated durable in ground contact, rarely attacked by termites, and used mainly for railroad ties. Its flowers yield an essential valued in perfumery and medicine. *M. ferrea* tree mortality has been observed in last few years in this area located at Nirjuli, Arunachal Pradesh, India. Despite extensive use from the earliest times, the species has received minimal research attention. Arbuscular Mycorrhiza (AM) is known as an important biological agent for growth enhancement and plant disease protection. The present study was undertaken to evaluate AM associations at different age classes i.e., mature trees, saplings, and seedlings of *M. ferrea,* and their influences on the growth performance of seedlings. The result showed that *M. ferrea* is a regular mycorrhizal species with high AM species diversity at all age classes. *Glomus*, the most abundant genus with 15 species was recorded with maximum AM spores at the seedling stage (96±4.67) per 100g of soil while mature trees had the least number (80±1.52). *Glomus constrictum* and *G. feugianum*, recorded with the higher density (3.07 and 5.87 respectively) and highest abundance (9.20 and 17.6 respectively), were selected to assess their effects on the growth and establishment of *M. ferrea* seedlings. *G. feugianum* was found most suitable with enhanced height growth (>133%) with 80% seedling survival rate under greenhouse conditions against *G. constrictum*, both AM species together and control (without AM). Thus *G. feugianum* species may be recommended for artificial inoculation for sustainable *M. ferrea* plantations.

PP33(On)2E: Serological characterization of *Tospovirus* infecting cowpea and tomato in Kerala and the role of defense related enzymes in host plant resistance to *Tospovirus* infection

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Topsoviruses belonging to the family *Bunyaviridae* are causing devastating losses worldwide to many crops. The study was undertaken with the objective of serological characterization of *Tospovirus* infecting cowpea and tomato as well as to determine the role of defense related enzymes in tospovirus infection resistance in host plants. An ELISA was conducted using polyclonal antibodies to *Tomato spotted wilt virus* (TSWV) and *Watermelon silver mottle virus* (WSMoV) to characterise the viruses causing bud necrosis in both cowpea and tomato. From serological characterization, it was confirmed that samples showing bud necrosis symptoms in cowpea are orthotospovirus belonging to serogroup IV, and in the tomato, two serogroups were seen: serogroup I and serogroup IV. Assessment of disease tolerance to *Tospovirus* in different cowpea and tomato varieties was evaluated based on the number of days taken for symptom development and nature of symptoms on mechanical and graft inoculation of *Tospovirus* to selected varieties of cowpea and tomato, respectively. Cowpea variety Co-6 and tomato variety Arka Rakshak were found to be tolerant, whereas cowpea variety Vellayani Jyothika and tomato variety Vellayani Vijay were found to be susceptible. The mechanism behind the host resistance of these varieties was analysed based on the changes in defense related enzymes like peroxidase, polyphenol oxidase and phenylalanine ammonia-lyase at 10,15 and 30 days after challenge inoculation with the virus. The activity was more observed on tolerant varieties such as Co-6 and Arka Rakshak as compared to susceptible varieties such as Vellayani Jyothika and Vellayani Vijay, respectively. Due to the vulnerability of plants to disease, enzyme activity declined with increasing disease intensity in the current study, and enzyme activity was higher and maintained for longer in the tolerant varieties than in the susceptible varieties. Breeding programmes could benefit from these tolerant genotypes. The use of tolerant genotypes as well as biopesticides that can boost these defense-related enzymes can help these plants become more disease resistant.

PP34(On)2E: Molecular basis of plant resistance and defence response to pathogen

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Being sessile organisms, plants are often exploited as a source of food and shelter by a wide range of parasites. To combat this plant have evolved wide range of constitutive or inducible biochemical and a two tiered immune system. The primary immune response is known as PAMP triggered immunity (PTI) and recognize the conserved molecular patterns of microbial pathogens such as flagellin. During course of evolution some pathogens overcame the PAMP triggered basal resistance by ability to deliver effector proteins into plant cells. In response to this, plants evolved R proteins such as NB-LRR to identify the presence of pathogen effector proteins which leads to the activation of defense cascade. The plants produce several phytohormones such as ethylene, jasmonate, salicylic acid, and reactive oxygen intermediates prior to upregulation of R genes. The “gene-for-gene” model was proposed to explain genetically the high specificity of plant-pathogen. Salicylic acid (SA) level increase in response to pathogen attack and is required in the establishment of Systemic Acquired Resistance. The SA dependent defense responses are considered effective mainly against biotrophic pathogens whereas the Jasmonic acid (JA) dependent defense responses are effective against necrotrophic pathogens Biotechnological approaches like gene pyramiding, gene silencing also plays a significant role in improving disease resistance in plants. The transfer of traits conferring pathogen resistance is conceptually the most straight forward strategy to engineer disease immunity in plants. For e.g., transfer of the rice cell-surface receptor Xa21 to banana, increased resistance to *Xanthomonas* sp. The new insights in the discovery of molecular basis of host pathogen interaction are changing the way as we think about pathogenesis and the treatment of various plant diseases. An integrated approach based on the combined knowledge of the molecular basis of ‘defense systems’ used by the plant and the assault systems used by pathogens will help us to design novel methods for plant disease management.

PP35(On)2E: Identification of adult plant resistance in promising wheat genotypes against stripe rust

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Wheat is one of the world's major staple food cereal crops. Stripe rust caused by *Puccinia striiformis* f.sp. *tritici* (*Pst*), is a major disease of wheat. Resistance is most effective and ecofiendly approach to mange the disease. Hence to identify resistance variety/genotype is major issue of concern in present investigation. On the basis of experimental results of two cropping seasons 2019 and 2021 revealed highly resistant and slow rusting genotypes/advance lines. Most promising resistant wheat genotypes /lines which expressed consistent resistance and free from rust in both the cropping seasons were PBW725 and advance lines number 2, 4, 11, 16, 33, 40 and 41. Likewise, the Advance lines number 22, 31, 44, 45 and 49 had stripe rust severity e"20MR during both the seasons. Similarly, the advance lines3, 5, 6, 9, 12, 18, 20, 21, 23, 42 and 46showed MS type of reaction and their severity was not beyond the 30MS during both the cropping seasons. In 10th SMW there was no change in stripe rust severity and infection type on all the varieties and Advance lines.

PP36(On)2E: Identification of hot spot pockets for occurrence of Root Lesion Nematode (RLN) in Madhya Pradesh and deciphering it's mechanism of resistance in chickpea

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Human population expansion coupled with stunning changes in global food consumption patterns under unpropitious climatic alterations is posing formidable obstacles towards attaining sustainable global food security. Chickpea is cognized as economically viable sources of plant-based protein for human consumption and is also beneficial for the environment owing to their inherent capacity of nitrogen fixation. The root lesion nematodes, *Pratylenchus thornei* is among the one of the most important constraint to legume production and have a wide distribution affecting many agricultural crops around the world. Standardization of factors is important for development of a screening methodology that is stable and able to distinguish various levels of resistance. Keeping this in view, the present investigation was undertaken firstly to observe the prevalence of *P. thornei* in Jabalpur and adjoining areas and secondly to identify the source of resistance for root lesion nematode in chickpea. In total five blocks namely Panagar, Patan, Sihora, Majholi and Jabalpur were surveyed and 44 soil samples were collected. All the collected soil samples revealed the presence of nematode population. In total four nematode species namely *Meloidogyne* spp., *Rotylenchus* spp., *Pratylenchus thornei*, and *Helicotylenchus* spp. could be detected from these 44 soil samples. The maximum occurrence was recorded for root knot nematode *Meloidogyne* spp. (37.20 % soil samples from 15 villages) from all the five blocks. However, the population of the target nematode, *P. thornei,* was recorded in five soil samples only from two blocks namely Patan and Sihora. The maximum population of 8500.64 nematode/1000 cc soil was recorded in soil sample from Luhari village of Patan block, followed by 8300.92 nematode/1000 cc in Luhari village of Patan block. However, minimum population of 5242.86 nematode/1000 cc of *P. thornei* was recorded in Muskara village of Sihora block. Further, it was also observed that three soil samples showed the presence of both *P. thornei* and *Meloidogyne* spp from three different villages namely Binaki (23.2112346, 79.8471057) and Chhopra (23.2076941, 79.8426689) from Patan; and Muskara village (23.4181192, 80.0755178) from Sihora. During screening of a set of 73 chickpea accessions in glass house conditions for identification of resistance source against RLN, significant extraction of nematode could be observed from soil and it widely - ranged from 940 to 3879.6. The minimum RLN count of 940 N/500 cm^3 soil was recorded from ICC 3512. Maximum RLN count of 3879.6 could be observed in ICC 15518. Among the different accessions studied, a set of 35 accessions exhibited fairly elevated nematode population extraction and ranged from 2000 to 3000. Rest of the accessions exhibited alongside unfavourable consequences against lesion nematode reproduced within the root system and later available in soil after infestation which indicated assorted performance of such residents. In root system, RLN population ranged from 8.33 (ICC 4495) to 30.33/g (ICC 1882) of root. In this way, the calculated reproduction factor (Rf) ranged from 0.9547 to 3.906. Among the different evaluated accessions, only a single accession, ICC 3512 could maintain the less than one Rf and could be designated to exhibit highest degree of tolerance towards RLN.

PP37(On)2E: Screening and identification of resistant sources against *Colletotrichum lindemuthianum race-3* causing anthracnose in common bean

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Anthracnose caused by *Colletotrichum lindemuthianum* is a devastating disease causing considerable yield losses in common bean. The economy of small and marginal farmers of hilly areas is dependent on couple of crops among which bean is very important. To tackle anthracnose, many chemicals are already recommended but their use could be costly affair for small & marginal farmers, additionally their use has health and environmental hazards. Considering this, the efforts were made to screen 87 indigenous and 90 exotic origins for their reaction to anthracnose under controlled conditions. Only 62 bean accessions showed resistant reaction and rest 115 lines were susceptible. Additionally, 29 highly resistant accessions were analysed using R-gene linked SCAR markers to predict the presence of *Co-4*, *Co-42*, *Co-6*, *Co-10* and *Co-Ind* R-gene(s). Multiple genes were found to be present in some common bean accessions like IC262769, IC265940, IC260336, IC258273, IC202271, IC262749, IC265938, IC47839, IC260336, IC258273, IC262749, IC278499, EC500328, EC4003433, EC4003433, EC398586 and EC325078. The generated information will be beneficial in future for anthracnose resistance breeding and to come up with the resistance sources effective against bean anthracnose.

PP38(On)2E: Impact of different Arbuscular Mycorrhizal fungi on the growth of Onion

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Onion (*Allium cepa*) is one of the major bulb crop(s) of the world, which is also grown in India. The onion was compared to a pearl not only for its shape but also for its highly valuable nutritional quality; rich source of carbohydrates and minerals like phosphorus, calcium. It also contains protein and vitamin C. Mycorrhiza is the most prevalent form of symbiosis relationship between plant roots and soil fungi. Since Arbuscular mycorrhizal (AM) fungi could colonize about 80% of higher plants, with the potential to increase seedling survival and improve plant growth. In the present investigation effect of four species of mycorrhiza (*Glomus mosseae, Glomus fasciculatum, Glomus hoi,* and *Glomus intraradices*) were tested on onion (Plant height, fresh shoot weight, dry weight of root and shoot). Maximum plant height was recorded in *Glomus mosseae* followed by *Glomus hoi, Glomus fasciculatum* and *Glomus intraradices* the minimum was recorded in control at 90 days after transplanting. Among the four species of mycorrhiza, *Glomus mosseae* [Plant height (41.5 cm), fresh shoot weight (10.11 g), dry weight of root (3.24 g) and shoot (1.13 g), Mycorrhizal colonization (79.87 %)] was found most effective as compared to others.

PP39(On)2E: Screening of cowpea (*Vigna unguiculata* (L.) Walp) genotypes for host resistance against viral diseases under natural conditions

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Cowpea (Vigna unguiculata (L.) Walp) is a drought-tolerant, hardy plant with large, drooping leaves that shade the soil and help to conserve the soil moisture content. Cowpea belongs to the family Leguminosae and the subfamily Papilionaceae. Cowpea production is severely affected by nearly 20 plant viruses that are known to have widespread distribution, which cause moderate to severe yield losses and have become a major constraint on its production. Mungbean yellow mosaic India virus (MYMIV) and blackeye cowpea mosaic virus (BlCMV) are two of these viruses that have recently become more common and an emerging threat to cowpea cultivation in northern Karnataka during the summer months, affecting cowpea yield potential both quantitatively and qualitatively. Hence, the development of high-yielding resistant varieties is of the utmost importance. A total of fifty different cowpea genotypes along with a check (C-152) were tested for their susceptibility to different viruses causing mosaic diseases under irrigated-field/natural conditions at the MARS, UAS, Dharwad during summer-2021. The disease incidence varied from 10.3% (EC390219) to 87.9% (IC202919) among 50 cowpea genotypes. Categorization of genotypes into different disease reaction classes revealed that none of the genotypes showed resistant reaction against different viral diseases, but only one genotype, EC390219, showed moderately resistant reaction, while the other 7, 19, and 23 genotypes (along with the check) showed moderately susceptible, susceptible, and highly susceptible reaction, respectively. The present findings are useful for the selection of resistant genotypes of cowpea against major viral diseases as varieties, or for further resistance-breeding programmes in cowpea.

PP40(On)2E: Cultural, Morphological Characterization and Aggressiveness of Alternaria alternata Causing Leaf Spot of Soybean

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Alternaria leaf spot caused by *Alternaria alternata* is one of the most important and destructive disease of soybean causing severe yield loss in all soybean growing areas of southern and eastern part of Rajasthan. Successful management of Alternaria leaf spot is mainly dependent on accurate and efficient detection of pathogen, amount of genetic and pathogenic variability present in pathogen population. The main reason for frequent "breakdown" of effective resistance is the variability that exists in the pathogen population, which necessitates a continual replacement of cultivars due to disease susceptibility. The twelve fungal isolates randomly were collected from six districts of major soybean growing part of Rajasthan *i.e.,* Udaipur, Chittorgarh, Pratapgarh, Kota, Baran and Jhalawar. The culture was purified single spore techniques. These were then further compared among each other for any variations in cultural characters, colour of colonies, Growth rate, conidial morphology and pathogenic variability. Twelve different isolates of *A. alternata* were obtained in pure culture and characterized for cultural, morphological variation and aggressiveness of this fungus varied in their cultural characters, colour of colonies, growth rate of isolates, conidial morphology and isolates also exhibited variations in incubation period, latent period, number and size of lesions were produced.

PP41(On)2E: Genome-wide identification characterization and transcriptional profiling of host Susceptible (S) gene favoring Fusarium wilt development in tomato

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Fusarium wilt is one of the most important diseases of tomato that affects its economic productivity across the globe. Despite of having intensive research in the field of tomato-Fusarium interaction pathogenomics, still we do not have developed stable solutions to counteract the yield losses. Although, some efforts have been put forward to understand the disease dynamics and to control the disease including identification and characterization of potential QTL**s** associated with host defense, transcriptional profiling of the differentially expressed genes (DEGs) in both resistant and susceptible cultivar, establishment of high throughput and robust hydroponics based screening methods and characterization of important metabolites involved in host defense and their comparative evaluation in compatible and incompatible interactions. However, with the advent of CRISPR/Cas9 genomic editing tool it has now become possible to target and edit the genes playing a crucial role in disease dynamics. Pathogen exploits plants' susceptibility (S) genes to facilitate their proliferation. S genes include all plant genes manipulated by the pathogen for its proliferation and the promotion of disease development (Gawehns et al., 2013). Loss- of- function of S genes is expected to lead to durable, broad spectrum, recessively inherited resistance (Pavan et al., 2010; Berg et al., 2015). In this work, we have identified and characterized the list of putative "S" genes in tomato whose loss-of

function causes resistance in tomato. The identified and characterized gene was facilitating lipid transport/uptake in the Xylem (XSP10). We have sorted all the differentially expressed XSP10 transcripts based on their p-value and log fold change to compare their expression profile in tomato resistant (wild) as well as susceptible variety (Pusa Rohini). This work highlights the relevance of tomato susceptibility genes in Fusarium wilt development and therefore, could be an efficient target for CRISPR/Cas9 mediated genome editing for Fusarium wilt resistance.

PP42(On)2E: Novel source of resistance to Phytophthora capsici isolate from South India in AVRDC germplasm of Sweet pepper

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Under open field and semi-controlled climatic condition of polyhouse, the biotic stresses like *Phytophthora* (*P. capsici*) can infect capsicum (sweet pepper) plants at any stage of growth and development causing damping off, root rot, stem rot, collar rot, fruit rot, and foliar blight. Out of which, *P. capsici* root rot (PcRR) is the most devastating disease, causing up to 100% yield losses under warm (25–28 °C), humid environmental conditions. The broad range of host species of *P. capsici*, including solanaceae, fabaceae, and cucurbitaceae, as well as its soil-born random mating nature, makes quite difficult to control PcRR. The chemical control measures for PcRR have proven to be ineffective and unsafe. The use of cultivars resistance to PcRR represents the best control measure due to its eco-friendliness and cost-effectiveness. Resistance to PcRR is influenced by several factors, including environmental cues, the virulence of the *P. capsici* isolates, their physiological races, and the source of resistance. Nevertheless, breeding for PcRR resistance is a complex process, and the resistance levels of commercial capsicum cultivars are not comparable to those of the original resistance sources. Therefore, the need of the hour is to breed new strategies for combining resistance for open field and protected conditions. We collected the *Phytophthora* isolates from southern part of India and screened 34 accessions of sweet pepper from AVRDC, Taiwan through leaf detached method with resistant check KTCH-144. Out of thirty four, 4 accessions namely CPCT-143, CPCT-116, CPCT-132, CPCT-133 were found highly resistant with 0-5% disease severity and CPCT-144 was moderately resistant having 5.1-10.0% disease severity. We would further confirm the level of resistance in above findings through molecular linked marker available in capsicum for *phytophthora* root rot and blight.

PP43(On)2E: Screening of germplasm of Gossypium barbadense against Tobacco streak virus (TSV) under natural conditions

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Cotton necrosis disease caused by *Tobacco streak virus* (TSV) is the most devastating one. TSV is the type species of the genus Ilarvirus, of the family Bromoviridae that include viruses having tripartite quasi-isometric particles of size 27 to 35 nm. The symptoms developed due to TSV infection in cotton plant resembled almost similar to physiological or nutritional disorders and herbicide phytotoxicity which is very difficult to distinguish. The occurrence of TSV in the germplasm of Extra Long Staple cotton (*Gossypium barbadense*) for the period of two years in Coimbatore revealed the per cent disease incidence varies from 5.81% (DB 3, DB 25) to 26.60 % (ICB 71). The most economical and convenient way to manage TSV is to grow resistant varieties. Screening of germplasm to explore resistant source is a basic step towards the solution for this hazardous virus problem. The same can be utilized in the breeding programme for evolving TSV tolerant/resistance varieties of cotton. Totally 300 germplasm of *Gossypium barbadense* were screened under natural occurrence of TSV for the cropping season 2019-2021. ICB 84, ICB 85, ICB 86, ICB 87, ICB 90, ICB 91, ICB 122, ICB 124, ICB 125, ICB 127, ICB 153, ICB 161, ICB 162, ICB 163 (14) were categorized as highly resistant (HR). ICB 41, ICB 43, ICB 45, ICB 46, ICB 47, ICB 48, ICB 50, ICB 51, ICB 53, ICB 54, ICB 55, ICB 58, ICB 59, ICB 60, ICB 61, ICB 62, ICB 65, ICB 67, ICB 70, ICB 71, ICB 72, ICB 74, ICB 75, ICB 76 (24) were categorized as moderately resistant (MR). Remaining 168 and 94 germplasm lines were categorized as moderately susceptible (MS) and highly susceptible (HS) respectively.

PP44(On)2E: Influence of morphological parameters on *Mungbean yellow mosaic virus* (mymv) incidence in mungbean and urdbean

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Mungbean and urdbean are important pulse crops; their productivity is hampered by many viral diseases. Among all the diseases, Yellow mosaic disease (YMD) is one of the destructive disease which causes 0-100 percent yield loss. YMD is caused by *Mungbean yellow mosaic virus* (MYMV) in mungbean and urdbean, transmitted by Silverleaf whiteflies (*Bemisia tabaci.* Genn). The transmission efficiency of MYMV by whiteflies indirectly depends on morphological characters of mungbean and urdbean. Present investigation was conducted to know the influence of morphological parameters *viz.,* epicuticular wax content, trichome density, and leaf thickness on MYMV transmission from 15 to 60 days after sowing (DAS). The epicuticular wax content, leaf thickness, and trichome density of lower and upper surface leaves were maximum in urdbean than in the mungbean plants. All these morphological parameters showed a significantly maximum during 60 DAS, where it counted from 15, 30, 45, and 60 DAS, similarly, percent disease incidence was also observed from 15 to 60 DAS, and it showed a maximum in mungbean (83.72%) than the urdbean (47.41%) plants. Hence it's confirmed that morphological parameters are correlated with disease incidence and that acts as a primary defense mechanism to inhibit the MYMV transmission by avoiding the whitefly's preference.

PP45(On)2E: Biochemical variations in mungbean and urdbean in response to *Mungbean yellow mosaic virus* (MYMV)

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Host-pathogen interaction induces some biochemical changes in plants which may help to overcome either biotic or abiotic stress. Various biochemical parameters *viz.,* phenol, tannin, total soluble sugar

(TSS), chlorophyll, peroxidase (PO), polyphenol oxidase (PPO), and L - phenylalanine lyase (L-PAL) activity were assessed in response to *Mungbean yellow mosaic virus* (MYMV) in mungbean and urdbean susceptible verities from 15 to 60 days after sowing (DAS) in healthy and diseased plants. The present investigation reports revealed that all the above parameters except TSS and chlorophyll content were observed to be increasing as the crop age increased in both diseased plants of mungbean and urdbean than compared to the healthy mungbean and urdbean plants. The TSS and chlorophyll content of mungbean and urdbean maximum in healthy plants than the diseased mungbean and urdbean plants. Hence it's confirmed that the disease incidence was correlated with the biochemical parameters, so these are all biochemical interactions and enzymes activities involved in the defense reaction of the host against the pathogen. Present experiment results concluded urdbean plants are more resistant to MYMV with low disease incidence (47.41%) and high biochemical activity than the mungbean plants which showed the highest disease incidence (83.72%) and lower biochemical activity.

PP46(On)2E: Brown and yellow rust of wheat in India – significance of climate on it's races and resistance

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Wheat is one of the most important staple food crops having global economic significance. Grown globally around 215 million hectares area with production of more than 600 million tons. Wheat is constrained in its production due to several biotic factors, among them yellow rust of wheat, *Puccinia striiformis* Westend. f.sp. *tritici* Eriks and Henn. (Pst) and brown rust of wheat, *Puccinia recondita* f.sp. *tritici* (Eriks. and E. Henn.) D.M. Henderson (Ptr) continues to be a serious threat and dominant factor limiting its yield potential globally. The estimated yield losses range from 10- 70%, while in a severe epidemic the grain damage can be as great as 100%. Pathogens are considered to be favoured by the cooler areas but current races are more adaptable to high temperatures causing significant yield reduction in wheat. In India, prevalent pathotypes for yellow rust include 46S119, 110S119, and 238S119. *Yr5*, *Yr10*, *Yr15*, *YrSp*, and *YrSk* genes are resistant to Pst pathotypes in Indian conditions, while in the case of leaf rust of wheat, prevalent pathotypes are 77-5, 77-9, and 104-2. *Lr9*, *Lr19*, *Lr24*, *Lr25*, *Lr29*, *Lr32*, *Lr39*, *Lr45*, and Lr47 are the genes having resistance to Ptr pathotypes in Indian conditions. This publication provides a comprehensive overview of the stripe and leaf rusts of wheat in India and their virulent races, types of host resistance and provides a tool for effective management of wheat rust disease.

2 F. Epidemiology and crop loss assessment

PP47(On)2F: Status of the false smut of paddy in Telangana state

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False smut is recently emerging as a major rice disease which was previously considered to have a negligible impact. An ascomycetes fungus, *Villosiclava virens* is the pathogen that causes the False Smut disease of rice. In India the disease has been observed in severe form since 2001 in major rice-growing states. As per earlier reports, in Telangana state the incidence of false smut of rice during *Kharif*-2019 was ranged from 1 to 70% and during *Kharif*-2020 it was from 1 to 60%. An intensive roving survey was conducted during *Kharif* -2021 to determine the false smut intensity in rice growing regions of Telangana state. The incidence was ranged from 0.41-56.67% across the districts surveyed. Whereas severe incidence was reported at Nizamabad (1.11-56.67%) followed by Jagtial (1.9-43.25%) and Rajanna Siricilla (2.78-42.18%). Among the different fine grain varieties, highest incidence was recorded in super sona (15.49-56.67%) with an average of 10.78 smut balls per panicle followed by Sriram gold (10.71-43.25%), Chintu (2.14-42.14%), Jai sriram (1.88-39.88%) and BPT 5204 (0.63-29.25%). Coarse grain variety JGL-24423 recorded highest disease incidence (1.43-42.23%) with 3.94 smut balls per panicle. During the survey it was observed that in fine grain varieties maximum number of smut balls were distributed in middle portion of the panicle i.e. 2.93 (58.19%) compared with bottom [0.94 (21.07%)] and upper portions [1.26 (19.45%)]. But in case of coarse grains maximum number of smut balls observed at bottom portion [1.09(72.96%)] of panicle.

PP48(On)2F: Effect of different temperature and pH levels on mycelial growth and sporulation of *Fusarium oxysporum* f. sp. *lentis* causing wilt of lentil

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The present investigation was carried out *in vitro* to study the effect of six different temperatures regimes *viz*., 10, 15, 20, 25, 30 and 35°C and eleven different pH levels *viz*., 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0 and 8.5 on mycelial growth and sporulation of *Fusarium oxysporum* f. sp. *lentis* causing lentil wilt. Among the tested temperatures, highest mycelial growth of the fungus (81.66 mm) was recorded at 25°C with excellent (++++) sporulation, which was followed by 30°C (70.00 mm) and 20°C (57.33 mm). However, lowest mycelial growth was observed at 10°C (23.33 mm) with poor sporulation (+). Of all pH levels, maximum mycelial growth was recorded at pH 6.5 (80.00 mm) followed by pH 6.0 and 7.0 showing 70.33 and 61.33 mm growth, respectively. While as, lowest mycelial growth of pathogen was found at pH 3.5 with poor sporulation (+).

PP49(On)2F: Effect of powdery mildew on growth parameters of cucumber and its sensitivity to sulfur dioxide

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An experiment was conducted to study the effects of SO2 exposures for five hours, alternate day for three months on the susceptibility of cucumber to *Sphaerotheca fuliginea* causing powdery mildew. The study was undertaken in open-top exposure chambers over 2 successive years. Four week old plants were inoculated with *S. fuliginea* by modified leaf roll method 2 days before gas exposure. Only 75 ppb out of the three SO2 levels caused noticeable injury on foliage and decreased plant growth and biomass production of pumpkin. Plants inoculated with the fungus developed specific mildew colonies on leaf surface and suppressed the plant growth. Mildew severity became aggravated on plants exposed to SO2 at 25 or 50 ppb concentrations. The fungus and SO2 interaction varied with the levels of SO2. SO2 at 25 or 50 ppb concentrations stimulated pathogenesis of *S. fuliginea* on cucumber. The combined effect of 50 ppb SO2 and *S. fuliginea* suppressed plant length significantly against the sum of decreases observed by SO2 and *S. fuliginea* individually. At 75 ppb SO2, the colonization of *S. fuliginea* was decreased and combined effect of SO2 and *S. fuliginea* was equal to sum of their individual effects. The study has demonstrated that powdery mildew disease might become aggravated in the regions with elevated levels of SO2.

PP50(On)2F: Present status and severity of Turcicum Leaf Blight of maize in maize growing districts of West Bengal

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Maize, the “Queen of Cereals” is the third most important cereal crop of India and presently the second most important cereal of West Bengal in respect of area, production and productivity. A number of biotic stresses causing reduction in yield of this crop and Turcicum leaf blight disease is one of the important among them. This fungal disease is happening from seedling to maturity stage and may cause upto 70% yield loss. For prediction of present status and severity of this specific disease an intensive roving survey was conducted during Kharif and Rabi 2020 in major maize growing areas of West Bengal viz., Nadia, Alipurduar, Malda, South Dinajpur, North Dinajpur, Murshidabad, Kalimpong, Darjeeling and Burdwan. The present investigation revealed that the PDI varied from 58.88 to 22.22 PDI (Percent Disease Index) in all the districts of West Bengal and the maximum mean disease severity of Turcicum leaf blight was recorded in Kalimpong district (58.88 PDI) followed by Darjeeling district (55.18 PDI) and North Dinajpur district with 44.12 PDI. The lowest mean disease severity was noticed in the Burdwan district (22.22 PDI) followed by Nadia district (27.63 PDI) and South Dinajpur with 31.11 PDI. The studies on survey reveals that high intensity of disease was noted where mean maximum temperature was below 30! and relative humidity was above 85 percent during Rabi season in West Bengal. Maximum PDI was recorded in Kalimpong district (58.88 PDI) and minimum in Burdwan district (22.22 PDI).

PP51(On)2F: Occurrence and Distribution of Alternaria Blight Disease of Sesame in Seven Agro Climatic Zones of Rajasthan State, India

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A roving survey to record sesame Alternaria blight disease intensity was conducted during *Kharif* seasons (2019) in seven districts *viz.,* Pali, Sawai Madhopur, Jodhpur, Karauli, Bikaner, Ajmer and Jaipur, covering seven agro climatic zones of the Rajasthan state, respectively. Survey was conducted in four villages from two Tehsil of each districts. During the survey small debate held with farmers concerned related to disease occurrence and severity. The results of the survey indicated that disease intensity of Alternaria blight of sesame was ranged from 20.35 per cent to 61.43 per cent in all surveyed field of various districts of Rajasthan. The maximum per cent disease intensity was observed from Jaipur district with 61.43 per cent, respectively. While minimum per cent disease intensity was observed from Bikaner district with 20.35 per cent. Highest mean per cent disease intensity 60.51 per cent was recorded in Phulera tehsil of Jaipur district followed by Chomu tehsil with 56.08 per cent. Lowest mean per cent disease intensity was observed in Sri Durgapura tehsil with 19.45 per cent of Bikaner district followed by Bikaner tehsil with 20.35 per cent.

PP52(On)2F: Cross infectivity studies on rice blast (Magnaporthe oryzae) pathogen, on economically important cereal hosts under ubn conditions

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Rice blast caused by *Magnaporthe oryzae* (Anamorph *Pyricularia* oryzae) is one of the most devastating diseases and major biotic cause for limiting the rice yield worldwide including India. The rice blast pathogen attacks a wide range of grasses which act as collateral hosts. The disease has continued to be a major threat in many major rice-growing areas limiting the yield potential of cultivars. Transboundary movement of the pathogen is of serious concern now days in the era of modern agriculture which can noted from the outbreak of wheat blat in Bangladesh and adjoining areas of West Bengal. Un-fortunately there is a very less information on cross infectivity of rice blast pathogen on other economically important cereals in India. Under this scenario the present experiment was conducted at ICAR-Indian Institute of Rice Research(ICAR-IIRR), Hyderabad (17° 19' 21'' N and 78° 23' 43'' E) under controlled climatic conditions to test the infectivity of rice blast fungus on other cereal hosts. Seedlings of rice (Tetep, Rasi, CO-39 and HR 12), finger millet (UFM-149, MR-6 and GPU-28) and wheat were sown (LOC-1, PBW 343 and HD 2967) at two to three leaf stages they were inoculated with virulent rice blast isolate (POIIRR) collected from Nizamabad district of Telangana. Typical blast symptoms were observed on inoculated leaves of rice and finger millet within 5 days after inoculation and subsequently lesions coalesced all along the leaf, however wheat genotype seedlings were free from the infection. The pathogen was re-isolated from the infected leaves of finger millet and rice then

again re-inoculation was done on the same set of healthy seedlings of these hosts produced the similar symptoms hence proving the Koch postulates. Hence with the present study we may conclude their might be the possibility of cross infection of rice blast to finger millet under conducive weather conditions. The present findings will act as an alarm in some regions of South India where rice- finger millet cropping system is predominant and also serves as preliminary information for the farming community about the existence of the disease and the chance of the epidemic.

PP53(On)2F: Survey of banded leaf and sheath blight of maize in Haryana

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Globally, maize (*Zea mays* L.) is known as 'Queen of the Cereals' because of its genetic makeup conserves the highest yield potentiality among the other cereals and gaining popularity due to its large-scale consumption as food, feed, fodder for animals, and as a source of industrial raw materials. Despite its high yield potential, maize is constantly devastated by a wide range of pathogens in its natural environment. Banded leaf and sheath blight (BLSB) incited by *Rhizoctonia solani* f.sp. *sasakii* is one of the most serious diseases of *kharif* maize and can cause significant economic losses. The magnitude of grain loss may reach 100 per cent in Haryana when the ear rot phase of the disease predominates. Therefore, the survey of banded leaf and sheath blight was conducted during *Kharif* 2020 in major maize growing districts of Haryana *viz.,* Sonipat, Panipat, Yamunanagar, Ambala, Karnal, Panchkula, Kurukshetra for assessing the disease intensity. Among the seven districts, the maximum disease intensity designated as medium (25-50%) was recorded in Karnal, followed by low to medium (5-25%) was observed in Kurukshetra and Yamunanagar districts, whereas the occurrence of low (d"5%) disease intensity was recorded in Sonipat, Panipat, Ambala, and Panchkula districts. The results indicated that the Karnal, Kurukshetra, and Yamunanagar districts were considered as highly favorable niches for BLSB pathogen to cause significant economic yield losses.

PP54(On)2F: Efficacy of salicylic acid against banded leaf and sheath blight of maize incited by Rhizoctonia solani f.sp. sasakii

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Maize (*Zea mays* L.) is popularly known as 'Miracle C4 crop' due to its high yield efficiency, as important human food and animal feed. About sixty-five pathogens *deteriorate* maize and out of these, banded leaf and sheath blight is considered as one of the major constrain of maize. The disease is widely distributed in India during *kharif* season. Banded leaf and sheath appear every year with maximum yield losses up to 100 per cent during July and August in Haryana due to continuous rainfall. Adoption of only the fungicides management approach is not effective to manage this disease. Therefore, the salicylic acid (SA) as seed priming for activation of systemic acquired resistance (SAR) of plants in controlling the disease. The experiment was conducted against BLSB at CCS HAU Regional Research Station, Karnal which is one of the main hot spots for BLSB. The experiment included seven treatments *viz.,* seed priming of salicylic acid (SA) at concentration 50 ppm, 60 ppm, 70 ppm, 80 ppm, 90 ppm, and 100 ppm along with recommended check seed dip in the water. The plants were inoculated at 30 DAS and a conducive environment was maintained for disease development. Among the treatments, 100 ppm concentration resulted in the highest disease control 36.7 per cent and 30.2 per cent increase in yield followed by 90 ppm and 80 ppm with 30.9 per cent, 17.6 per cent disease control, and 24.9 per cent, 14.2 per cent increase in yield respectively. The results indicated that 80 ppm, 90 ppm, and 100 ppm concentration seed priming with salicylic acid (SA) significantly reduce the disease incidence and progress in comparison to 50 ppm, 60 ppm, and 70 ppm concentration seed priming. Therefore, seed priming at different concentrations exhibited more effectively managing the banded leaf and sheath blight of maize.

PP55(On)2F: Rapid detection of airborne inocula of grapevine mildews using Impaction spore trap and LAMP assay

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Grapevine is cultivated worldwide predominantly for the production of fresh fruits, wines and raisins and has an important role in economy of many countries. The production of grapevine was hindered by many fungal plant pathogens. Among them, powdery mildew and downy mildew caused by *Erysiphe necator* and *Plasmopara viticola* are the most devastating diseases in worldwide. Epidemic development of grapevine mildews are caused by airborne inocula of conidia and sporangia. The detection of airborne inocula will help to face up timely management strategies under field conditions. In this study an impaction spore trap were designed for trapping the airborne inocula of grapevine mildews in Appachipannai grapevine field. The impaction spore trap was capable of sampling 48.3 ± 1.2 L air min^{-1} by spinning of two stainless steel sampling rods at speed of 1.151 m/s. The sampling rods were coated with silicone vacuum grease affixed on rotating arm and the spore trap was installed at a height of 1.5m above ground level which operated continuously by 6V - 4.5Ah rechargeable battery which was charged by a solar panel. A total of sixteen air samples from impaction and suction spore trap were collected at weekly intervals from 3rd to 18th standard weeks of 2021(Pruning to harvest) during cropping season. The air samples were subjected to rapid, highly specific and sensitive Loop mediated isothermal amplification (LAMP) assay to detect the airborne inocula of *P.viticola* and *E. necator* using six sets of LAMP primers targeting Ces A4 gene and *rDNA* region encoding the *ITS* and *5S ribosomal RNA* gene, respectively. LAMP assay was efficiently detected the airborne inoculum of *P.viticola* in all air samples collected from 3rd to 18th standard weeks. The presence of airborne inoculum of *E.necator* was detected from 3rd to 7th and 10th to 18th standard weeks. The cluster sampling method was conducted to assess the downy and powdery mildew disease incidence during cropping season from 3rd to 18th standard week. For downy mildew, the highest disease incidence was recorded on 10th standard week (13.6%) and lowest disease incidence was recorded on 6th standard week (3.2%). For powdery mildew, the highest disease incidence was recorded on 18th standard week (20.8%) and lowest disease incidence was recorded on 12th standard week (6.4%).

The correlation between weather parameters and disease incidence of grapevine mildews was studied using Karl Pearson's coefficient of correlation. For downy mildew, the minimum temperature showed a highly positive correlation and wind speed showed a highly negative correlation. Whereas, for powdery mildew relative humidity showed a highly positive correlation and wind speed showed a highly negative correlation.

PP56(On)2F: Prevalence of Tomato leaf curl disease in *Tarai* Region of Uttarakhand, India

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Tomato Leaf Curl Virus is a serious threat to the tomato cultivation in Indian subcontinent. The infestation is too serious in the tomato growing areas of *Tarai* region of Uttarakhand. The disease spread with the vector *Bemisia tabaci* in persistent circulative manner with 10 adult whiteflies per plant required for the better transmission revealed in study. Morphology of the virus particle was done with the help of electron microscopy showing presence of the twinned geminate particles in leaves showing typical leaf curling symptoms, measuring approximately 30 nm x 20 nm. Highest mean disease incidence of the tomato leaf curl disease was observed in 2020 while severity was recorded maximum in 2021. The mean disease incidence was varied from 68.76 to 67.19 per cent and severity from 26.60 to 27.57 per cent in the year 2020 and 2021, respectively. The maximum disease incidence and severity of ToLCV was observed in Nainital district, followed by U S Nagar. There was no significant difference among the two years in different locations for disease incidence ($p = 0.720$) and severity ($p = 0.698$). Disease severity had highly significant ($p<0.01$) positive correlation with disease incidence ($r = 0.865$). The present study revealed the status of tomato leaf curl disease in important tomato-growing pockets in *Tarai* region of Uttarakhand inferred that ToLCD is prevalent, inflicting economic losses to the farmers. To successfully control the disease and combat the threat, an integrated approach utilizing disease resistant cultivars as well as vector management must be established.

PP57(On)2F: Epidemiology of sesamum phyllody

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Sesamum (*Sesamum indicum* L.) is one of the oldest oilseed crops and has been cultivated in ancient's times. The crop is affected by sesamum phyllody disease and transmitted by leaf hopper (*O. albicinctus*). Yield losses up to 34 per cent or even 100 per cent, in case of severe incidence (Sarwar and Haq, 2006). Present investigation on the phyllody disease was carried out during 2019-20 at the department of Plant Pathology, College of Agriculture, Latur. Symptoms observed due to sesamum phyllody i.e. floral virescence, floral proliferation, drying of phyllody affected flower, withes broom, shoots apex fasciations, stunted growth of infected plant, sepals and petal converted into leaf like structure etc. The hosts observed were brinjal, periwinkle, chickpea and parthenium during investigation. Disease incidence and leaf hopper population observed was 25.06 per cent and 0.83 leaf hopper per plant in variety JLT-408 and 17.25 per cent and 0.75 leaf hopper per plant in variety Madhuri. The yield loss was high at 45 days after sowing. In the cultivar JLT-408 maximum losses16.81 per cent were recorded when, it was infected at 45 days after in the cultivar Madhuri maximum losses 12.94 per cent recorded when, it was infected at 60 days after sowing. The correlations between leaf hopper population and disease incidence were found positively correlated in both JLT-408 and Madhuri but non-significant. Correlation between climatic factors and leaf hopper population was worked out in both the varieties JLT-408 and Madhuri revealed that, the correlation between temperature max. and min. was negatively correlated with leaf hopper population and was significant in JLT-408 and non-significant in variety Madhuri. The correlation between climatic factors like Temperature (max. and min.) and Relative humidity % (am and pm) with phyllody disease incidence was negative and significantly correlated in variety JLT-408.

PP58(On)2F: Comparative Studies of Fusarium Wilt in Chickpea on Effect of Bio-agents and Essential Oils in Aspects of Cost Benefit Ratio

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Chickpeas provide high quality protein to large population sectors in South and West Asia, and the Mediterranean Basin. This crop has a significant role in farming systems as a substitute for fallow in cereal rotations. Chickpea wilt caused by *Fusarium oxysporum f. sp. ciceris* is one of the major yield limiting factors in chickpea. The disease causes 10–90% yield losses annually in chickpea. Development and use of high-yielding cultivars resistant to the prevalent pathogen race(s) in a given area is the most practical and cost-efficient individual disease control measure for management of the disease. Use of seeds certified free from *F. oxysporum f. sp. ciceris*, sanitation and cropping practices to reduce inoculum in soil, choice of sowing site and time to reduce disease potential, and protection of healthy seeds with fungicides or biocontrol agents, would be of help for the management of Fusarium wilt in chickpea in the absence of high-yielding, well-adapted resistant chickpea cultivars. The present investigation was carried out to control this disease using different treatments and there combination. The treatments were Control (water irrigation), Neem oil 5%, Eucalyptus oil 5%, *Trichoderma viride* 5%, *Pseudomonas sp.* 5%, Neem oil 2.5% + *Trichoderma viride* 2.5%, Neem oil 1.25% + *Trichoderma viride* 1.25% + *Pseudomonas sp.* 1.25%, Neem oil 1.25% + *Trichoderma viride* 1.25% + Eucalyptus oil 1.25% seed treatment was done. Among all the treatment in managing the wilt disease, Neem oil + *Trichoderma viride* + *Pseudomonas sp.* showed best cost benefit ratio of 1:2.89.

PP59(On)2F: Occurrence of Choanephora fruit rot on cucumber in Rajasthan: An emerging threat to protected cultivation in chaining climate

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The present investigation was conducted to know the status of cucumber diseases in Rajasthan, a survey was carried out in major cucumber growing districts viz., Jaipur, Tonk, Dausa, Alwar, Ajmer and Jhunjhunu during mid-September to mid- November 2019 and 2020 and first time, a new disease "*Choanephora* fruit rot of cucumber" was observed and recorded. Twenty four locations were visited of six districts and fruit rot disease samples were collected for further studies. During survey, typical symptoms of *Choanephora* fruit rot and Per cent disease incidence were documented. The results revealed that *Choanephora* fruit rot disease incidence ranged from 40.61-53.95%, in Jaipur district, 50.93- 64.69 % in Tonk district, 53.54-62.47% in Dausa, 48.86- 63.56% in Ajmer, 61.87-69.48% in Alwar and 44.32- 59.79% in Jhunjhunu district were recorded during *kharif* 2019. In *kharif* 2020, *Choanephora* fruit rot disease incidence ranged from 38.75- 50.10% in Jaipur district, 48.69- 62.70% in Tonk district, 50.41- 60.80% in Dausa, 46.60 - 60.20% in Ajmer, 58.54-67.88 % in Alwar and 42.02- 56.04 % in Jhunjhunu district were noted under protected cultivation. Typical symptoms were seen on immature and young fruits, flowers, leaf, twinges with water soaked lesions and soften of tissues on affected parts, later it turned brownish and whitish mycelial growth and monosporous sporangiola were produced on the lesions under high humidity. Black pin head like emerging sporangiola formed a cushiony mat appearance on surface of infected part. Our observation clearly indicates that *Choanephora cucurbitarum* (Berk. & Ravenel) Thaxter causing fruit rot disease of cucumber in India. As far as the authors are aware according to the available literature, this is first record of *Choanephora cucurbitarum* as new pathogen of cucumber fruit rot in India and confirmed by ITCC (ITCC No.- 11,258.19 dated.16/12/2019).

PP60(On)2F: Pathogenicity and host-parasite relationships of Meloidogyne javanica in spinach

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The host-parasite relationship between initial inoculation density (Pi) of root-knot nematode, *Meloidogyne javanica*, and growth of spinach *cv*. all Green was evaluated. Initial inoculation densities were 0, 0.125, 0.25, 0.5, 1, 2, 4, 8, 16, 32, 64 and 128 second-stage juveniles (J2s) g-1 soil. A Seinhorst model [y = m + (1 " m)z P–T] was fitted to shoot length and shoot dry weight data for inoculated and control plants. Tolerance limits (T) of spinach to *M. javanica* for shoot

length and shoot dry weight were 1.5 J2s per g-1 soil. The minimum relative values (m) for shoot length and shoot dry weight were zero in both cases at Pi, equal to or greater than 64 J2s g-1 soil. We also observed that the root galling was least at low initial population densities and greatest at 32 J2s per g-1 soil. The maximum nematode reproduction rate (Pf/Pi) was 47.20 times at an initial population density of 0.5 J2s g-1 soil. Such studies are useful in predicting the magnitude of crop damage and nematode population dynamics in fields infested with *M. javanica,* which is essential for making decisions regarding their management.

PP62(On)2F: Incidence of stem rot disease of groundnut in relation to weather parameters in major groundnut growing areas of Telangana

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Groundnut (*Arachis hypogaea* L.) is an important oilseed crop. Soil borne diseases of groundnut act as the limiting factor to its economic production. Hence, to get a preliminary idea regarding the incidence level and pattern of prevalence of the stem rot disease, roving survey was conducted in major growing areas of Telangana during *kharif* 2019 and *rabi* 2019-20. The highest incidence of stem rot was observed in Warangal district. Whereas, lowest incidence of stem rot was observed in Wanaparthy and Nagarkurnool districts of Telangana. Disease incidence was correlated with weather parameters, during *Kharif*-2019, temperature, relative humidity and rainfall showed positive correlation, whereas evaporation showed negative correlation, during *Rabi*-2019-20, temperature, relative humidity and evaporation showed positive correlation and rainfall showed negative correlation.

PP63(On)2F: Effect of weather parameters on the severity of Sorghum Anthracnose (Colletotrichum graminicola) in Tarai region of Uttarakhand

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Sorghum (*Sorghum bicolor*) is an important multipurpose millet cultivated for both grain and fodder purposes. Anthracnose, caused by the hemibiotrophic fungal pathogen *Colletotrichum graminicola*, is an economically major constraint on worldwide sorghum production. The disease is widely distributed across sorghum growing areas causing significant yield losses up to and beyond 50 % under favorable conditions. This investigation was carried out at livestock research center, sorghum pathology block, GBPUA&T, Pantnagar, Uttarakhand during the 2020 and 2021 *Kharif* season. The effect of various weather parameters on anthracnose disease severity was evaluated with two sorghum varieties, Pant chari-4 and CSV 33MF under epiphytotic field conditions. The pooled AUDPC value of both seasons was calculated as 343.47 and 53.21 with an apparent rate of infection 0.266 and 0.057 for Pant chari-4 and CSV 33MF respectively. The correlation coefficient between disease severity and different weather parameters revealed that both maximum and minimum temperature showed negative correlation with anthracnose severity whereas a positive correlation was recorded with relative humidity and rainfall respectively. The findings support that various weather parameters influence the severity of sorghum anthracnose in the field and the results obtained could be used for planning timely management strategies for the disease.

PP64(On)2F: Impact of atitude on phytoparasitic nematode distribution in medicinal plants

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As medicinal plants are gaining importance globally their cultivation is also increasing but at the same time pest problems are also increasing at same pace. Among all the pest of medicinal plants, Plant parasitic nematodes (PPNs) are one of the most important groups of pathogenic organisms. Keeping this in view an extensive survey was conducted at different region of Uttarakhand. Survey location was divide into three parts on the basis of altitude below 500m (location 1), 900-1900m (location 2) and above 2000m (location 3). Nine genera of plant parasitic nematodes were found in association with 7 medicinal plants. Soil samples were collected from different altitude and from 200cc soil PPNs were identified on morphological basis as *Helicotylenchus* spp., *Pratylenchus* spp., *Meloidogyne* spp., *Rotylenchulus* spp., *Tylenchorhynchus* spp., *Tylenchus* spp., *Criconemoides* spp. and *Trichodorus* spp.Altitude ranges below 500m (location-1) harbours a total of 8 genera of nematodes, among which *Helicotylenchus* spp. was presented in all tested medicinal plant and recorded in highest number followed by *Meloidogyne* spp. while in case of plants Mentha (*Mentha piperita*) was showing highest nematode population followed by Bhrami (*Bacopa monnieri*). In location 2 (900-1900m) *Helicotylenchus* spp exhibited maximum population followed by *Meloidogyne* spp, and *Pratylenchus* spp. while Aloevera (*Aloe barbadensis*) was showing maximum nematode association in its rhizosphere followed by Ashwagandha (*Withania somnifera*). In location 3 (above 2000m) population of *Meloidogyne* spp. was most prevalent among all, followed by *Tylenchorhynchus* spp. and *Helicotylenchus* spp. while in case of plants Stevia (*Stevia rebaudiana*) was most infected followed by Mentha (*Mentha piperita*). On the basis of survey, it can be concluded that at different altitude the population of nematode varies and within the same host nematodes were observed at different frequency level.

PP64(On)2F: Influence of weather parameters on Myrothecium leaf spot disease of coffee seedlings

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Leaf spot disease of coffee seedlings caused by the pathogen *Myrothecium roridum* is major destructive disease which causes 30% seedling loss in the coffee nursery. The fungus *M. roridum* is reported to be a weak pathogen and weather conditions play a major role in determining the course of epidemics. Hence to understand the role of different weather factors in the *Myrothecium* leaf spot disease, studies were carried out to know the effect of weather parameters such as, rainfall, minimum and maximum temperature and morning and evening relative humidity on the development of leaf spot disease. The experiment was conducted during the years 2018 and 2019 with the study material *Coffea arabica* L. cv. Chandragiri. The percent leaf spot disease incidence and severity were recorded in each standard meteorological week after initiation of the disease till the seedlings were sent to the field for planting. The weather data for each standard meteorological week relevant to the study was also recorded at the experimental site and correlated with percent disease incidence and severity. The correlation analysis indicated that among the various weather variables, the cumulative rainfall showed significant positive correlation in the disease development followed by evening relative humidity and morning relative humidity. Whereas maximum temperature exhibited the least positive correlation and minimum temperature showed significant negative correlation. The standard week which received maximum rainfall coupled with high humidity during the period of the study were observed to be more congenial for the rapid build of the disease. Further linear regression mathematical models were also developed for disease prediction.

PP65(On)2F: Status of bacterial blight of bean in Himachal Pradesh and role of various epidemiological factors in disease development

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Common bean (*Phaseolus vulgaris*. L) is one of the important vegetable crop grown in tropical, subtropical and temperate regions of the world. The outbreak of bacterial blight incited by *Xanthomonas axonopodis* pv. *phaseoli* in key bean growing areas of Himachal Pradesh has harmed the crop's success and profitability. Hence, the severity of the disease in various regions of Solan and Sirmour districts was assessed during the year 2019 and 2020 for two different growing seasons i.e. March sown crop (Summer season crop) and June sown crop (Rainy season crop). In overall the bacterial blight was recorded in higher proportions in Sirmaur district as compared to Solan district. Highest disease severity (58.2%) was documented in Karganoo locality of Sirmaur district in rainy season crop. The bacterial blight severity was also significantly higher (37.4% to 46.2%) in all the bean growing localities of Sirmaur district during rainy season. Therefore, the effect of different abiotic factors like temperature, relative humidity and duration of leaf wetness on the progression of the disease was assessed under controlled conditions using detached leaf technique. The epidemiological studies revealed that the progression of bacterial blight was maximum at 30°C, high relative humidity of 100% and 24 hours of leaf wetness duration.

PP66(On)2F: Disease severity and prevalence of Maydis leaf blight of maize in Mandya, Hassan, Chamrajnagar and Mysuru districts of Karnataka

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Maize (*Zea mays*), is the fastest growing crop in recent years due to its multiple uses such as food (9.53%), feed (49.60%), industrial use (23.51%), and ethanol (14.07%). Losses due to Maydis leaf blight may range from trace to 50 % of the grain yield depending on the severity of attack and time of incidence of disease. A roving survey was undertaken to record the disease severity in the maize growing regions during October-November 2021 in Mandya, Hassan, Chamrajnagar and Mysuru districts of Karnataka. The symptoms in the field were recognized by the elongated to diamond shaped lesions, creamish-brown in color which were restricted to leaf veins. The disease severity in the various locations surveyed ranged from 19.64 to 30.83 per cent. Among the districts surveyed, Hassan recorded highest disease severity of 30.83 per cent followed by Chamrajnagar district (28.89%) and Mysuru district recorded lowest disease severity of 19.64% followed by Mandya district (21.90%). Among the taluks of 4 districts, Chennaraypatna taluk of Hassan district recorded highest disease severity with average disease severity of 42.23 per cent followed by Chamrajnagar and Belur taluk being on par with 28.89% of Chamrajnagar and Hassan district respectively and Hassan taluk (28.15%) of Hassan district. The lowest average disease severity was recorded in Mandya taluk of Mandya district of 18.89% followed by Nanjungud taluk (19.26%) of Mysuru district. This information regarding disease severity with respect to the prevailing conditions and the need to know an efficient and inexpensive management approaches against the disease.

PP67(On)2F: Effect of weed management practices and nitrogen levels on growth and yield and purple disease in onion (Allium cepa L.).

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Onion (*Allium cepa* L.) is an important vegetable crop grown extensively in most of the part of Rajasthan during rabi season. A field experiment was conducted at Horticulture farm, SKN College of Agriculture, Jobner during rabi seasons of 2016-17 and 2017-18 to study the influence of integrated weed management and nitrogen levels on growth parameters of crop and weed population, yield of crop and purple blotch disease of onion. The experiment was laid out in split plot design with 07 treatments in main plots related to weed management practices and 04 treatments in sub plots related to nitrogen levels with three replications. As per results of experiment, weed management treatments showed non-significant influence on purple disease of onion although more infection recorded in weedy check (W0) and less infection with twice HW (W2) followed by application of pendimethalin (PP) fb 1 HW at 40 DAT. Among nitrogen, increasing levels of N resulted in significantly less infection of purple blotch upto 100 kg/ha and remained at par to 150 kg N/ha during both the years as well as in pooled analysis.

PP68(On)2F: Influence of weather parameters on differential response of soybean genotypes to Rhizoctonia aerial blight disease

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Rhizoctonia aerial blight (RAB) has been considered as the most common and widely distributed fungal disease of soybean, causing considerable losses in crop yield under favourable condition. A field experiment was conducted in 2020 & 2021 to ascertain the influence of various meteorological parameters on disease severity on soybean. The data from the two crop seasons revealed that the period from the month of September to October is most favourable time for the development of RAB of Soybean. The maximum temperature of 31 °C and average minimum temperature of 25.5 °C, relative humidity of 76 to 80 per cent was recorded during the period of initiation of the disease in the field during the two crop seasons. This implies that a warm and humid weather encourages the initiation aerial blight in the field. The present study was undertaken based on two years field data of screening under epiphytotic condition, out of them, 4 varieties were observed as phenotypically resistant to RAB. Their AUDPC value ranged from 56.52 to 441.87 and apparent rate of infection ranged from 0.003 to 0.026 percent also confirmed their resistance response. The correlation analysis revealed that disease severity of RAB showed significant negative correlation with minimum temperature (r = (-0.845) –(-0.906)) and also showed significant negative correlation with no. of rainy day (r = (-0.623) –(-0.714)). The correlation of relative humidity with the disease index was highly significant and positive (r = (0.840) –(0.862)) whereas sunshine hour with disease severity was significantly positive (r = (0.512) –(0.605)).

PP69(On)2F: Effect of different inoculum level of root knot nematode Meloidogyne javanica on coriander

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Coriander is one of the most important and nutritive seed spice crops grown all over the world. The production of coriander is affected by various biotic and abiotic diseases. Among the diseases of coriander, nematode diseases are also most important. Root-knot nematodes are dangerous and economically very important pest of cultivated crops in the world. In view of this, a pot experiment was conducted to test the pathogenicity of *Meloidogyne javanica* on coriander at different inoculum densities (0, 10, 100, 1000, and 10000 J2 per pot). The pots were filled with sterilized sandy loamy soil. Root-knot nematodes (J2 stage) were inoculated in each pot according to their different levels of inoculum. The experiment was laid out in completely randomized design with four replications. The observations recorded on plant growth characters {shoot length (cm) and shoot weight (gm), root length (cm) and root weight (gm)} and nematode reproduction-

{number of galls /plants, number of egg masses/ plant, number of eggs/egg mass, nematode juvenile/200 cc soil and final nematode population}. Results revealed that the growth criteria of coriander plants decreased with increasing of inoculum levels of nematode juveniles. At the same time nematode reproduction rate increased with increasing of nematode inoculum levels. The progressive reduction in growth and yield parameters with the increasing inoculum levels of *Meloidogyne javanica was* observed. The disease symptoms (*i.e.,* stunting, yellowing *etc.*) appearance started from inoculum level 100 J2 per pot and maximum on 10000 J2 per pot while, healthy plants appeared in uninoculated pots.

PP70(On)2F: Occurrence of leaf spot disease on ginger (Zingiberi officinale Rosc.) caused by Phyllosticta zingiberi Ramakr. in Mandya, Hassan, Kodagu and Mysuru districts

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Ginger (*Zingiberi officinale* Rosc.) is an important tropical spice belonging to the family Zingiberaceae. Among the diseases in ginger *Phyllosticta* leaf spot caused by *Phyllosticta zingiberi* Ramakr. is considered to be destructive, appearing in mild or severe form in all ginger growing tracts of the country causing13-66 per cent yield loss depending upon its severity. A roving survey was undertaken to record the disease severity in the farmer's field during October 2020 in Mandya, Hassan, Coorg and Mysuru districts. The symptoms in the field were recognized by the oval to elongated whitish spots surrounded by dark brown margin with yellow halo. The disease severity in the various locations surveyed ranged from 19.73 to 31.32 per cent. Among the districts surveyed, Hassan recorded highest disease severity of 31.32 per cent followed by Mysuru district (29.31%) and Kodagu district recorded lowest disease severity of 19.73 per cent followed by Mandya district (25.20%). Among the taluks of 4 districts surveyed the highest disease severity was recorded in Hassan taluk with average disease severity of 32.10 per cent followed by Arkalgud taluk (32.06%) of Hassan district and Periyapatna taluk (30.16%) of Mysuru district. The lowest average disease severity was recorded in Madikeri taluk (17.30%) followed by Somwarpet taluk (19.69 %) of Kodagu district. The survey study will give the information regarding disease severity with respect to the local conditions and thus provides an insight to develop an efficient and inexpensive management approaches against the disease.

PP71(On)2F: Effect of Pepper mild mottle virus (PMMoV) on Capsicum Yield and Yield Loss Assessment in Capsicum

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Plant viruses are systemic in nature which destroys whole plant and causes huge yield losses directly or indirectly. Association of PMMoV in polyhouse grown capsicum hybrid was reported in

Himachal Pradesh. So, in this study effect of PMMoV on fruit yield components of capsicum cultivar hybrid Indra and interactions between these components were analyzed under both pot and polyhouse conditions. The plants raised from commercial seeds of hybrid Indra were grown in plug trays to assess the effect of PMMoV on yield. Infected and healthy seedlings were selected after indexing of seedlings through DAS-ELISA. Transplanted healthy capsicum plants were further inoculated with PMMoV at different plant growth stages *viz.,* inoculation at 3-4 leaf stage, at initiation of flowering and at initiation of fruiting and one treatment was kept as plant raised from PMMoV infected seeds and one as healthy control. Data recorded on all the plants showing prominent disease symptoms like plant height, number of leaves, leaf size, days to first flowering, days to first fruiting, fruits per plant, days to first harvest, average fruit weight, total fruit yield per plant and harvest duration. PMMoV infection significantly affected the entire yield contributing factors. The plants raised from infected seeds were severely affected and showed pronounced symptoms compared to artificially inoculated plants. Average leaf size, plant height, average fruit yield and weight and total fruit yield and other yield contributing traits were drastically reduced in plants raised from infected seeds and early inoculated plants than late inoculated plants and healthy control.

PP72(On)2F: Effect of date of sowing on whitefly and mungbean yellow mosaic virus

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Greengram commonly known as mung or mungbean (*Vigna radiata* (L.) Wilczek) is an important short duration summer food legume in the tropical and sub-tropical countries of the World. Among all the diseases of mungbean,mungbean yellow mosaic virus (MYMV) is the most destructive one and it was transmitted by whitefly, *Bemisia tabaci* (Genn.) in a persistent, circulatory manner and grafting but not by sap, seed or soil (Nariani, 1960). It has potential to inflict 100% damage to mungbean crop (Nene,1972 and Singh,1980). The field experiment was conducted to study the influence of sowing dates on whitefly population and disease incidence of mungbean yellow mosaic virus disease revealed that the crop sown earlier (20th May) exhibited minimum mean whitefly population (0.76 whitefly/leaf), disease incidence (7.73%) and gave significantly highest yield (5.20 q/ha) while maximum mean whitefly population 1.24 and 1.11 whitefly/leaf and mean disease incidence 17.40% and 15.70% and least grain yield (3.51) and was recorded in the late sown crop 1st July and 21st June,respectively. Among the varieties, variety JL-781 recorded least whitefly population (0.84whitefly/leaf) and disease incidence (11.59%) and gave highest grain yield (5.68 q/ha). Correlation between whitefly population and disease incidence were significant. Correlation between whitefly population and disease incidence with climatic factor was statistically significant and positively correlated with rainfall (mm), rainy days and relative humidity % (AM and PM) and negative correlated with temperature (Max.and Min.).

PP73(On)2F: Districtwise status on incidence and disribution of major rice diseases in south Gujart region

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A roving survey of farmers field was conducted, to identify the major rice diseases, their incidence and distributions in rice grown districts *viz.,* Navsari, Surat, Valsad, Tapi and Dangs of south Gujarat region at a fortnightly interval during *Kharif* 2018 and 2019. The results revealed that, the prevalence of six rice diseases *i.e.,* sheath rot, bacterial leaf blight, grain discoloration, false smut, blast and sheath blight in rice fields which were appeared predominantly in low to moderate from with considerable proportions in south Gujarat during the study period. These diseases varied from year to year and rice varieties grown in particular area. In Navsari district, sheath rot (5.88%), bacterial blight (5.84%) and grain discoloration (8.15%) were the predominant diseases and sheath blight (0.53%) as minor diseases in the rice field. In Surat district, sheath rot (3.74%), bacterial blight (4.05%), grain discoloration (5.30%) had shown the maximum per cent of incidence. High per cent of sheath rot (4.86%), bacterial blight (4.48%), grain discoloration (6.21%) and (0.75%) of blast diseases recorded in the rice field of Valsad district. Sheath rot (5.18 and 6.38%), bacterial leaf blight (3.38 and 2.95%), grain discoloration (7.68 and 7.98%) were predominant diseases with minor incidences of false smut (1.72 and 1.94%), blast (1.67 and 2.95%) and sheath blight (0.30 and 0.70%) in Tapi and Dangs districts, respectively. According to the importance, districtwise status of rice diseases in south Gujart was documented for future use.

PP74(On)2F: Severity of peduncle blight and anthracnose of tuberose in Northern part of Karnataka

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Tuberose (*Polianthes tuberosa* L.) is the most important plant for the cultivation of long term spikes under tropical and subtropical ornamental bulbous flowers. Among Indian states, Karnataka ranks fourth in area and third in production after West Bengal, Tamil Nadu and Andhra Pradesh. The area under tuberose cultivation in Karnataka is 2.19 thousand hectares with a production of 17.43 thousand metric tonnes of loose flowers and 3.71 thousand metric tonnes of cut flowers (Anon., 2016). In recent days two new diseases *viz.,* Peduncle blight and Anthracnose is causing severe yield loss in northern Karnataka. Peduncle blight caused by *Lasiodiplodia theobromae* causes 40 to 60 per cent yield loss. Whereas in favourable condition extends up to 92 per cent (Durgadevi and Sankaralingam, 2012). The anthracnose caused by *Colletotrichum gloeosporiodes* severity is ranges from 18-27 per cent (Mahadevakumar *et al.,* 2019). A roving survey was carried out in major affected areas of northern Karnataka. From the results obtained, it was clear that, vegetative state is more vulnerable to the attack of the pathogens then flowering stage irrespective of the locations. Red soil type

recorded higher disease severity as compared to black soil. Among the surveyed areas, the severity of peduncle blight of tuberose was maximum in Tumminakatti village (45.33 %) of Haveri district while anthracnose severity was maximum in Saidapur farm (31.11%) of Dharwad district. Least disease severity of peduncle blight and anthracnose was recorded in Chandanamatti (13.33 %) and Nigadi (6.67 %) villages of Dharwad taluk of Dharwad district respectively.

PP75(On)2F: Alternaria spp. on flaxseed in Southeast of Kazakhstan

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In recent years, flax blight was caused by the fungus Alternaria linicola Grov. et Skolko. and *Alternaria lini* Dey affects flax crop everywhere in all over the world. Identification of the pathogenic species prevalent in the study area is essential to select an appropriate disease control strategy. Flaxseeds from Almaty region of Kazakhstan were analyzed in 2021 at the laboratory of the Kazakh Research Institute of Plant Protection and Quarantine with the purpose to isolate and describe the morphological features of the causative agent of Alternaria spp. We found some significant differences between 3 isolates in length, conidia width, several longitudinal and transverse septa (P-value >0.05). It has been established that the mycelium of Alternaria spp. was olive-gray to grayish-black, dark, conidiophores were olive-septate, branched, from cylindrical to oblong shaped, 111-117 μm long and 25-29 μm wide, with 5-6 transverse and 1-2 vertical septa, gradually turning into a filiform neck with septa.

PP76(On)2F: Role of different weather parameters on disease progression of stem gall of coriander under different sowing dates

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The field experiments were conducted during *kharif* seasons 2018 with two varieties to study the effect of different meteorological parameters on stem gall of coriander under different sowing dates. The experiment was laid out in RBD design with five different sowing dates (1st week of November to 1st week of December). The stem gall severity was recorded at weekly interval from the start of its incidence. The disease severity was lower (5.42%) on the variety DH-36 followed by DH-228 (7.08%) in crop sown on 3rd week of November and maximum disease severity observed on DH-36 (11.67%) followed by DH-228 (11.88%) in crop sown by 1st week of December and the quantitative relationship between the disease severity and weather variables for different dates of sowing for two varieties was obtained by performing correlation analysis. The temperature (maximum and minimum) and sunshine hours had positive correlation with per cent disease intensity, while relative humidity (morning and evening) and remaining weather parameters was non-significant at each date of sowing but correlated with the disease intensity.

PP77(On)2F: Crop loss (disease) assessments

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Crop losses due to diseases are a major threat to incomes and food security of thousands of rural families worldwide. The losses from pathogens are direct, as well as indirect; they have a number of facets, some with short-, and others with long-term consequences. Most of the agricultural research conducted in the 20th century focused on increasing crop productivity. Plant pathology thus primarily focused on protecting crops from yield losses. The challenge posed today is greater, however, because the food security challenge is compounded by other essential issues, such as food safety and harvest quality, combined with increasing limits to manage diseases due to shrinking natural and human resources. Applications of disease assessments, their timing and quantifications, as well as their relationships and their predictive value for crop losses. This abstract should also lead to a reconsideration of oversimplified crop loss estimates, account for the multidimensional costs of crop losses, and start to evaluate the indirect cost of reduced product quality to add to the disease-yield loss relationship. Methods for measuring and quantifying disease intensity in single plants and fields and for determining and predicting crop losses are improving. (James, W. C., and Teng, P. S. 1979; Liodow, S. E. 1983; Teng, P. S. 1983.) Pimentel et al. (1978) found that "estimates" of apple losses due to diseases, insects, and weeds totaled 126%.

PP78(On)2F: Occurrence and distribution of chickpea (*Cicer arientinum* L.). collar rot disease caused by *Sclerotium rolfsii* in Telangana state

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Chickpea is one of the major grain legume grown after dry beans and dry peas globally. A survey was conducted during *Rabi* 2021-22 to obtain collar rot disease incidence in respect to soil type, cultivar used, previous crop grown and seed treatment in major chickpea regions of Telangana *viz.,* Northern Telangana, southern Telangana zones and few parts of Central Telangana zone.It was noticed during the survey that only 29% of farmers are practicing the seed treatment with fungicide and majority of the farmers practicing Soybean-chickpea, Maize-chickpea and Tobacco-chickpea cropping system. Collar rot caused by *Sclerotium rolfsii* was found only in Adilabad, Nizamabad, Jogulamba-Gadwal and Jagtial districts of Telangana. Out of these four districts, in three districts farmers were practicing Soybean-chickpea cropping pattern except in Jogulamba-Gadwal district, where they are following Tobacco-chickpea cropping pattern. The survey results indicated that minimum disease incidence (8%) was recorded from Polasa village of Jagtial district and highest incidence (15%) recorded from Boregoan Village of Nizamabad District.

PP79(On)2F: Management of Ascochyta blight of chickpea

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Chickpea is the third most important grain legume crop in the world after common bean and pea. India is the main producer, contributing 60% to world production. Chickpea crop is affected by various plant diseases in which including Ascochyta blight, dry root rot, Fusarium wilt, collar rot, and Botrytis gray mold. Amongst them, Ascochyta blight of chickpea caused by a fungal pathogen *Ascochyta rabiei* (*A. rabiei*) belongs to the class *Dothideomycetes*, order Pleosporales, and family Didymellaceaeis is a major problem in chickpea growing areas that significantly affect production worldwide, it causes major loss in yield and decreases quality. Several approaches have been used to minimize the AB infection, including cultural, botanical biological, and chemical. Out of them, chemical treatment for plant disease management is most reliable. To manage this disease a field trial was conducted in *rabi* 2017-18. In which, thirteen treatments of different fungicides and biological agents were used. Amongst them, maximum percent disease control (72.59) was recorded in seed treatment with Carbendazim+ Thiram +2 foliar spray of Carbendazim 50 WP @0.25% (18.50%), followed by (66.37) seed treatment with Benomyl + 2 foliar sprays of Carbendazim 50 WP@ 0.25% and (62.22).

PP80(On)2F: Importance of survey and surveillance in Plant Diseases Management

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Assessment of presence, distribution and abundance of plant disease are essential pre requisites to plant diseases management. Modern diseases management cannot operate without accurate estimates of diseases or plant damage and its effect on yield. This is made possible by undertaking surveys. Survey is the planned procedure to determine the characteristics of pathogen population over a defined time period while surveillance is the regular monitoring of pathogen population dynamics, its incidence and damage on crop at fixed intervals. The basic principle of surveys to manage plant diseases is that no management strategy is to be undertaken unless it is known that pathogen population has reached economic threshold. The survey can be qualitative or quantitative. Generally two types of surveys are employed in field of plant pathology: Intensive and extensive surveys. Roving survey and fixed plot survey are the two basic techniques employed in surveillance of plant diseases. The former technique involves the assessment of pathogen population or damage from randomly selected spots representing larger area while the latter involves assessment from the fixed plots selected from field at periodic intervals. Every year there is significant loss to agricultural yield and productivity owing to no proper and centralised database for analysis and forecasting of diseases and also due lack of timely advisory service and early warning to farmers to implement necessary disease-prevention measures. Hence it is the need of hour that different agencies should work together on pest surveillance and present convergent good quality data on actual diseases problems.

3A. Diagnosis of plant pathogens

PP81(On)3A: Pathological investigations on southern blight disease caused by Sclerotium rolfsii on cabbage – a new record in India

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A severe outbreak of foot rot and head rot disease of cabbage was observed during September 2017 to November 2019 in major cabbage growing regions of southern Karnataka state of India. The disease incidence ranged between 3–28%. The initial symptoms were observed as tan, water-soaked lesions at the point of infection and development of mycelia, followed by quick wilting of the whole plant. Subsequently, numerous sclerotia were produced. The pathogen isolated on PDA medium produced white fluffy aerial mycelia and numerous reddish-brown sclerotia after 7-10 days. A total of 18 fungal isolates were used for mycelial compatibility analysis. Isolate SrBoC28 was used to test for pathogenicity on cabbage, marigold, chilli and brinjal plants. Typical disease symptoms on leaves, stem and roots were evident 5, 8 and 10 days' post-inoculation, respectively. The isolate was pathogenic on all tested hosts and the identity was confirmed by re-isolation and morpho-cultural and molecular studies. The latter were based on amplification of ITS-rDNA and phylogenetic analysis which showed 100% sequence similarity with reference sequences. The identity was confirmed as *S. rolfsii*. This is a well-known pathogen and causes disease on various economically important crop plants. To date there are no reports on the association between *S. rolfsii* and foot and head rot disease of cabbage in India and elsewhere. Thus, to the best of our knowledge, this is the first report of foot rot and head rot of cabbage caused by *S. rolfsii* in India.

PP82(On)3A: Mortality of mesua ferrea trees and its management using arbuscular mycorrhizal fungi

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Trees growing in moist tropical areas are potentially threatened by mortality because of environmental and biotic changes. *Mesua ferrea* Linn. (Family Calophyllaceae) is a native tree species of Arunachal Pradesh, Northeast India commonly known as 'Nahar'. It is an important medicinal and aromatic tree that yields high quality timber. Several Nahar trees growing as roadside plantation in our institute campus were wilted and ultimately died in recent past. A biotic cause was asserted as root xylem vessels of infected trees were found occupied by fungal mycelia. Thus, detail studies were performed with aims to identify the cause of mortality and to control disease using arbuscular mycorrhizal (AM) fungi. In total, 96 root samples were screened (24 each from 2 completely wilted individuals, one partially wilted and one healthy individual). A total of 52 colony forming units (CFUs) were obtained with 3 distinct morphotypes. Among them,

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about 67% CFUs were identified as *Fusarium oxisporum* and thus disease as 'Vascular Wilt'. Pathogenicity of *F. oxysporum* was confirmed through Koch's postulates. *Glomus constrictum* and *G. feugianum*, two most dominant AM associates of *M. ferrea* were selected for artificial inoculum production and trials to control the disease. *G. constrictum* could control *F. oxysporum* and thus wilt disease more effectively as compared to seedlings grown with *G. feugianum* species which showed stress and ultimately died and control (without any AM inoculant). The results will be presented and discussed in detail.

PP83(On)3A: Study of a new leaf spot disease diagnosed in Dendrobium sp of orchid caused by Curvularia aeria

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Among the different cultivated orchids, *Dendrobium* orchids are gaining huge popularity due to its great aestethic value. In the month of September 2017, leaf spots with irregular shape, straw colour in centre and dark brown colour in the margin were detected on *Dendrobium* spp. of orchid in a nursery of Darjeeling, West Bengal, India (27p 3'32''N and 88p 22'20''E). The fungus was isolated from the periphery of the symptoms followed by its cultural characterization in various mediums, different temperature conditions, different pH conditions and different sources of nitrogen and carbon. After 6 days of inoculation, out of seven tested media CDA (9 cm) & PDA (8.20 cm) were found to be the best media for mycelial growth of the pathogen at 30p C (9.00 cm) and at pH level-7 (9.00 cm). Among the 6 carbon and 6 nitrogen sources tested, best mycelial growth was achieved in Sucrose (8.5 cm) & Potassium Nitrate (8.3 cm) respectively. On morphological characterization, conidiophores were septate, straight or flexuous, unbranched, pale brown to dark reddish brown, multiple three-four celled conidia with two-three septa developed at the tip of conidiophores were observed. Conidial dimensions were 14.21-26.88µm (Avg 22.83 ±3.80µm) × 7.69-11.89µm (Avg 9.65± 1.26µm), inter septa length varied from 3.05-6.53µm (Avg 4.83 ±1.11µm). The tested pathogen isolated from Dendrobium orchids was identified as *Curvularia aeria* (Bat., J.A.Lima and C.T.Vasconc.) on the basis of morphological, cultural characteristics and DNA sequences of the ITS region of the rRNA gene. Pathogenicity test of the fungus was carried out in the detached leaves methods; similar type of symptoms was produced on treated ones, while control remains symptomless.

PP84(On)3A: Alternaria burnsii detected as a new causal agent of Leaf spot disease in Mokara orchids

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Mokara spp., sometimes known as 'Smile Orchid,' is gaining steam in floral nurseries due to its attractive star-shaped flowers of various colours. During roving survey in January 2018, a new leaf spot disease was observed in *Mokara sp*. with 11% incidence and 15.33% severity which were necrotic, variable in size, circular to oval, depressed brownish centres surrounded by a thin distinctive yellowish halo at Hooghly district of West Bengal (22.90p N and 87.76p E). One fungus, *Alternaria burnsii* was isolated from the characteristic symptoms. Koch's postulates were carried out to establish the pathogenic nature of the pathogen where treated leaves produced similar symptoms and the control remains symptomless. For cultural characterization of the pathogen, different culture mediums, temperature conditions, pH ranges and various sources of nitrogen and carbon were tested. Eight days after inoculation, among the seven tested media PDA (9cm) & CDA (8.50cm) was found the best media for mycelial growth of the pathogen at 25p c (9.00 cm), and pH level-6 (8.55cm). However, among the six carbon and nitrogen sources tested, Dextrose (4.75 cm) and Urea (5.2 cm) produced the best radial mycelial growth. The morphological characterization showed that the pathogen produced septate, filamentous hyphae (width: 2.96 ± 0.34μm), erect, flexuous conidiophores bearing dark brown to olavaceous, smooth walled or somewhat warty, muriform, condia having dimensions of 22.23- 49.53 μm (Avg 37.47 ±7.14μm) × 8.18-14.98 μm (Avg 11.60 ± 1.80μm). Comparing the conidial morphology, cultural characteristics, and obtained DNA sequences of the ITS region of the rRNA gene of the studied pathogen, it is found grossly similar to *Alternaria burnsii* described by Paul et al., (2015) from *Cucurbita maxima.*

PP85(On)3A: Application of biotechnology in plant disease management and its current status and future perspective

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Biotechnology is the genetic manipulation, and multiplication of any living organism through novel techniques and technologies such as tissue culture and genetic engineering resulting in the production of improved or new organism. Plant diseases are a threat to world agriculture and general food security. Significant yield losses occurs due to the attack of pathogen in most of the crop species. Several biotechnological tools and approaches have been emerging in the recent years which are becoming very effective in disease management. Among these successful biotechnology tools tissue culture techniques were widely adopted by many countries in the early stage for producing disease free plants. Meristem or shoot tip culture is used to obtain virus free plants. The most common tissue culture technique used is protoplast fusion. Some of the highly acceptable modern techniques include recombinant DNA technology (in which gene of interest is transfered from the donor to recipient using genetic engineering tools), RNAi (Gene Silencing) technology. The recent advances in biotechnology includes genome editing which allow genetic material to be added, removed, or altered at particular locations in the genome. Genome modification of different types can be achieved through use of ZFN, TALEN, CRISPR which has proven itself as viable technology for the management of disease. An increasing consciousness about environmental pollution and health hazards due to fungicides and development of disease resistance in pathogen population has challenged the plant pathologists to search eco-friendly tools such as these biotechnological technologies which are effective, economical and ecological and requires less time compared to conventional breeding techniques.

PP86(On)3A: "Reverse transcription - Recombinase polymerase ampliûcation (RT-RPA)" A promising assay in detection of Onion yellow dwarf virus (OYDV) in onion cultivars

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Onion yellow dwarf virus (OYDV) is prominent virus affecting Allium species like onion and garlic worldwide. Reverse transcription polymerase chain reaction (RT-PCR) and Enzyme-linked immunosorbent assays (ELISA) assays are two most commonly used assays for the detection of OYDV but the sensitivity of RT-PCR is far more than that of ELISA. PCR based assays are often known for their high sensitivity, specificity but they are time consuming and require costly equipments and specific technical expertise. To overcome these difficulties, a simple and rapid RT-RPA assay for the detection of OYDV was developed. For the amplification of the coat protein region of OYDV, A common set of primer was designed to perform RT-PCR and RT-RPA. Sensitivity, as well as specificity test using 10 fold serial dilution series of the puriûed RNA, was performed for both the assays. Both asymptomatic and symptomatic samples of different varieties of onion were collected from Delhi NCR region and evaluated for OYDV infection using RT-RPA along with RT-PCR assay. The comparative results have shown that sensitivity of RT-RPA was similar to RT-PCR. However, RT-RPA is rapid and simple assay for the large scale virus indexing of onion.

PP87(On)3A: Molecular characterization of a Tospovirus infecting cowpea (Vigna unguiculata L. Walp.) in Rajasthan

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Tospovirus is a group of plant virus causes great loss to cultivated crops worldwide which has severe economic impact. Cowpea (*Vigna unguiculata* L. Walp.) is an economically important legume crop cultivated in semiarid region (specifically of Shekhawati belt) of Rajasthan. Cowpea plants has indicated certain virus like symptoms which were prevalent in the area for last few years. Field surveys were conducted in year 2019-20 and 2020-21 during the month of August-September and leaves from 40 symptomatic plants were collected to identify and characterize the related virus. In leaf dip electron microscopic study, 80-100nm Tospovirus like particles were observed. Serogroup level confirmation of the virus of interest was made by DAC-ELISA method. 26 samples showed positive reaction with Tospovirus (serogroup IV) specific antiserum. These positive samples were subjected to bioassay to ascertain association of specific virus using tobacco and cowpea as indicator plants. Further, positive samples were selected for characterization at molecular level. RT-PCR, cloning and sequencing of N- gene were performed and finally 6 sequences of N gene were analyzed for phylogeny and the result of sequences showed maximum similarity (99%) with Groundnut bud necrosis orthotospovirus (GBNV).

PP88(On)3A: Occurrence and distribution of Common rust of maize inciting pathogen (Puccinia sorghi Schw.) in West Bengal.

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Common rust (CR) of maize (*Zea mays* L.), incited by *Puccinia sorghi* Schw., is a yield-limiting disease. Surveys were conducted in farmers' fields to determine the distribution of common rust on different maize growing districts of West Bengal. A total of six districts (Northern part of West Bengal) were found to be infected by common rust. On the contrary, the Southern part of West Bengal was free of common rust incidence. The highest severity and incidence were recorded from Malda district (70.17% &73 % respectively) and lowest from Jalpaiguri district (31.48% & 36.33 % respectively), with a mean severity and incidence of 53.20% and 56.78% respectively. For preliminary investigations into the diversity of the pathogen, the morphological comparisons of rust pustules, a dimensional study of urediniospores and teliospores were conducted using stereo microscopy, light microscopy and scanning electron microscopy (SEM). From the collection of six isolates, the pustules of urediniospores were found to be significantly different (P Â 0.01) as compared to pustules of teliospores. The pustules of teliospores showed no significant difference in width. Assessment of urediniospores and teliospores morphology provided significant evidence of variation based on different locations. The dimension of urediniospores (length, width and wall thickness) differs significantly (P Â 0.01) between the isolates whereas the dimension of teliospores (teliospores length, apical cells length, septum thickness, apical papilla and wall thickness) also differed significantly (P Â 0.01). The length of teliospores and basal cells width were also found to be significantly different (P Â 0.05). The other morphological attributes (teliospores width, apical cells width, basal cells length and pedicel length) were not significantly different. The findings of the present study clearly revealed that severity, incidence and morphological variability did exist among the different isolates of *P. sorghi.*

PP89(On)3A: Molecular detection and identification of mungbean yellow mosaic India virus (mymiv) infecting cowpea in northern Karnataka

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Cowpea is an important legume crop grown throughout the world, particularly in Africa, Latin America, Europe, and some parts of Asia, due to its high protein, carbohydrate, lipid, mineral, and vitamin content. Among many viruses infecting cowpea, the disease caused by YMVs, particularly mungbean yellow mosaic India virus (MYMIV), nowadays, has become more common and an emerging threat to cowpea cultivation in northern Karnataka during the summer months, affecting the yield potential of cowpea both quantitatively and qualitatively in recent years. Because there hasn't been much study on characterization of MYMIV on cowpea in northern Karnataka, an attempt was made to partially characterize it. Yellow mosaic virus-infected cowpea leaf samples gave positive results with Deng-universal primers and yielded amplicons of ~350bp, whereas no PCR product was obtained from DNA extracted from healthy samples in PCR. The ~350bp PCR products were directly sequenced and assembled. Phylogenetic tree formed 4 major clusters based on CP sequences of the isolated MYMIV and other strains of MYMIV (begomovirus) downloaded from NCBI Genbank. The current isolate (UAS-Dharwad MYMIV isolate of cowpea) formed a distinct cluster with Group-IV, which included other MYMIV isolates with accession numbers AF126406.1, MN885464.1, AY271895.1, and MN026271.1. Comparison of the nucleotide sequence of the CP gene of the isolated strain revealed that it had the highest similarity with AF126406.1 (100.00%), followed by MN885464.1 (98.90%), and the lowest similarity with MN885463.1 and JN368433.1 (95.56%), respectively. This is the first report of the occurrence of MYMIV on cowpea in natural conditions in northern Karnataka.

PP90(On)3A: Pivotal role of Rhizosphere Microbes on Plant and Human health in Global Perspective

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Agricultural crops are always faced with many challenges and some of the common challenges are excessive application of chemical fertilizers and pesticides for plant pests; and diseases management, related with increases of food productivity. However, their application imbalances micro-biota of soil. For mitigating challenges encountered in food production and mycotoxin contamination by plant pathogens and mycotoxigenic fungi, scientist across the globe applied their idea to combat it with the help of several beneficial microbes. Amongst all groups of microbes, rhizosphere micro-flora such as bacteria, fungi, Actinomycetes and mycorrhizae are well explored for plant disease management, decontamination and detoxification of mycotoxin as well as plant growth promotion. With the advent of modern scientific tools/approaches, the science of plant pathology has got transformed to a greater extent resulting in the ease of handling the subject in a more focused manner. The main goal of plant disease management is to reduce the economic cost caused by pathogens either through biological control or through integrated approaches. During biological programme, antagonists must have some antimicrobial compounds and which may be applied for decontamination of foods during storage. Revitalizing depleted agricultural soils with synthetic fertilizer results in temporarily improved yields but selection and application of plant growth promoting bacteria, fungi and mycorrhizae improves soil fertility forever as reported by several global researchers. This present study is mainly focused on some general aspect of disease control strategies and tactics used for mycotoxin management and plant growth promotion.

PP91(On)3A: Survey for the incidence of sclerotium wilt of brinjal in northern Karnataka

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Brinjal (*Solanum melongena* L.) or egg plant is an important solanaceous crop of subtropics and tropics. It is known as king of vegetables in India. It is a good source of mineral and vitamins and it rich in total water soluble sugars. Brinjal is known to have ayurvedic medicinal properties and is good for diabetic patients. In Karnataka brinjal is grown in an area of 17.04 thousand hectares with production of 431.80 thousand metric tonnes and productivity accounts for 25.34 tonnes / ha. The brinjal is affected by many plant pathogens. Among them important fungal disease is *Sclerotium rolfsii* which is soil borne saprophytic fungus that causes different types of diseases such as collar rot, Sclerotium wilt, stem rot and root rot etc. The sclerotium wilt of brinjal caused by *Sclerotium rolfsii* is an important disease and occurs in the brinjal growing areas of northern Karnataka. Looking to severity of the disease roving survey was conducted during rabi 2020-21 in five brinjal growing districts of northern Karnataka *viz.,* Bagalkot, Bijapur, Dharwad, Gadag and Haveri observation on disease incidence were recorded and the results revealed that maximum disease incidence of 35.07 per cent was recorded in Narendra village of Dharwad district followed by Nulageri village (17.71%) of Hirekerur taluka and Garag village (15.67%) of Dharwad taluka. The maximum mean PDI (9.75%) was observed in the red soils compared to the black soils (8.31%) crop irrigated with drip system recorded the least per cent disease incidence of 6.83 per cent compared to flood irrigation (9.58%). And crop grown under polythene much has recorded the least mean PDI (4.33%) than in the crop grown without mulch (9.68%.)

PP92(On)3A: Genetic diversity and natural reservoirs of phytoplasmas strains associated with sesame phyllody

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During the year 2020-21, sesame phyllody disease incidence of 22-80% was recorded in major sesame germplasms of New Delhi (EC370386), Madhya Pradesh (EC3463480), Punjab (EC347054), Uttar Pradesh (Jh-1), Tamil Nadu (EC0377268) and Rajasthan (EC346819). The results revealed the presence of two ribosomal groups/subgroups of phytoplasma strains (16SrI-B and 16SrII-D) by employing phytoplasma specific primer pairs (P1/P7 and R16f2n/R16r2) and 16S rRNA gene sequence comparison analysis. The leafhoppers, *Hishimonus phycitis* and *Orosius albicinctus* were also tested positive for the identified sesame phyllody phytoplasma strains at New Delhi and Vriddhachalam.

Ca. P. australasia strain associated with cowpea and faba bean at New Delhi and *Ca*. P. asteris with weed *Cleome viscosa* at Vriddhachalam was also confirmed. The identified weeds and insects are also suggested to play an important role in the epidemiology of sesame phytoplasma strain. Our results confirmed wide occurrence of two phytoplasma strains (16SrI-B & 16SrII-D) infecting sesame germplasms in six states of India.

PP93(On)3A: Occurrence of Lasiodiplodia theobromae (Pat.) Griffon & Maubl causing leaf blight disease of coconut in Andhra Pradesh

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Coconut is important oil, seed and plantation crop in Andhra Pradesh. A new disease, leaf blight affecting the coconut in Andhra Pradesh was observed in 2019. The symptoms were observed on leaflets, which showed minute yellow dots initially and later started drying from the tip towards middle rachis and then drying spread to entire leaf let and depicted a charred or burnt appearance from distance. *Lasiodiplodia theobromae* was isolated consistently from the diseased tissues of affected palms. Pathogenicity of *L. theobromae* was confirmed by artificial inoculation on seventh month old seedlings. This is the new report of leaf blight disease of coconut in Andhra Pradesh. Koch's postulates were established to confirm pathogenicity of the fungus.

PP94(On)3A: Molecular detection and identification of Chilli leaf curl virus infecting bell pepper variety "California Wonder" in India

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California Wonder is an open-pollinated heirloom bell pepper variety which is known as a perfect stuffing pepper because of its thick flesh and large size. During November, 2021, leaf curl disease symptoms were observed in California Wonder variety of bell pepper at Centre for Protected Cultivation Technology (CPCT) of ICAR-IARI, New Delhi with disease incidence of 38%. The characteristic symptoms were upward leaf curling, thickening of veins, shortening of internodes and petioles, leaf puckering and stunted growth of plants. These symptoms were indicative of virus infection. To confirm the association of virus infection, healthy and infected samples were subjected to electron microscopy. Electron microscopy showed the presence of typical Geminate virus particles in infected samples. For further characterization of virus, DNA extraction was carried out using the DNeasy® Plant Mini Kit (Qiagen) from symptomatic and asymptomatic plants and PCR was performed using universal primer pair. The 520 bp amplicon obtained in PCR, was cloned, sequenced. The sequence analysis revealed highest identity of 97.63% with chilli leaf curl virus (Accession: JN663846 and MH577035) reported from chilli and tomato from Ahmedabad and Pune respectively. To the best of our knowledge, this is the first report of chilli leaf curl virus infecting bell pepper in India. Begomoviruses infect a wide range of dicotyledonous plants and cause heavy economic losses to farmers and detection of this virus is essential to control the spread of the disease and to prevent the loss.

3B. Resistant cultivar development

PP95(On)3B: Pathogenic Variability of Alternaria lini Dey causing Alternaria blight of Linseed in Jharkhand

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Alternaria blight caused by *Alternaria lini* Dey and *Alternaria linicola* (Groves and Skolko) is a major biotic stress limiting yield in hot and humid environment (Groves and Skolko, 1944). The disease attack both assimilative and reproductive part of the plant and cause huge amount of yield losses in terms of quality and quantity of fiber and seed. Development of resistant cultivars requires knowledge of pathogenic variation present in different regions where the crops are grown. Therefore, the present study was undertaken to determine pathogenic variability of 17 isolates of *Alternaria lini* Dey on four cultivars (Meera, Nagarkot, Divya and Priyam) grown in pot culture. Studies on pathogenic variations revealed that variation observed in accordance with the latent period, lesion size, lesion shape and plant disease index. With respect to incubation/ latent period, *A.lini* isolates varied from 4.75 to 6.25 days in which shortest (4.75 days) latent period was recorded by the isolates Alt-3, Alt-11 and longest latent period of 6.25 days was observed in isolates Alt-6, Alt-14, Alt-16. Majority of isolates showed 5.75- 6 days of incubation period. Distinct differences in number of lesion and size were seen among the isolates of *A.lini*. Number of lesion varied from 2.75 to 4.00 with the maximum average number of lesion recorded in isolate Alt-13 (4.00) followed by isolate Alt-16 (3.75) whereas size of lesion varied from 2.25 to 4.75 mm with maximum lesions size (4.75 mm) was observed in isolate Alt-4 and minimum (2.25 mm) in isolate Alt-5. In respect to lesion shape, 4 isolates produced elongated lesions, 7 isolates produced oval lesions and 6 isolates produced irregular lesions. According to plant disease index Meera and Nagarkot were more severe compare to Divya and Priyam. The maximum disease severity with 30.44% and 30.33% was recorded on var. Meera inoculated by isolates Alt-4 and Alt-6 respectively indicating most virulent and isolate Alt-10 was found least virulent showing 10.99% in variety Divya.

PP96(On)3B: Molecular screening of bitter gourd genotypes against leaf curl disease caused by Tomato leaf curl New Delhi virus

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Bitter gourd (*Momordica charantia* L.) is an important cucurbitaceous vegetable crop cultivated mainly in Asia and tropical countries. Severe leaf curl symptoms *viz*., mosaic mottling, crinkling and curling of leaves, stunted growth with fewer fruits were observed in bitter gourd crop grown at Main Research Station, Hebbal, Bengaluru during summer 2021 along with leaf curl infected tomato, chilli and yellow mosaic infected mungbean. The DNA of symptomatic bitter gourd samples amplified with begomovirus specific Deng primers with amplicon size of 550 bp. The similar samples were further amplified with ToLCNDV, ChiLCV, MYMV specific primers, confirmed the amplification only with *Tomato leaf curl New Delhi virus* (1200 bp) and showed 97.67 per cent identity with ToLCNDV/C11 segment DNA-A (MW620977.1). The severity of leaf curl disease found associated with Tomato leaf curl Bangladesh betasatellite (ToLCBDB) [India/Kanpur/Chilli/2008] (HM007107.1). Fourteen commercial bitter gourd varieties/hybrids were screened for phenotypic reaction under natural infection. The initial symptoms was observed between 20 to 50 days after sowing. The presence of ToLCNDV infection in bitter gourd varieties/hybrids was confirmed through PCR. Maya (F1) hybrid and variety Long showed least PDI with 26.67 and 28.00 percent respectively and AUDPC of 810.0 and 825.0 respectively compared to susceptible White long (92.67% PDI & 2775.00 AUDPC). The phenotypic reaction of Maya (F1) hybrid and variety Long was further confirmed through artificial whitefly inoculation. The hybrid Maya (F1) and variety Long were found moderately susceptible to ToLCNDV.

PP97(On)3B: Varietal screening of green gram against root-knot nematode, Meloidogyne incognita and its impact on morphological, physiological, and biochemical host response

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Eighteen cultivars of green gram, *Vigna radiata* were evaluated for their relative susceptibility to root-knot nematode, *Meloidogyne incognita* under pot condition. Inoculation with 2000 J_2 of *M. incognita*/ kg soil caused stunted growth and leaf chlorosis. On roots, characteristic galls were formed, however the severity varied with the cultivars. Out of eighteen, four cultivars showed high degree of susceptibility (106-118 galls/root system). Eight cultivars developed 42-88 galls/root system and six cultivars were found moderately susceptible with 20-30 galls/root system. The highest number of galls/root system was recorded on the cv. SML-668 (118), whereas the lowest galling occurred on the cv. K-851 (20). The highest reduction in morphological parameters *viz.,* plant growth, nodulation, grain yield, was recorded on cv. SML-668 over control, whereas the lowest reduction was recorded on cv. K-851 over control. The soil population (mid and harvesting) of *M. incognita* also showed varied reactions with the cultivars screened. The highest increase in the soil population of the nematode was recorded on the cv. SML-668 (162% and 134%) over initial population and lowest on cv. K-851 (86% and 58%). The biochemical parameters *viz.,* chlorophyll, carotenoids, total phenol (TP) salicylic acid (SA), and total protein contents were found corelated with host reaction. The chlorophyll and carotenoid contents were significantly reduced in the leaves of green gram inoculated with the root-knot nematode over control. The highest reduction in chlorophyll and carotenoid contents were record in cv. SML-668 (28-36%), whereas the lowest decrease was detected in cv. K-851 (10-14%) over control. The TP and SA contents of green gram leaves significantly increased in *M. incognita* inoculated plants. The highest increase in the TP and SA contents of the leaf was recorded in cv. K-851 (54% and 58%), whereas the lowest increase was detected in cv. SML-668 (10% TP and 13% SA). Maximum decrease in total protein was recorded in cv. SML-668 (44%), and minimum cv. K-851 (23%), as compared to control. The physiological parameters, *viz.,* photosynthesis rate measured on one-month-old nematode inoculated plants showed significant decrease (16-30%) whereas the stomatal conductance and transpiration were increased (18-28%) over control. The maximum

decrease in photosynthesis rate (30%) was recorded in cv. SML-668, in which transpiration rate and stomatal conductance showed maximum increase (28%) over control.

PP98(On)3B: Introgression of broad spectrum blast resistance gene Pi2 into maintainer line of DRR 9A CMS line by marker assisted selection in rice

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The CMS line DRR 9A is a wild abortive cytoplasmic male sterile line highly susceptible to major rice disease, blast. To improve DRR 9B for resistance against blast, we have introgressed a major dominant gene (*Pi2*) against blast disease into the maintainer line through marker-assisted selection, using NIL of Samba Mahsuri, (a near-isogenic line of Samba Mahsuri possessing *Pi2*) as the donor parent. PCR-based molecular markers tightly linked to *Pi2* were used for foreground selection of the resistance plants at BC1F1 generation and molecular markers tightly linked to the major fertility restorer genes, *Rf3* and *Rf4*, were used for negative selection (i.e. selection of plants possessing non-fertility-restoring alleles at the two loci) at BC1 generation. Positive BC1F1 plants were selfed and their progeny were subjected to MAS for *Pi2* coupled with phenotype-based visual selection for agro-morphological and grain quality traits. At BC1F3 generation, one hundred families were screened for the *Pi2* gene and phenotyped in the UBN nursery for the blast resistance and advanced to next generation. In the BC1F5 generation twenty backcross derived lines possessing higher yield than DRR 9B with desirable traits like short plant stature along with short bold grain type were screened for blast resistance, selected resistance plants were transplanted in the main field. The improved version of DRR 9B lines were crossed with DRR 9A to assess the maintainer ability and further back crossed to derive improved version of DRR 9A CMS lines for hybrid rice breeding.

PP99(On)3B: Cultural Variability of *Alternaria* sp. among different Isolates of Mungbean and Urdbean

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The isolates of *A. alternata* collected during *Kharif* 2017 from three mungbean and three urdbean crop fields of six different locations *viz.,* RCA campus, Sisarma, Jhadol, Mavli, Kotra, and Sarada villages of Udaipur district showed significant variations in colony diameter, size, colour of the colony and sporulation on PDA medium at 28± 1^0C after 7 days of incubation. Results indicated that the *A. alternata* isolates of mungbean and urdbean exhibited considerable diversity in the cultural and morphological feature. The sporulation for mungbean isolates was observed maximum in MAa- 2 islolate with 15.70 x10^3 conidia/mm^2 of medium and least rate of sporulation i.e. 14.30 x 10^3 conidia/mm^2 was recorded in MAa- 3 isolate. Likewise, the rate of sporulation for urdbean isolates also differed significantly. Maximum sporulation was noted in UAa- 2 isolate which was 13.43 x 10^3 conidia/mm^2 of medium and the least sporulation 11.67 x10^3 conidia/mm^2 was observed in UAa- 1 isolate.

PP100(On)3B: Genotype by environment interaction for evaluation of test environments and identification of resistant sources against powdery mildew and yellow rust

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owdery mildew, PM (*Blumeria graminis* f. sp. *tritici*) and yellow rust, YR (*Puccinia striiformis* f. sp. *tritici*) are the most important biotic factors for successful wheat cultivation in North Hill Zone (NHZ) and North Western Plain Zone (NWPZ) of India. Most of the recommended wheat varieties grown in these epidemiologically important regions are susceptible to the prevailing virulences of the pathogens of both the diseases. Hence, continuous breeding for resistance to these diseases becomes a compelling responsibility of breeders and pathologists with the pre-requisite need for identification of new and diverse sources of resistance. In this context, 131 genotypes of *Triticum* spp. and *Triticale* were evaluated at four and three hot spot locations for PM and YR respectively. Among the three source of variation, genotype x environment interactions had the greatest effect on PM severity, accounting for 44.26% of the total variation, whereas genotypes for YR severity, accounted for 68.19% of the total variation. Biplot analysis showed that eight and fifty one genotypes showed stable resistance against PM and YR, respectively. Thirty four genotypes developed mean disease severity d"15, AUDPC of d"600, rAUDPC between 4.90-41.97 and infection rate between 0.01-0.06 unit/day, respectively in comparison to the susceptible cultivar Lehmi showing mean TDS, AUDPC, rAUDPC and 'r' of 41.25%, 1510.88, 99.18 and 0.04, respectively, and were categorized as slow mildewing genotypes. Five genotypes, HD 3043, TL 2942, TL 2969, HPPAU 08, and HW 1095, showed combined resistance, which could be effective in speeding up PM and YR-resistant wheat breeding programme. Moreover, Kukumseri and Keylong appeared to be ideal testing site or 'hot spot' for screening against PM and YR disease of wheat.

PP101(On)3B: Identification of resistant rootstocks of egg plant to bacterial wilt and their application in development of grafted saplings with resistance to bacterial wilt

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Bacterial wilt (BW) causes huge crop loss in eggplant in the tropics. Grafting commercial cultivars onto selected rootstocks is an effective approach to control wilt disease without requiring large breeding cycles. We screened 26 wild and cultivated eggplant accessions for tolerance to BW disease (*Ralstonia solanacearum* Biovar IIIA) in artificially created sick beds. Two each of *Solanum torvum* accessions (BCB ST 1 and IARI ST 1) and cultivated varieties Utkal Anushree and Utkal Madhuri were identified as promising rootstocks. Two widely cultivated but susceptible cultivars, Bidhan Suphala and Bidhan Supreme were grafted as scions on identified rootstocks and reproductive growth, fruit quality and disease incidence of grafted plants under bacterial wilt infected experimental and growers' fields were recorded. Although grafted plants had lower mortality and higher yield, quality of fruits was uninfluenced. '*S. torvum*'-grafted plants had some negative effects on yield and economics compared to cultivated rootstocks, suggesting least compatibility. Bidhan Suphala grafted on the cultivated rootstock 'Utkal Anushree' recorded the maximum yield and economic return than that grafted on wild rootstocks. Results suggest that Utkal Anushree could be equally and effectively used as a rootstock for controlling eggplant wilt through grafting. Commercial use of rootstock of cultivated variety for large-scale production of grafted plants could make a dent in nursery business, after critical testing across regions having different biovars.

PP102(On)3B: Screening of promising rootstocks against root rot in Citrus

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Citrus root rot caused by *Phytophthora parasitica* var. *nicotianae* is the most damaging disease in citrus cultivation in Maharashtra's Vidarbha region. To overcome the damage caused by this disease, tolerant/resistant rootstocks must be selected. In present study, twelve varied root stocks were tested in sick pot condition to determine tolerance/resistance against *Phytophthora nicotianae* during 2020-21 by inoculating 6 month old seedlings with a 20 ml spore suspension (108 cfu/ml) of *P. nicotianae* per pot. Disease incidence, feeder root rot index, percent leaf fall, and Phytophthora population density were all assessed six weeks after inoculation. The response of root stocks to the tested pathogen varied. The minimum per cent root rot incidence (4.44 %) and feeder root rot (0.63) was observed in Alemow (*C. macrophylla*) while maximum root rot incidence (28.89%) and feeder root rot (3.20) was noticed in susceptible check Rough lemon (*Citrus jambheri*). Rangpur lime Akola had the highest seedling height (27.97 cm), while root stock CRH-12 had the lowest (21.07 cm). The results showed that there were no significant differences in the population density of Phytophthora cfu/cc soil in the tested root stocks. It is thought that the rootstock Alemow is involved in citrus plant resistance to *P. nicotianae*.

PP103(On)3B: Screening and characterization of exotic germplasm of bread wheat against leaf rust disease under epiphytotic conditions

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Wheat is the foremost cereal crop consumed by approximately 2.5 billion of the global population. Among three rusts, leaf rust or brown rust caused by *Puccinia triticina* is the most common, widely distributed, and destructive disease of wheat. Climatic changes are leading to a resurgence of new pathotypes. The breakdown of very effective resistance genes of leaf rust, namely, Lr9, Lr18, and Lr28 led to the investigation of adult plant resistance (APR) and slow rust-resistant genes, which are considered more durable. In the present study, one hundred and sixty-four exotic germplasm of bread wheat were screened for leaf rust under epiphytotic conditions at G.B. Pant University of Agriculture & Technology, Pantnagar. The disease severity in different accessions was analyzed with Area Under Disease Progress Curve (AUDPC). The lines showing phenotypic resistance were confirmed using gene-specific molecular markers. Out of one hundred sixty-four germplasm accessions, eighteen were found resistant to leaf rust under field conditions (2019-2020) with lower AUDPC values. Therefore, the selection of cultivars having lower AUDPC values is acceptable for practical purposes. Molecular marker characterization revealed that out of 18 accessions that were phenotypically resistant to leaf rust, thirteen accessions were found possessing Lr19 gene and eight showed the presence of APR gene i.e. Lr67. The confirmed resistant germplasm lines against leaf rust could be utilized by the breeders to incorporate leaf rust resistance in their breeding programme.

PP104(On)3B: Identification and Quantification of Novel Sources of Resistance in Elite Pea Genotypes against Ascochyta Blight Complex

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Ascochyta blight complex of pea, is caused by three concurrently infecting fungal pathogens, *Ascochytapisi*, *Didymella (Ascochyta)pinodes* and *Phoma (Ascochyta) pinodella*. One hundred elite pea genotypes were screened for their relative resistance to three pathogens associated with blight complex including susceptible check (PB-89) both under natural as well as artificial epiphytotic conditions for two consecutive seasons. Of the one hundred genotypes evaluated five genotypes namely,Eddy, PS-24, Arya Veer, CHPMR-2 and PS-19 exhibited resistant reaction under natural epiphytotic conditions with disease severity of <15%. Under artificial epiphytotic conditions,the severity of pea blight as Area Under Disease Progress Curve (AUDPC) and susceptibility index value (Sx) were calculated. Sx value, RaRUDPC, apparent rate of infection (r)and percentage of stem girdling (%HTM) differed widely among test genotypes ranging from 1.38 to 14.34, 0.37 to 2.39, 0.06 to 0.22 and 7.03 to 68.9%, respectively indicating the high variation in test genotypes against three major pathogens of pea blight complex. The five genotypes demonstrated consistent resistant reaction to disease complex both under natural as well as artificial conditions with susceptibility index (Sx) value <2 and apparent infection rate (r) between 0.06-0.07. Maximum incubation period (IP50) with minimum percentage of stem girdling (%HTM) was recorded in genotype CHPMR-2 with the value of 7.46 days and 7.03%, respectively. Correlation analysis indicated that AUDPC was positively correlated with the percentage of stem girdling (%HTM) and disease severity (%) while, negatively correlated with IP50. The newly identified resistant sources have the potential to provide impetus to the ongoing pea disease resistance-breeding program in India. This is the first report for the evaluation of disease resistance against three pathogens of pea blight in combination under Punjab conditions.

PP105(On)3B: Fungicidal activity of the herbicidal compound, Glyphosate, against Rice blast disease on glyphosate-tolerant OsmEPSPS transgenic rice

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Rice is the second most widely-grown cereal whose productivity is constrained by weeds, insects, and pathogens primarily. For weed management, many herbicides including glyphosate [N-(phosphonomethyl) glycine], a broad-spectrum systemic chemical is extensively used in agriculture. Being a competitive structural analog to phosphoenolpyruvate, it selectively inhibits the conserved 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme required for the biosynthesis of aromatic amino acids and essential metabolites conserved among plants, fungi, oomycetes, and bacteria. In the present study, we investigated the glyphosate activity against filamentous fungus *Magnaporthe oryzae* (Hebert) Barr (anamorph: *Pyricularia grisea*) on transgenic-rice overexpressing a glyphosate-resistance *Osm*EPSPS gene (T173I + P177S; TIPS). *In vitro* minimum inhibitory glyphosate concentration was foliar sprayed on transgenic rice lines which showed both prophylactic and curative suppression comparable to a well-known blasticide, tricyclazole. Overall, the glyphosate displayed direct antifungal activity against *M. oryzae* as well as enhanced the levels of antioxidant enzymes and photosynthetic pigments. However, the defense-related genes were found repressed upon glyphosate application. Altogether, this first report highlights overexpression of crop-specific TIPS mutation in conjugation with glyphosate application showing potential for blast disease management in rice cultivation.

PP106(On)3B: Screening of wheat germplasm for spot blotch (Bipolaris sorokiniana (Sacc.) Shoemaker) resistance under epiphytotic conditions with analysis of Area Under Disease Progress Curve (AUDPC)

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Wheat ranks first among the cereal crops accounting for all cereal food worldwide. Spot blotch of wheat incited by pathogen *Bipolaris sorokiniana* (Sacc.) Shoemaker causes severe losses in productivity and deterioration of seed quality. The disease is prominent in warm-humid wheat growing areas and is of wide occurrence in the North Eastern Plain Zones (NEPZ) of India, however with the climate change its occurrence is gradually increasing in the North Western Plain Zone (NWPZ). One hundred ninety two germplasm accessions were screened against the spot blotch disease under epiphytotic conditions during 2019-20 and 2020-21. Data on disease infestation was recorded three times on regular interval and disease severity was analyzed with Area Under Disease Progress Curve (AUDPC) and infection rate. Out of 192 accessions, fifty three were found resistant for spot blotch under epiphytotic conditions during the 2019-20 crop season. Out of selected 53 accessions, three were found to be immune (accession no. 82-

IC252705; 122- IC531178 and 172- EC577738) whereas, 50 accessions were resistant to the disease during the crop season 2020-21. Within 53 accessions two (82- IC252705 and 172- EC577738) showed the lowest AUDPC values (7) with zero rate of infection. Therefore, resistant accessions having lower AUDPC values can be used by the breeders in crossing programmes for developing spot blotch resistant varieties.

PP107(On)3B: Phenotyping of Recombinant Inbreed Lines (RILs) for Sheath Blight Response in Rice

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Rice sheath blight (*Rhizoctonia solani* Kühn) is the third most important disease next to Blast and BLB. The typical symptom includes lesions that appear as circular, oblong, greenish-grey water-soaked spots on the leaf sheath near the water level. Two Oryza rufipogon accessions, namely, IC336719 and IC336721 were identified as resistant lines at Division of Plant Pathology, ICAR-IARI. An introgression line, Pusa 1908-13-12-5 (ILS12-5) was developed from the cross Pusa 1656-638/IC336719 at Division of Genetics, ICAR-IARI. The genomic regions governing sheath blight resistance in this resistant line, ILS12-5 need to be studied that may help in developing resistant rice cultivars. A RIL population of 170 genotypes was developed from ILS 12-5 and Pusa Basmati-1, which will be used for screening sheath blight response. Artificial inoculation (Typha bit method) was done at the maximum tillering stage of rice. Relative lesion height (RLH) was recorded at 30days after inoculation. The average RLH was recorded as 33.6 %. The RILs no. MSG4, MSG62, MSG84, MSG102 and MSG162 showed resistant responses having RLH value less than 20%, whereas the RILs no. MSG32, MSG50, MSG71, MSG78 and MSG99 showed highly susceptible responses having RLH more than 70%. This complete set of RIL populations will be genotyped further and will be used for identifying the genomic regions governing sheath blight resistance in ILS 12-5.

PP108(On)3B: Occurrence, Pathogenicity and Assessment of Groundnut Cultivars Resistance to Aspergillus niger Inciting Collar Rot Disease

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A survey was conducted in major groundnut growing areas of different tehsil of Jodhpur district, Rajasthan during *kharif* to assess the distribution and the incidence of collar rot diseases. The highest incidences of collar rot were observed in Phalodi (15.31 %).Whereas, least collar rot incidence was observed (10.0%) in Tewari. The overall average disease incidence of the Jodhpur district was (12.43%) based on 125 fields surveyed. Collar rot of groundnut pathogen was isolated by following standard tissue isolation method and the culture was identified through morphological and cultural characters. Pathogenicity was proved by blotter paper technique and sick pot method and the culture was compared with original culture. Twelve groundnut Cultivars along with one susceptible check (TMV-2) were screened against collar rot disease caused by *Aspergillus niger* under field condition. Among them none of entry was found immune or resistant to collar rot.

Three cultivars TG-37A, HNG-69 and GJG-22 were shown 1-10 % disease incidence and considered as moderately resistant. Four cultivars GG-20, GG-7, GL-501 and GJG-9 were shown 11-20 % disease incidence and considered as moderately susceptible. However, TMV-2 was shown > 51 % disease incidence and considered as highly susceptible reaction.

PP109(On)3B: Screening of the maize inbred lines and hybrids for resistance to Bipolaris maydis

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Maize (*Zea mays*) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. Karnataka is one of the important maize growing region in India. Maydis Leaf Blight (MLB) caused by *Bipolaris maydis* is one of the serious fungal disease of maize throughout the world which alone accounts to 6.9-62.4 % yield losses. Hence, identification and subsequent development of disease resistant lines is crucial. In the present study, infector row technique was used to identify the disease resistant sources. 70 inbreds lines and 23 hybrids were screened under natural conditions at Zonal Agricultural research station, V.C.Farm, Mandya. Artificial inoculation of virulent isolate of *Bipolaris maydis* with fungal spore suspension of 106 spores/ml at 25 DAS was carried twice per week for three weeks (with three days interval). The disease severity was recorded after 10 days of disease appearance. Initially, lesions were diamond shaped which later turned rectangular restricting to leaf veins with tan in color. Disease scoring was done using disease score scale of Hooda *et al.* 2018. It was found that, 7 inbred lines and 1 hybrid were resistant (PDI: d”33.33), 33 inbred lines and 16 hybrids were moderately resistant (PDI: 33.34-55.55), 18 inbred lines and 6 hybrids were moderately susceptible (PDI: 55.56-77-77), 11 inbred lines and none of the hybrids were susceptible (PDI: e”77.77). As, Maize crop is fastest growing crop in recent years identification of resistant sources helps in developing resistant hybrids and varieties to prevent yield loss.

PP110(On)3B: Biochemical basis of resistance in maize genotypes against Rhizoctonia solani f. sp. sasakii causing banded leaf and sheath blight (BLSB) disease

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The experiment was conducted in the glasshouse at the Department of Plant Pathology, UAS, Dharwad, during *kharif* 2019. The seedlings of selected maize genotypes were raised in pots and replicated thrice. After 40 days of sowing, the local isolate (*RsKH*) of *R. solani* f. sp. *sasakii* was inoculated on test entries *viz.,* CI-5, BIO9682 (resistant); CI-4, KDMI-16, CM202, and GPMH1101 (moderately resistant); CM501 and GPM 744 (moderately susceptible); and GPM 649, GPM 608 and DKC7074 (susceptible), by placing 5 days old fungal disc between the rind and the leaf sheath of test entries. Un-inoculated plants of each test entry serve as a check. After 8 days of inoculation, the leaf samples were collected from both inoculated and uninoculated maize test entries to estimate the activities of defense enzymes *viz.,* Peroxidase (POX), Polyphenol oxidase (PPO), Phenylalanine ammonia-lyase (PAL), and total phenols. The infected, as well as healthy leaf samples, were collected to carry out the biochemical analysis. The results revealed that the per cent increase in phenol content was higher in inoculated resistant inbred CI-5 (59.89 %) and hybrid BIO9682 (44.44 %), compared to their uninoculated counterpart. However, in inoculated susceptible entries the rate of per cent increase of phenol content was very low (2.01 to 3.45 %). The per cent increase of POX activity in disease-resistant and inoculated maize test entries was maximum (41.15 to 42.74 %), over their uninoculated counterpart. However, it was very meager (2.04 to 3.71 %) in inoculated susceptible entries. The per cent increase in PPO activity was higher in inoculated resistant inbred CI-5 (56.69 %) and hybrid BIO9682 (45.23 %), compared to their uninoculated counterpart. However, in inoculated susceptible entries the rate of per cent increase of PPO activity was very low (7.88 to 10.18 %). The per cent increase of PAL activity in disease-resistant and inoculated maize test entries was maximum (38.74 to 42.47 %), over their uninoculated counterparts and it was very low in inoculated susceptible entries (2.38 to 3.33 %). Thus, the defense molecules produced against the pathogen showed a key role in imparting disease resistance to maize BLSB.

PP111(On)3B: Selection of a highly pathogenic Fusarium oxysporum isolate and screening brinjal (Solanum melangena L.) germplasm accessions for vascular wilt resistance

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Fusarium oxysporum inciting vascular wilt is one of the major limiting factors for the successful cultivation of brinjal. Presently, the disease is being managed by fungicides with no adequate control. Controlling by use of fumigants such as chloropicrin and dazomet though largely effective in greenhouse cultivated brinjal plants, are expensive and time-consuming. The use of chemicals may affect the environment, and inflict the development of fungicide resistant strains. The use of resistant cultivars appears to be the most effective, and eco-friendly method of disease control, if available. Fungal isolates representing 14 locations and preserved as laboratory collections were characterised on the basis of their cultural, and morphological characteristics. The putative *Fusarium* spp. identified from the above studies were then assessed for their pathogenicity on a vascular wilt susceptible cultivar. An isolate, BRFO-VRF8 was identified as the highly aggressive isolate and hence its identity was confirmed by sequencing of ITS region and translation elongation factor 1-alpha (EF-1±) gene. The sequences established the identity of the isolate as *F. oxysporum.* In phylogenetic analysis, the strain displayed 100% homology with other *F. oxysporum* isolates available in the database. In screening 17 germplasm accession cultivars available in the Division of Vegetable Science for vascular wilt resistance, root dip inoculation with the BRFO-VRF8 identified three cultivars, 271, 78, and 270 as highly resistant for displaying no wilt incidence, whereas three cultivars, 87, 76 and 89 were identified as the highly susceptible ones for displaying complete wilting. The resistant cultivars may serve as a potential source of resistance genes for further applications.

PP112(On)3B: Development of rapid inoculation protocol for Ganoderma in oil palm for screening for levels of resistance

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Basal stem rot (BSR) caused by *Ganoderma* spp. is a major impediment to India's efforts to achieve palm oil self-sufficiency. To date, numerous control strategies have been attempted for BSR, but none are completely effective due to perennial nature of the oil palm, high inoculum load and lack of early detection tools. Proving pathogenicity of BSR by conventional rubber wood block and soil inoculation techniques is a laborious and prolonged task owing to slow disease progress which will further delay useful research on the disease. A study on evaluation of effectiveness and rapidity of different inoculation protocols *viz*., root immersion (T1), root immersion+ soil inoculation (T2), soil inoculation(T3) was conducted on 4 months old oil palm seedling based on disease progression and scoring of external and internal severity. Early manifestation of symptoms was achieved within 15 days post inoculation *only in T1 and T2 with mean severity for external symptoms 70% and 80%, respectively.* Koch postulates were validated by reisolating cultures on *Ganoderma* selective medium and also confirmed the morpho molecular identity using Ganoderma specific primers (*Gan 1* and *Gan 3*). Hence, the root immersion methodology can be used as a standard and routine inoculation method for evaluation of fungicide, bioagents, pathogenic race determination and genetically controlled resistance. Another study conducted to discriminate different progenies of 5 DXP and 3 DXD crosses revealed varying levels of susceptibility based on foliar, stem and bole severity at 15, 30, 45 and 60 days after inoculation. The developed technique will help in accelerating research in identifying resistant oil palms for sustaining economic benefits of the palm oil industry.

PP113(On)3B: Genetic dissection and anthracnose resistance QTL mapping in common bean landrace-KRC5

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KRC-5, an Andean landrace of common bean native to Himachal Pradesh, has been characterized as resistant to more than 17 *Colletotrichum lindemuthianum* races. The current study is the first of its kind in the world wherein a BSA-seq was used to map anthracnose resistance genes in KRC5. Pathogenicity tests using 119 Recombinant Inbred Lines (RILs) produced by crossing Jawala (sensitive parent) with KRC5 (resistant parent) were performed against race 3 and race 211 to discern the genetic basis of anthracnose. The segregation revealed that the 3R:1S and 1R:1S Mendalian ratios were well-fit. For Whole Genome Sequencing on the Illumina HiSeq platform, 36 distinct samples (18 resistant and 18 susceptible) were used to map resistance gene. After BSA Seq we found a unique region in KRC-5 imparting resistance to two anthracnose races. This region mapped to Pv10 at a physical position of 4.0 to 4.1 Mb using Single Nucleotide Polymorphism (SNP) markers. To map the gene using PCR based markers a physical region between 3.0 to 5.1 Mb was searched for Simple Sequence Repeat (SSR) and Insertion Deletion (InDels) markers. We designed 100 InDels, and 100 SSRs markers. Polymorphism survey using

parents and two bulks (Bulk Segregant Analysis) has yielded 5 polymorphic Indels and 2 polymorphic SSRs so far.

PP114(On)3B: Screening of mustard varieties against White rust and Alternaria blight

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Mustard is one of the most important cruciferous crops which are grown basically for oil. The crop is infesting by many diseases prominently fungal diseases which cause limitation in the productivity of the crop. White rust (*Albugo candida*) and *Alternaria* blight (*Alternaria brassicae*) are the most serious fungal diseases of mustard. The study was conducted to find out the resistant response of mustard varieties against these fungal diseases. To screen the rice varieties, a field experiment was conducted in *Rabi* season of 2021-22 at Research Farm of Amar Singh (PG) College, Lakhaoti, Bulandshahr (UP). Among the tested sixteen mustard varieties, four mustard varieties like PT-305, PM-44, Kanchan and MYSL-203 were shown resistant against white rust disease. Whereas, thirteen tested mustard varieties like Jagannath, Radhika, Hybrid-805, Dev-142, Nandi bull, Araurali, 45L46 Lohiya, Kranti, Pusa Mahal, Pusa Vijya, PM-31 and Rh-149 were susceptible of white rust disease. Infection of *Alternaria* blight was observed in all tested mustard varieties. Postules of white rust on lower surface of leaves were starting appear after 5th January (Temperature min. 70C to max. 190C). The highest incidence of white rust on leaves was observed from 16 January to 08 February (Temperature ranging min. 8 - 100C and max. 20 - 220C). Incidence of *Alternaria* blight was regularly increasing after 28 January.

3C. Success stories in plant diseases management

PP115(On)3C: Finger millet blast disease management by using bio-agents and fungicide under field condition

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Finger millet blast incited by *Magnaporthe grisea* is an important fungal disease causing more yield loss and economic loss in major ragi growing regions. The present field management study was undertaken to identify potential bio-agents against *Magnaporthe grisea* infecting ragi. An field experiment was conducted at Agricultural Research Station, Vizianagaram during *kharif:* 2021-22 to control the blast disease with different bio-agents and chemicals which includes, Seed treatment with Chitosan @3.75g/kg seed + 2 sprays of *Pseudomonas fluorescens* @10g/l after 20 DAS and 35 DAS, Seed treatment with Chitosan @3.75g/kg seed + 2 sprays of *Bacillus subtilis*@10g/l after 20 DAS and 35 DAS, Spray treatment with *Pseudomonas fluorescens* @10g/l 20 DAS and Trifloxystrobin + Tebuconazole @ 0.04% after 35 DAS, Spray treatment with Trifloxystrobin + Tebuconazole @0.04% 20 DAS and *Bacillus subtilis* @ 10g/l after 35 DAS, Trifloxystrobin + Tebuconazole @ 0.04% 2 sprays after 20 DAS and 35 DAS along with a control. Among the treatments, spray treatment of *Pseudomonas fluorescens* @10g/l 20 DAS and Trifloxystrobin + Tebuconazole @ 0.04% 35 DAS proved to be best in controlling the disease with lowest leaf blast disease severity (2.3 Grade), neck blast (11.3%) and finger blast (9.0%) with highest grain yield of 1539.0 kg/ha and fodder yield of 3827.0 kg/ha. However, highest disease severity (leaf blast-8.3 Grade; Neck blast-83.5% and Finger blast-84.5%) with less grain yield (823.4 kg/ha) and less fodder yield (2413.2 kg/ha) was recorded.

PP116(On)3C: Exploring plant disease antagonistic behavior of fungal entomopathogen Beauveria bassiana (Balsamo) Vuillemin against Rhizoctonia solani Kuhn causing sheath blight disease of rice

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Beauveria bassiana being a widely studied entomopathogenic fungus recently drawn attention worldwide as potential biocontrol agent not only against insect-pests but also against several plant pathogens. In the present study, we evaluated antagonistic abilities of fifty-three *B. bassiana* against *Rhizoctonia solani* both under *in vitro* and field conditions. The results showed that only 15 isolates of *B. bassiana* showed efficient antagonistic abilities against *R. solani* with maximum per cent mycelial inhibition recorded up to 71.15%, whereas, the mechanisms were identified as production of cell wall degrading enzymes *viz.,* á-amylase, caseinase, cellulase, lipase, siderophore and virulent genes i.e., Bbchit1 and Cdep1 encoding for chitinase and subtilisin-like protease enzymes. Under field condition, application of liquid based microbial consortium of five potential *B. bassiana* isolates as seed treatment, seedling root dip and four foliar sprays of 10 ml in 1000 ml water at 15 days interval at 60 days after transplanting, resulted in 65.80 % lower sheath blight disease production and double the yield in treated plots as compared to control plots. From the present study, the hidden, diversified role of *B. bassiana* as plant disease

antagonist and plant growth promoter were identified in addition to its exclusive insect pathogen behavior, which further adds new dimension in crop protection by introducing newer concept in Integrated plant disease management programmes along with overall health of plant.

PP117(On)3C: Effect of different spray modules on vector population and leaf curl incidence in chilli

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Chilli is an important vegetable cum spice crop grown in almost all parts of tropical and subtropical regions of the world. Leaf curl disease of chilli is a serious problem in all the major chilli growing area of India. For the management of viral diseases, preventive measures are more economically justified and not a single method of control is likely to keep crops entirely free from virus infection. Therefore,the present study was carried out at Horticultural research cum instructional farm, COA, IGKV, Raipur (C.G.) for two consecutive rabi seasons (viz., 2018-19 and 2019-20) where, eight spray modules were tested by incorporating them in an integrated pest management practices *i.e,* vector proof nursery net, seedling dip treatment with fungicidal solution Carbendazim 50 WP, along with silver polythene mulch in the main field and growing of 2 rows maize as border crop, one month before tranplantation, to find out the best suited and cost-effective spray module for the management of chilli leaf curl complex. All the eight spray modules were able to reduce the whitefly population significantly.Maximum percentage reduction of disease (*chilli leaf curl*) was observed in T6 (Spray of Spinetoram 11.7% SC w/w @ 0.1% + neem oil @ 2ml/l + Thiomethoxam 25.00% w/w 1ml/ 2l water in rotation).Spray of Cyatraniliprole 10.26 OD @1.8ml/ l + Neem oil @ 2ml/l in rotation recorded highest marketable yield (46.5 q/ha). However, the best benefit ratio (1:23.1) was achieved in T5 (spraying of *Beauvaria bassiana* + Neem oil @ 2ml/l water in rotation).

PP118(On)3C: In vitro efficacy of different bioagent against Rhizoctonia solani Kuhn, the incitant of sheath blight of rice

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Rice (*Oryza sativa*) belongs to Poaceae family. India has the largest area under rice and is the second largest producer of rice after China. The rice crop is attacked by more than 70 diseases caused by fungi, bacteria, viruses. Out of these *Rhizoctonia solani* Kuhn which incites sheath blight of rice is major and most widespread disease. In the current era it is required to judiciously use the pesticides or to use other control measure for prevention of diseases without usage of pesticides. Interest in biological control has increased recently fuelled by public concern over the use of agrochemicals and the need to find alternatives to the use of chemicals for diseases control. The key to achieve successful and reproducible bio control is to understand ecological interactions occurring in the system. To evaluate the antagonistic activity of biological agent against *Rhizoctonia solani*, a total of six biological agents named *Trichoderma harzianum* strain KBN-29, *Trichoderma harzianum, Trichoderma viride, Pseudomonas fluorescens, Pseudomonas* *maltophila, Bacillus subtilis* were tested in vitro against fungus. Among these *Pseudomonas fluorescens* was most effective followed by *Pseudomonas maltophila* and *Bacillus subtilis* was least effective. The biological agents also had inhibitory effect on sclerotial formation. The promising biological agent could be exploited for their antagonistic activity against *Rhizoctonia solani* Kuhn. These biological agents are environmentally safe and do not have any residual effect. Hence looking at the present scenario biological agent can be a better substitute for pesticides.

PP119(On)3C: Biogenic Synthesis of Silver Nanoparticles using Aqueous Leaf Extract of Tagetes erecta and Evaluation of their Antifungal Activity against Phytopathogenic Fungi

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Recently, nanotechnology has emerged as a dynamically developing area of scientific interest in the world. Nanoparticles are defined as a nanoscale particle of size ranging from 1 to 100 nm. Nanoparticles show the multidisciplinary versatile utility and are gaining the prime place in various fields such as medicine, electronics, pharmaceuticals, electrical designing, cosmetics, food industries and agriculture, due to their small size and large surface to volume ratio. Among the metallic nanoparticles, silver nanoparticles (AgNPs) have gained increasingly attention due to its unique physical, biological and chemical properties. AgNPs are well-known to exhibit a strong antimicrobial activity against various microorganisms such as bacteria, viruses, and fungi due to its smaller in size and large surface area. AgNPs are also widely used as anti-fungal, anti-inflammatory, and anti-viral properties. Biogenic or green synthesis methods are environmentally friendly, economically feasible, rapid, free of organic solvents and reliable over conventional methods. Plant extracts are of incredible potential in the biosynthesis of metal nanoparticles owing to their bountiful availability, stabilizing and reducing ability. In the present study, the aqueous leaf extract of *Tagetes erecta* was mixed with 0.5mM silver nitrate and incubated at 70°C for 1hr and synthesized a good quantity of AgNPs. The synthesized AgNPs were characterized using UV-Visible spectroscopy, X-ray diffractometry (XRD), transmission electron microscopy (TEM) and scanning electron microscopy (SEM). Furthermore, SEM and TEM results inferred that the size of the particles was 20-61nm, spherical, crystalline, uniformly distributed and negatively charged. In addition, the antifungal activities of the AgNPs were evaluated against two phytopathogenic fungi *Fusarium oxysporum* f. sp. *ciceri*s and *Rhizoctonia bataticola* causing wilt and dry root rot of chickpea respectively *in vitro* using poison food technique on PDA media. The maximum rate of mycelia inhibition was found in 150ppm concentration of AgNPs against both phytopathogenic fungi.

PP120(On)3C: In vitro, Efficacy of Fungicides to control stem rot of groundnut (Arachis hypogaea L.) caused by Sclerotium rolfsii Sacc.

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Groundnut (*Arachis hypogaea* L.) is an important oilseed crop of tropical and subtropical regions of the world. Groundnut is called as 'King' of oilseeds on account of its diversified uses. Groundnut is reported to have originated from South America. Groundnut is the 13th most important food crop and 3rd most important oilseed crop of the world. In India, groundnut is grown in four seasons, namely, *Kharif* (85 %), *Rabi* (10 %), Summer (4 %) and Spring (less than 1 %). Stem rot caused by *Sclerotium rolfsii* Sacc. is one of the most widely spread and destructive disease of groundnut (Arachis hypogea L.). About 27% or more yield loss due to this disease has been reported from India and 25% yield loss in Maharashtra. Among the systemic, non-systemic and combi fungicides tested in vitro against *Sclerotium rolfsii* Sacc. However, systemic fungicide viz., Tebuconazole (92.97 % @ 500 ppm and 94.36 % @ 1000 ppm), Non-systemic fungicide Mancozeb (94.00 % and 94.44 %), Combi-fungicide Carboxin 37.5% + Thiram 37.5% (94.35 % and 94.44 %) at 1500 ppm and 2000 ppm recorded significantly highest average mycelial inhibition of the test pathogen.

PP121(On)3C: Biological control of charcoal rot in chilli (Capsicum annuum L.) by glycolipid producing streptomyces puniceus RHPR9

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Chilli (*Capsicum annuum* L.) is a major vegetable, spice crop and in India, a number of soil-borne fungi have been found to cause diseases in the chilli crop that results in significant yield loss. *Macrophomina phaseolina, Fusarium oxysporum, Phytophthora capsici* and *Sclerotium rolfsii* are few of the soil-borne fungi used in this study. *In vitro* and *in vivo* anti-fungal studies were carried out with the Streptomyces spp. isolated from the rhizosphere of *Coscinium fenestratum Gaertn,* an endangered medicinal plant from Western Ghats of Karnataka, India. Inhibition percentages calculated with *Streptomyces puniceus* RHPR9 against *M. phaseolina* (76±0.1%)*, F. oxysporum* (62±0.1%), *P. capsici* (57±0.2%) and *S. rolfsii* (52±0.1%), with a severe inhibitory effect on fungal growth. In chilli plants treated with *M. phaseolina* and *S. puniceus* RHPR9 there was a substantial increase in the formation of peroxidase (POX), polyphenol oxidase (PPO) and phenylalanine ammonia lyase (PAL) enzymes compared to the control. *S. puniceus* RHPR9 also showed different plant growth promoting traits and glycolipid biosurfactant production.

PP122(On)3C: Evaluation of fungicides for antioomycete activity against Phytophthora spp., the incitant of foot rot in black pepper

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Foot rot caused by the oomycete pathogen *Phytophthora* is an economically important disease of black pepper. Sustainable management of *Phytophthora* incited diseases with synthetic fungicides often pose long-term threat to agricultural ecosystems since repeated and non-judicious application might result in resurgence of resistant strains. Hence, it is highly imperative to analyze the efficacy of new generation molecules with diverse mode of actions and generate preliminary information so as to subsequently device effective disease management modules. In the present study, thirteen systemic, contact and combination of systemic-contact fungicides were evaluated for their efficacy against *P. capsici* and *P. tropicalis* under *in vitro* condition. Propineb, Bordeaux mixture, metalaxyl-mancozeb, copper oxychloride, cymoxanil-mancozeb, fluopicolide-propamocarb and iprovalicarb-propineb completely inhibited mycelial growth of *P. capsici* at their recommended concentrations. Sporangial production of *P. capsici* was significantly reduced by cymoxanil-mancozeb and chitosan oligosaccharide. The hyphae of *P. capsici* exhibited abnormalities like hyphal swelling with propineb and chitosan oligosaccharide treatments. *P. capsici* also found to be insensitive towards metalaxyl, chlorothalonil, kresoxim methyl, potassium phosphonate, penflufen-trifloxystrobin and chitosan oligosaccharide. Whereas, *P. tropicalis* was found to be sensitive to Bordeaux mixture, metalaxyl-mancozeb, copper oxychloride, cymoxanil-mancozeb, fluopicolide-propamocarb and iprovalicarb-propineb at recommended concentrations. Sporangial production was significantly inhibited by Bordeaux mixture and iprovalicarb-propineb. Abnormalities in hyphal architecture were caused by propineb, potassium phosphonate and chitosan oligosaccharide. *P. tropicalis* was found to be resistant towards metalaxyl, chlorothalonil, propineb, kresoxim methyl, potassium phosphonate, penflufen-trifloxystrobin and chitosan oligosaccharide. Both the isolates also exhibited cross resistance towards certain categories of fungicides.

PP123(On)3C: Post-harvest management of banana anthracnose (Colletotrichum musae Berk. & Curt.) by integrating fungicides, plant-based products and biocontrol agents

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Banana (*Musa paradisiaca* L.) is an important commercial fruit crop in tropical and sub tropical regions which can be grown round the year. It is a staple food for millions of people. The fruits are used both for cooking and post harvest products like chips, flour, jam, jelly and drinks. The post-harvest loss is 25 to 30% due to its perishable nature, improper handling, lack of storage and post harvest diseases. Fruits suffer from many serious diseases such as anthracnose, crown rot, finger rot, white rot, cigar end rot etc. The fungus *Colletotrichum musae* can cause both crown rot and anthracnose. In this study, for its management different fungicides, essential oils, phytoextracts and biocontrol agents were tested by fruit dip method. Results revealed that fruit treatment with carbendazim 12% + mancozeb 63% WP tested at 0.05% concentration gave minimum disease intensity (11.54%) and it was significantly superior over control and remaining other treatments. For obtaining residue free organic banana fruits cinnamon oil at 0.1% and *T. harzianum* (106 cfu/ml) were found best which minimized 36.87 and 52.89 per cent disease, respectively. Minimum weight loss of 9.31% was recorded in carbendazim 12% + mancozeb 63% WP and shelf life of fruits treated with these was also more (10 days) as compared to the untreated control fruits (3 days). Therefore, by economical and eco-friendly disease management shelf life and storage time of banana fruits were increased and maintained the quality of fruits.

PP124(On)3C: Utilization of fungal biocontrol agents against rice sheath blight disease provides insight into their role in plant defense responses

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Rice production worldwide is affected by various biotic and abiotic stresses. Among biotic stresses, diseases are considered as major constraints for rice production, in which rice sheath blight (*Rhizoctonia solani Kühn*) is one of the most important disease which cause major damage to crop. In recent times, biocontrol of fungal plant pathogens appears as an attractive and realistic approach. Present investigation was undertaken to evaluate different biocontrol agents like *Talaromyces flavus*, *Chaetomium globosum, Pseudomonas fluorescens* and *Aspergillus niger* against sheath blight disease of rice. Prior to sowing seeds were bioprimed with each isolates and were sown in nursery. After 21 days seedlings were transplanted under field conditions and were inoculated with virulent isolate of *Rhizoctonia solani* at maximum tillering stage. Observations on biochemical parameters and gene expression studies were carried out at 24, 48, 72 and 96 hours of post inoculation. Enzymatic activity viz., chitinase, â-1-3, glucanase, catalase and phenylalanine ammonia lyase was observed maximum in *Chaetomium globosum.* The pathogenicity related genes viz., Inorganic phosphate transporter (IPT), Bromodomain (BrD), Heme peroxidase (HmPr), AMP binding domain (AMP), Aldehyde dehydrogenase (AldD), Nuclear pore protein (NIC) and Lissencephaly-1 homolog (LisH) showed up-regulation at 96 hpi. *Chaetomium globosum* had highest yield having maximum number of tillers as well as least relative lesion height as compared to all other treatments. The expression of pathogenicity related genes are found to be less in biocontrol treatments as compared to the inoculated control.

PP125(On)3C: Bacterial endophytes mediated growth promotion and suppression of Fusarium wilt in banana (Musa spp.)

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Beneficial bacterial endophytes isolated from the *Fusarium* wilt resistant banana cv. Yengambi KM 5 (AAA) (YKM 5) were used in the current study. The pot culture experiment was consists of seven treatmental combination of endophytes *viz*., *Brachybacterium paraconglomeratum* +

Bacillus amyloliquefaciens, *Brachybacterium paraconglomeratum* + *Bacillus velezensis, Brucella melitensis* + *Bacillus amyloliquefaciens, Brucella melitensis* + *Bacillus velezensis, Myroides odoratimimus* + *Bacillus amyloliquefaciens, Myroides odoratimimus* + *Bacillus velezensis,* and control. Data from the pot culture study revealed that banana cv. Ney Poovan (AB) inoculated with *Brachybacterium paraconglomeratum* + *Bacillus amyloliquefaciens* (T_1) registered better values for all the morphological attributes *viz.,* pseudostem height, pseudostem grith, phyllochron, number of leaves, total leaf area, number of roots and root length observed during primary and secondary hardening stages compared to control (T_7). Similarly, physiological attributes observed at secondary hardening stage revealed that better values were registered in banana cv. Ney Poovan (AB) inoculated with *B. paraconglomeratum* + *B. amyloliquefaciens* when compared to control (T_7). Adding to that, banana cv. Ney Poovan (AB) biohardened with *Brachybacterium paraconglomeratum* + *Bacillus amyloliquefaciens, B.paraconglomeratum* + *Bacillus velezensis* challenged with *Foc* revealed that there is no external and internal disease expression during entire period of pot culture study whereas, a disease score of 3.0 with 100% severity were observed in control (T_7). GCMS analysis of root exudates from the different bacterial endophyte combinations revealed that Stigmasterol have the highest proportion among the other volatile compounds when challenged with *Fusarium* pathogen which showed significant antimicrobial activity in plants. Similarly, other volatile compounds observed in high proportions in the present study are Methyl stearate which promoted the banana growth and inhibited the nematode damage whereas, hexadecanoic acid showed mechanism of stress tolerance in plants which although contributed to improving the plant's innate defence mechanism against biotic stresses. Scanning electron micrographs of biohardened banana plantlets with *Bacillus amyloliquefaciens* revealed that it is successfully colonised in the root proliferation zone whereas, control (T_7) plants produced an enormous amount of micro and macroconidias of *Fusarium oxysporum* f. sp. c*ubense*. Data on the morphological attributes of biohardened plantlets under field condition revealed that values are significantly differed among treatments.The endophytes combination, *Brachyybacterium paraconglomeratum* + *Bacillus amyloliquefaciens* inoculated plantlets registered highest values for morphological attributes during 3MAP and 5MAP compared to other endophytic bacterial combinations. In the light of foregoing, it is inferred that endophytes isolated from the resistant banana cv. YKM 5 (AAA) had ability to induce plant's innate defence mechanism through growth promotion and production of volatile compounds. Hence, *Bacillus paraconglomeratum* YEBPT2 (MK263736), *Bacillus amyloliquefaciens* YEBFL3 (MT326231) and *Bacillus velezensis* YEBBR6 (MT372157) with their antifungal activity against *Foc* and diverse biomolecules produced during the ditrophic interaction with *Foc* can be further investigated for commercial exploitation in order to manage different races of *Fusarium* in the context of emerging thread from *Foc* TR4 in bananas.

PP126(On)3C: Efficacy of biocontrol agents on dry root weight of cowpea infected with Rhizoctonia solani and Fusarium oxysporum

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Forage crops have a major importance in Indian agriculture. Among the various Forage legumes, Cowpea (*Vigna unguiculata* (L) walp) belongs to family Fabaceae, is one of the most important fodder legume and also the most ancient crops known to man. The fungi *Rhizoctonia solani* and *Fusarium oxysporum* is the most widespread and destructive plant pathogen causing root rot in cowpea. These pathogens are restricted to infect the crop either alone or as a complex there by resulting in rots before and after emergence of seedling and wilting of plants. The efficacy of biological control agents on dry weight of cowpea (*Vigna unguiculata* (L.) Walp) was studied at bundelkhand region. Study reveals that maximum increase in the dry weight of root was observed due to *Trichoderma harzianum* followed by *Trichoderma viride* at various doses. Both the biological agents, *Trichoderma harzianum* and *Trichoderma viride* acted more effectively at 10 to15 g dose. The study also reveals that other two *Trichoderma* species namely *Trichoderma pseudokoningii* and *Trichoderma koningii* did not visualize any significant difference in their efficacies when compared from each other. The least effective biological agents were *Aspergillus flavus* and *Aspergillus niger* when compared with other bioagents. The data also indicate that the efficacy of all treatments significantly varied at different concentration. However, a gradual increase in dry root weight of cowpea plant was recorded with increase of dose. The most effective dose was recorded as 15g/kg seed dose but a reverse trend was observed at lower dose 2g/kg seed dose.

PP127(On)3C: In vitro efficacy of fungicides against Alternaria lini causing Alternaria blight of linseed

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Alternaria lini casing *Alternaria* blight is probably the main disease problem facing the linseed grower. *Alternaria* blight can cause severe damage to seedlings; seedlings may be seriously weakened or killed which may result in substantial reduction in plant stand. A total eight fungicides at their recommended dosages were evaluated *in vitro* by poisoned food technique, against *Alternaria lini* causing *Alternaria* blight of linseed. The systemic fungicides *viz*., Carbendazim 50% WP, Thiophanate methyl 70% WP, Tebuconazole 25% WG, contact fungicides viz., Captan 75% WP, Mancozeb 75% WP and combi fungicides *viz*., Carboxin 37.5% + Thiram 37.5% 75 WP, Carbendazim 12% + Mancozeb 63% WP were evaluated. However, the fungicide *viz*., Carboxin 37.5% + Thiram 37.5% 75WP was found most effective with 92.04 per cent mycelial growth inhibition of *Alternaria lini* followed by Tebuconazole 25% WG (89.93%), Captan 75% WP (72.37%), Carbendazim 12% + Mancozeb 63% 75WP (60.11%), Mancozeb 75% WP (28.82%), Carbendazim 50% WP (22.15%) and Thiophanate methyl 70% WP (12.26%) were found effective against *Alternaria lini*.

PP128(On)3C: Integrated approach for the Management of Yellow Mosaic Disease of Blackgram (Vigna mungo L.) at farmeJrs field

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Blackgram (*Vigna mungo* L.) is one of the important pulse crop grown throughout India. It contains protein (25%), carbohydrates (60%) and fat (1.3%) and considered as the richest source of phosphoric acid among all the pulses. It accounts 13% total pulses area and 10% total pulses production in India. Since pulses are an important source of protein hence play an important role in maintaining nutritional standards in India which is predominately a vegetarian country. Thus, to increase pulse production has been central to agricultural policy. In Panna district the productivity of Black gram crop was 680 kg/ha during 2016-17 which was quite low as compared to the yield potential of the variety. Yellow Mosaic disease (YMD) of blackgram is a major constraint to reduce the production and productivity of blackgram crop in the district. Yellow mosaic disease caused by Mungbean Yellow Mosaic Viruses (YMVs) is of key importance especially in South and Southeast Asia. The disease spread to the blackgram crop through whitefly (*Bemisia tabaci* Gennadius) - an insect vector for YMVs, the virus enters the phloem cells of the host through the whitefly proboscis and the viral aggregates appear in the host cell nuclei roughly two days before the symptom appearance. The visible symptoms appear as scattered yellow-colour spots on the young leaves which later turns into a yellow mosaic pattern and ultimately results in complete yellowing, drying and withering of leaves. The pods on the infected urdbean plant become smaller in size, yellowing of the leaves decreases the photosynthetic efficiency which ultimately manifested as severe yield loss. Therefore, in order to curb the negative impact of the disease, an integrated disease management module was assessed for the management of yellow mosaic disease of blackgram at farmer's field during 2017-18 to 2019-20. The module was comprised of deep summer ploughing, use of YMV resistant variety (Pratap Urd-1), seed treatment with Carboxin + Thiram @ 2 g/kg, Thiamethoxam (70 WP) @ 3 g/kg followed by Rhizobium and PSB cultures @ 10 g/kg seed and foliar spray of Thiamethoxam (25 WG) @ 100 g/ha at 30 DAS. Higher production (9.3 Qt/ha) was obtained from the assessed field as compared to control plot (6.5 Qt/ha). Higher disease incidence (35%) was also recorded from the control plot as compared to assessed plot (5.8%). Higher net income (Rs. 34604/ha) and benefit cost ratio (1:2.9) was also obtained from the assessed field as compared to control plot (Rs.21090/ha) and (1:2.3) respectively. Thus, this technology must be disseminated among farmers through various extension activities for successful management of YMV of blackgram.

PP129On)3C: Effect of fungal endophytes of soybean (Cv. JS335) on growth parameters and charcoal rot disease incidence of soybean

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Use of chemicals for growth enhancement and disease control in plants has resulted in hazardous influences to the environment and human health. Therefore, less harmful methods should be implemented and the possibility of using microbes for this purpose has been investigated.

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Endophytic fungal assemblages have been known to enhance plant growth and decrease disease incidence in some crops including soybean and thus can be used as an alternative to chemicals. A total seven effective fungal endophytes *in vitro*, which were evaluated to assess their efficacy against *M. phaseolina*, by sick soil method, in polybags, under screen house condition, they also influenced on growth parameter of soybean (Cv. JS-335), thereby improving seed germination, root length, shoot length and seedling vigour index (SVI) in soybean. In the present study, the results were obtained on per cent mortality (pre-, post emergence and average) and reductions, over untreated control. Fungal endophytes *viz*., *Paecilomyces lilacinus*, *Aspergillus niger*, *Fusarium oxysporum* and *Penicillium* sp. were found most effective in reducing the mortality (PRESR, POESM and average) over untreated control, against *M. phaseolina* in soybean.

PP130(On)3C: Potential of underutilized food crops and their integrated protection techniques

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With the increasing population and fast depletion of natural resources, it became necessary to explore the possibilities of using newer indigenous plant resources. Agriculture in today's context is one of the most important sources of renewable wealth in the world. There are many plants species still lying unexplored and underexploited. Therefore, there has been focused attention by the researchers on exploiting alternative or underutilized plant species for multifarious use. The underutilized foods can be defined as "the foods which are less available, less utilized or rarely used or region specific" (William and Haq, 2002). Underutilized crops are lesser-known plant species in terms of marketing and research, but well adapted to marginal and stress conditions. They have potential to contribute to poverty eradication through employment or income generation and provide crop diversification and global food security and better nutrition. Plant diseases are fact of life for gardeners. Although, these plants are well adapted in stress or harsh conditions but each species is susceptible to characteristic diseases when it is grown on a commercial scale. Plant diseases are the major constraints in increasing the productivity of these crops. In Rajasthan, many underutilized crops are kair (*Capparis decidua*), lasora *(Cordia myxa),* pilu *(Salvadora oleoides),* khejri (*Prosopis cineraria*), phalsa (*Grewia subinaequalis*), karonda (*Carissa carandas*), prickly pear (Opuntia ficus-indica), kachri (*Cucumis melo* var. *callosus*), snap melon (*Cucumis melo* var. *momordica*), bathua (*Chenopodium album*) and shatavari (*Asperagus officinallis) etc.* During the cultivation of these UUC's different types of fungal, bacterial and viral problems have to be faced by a farmer. The successful and profitable agriculture industry largely depends on the adoption of improved agricultural practices. A principle of plant disease management broadly includes preventive measures and curative measures that cure the plants suffering from diseases. But none of the control methods when applied individually provide satisfactory and effective disease control. Hence, Integrated Disease Management (IDM) is the complete solution of all the disease problems.

PP131(On)3C: In vitro efficacy of bioagents against Fusarium oxysporum f.sp. melongenae, causing wilt of Eggplant

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Eggplant (*Solanum melongena* L.) is a major vegetable crop grown in India and prone to many diseases. Among different diseases, wilt caused by *Fusarium oxysporum* f.sp. *melongenae* is one of the most important disease causes drastic losses in crop yield. *F. oxysporum* f.sp. *melongenae* is soil borne pathogen and difficult to manage by use of fungicides alone. Therefore, *in vitro* study was attempted to evaluate the *in vitro* efficacy of nine potent bioagents *viz*., *Trichoderma asperellum, T. koningii, T. hamatum, T. harzianum, T. longibrachiatum Aspergillus niger, Metarhizium anisopliae, Verticillium lecanii* and *Pseudomonas fluorescens* against *Fusarium oxysporum* f.sp. *melongenae*, during 2020-21, at the Department of Plant Pathology, College of Agriculture, Latur. All tested bioagents were found significant in controlling mycelial growth of pathogen over control. However, *Trichoderma harzianum* (91.51%) was found most effective with maximum mycelial growth inhibition of *F. oxysporum* f.sp. *melongeane* followed by *T. hamatum* (89.38%) and *T. longibrachiatum* (85.73%). *Aspergillus niger* (85.25%) and *T. koningii* (82.33%) were found equally significant in inhibiting the mycelial growth of pathogen. *T. asperellum*, *Metarhizium anisopliae*, *Verticillum lecanii* and *P. fluorescens* were inhibited mycelial growth up to 81.00%, 77.18%,73.48% and 55.29%, respectively.

PP132(On)3C: Management of Linseed Wilt (Fusarium oxysporum f.sp. lini) through Essential oil

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Linseed (Linum usitatissimum L.), also known as flax, is a member of the family Linaceae. The essential oils are Angiosperm plants species including herbs, shrubs, and tree; extracted by Clevenger Hydrodistillation method. So, the present study was undertaken to evaluate the effects of some eco-friendly essential oils against Fusarium oxysporum f. sp lini, by which we can improve the agricultural production of linseed. As we know that essential oils are the best alternative in place of chemicals. So, in this context, seven essential oils viz., Neem, Citronela, Lemon grass, eucalyptus, clove, Peppermint and Tulsi oil are used to manage the test pathogen of linseed wilt. All were effective in inhibiting the growth of the pathogen in vitro. Azadirachta indica and Tulsi are least effective in their 1000 to 5000 PPM concentrations, but the rest are highly effective and show 100 per cent inhibition. Lemon grass is highly effective at 200 PPM concentration and Peppermint lower concentration is 50 PPM. Citronela is effective at 5 PPM concentration. All tested concentration, No growth shown on clove essential oil. They are highly effective in their all concentration. In pot conditions, lemon grass essentials are best compared to all (31.15 per cent disease reduction over control plant), followed by citronella (25.39 per cent), and Clove (24.87 per cent). Least effective in Peppermint and Neem oil.

PP133(On)3C: Isolation and identification of native strains of Pseudomonas fluorescens and test their in vitro bio-efficacy against R. solanacearum

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The Potato (*Solanum tuberosum* L.) is a vitally important starchy food crop of the world, commonly known as the "Poor Man's Friend". The potato crop is infested by many bacterial, fungal, viral and nematodal diseases. Bacterial wilt is caused by the pathogenic bacterium *Ralstonia solanacearum* (Smith) Yabuuchi. Keeping these facts in mind, the present study focusing on bacterial wilt disease of potato was carried out at the Department of Plant Pathology, College of Agriculture, Dapoli. Isolation of *P. fluorescens* was made by following the serial dilutions and pour plate technique using the specific King's B agar medium. *P*. *fluorescens* isolates were identified based on morpho-cultural characteristics and biochemical test were carried out as per the standard methods. *In vitro* evaluation of native isolates of *P*. *fluorescens* as a potential bio control agent against *R*. *solanacearum* was assessed by following the Filter paper disc plate method. Total five isolates of *P*. *fluorescens viz*., Pf1, Pf2, Pf3, Pf4 and Pf5 were isolated and all isolates were developed typical colonies on Kings' B medium as, small to medium, mucoid smooth, yellowish white glistening colonies. All isolates were gram negative and rod shaped and exhibited weak to medium yellowish green pigmentation when observed under UV transilluminator. All five isolates of *P*. *fluorescens* were found positive for siderophore production, catalase test, starch hydrolysis, gelatin liquefication and denitrification test. All five isolates of *P*. *fluorescens in vitro* evaluated against *R*. *solanacearum* exhibited antibacterial activity with inhibition zone that ranged between 7.75 to 12.75 mm. However, significantly highest inhibition zone was recorded by isolate Pf2 (12.75 mm) followed by isolate Pf3 (11.75 mm), isolate Pf5 (9.5 mm), isolate Pf4 (9.0 mm) while the least was recorded by Pf1 isolate (7.75 mm).

PP134(On)3C: In vitro efficacy of phyto-extracts against C.musae causing post harvest fruit rot of banana (Musa paradisiacal L)

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Banana (*Musa paradisiacal* L) fruit rot is a commonly appearing postharvest disease causing significant yield losses. The present study was conducted to determine the efficacy of extracts of plant species against *C. musae*. Aqueous extracts of nine plant species were screened for their inhibitory effect against *C.musae* using poisoned food technique. Among the phyto-extracts tested (each at 10%) *Allium sativum* recorded highest mycelial inhibition (65.36) followed by *Lantana camara* (54.03%), *Allium cepa* (47.99%), *Aloe barbadensis* (46.58%), *Eucalyptus globules* (45.51%), *Bougainvillea glabra* (42.92%), *Pongamia pinnata* (39.62%) and *Zingiber officinale* (56.98%). Among the phyto-extracts tested (each at 20%) highest mycelial inhibition was recorded with *Allium sativum* (74.40%) followed by *Lantana camara* (59.40%), *Allium cepa* (54.40%), *Aloe barbadensis* (53.18%), *Azadirachta indica* (51.81%), *Eucalyptus globules*

(49.62%), *Pongamia pinnata* (46.29%), *Zingiber officinale* (44.88%) and *Bougainvillea glabra* (9.36%), respectively.

PP135(On)3C: Studies on bacterial leaf spot of chilli caused by Xanthomonas axonopodis pv. vesicatoria (Doidge) Dows

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Bacterial leaf spot of chilli caused by *Xanthomonas axonopodis* pv. *vesicatoria* has been found to affect severely and cause accountable qualitative and quantitative losses, average fruit losses to the tune of 52 per cent. The present investigations on *Xanthomonas axonopodis* pv. *vesicatoria* were carried out during the year 2018-19 with the objectives *viz*., Isolation, identification, pathogenicity and detection, *in vitro* evaluation of bioagents and antibiotics. Present investigations were undertaken with an objective to study the occurrence of the disease, role of abiotic environmental factors in disease development and to devise suitable disease management strategies. The disease was found to occur in moderate to severe form in different bell pepper growing areas of Solan, Shimla and Sirmour districts of Himachal Pradesh. The bacterium was isolated from infected samples showing typical symptoms of bacterial spot, yielded yellow, smooth, flat glistening, shiny, round, convex colonies on Nutrient Agar medium. Studied morphological, biochemical and physiological characteristics of *Xanthomonas axonopodis* pv*. vesicatoria.* Detected nature of bacteria i.e seed borne by different methods *viz*. Nutrient agar plate, Moist sand, Growing on test plant, Examination dry seed, Semi selective and Van varude method. Among the various antibiotics and bioagents tested in *in vitro* condition, the Streptocycline at 250+0.25% ppm and 500 ppm and *Psuedomonas fluroscence* were found to be most effective in inhibiting the growth of *Xanthomonas axonopodis* pv. *vesicatoria*, causing bacterial leaf spot of chilli.

PP136(On)3C: Bioefficacy of Phytoextracts Against Phyllosticta zingiberi, Causing Phyllosticta Leaf Spot of Ginger (Zingiber officinale)

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Ginger (*Zingiber officinale*) crop is affected by several diseases, of which *Phyllosticta* leaf spot (*Phyllosticta zingiberi*) is dreaded fungal disease, causing accountable quantitative and qualitative losses. Though, chemicals can manage the disease but due to their harmful effects on ecosystem and human health, alternative biological options needs to be explored. Therefore, present study was attempted to assess *in vitro* bioefficacy of nine solvent (acetone) phytoextracts against *P. zingiberi*, applying CRD and all treatments replicated thrice, during *Rabi*, 2020-21, at the Department of Plant Pathology, College of Agriculture, Latur. The results revealed all nine test phytoextracts (each @10 and 20%) were found fungistatic to *P. zingiberi* and significantly inhibited mycelial growth of the test pathogen, over untreated control. At 10 per cent, *Lawsonia inermis* resulted with highest mycelial growth inhibition (52.59 %), followed by *Allium sativum* L. (32.59 %), *Azadirachta indica* (24.81 %), *Zingiber officinale* (23.70 %), *Allium cepa* (22.59 %), *Pongamia* *pinnata* (19.99 %), *Aloe barbadensis* (19.62 %), *Lantana camara* L. (17.03 %) and *Eucalyptus globulus* (14.81 %). At 20 per cent, *Lawsonia inermis* resulted with highest mycelial growth inhibition (66.66 %), followed by *Allium sativum* L. (36.66 %), *Zingiber officinale* (32.22 %), *Azadirachta indica* (28.14 %), *Allium cepa* and *Aloe barbadensis* (26.66 %), *Pongamia pinnata* (25.55 %), *Lantana camara* L. (22.59%) and *Eucalyptus globulus* (18.8%). Thus, locally available plant species with antimicrobial properties and antagonistic microorganisms can be used as an alternative to the chemicals, to manage *Phyllosticta* leaf spot of ginger.

PP137(On)3C: Evaluation of potential antagonistic fungi and bacteria against Meloidogyne graminicola infesting paddy

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The reative effectiveness of fungal and bacterial biocontrol agents (BCAs) *viz., Trichoderma harzianum, Pochonia chlamydosporia, Purpurecillium lilacinum, Bacillus subtilis,* and *Pseudomonas fluorescens* were tested in paddy cv. PB-1509 under pot conditions by three different application methods such as root dip-treatment (RD), soil application (SA), and seed treatment (ST) against rice root-knot nematode, *Meloidogyne graminicola* in paddy under the CST-UP research project. The inoculation with 1500 juveniles of *M. graminicola*/kg soil caused characteristic symptoms root galls. The galls were hook shaped and developed on the terminal part of the roots (terminal galls), numbering around 104 galls/root system of rice. The nematode infection caused a significant decrease in the plant growth (28-32%) and yield (38%) over un-inoculated control. Application of biocontrol agents through RD, SA, and ST significantly improved the plant growth (3-11%, 4-14%, and 2-9%, respectivily) and yield of rice plants (4-8%, 3-11% and 3-6%, respectively) over un-inoculated control. The treatments with *P. fluorescens* were found most effective in promoting plant growth (26-34%), and yield (20-34%), and in suppressing the galling (40-52%), egg mass production (37-44%), and soil population of nematode (24-78%), respectively, over inoculated control. Next in effectiveness was *T. harzianum,* which also decreased the galling and significantly increased plant growth and yield, followed by *B. subtilis*, *P. lilacinum* and *P. chlamydosporia* over inoculated control. The overall order of effectiveness of BCAs was: *P. fluorescence Ã T. harzianum > B. subtilis Ã P. lilacinum Ã P. chlamydosporia*. Among various methods of BCA application, the soil application was found to be more effective followed by root dip and seed treatment methods. The present study has revealed that application of BCAs may effectively control the root-knot nematode problem in paddy. The SA treatment of the BCAs increased plant growth in both nematode inoculated and un-inoculated plants.

PP138(On)3C: Non-chemical and alternative approaches for management of Septoria leaf spot of tomato

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Tomato is affected by various foliar diseases amongst Septoria leaf spot (*Septoria lycopersici* Speg.) causes serious problem of defoliation that leads to economic losses. Management of the disease becomes major challenge as chemical method is not preferable in view of the fungicide residual effect on fruits which is harmful for environment and human consumption. Thus, the present study was emphasized on use of eco-friendly and alternative methods for management of disease in relation to prevalence during 2019 and 2020 cropping seasons. For alternative approaches of disease management, three botanicals *viz*., onion (*Allium cepa*), garlic (*Allium sativa*), darek (*Melia azedarach*) and three bioformulations *viz*., jeevamrit, beejamrit and amritkaraisal were tested at two concentrations (5% and 10%), as seed treatment, under *in vitro* and field conditions. The garlic extract was found significantly superior to rest of the extracts in terms of fungitoxicity in suppressing the 80.69% mycelial growth of pathogen followed by beejamrit and onion extract. Since the pathogen is seed borne thus to eradicate the pathogen using various treatments in which garlic extract showed best effect on seed growth parameters like germination per cent (87.69%), seedling length, dry weight and vigour index followed by beejamrit, onion and jeevamrit. Similar observations were recorded under field conditions in botanicals and bioformulations (10% concentration) treated seeds wherein garlic sprayed showed the minimum disease occurrence in relation to disease severity and incidence (36.78, 27.53%) and increased plant growth parameters *viz*. plant height, number of branches and fruits/ plant with increased fruit yield (251.57q/ha).

PP139(On)3C: Insights into the biocontrol activity and secondary metabolism genes of the antagonist fungus Chaetomium globosum potential strain Cg2 based on hybrid de novo genome assembly

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Chaetomium globosum Kunze strain Cg2, is an antagonistic fungus against several seed and soil-borne plant pathogens. Active biocontrol agent, *C. globosum* not only reduces the lesion formation on leaf, but also improves the growth of the host plant. In the present study, the genome of *C. globosum* strain Cg2 was sequenced and hybrid assembly was created with Illumina and Oxford Nanopore sequencing technology with an assembly size of 35Mb and GC content of 53.8%. A total of 34 scaffolds were obtained with N50 of 2973924 bp. Total 10038 genes were predicted with average gene density 377.08 genes/Mb. The predicted genes were further assigned with gene ontology (GO) terms and clustered in special functional groups. From a total of 46 functional annotated GO terms; dominant terms were ‘cellular process’ (in ‘biological process’), ‘membrane’ (in ‘cellular component’) and ‘catalytic activity’ (in ‘molecular function’) which are mainly involved in production of various biocontrol related enzymes. In addition, Rfam analysis of the Cg2 genome identified 33 non-coding RNA (ncRNA) sequences. Total 3034 simple sequence repeats (SSRs) were identified in the genome assembly, and the most abundant SSR type was trinucleotide having 73.6% of total SSRs. In the genome from total predicted proteins, 422 (3.2%) were screened as secreted proteins and 1781 CAZyme were predicted using the CAZy database which is mainly involved in glycoside hydrolases and glycosyl transferases activity. This genome was further screened for secondary metabolism genes, which resulted in 16 NRPS (non-ribosomal peptide synthases), 3 PKS (polyketide synthases), 2 terpenes, and 1 siderophore clusters. Genomic data of this fungus will provide new perspectives on the molecular basis underlying its biology, ecology, and biocontrol activity.

PP140(On)3C: Integrated management of rice root-knot nematode, Meloidogyne graminicola with biocontrol agents and nematicides

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Integrated management modules were assessed against rice root-knot pathogen of rice, *Meloidogyne graminicola* in pot conditions using two proven biocontrol agents (BCAs) viz., *Pseudomonas putida* AMUPP-1 and *Trichoderma harzianum* AMUTH-1 and two new nematicides (fluopyram and fluensulfone) on a susceptible rice cultivar Pusa Sugandha-5. Two treatment methods, root-dip (RD) and soil application (SA) were selected, based on the optimization of BCAs and nematicides in a previous experiment. Standard nematicide, carbofuran was also used to compare the efficiency of the new nematicides. The plant grown in soil infested with 1000 J_{2s} of *M. graminicola* suffered a 32-36% suppression in plant growth and grain yield. However, RD treatment with *P. putida* and *T. harzianum* combined with SA at 20 days after planting of fluopyram and fluensulfone reduced the adverse effect of the nematode but significantly varied with the treatments. Among the treatments, RD with *P. putida* followed by SA with fluopyram proved most efficacious and reduced the root-knot severity by 68-75% and reproduction factor by 81% resulted in a 34-40% plant growth promotion and yield enhancement by 57–72%. RD with *P. putida* and SA with carbofuran was next in effectiveness trailed by RD with *T. harzianum* + SA with fluopyram and RD of *P. putida* + SA of fluensulfone. The comparative effectiveness of RD with *T. harzianum* and SA of fluensulfone was found lowest in decreasing rice root-knot severity and plant growth promotion. The study demonstrated that the application of fluopyram will provide an alternative chemical for the control of *M. graminicola* in the scenario of carbofuran being banned.

PP141(On)3C: Field efficacy of various chemicals in controlling anthracnose disease of cotton incited by Colletotrichum gossypii Southw

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Cotton (*Gossypium* spp.) is most prehistoric and chief fiber crop in the world agricultural economy and key raw material for textile industries. It is also known as the ‘white gold’ or the ‘king of fiber’ and attains the position of important commercial crop. Production of cotton crop is hampered by various pathogens belonging to fungi, bacteria and viruses. Anthracnose disease caused by *Colletotrichum gossypii* is one of the vicious diseases which affect cotton crop at all the growth stages. This disease is wide spread throughout the country. For controlling this disease various chemicals were tested on cotton cultivar, H1098i during *Kharif* 2020. The crop was sprayed twice, first at initiation of disease and second spray after 15 days. Foliar sprays with azoxystrobin 18.2% + difenoconazole 11.4% SC @ 0.1% were found most effective in reducing the disease upto 71.38 per cent as compared to control. Results with foliar spray with kresoxim methyl 44.3% SC @ 0.1% was found effective next to the above treatment, as it reduced the disease upto 59.12 per cent over check plot. Carbendazim 50% WP @ 0.1% was also found effective in controlling disease (52.62%). Copper oxychloride 50%WP @ 0.25% controlled the disease upto

37.62 per cent and was found least effective against anthracnose disease. To overcome the yield and quality losses due to diseases can be minimized by using recommended dosage of chemical fungicides and by integration of other methods in as compatible manner as possible.

PP142(On)3C: Novel fungicides as efficient crop protectants with specific mode of action

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Population is increasing at an alarming rate and it's very knotty to increase the production with decreasing natural resources. Fungicide application is one of the most proficient and extensively method for managing plant diseases. New generation fungicides are highly efficient even at low doses, more target specific, leave less residue and these are less likely to develop resistance. Several novel compounds includes phenylpyrroles, anilinopyrimidines, strobilurin analogues etc. which effects on respiration, cell membrane components, protein synthesis, signal transduction and cell mitosis. The strobilurins (QoIs) represent the most successful class of respiration inhibitors. Azoxystrobin, pyraclostrobin, trifloxystrobin, fluoxastrobin, kresoxim methyl, picoxystrobin and dimoxystrobin as key strobilurin fungicides are effective against a wide range of plant pathogens and diseases (downy mildews, powdery mildews, *Phytophthora* and *Alternaria* blights, apple scab, *Rhizoctonia* infections etc.) caused by Oomycetes, Ascomycetes, Basidiomycetes and Fungi Imperfecti. These molecules specifically bind to the ubiquinonebinding site (Q-site) of the mitochondrial complex II, thereby inhibiting fungal respiration. Their use has to be regulated as per FRAC guidelines to sustain their efficacy levels. The various combination products have been recommended by CIB&RC taking into consideration; their usage, dose and target pathogens. The combination products such as azoxystrobin 18.2% + cyproconazole 7.3% SC against wheat rust and downy mildew of maize, azoxystrobin 18.2% + difenoconazole 11.4% SC against anthracnose of chilli and early blight of tomato have been recommended. In future more fungicides with novel mode of action likely to be developed to overcome problems of resistance and environment pollution from earlier chemicals.

PP143(On)3C: Evaluation of fungicides as a seed treatment on dominant seed mycoflora of chilli in vitro

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Chilli (*Capsicum annuum* L.) is an important spice crop grown extensively in India which have commercial and therapeutic value. The Association of different seed-borne pathogens with chilli seeds reduce the quality, quantity and longevity of seeds and transmit various diseases. Seed treatment with fungicides was carried out for preventing seed-borne diseases and for producing healthy seeds. *In vitro* study of chilli seeds (var.GVC101, GVC111) was carried out to check the efficacy of seed treatment by seven fungicides on the seed germination and seedling vigour by controlling the most dominant seed mycoflora (*A. niger*, *Colletotrichum* sp., *Fusarium* sp.) by Paper towel method. In GVC101, seeds pretreated with *A. niger* followed by treatment with captan@3.5g/kg seeds showed higher seed germination (96.67%) and vigour index (289.53). Seed treatment with metalaxyl+mancozeb@3.5g/kg seeds showed higher seed germination (79.33%) and vigour index (156.84) in seeds pretreated with *Colletotrichum* sp. In seeds pretreated with *Fusarium* sp., metalaxyl+mancozeb@3.5g/kg seeds exhibited higher seed germination (92.67%) and vigour index (268.91). In GVC111, seeds pretreated with *A. niger* followed by treatment with carbendazim +mancozeb@2.5g/kg seeds showed higher seed germination (90.67%) and vigour index (218.92). In seeds pretreated with *Colletotrichum* sp. followed by treatment with mancozeb@3g/kg seeds exhibited higher seed germination (72.00%) and vigour index (173.08). While in seeds pretreated with *Fusarium* sp., carbendazim@2g/kg seeds exhibited higher seed germination (84.67%) and vigour index (193.63).With tebuconazole@1.5g/kg seeds exhibited no seed germination when seeds were pretreated with all three dominant seed mycoflora in both varieties tested. This may be due to the toxic effect of tebuconazole@1.5g/kg seeds on chilli seeds.

PP144(On)3C: Effect of Biofertilizers on Growth and Yield of Okra (Abelmoschus esculentus L.)

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The present study on effect of biofertilizers on plant growth and yield of okra (*abelmoschus esculentus* l.) was conducted at Hemwati Nandan Garhwal University, Srinagar, Uttarakhand during the *kharif* season 2019-2020. The experiment was laid out in Randomized Block Design with three replications. Total of eight treatments combination in biofertilizers with organic sources i.e., T_0: Control, T_1: *Pseudomonas,* T_2: *Azotobacter*, T_3: Neem cake, T_4: *Pseudomonas* + *Azotobacter*, T_5: *Pseudomonas* + Neem cake, T_6: *Azotobacter* + Neem cake, T_7: *Pseudomonas* + *Azotobacter* + Neem cake. Out of these, treatment T_6: *Azotobacter* + Neem cake was observed as the most excellent treatments in terms of Germination of T_6 86.92%, plant height of 30.69 cm at 30 days after sowing, 50.75 days to produce 50% flowering, 25.56 number of fruit per plant, 85.64 number of seed per fruit, 281.47 gm of yield per plant, 5.96 kg of yield per plot and 429.69 gm seed index (per 1000 seed weight). However, the minimum values were found under control treatment.

PP145(On)3C: Use of organic amendments and biocontrol agents in limiting the secondary metabolite production of Sclerotium rolfsii Sacc. inciting Southern Blight of China aster

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Sclerotium rolfsii Sacc. is one of the most devastating soil borne pathogen affecting extensive variety of crops in India. China aster is an emerging crop in the state as well as the country hence increase in production area implicit higher risks of diseases. With recent report of this destructive disease from the state, an investigation was carried out regarding the sustainable management of the pathogen with the use of organic soil amendments and biocontrol agents. As the pathogen is known to produce various phytotoxic secondary metabolites which in turn increases the disease severity. Therefore, an experiment was carried out in order to estimate the effect of organic amendments and biocontrol agents in the secondary metabolite production of the pathogen wherein, the phytotoxicity of the culture filtrate was tested on germination of moong been seeds. It was revealed that *Trichoderma viride* was found to be most efficacious with germination of 80.66 per cent followed by mustard cake and cotton cake with germination percentage of 79.66 and 76.00 per cent, respectively. Additionally, *T. viride* also reduced the per cent pre-post germination mortality (15.66%) as well as deformed seedlings (1.66%) followed by mustard cake and cotton cake with per cent germination and pre-post-germination mortality of 79.66 %, 15.33% and 76.00%, 19.00%, respectively.

PP146(On)3C: Efficacy of bacterial antagonists against Root Knot Nematode, Meloidogyne incognita infecting Cowpea

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Cowpea is a widely grown kharif crop in India and due to its ability to survive under extreme biotic and abiotic stress, focus on management was neglected. Among various plant parasitic nematodes, Root Knot Nematode, Meloidogyne incognita is most important nematode species affecting cowpea. Management of root knot nematode, Meloidogyne incognita by using bacterial biocontrol agents is a recent trend in reducing nematode population. So, a pot culture experiment was carried out to assess the efficacy of the bacterial bioagents in reducing the nematode population and enhancing plant growth parameters of cowpea, comprising of eight treatments with three replications of each treatment. The assigned treatments were T 1 (Soil application of P. fluorescens @ 2.0 mg/kg), T 2 (Soil application of P. fluorescens @ 2.5 mg/ kg) ,T 3 (Soil application of Pseudomonas fluorescens @3.0 mg/ kg), T 4 (Soil application of Bacillus subtilis @2.0 mg/ kg), T 5 (Soil application of Bacillus subtilis @ 2.5 mg/ kg), T 6 (Soil application of Bacillus subtilis @ 3.0 mg/ kg), T 7 (Soil application of Carbofuran @ 0.5 mg a.i / kg) and T 8 (Untreated check). Among all the treatments, it was revealed that T 6 (soil application of Bacillus subtilis @ 3 mg/kg) observed maximum increase in the plant growth parameters like increase in shoot length by (53.32%), root length by (85.85%), fresh shoot weight by (69.79%), dry shoot weight by (75.07%), fresh root weight by (98.24%), dry root weight (80.59%) and with the decrease in number of galls (80.67%), number of egg masses/ plant (73.95%), nematode population in 200cc of soil (80.74%), nematode population in soil and roots (79.33%) over untreated check T 8 followed by T 3 (soil application of Pseudomonas fluorescens @ 3 mg/kg and T 7 (Soil application of Carbofuran 3G @ 0.5 mg a.i/kg). However, the present finding needs testing of treatments in microplots/ field condition for more concrete results.

PP147(On)3C: Identification of putative mild cross-protecting strains of Citrus tristeza virus using in-silico Codon Usage Biasness (CUB) analysis

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Citrus tristeza virus(CTV), an aphid-transmitted closterovirus, destroys millions of citrus trees worldwide including India. CTV occurs in all the geographical zones of India and infects all the commercial citrus species causing symptoms like decline, yellowing, growth stunting and stem pitting.Traditional management practices failed to protect citrus from CTV as there is no good source of resistance.Eradication and vector-control have proven unsuccessful and transgenic resistance has failed.Thus, deployment of cross-protection using mild strains remains the only means to protect citrus from severe infection.Efforts have been made to identify mild cross protecting strain using 12 Indian CTV isolates based on *in silico* analysis of sequences of CP and ORF1a gene of CTV genome considering nucleotide identity, phylogenetic and CUB.The $N_C$vsGC3 plot analysis indicated that codon choice of CTV is influenced by translational selection, gene length, and gene function alongwith mutational bias. GC1/GC2vsGC3 plot analysis showed unique pattern of higher GC1 and lower GC2 value similar to *Citrus* sp. Most of the Indian CTV isolates tested has higher Nc value, indicating that they might be severe and atypical type. In the CUB analysis, three Indian CTV isolates, K10, Mnp1 and MB3 were mild isolates as they showed higher CUB. When results of nucleotide identity, phylogenetic and CUB analysis were compared, the isolate MB3 was considered to be a strong MCPS as it is related with severe decline Israel isolate VT and India decline isolate Kpg3 by 98% and 91% nt identity for CP gene, and 95% and 97% for 5'ORF1a gene, respectively. However, this isolate needs to be confirmed as a true MCPS through biological indexing and challenging with the severe isolate.

PP148(On)3C: Isolation and characterization of rhizospheric bacteria with a potential for biological control of stem rot pathogen Sclerotium rolfsii Sacc. in groundnut

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Groundnut (*Arachis hypogaea* L.) is an important edible oilseed crop used extensively for oil extraction, cooking and domestic purposes. Though India is the second largest producer of groundnut, the area under cultivation has declined over the years due to various biotic and abiotic constraints. Stem rot caused by *Sclerotium rolfsii* Sacc. is an important soil-borne disease causing heavy yield losses in groundnut. This study was aimed at characterizing rhizospheric bacteria of groundnut with a potential to inhibit the growth of *S. rolfsii* for management of stem rot disease. Groundnut rhizosphere soil samples were collected from 12 different fields in ten villages covering six mandals of Nagarkurnool district of Telangana state during *Rabi* 2019-20. A total of 111 bacterial and actinomycetes colonies were isolated. Considerable variation was observed in colony morphology, both in type and number, among the isolates isolated from different samples suggesting the presence of diverse organisms in groundnut rhizosphere soil. Majority of the isolates were Gram-positive rods indicating genus *Bacillus* and most of them tested positive for Voges Proskauer, citrate utilization, catalase activity and negative for indole production and methyl red and oxidase. Preliminary screening of these 111 isolates against *S. rolfsii* identified 33 isolates (12 from King's B medium, 15 from nutrient agar and 6 from actinomycetes isolaton agar) with antagonistic activity indicating their potential in developing microbial consortia against *S. rolfsii* for the management of stem rot in groundnut.

PP149(On)3C: Molecular identification of fungal endophytes isolated from grapevine leaves for management of anthracnose disease in grapes

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Fifty-one fungal endophytes were isolated from the healthy leaves of ten grape varieties. These isolates were characterized based on colony morphology, microscopic observation, and antagonistic properties against *Colletotrichum gloeosporioides.* The *in-vitro* direct confrontation assay revealed that five isolates showed 78.78-83.33% growth inhibition of *C. gloeosporioides*, the incitant of anthracnose disease of grapes. Moreover, in the indirect confrontation assay, two isolates showed 80% inhibition of *C. gloeosporioides*. Further, PCR assay of the 51 fungal endophytes revealed amplification of 700-900 bp size amplicons using ITS1 and ITS4 universal primers. The analyses of the sequence information revealed the association of 15 diverse species of endophytic fungi belonging to eight genera *viz*., *Aspergillus*, *Bipolaris, Curvularia, Daldinia, Exserohilum, Fusarium, Nigrospora,* and *Pseudopithomyces* with the healthy leaves. Thus, the grapevine leaves were found to inhabit a maximum of eight species belonging to *the Aspergillus* genus out of the total fungal endophytes. Indirect confrontation assay revealed that *Curvularia lunata*, *C. verruculosa, Aspergillus nomiae*, and *Daldinia eschscholtzii* fungal endophytes inhibited the growth of *C. gloeosporioides* by producing volatile organic compounds (VOCs). The identification of VOCs and secondary metabolites produced by the fungal endophytes are the future line of research in the management of grapevine diseases.

PP150(On)3C: Evaluation of Effective Chemicals, Phyto-extracts, and Bio-agents against Fusarium oxysporum f. sp. radicis cucumerinum causing root and stem rot of cucumber in Rajasthan

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The objective of the work was to assess the efficacy of Effective Chemicals, Phyto-extracts, and Bio-agents against *Fusarium oxysporum* f. sp. *radicis cucumerinum* to identify the effective, eco-friendly management tools under controlled conditions. For the development of effective control measures of this disease, six chemicals at 250,500 & 750 ppm, six Phytoextracts at three different concentrations (10%, 20%& 30%) were evaluated and three bio-control agents were also tested against mycelial growth inhibition of *Fusarium oxysporum* f. sp. *radices cucumerinum*. Among chemicals, Carbendazim completely inhibited (100%) or no mycelial growth of the pathogen was observed at 500 and 750 ppm concentration and at 250 ppm concentration it was also

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found best by inhibited 72.22 percent with 25.0 mm mycelial growth followed by SAAF. Out of six phytoextracts, *A. indica* leaf extract was found more effective than others by inhibited 30.83, 51.39, and 69.17 percent growth inhibition at 10, 20, and 30 percent concentrations respectively. Among bio-control agents, *Trichoderma viride* was found most effective by inhibiting maximum growth inhibition (65.83% inhibition) of the pathogen, *In-vitro*.

PP151(On)3C: Development and testing of synergistic microemulsion formulation against Pythium aphanidermatum causing damping-off in chilli

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Botanicals, in the current scenario, have emerged as an efficient alternative to synthetic pesticides. Due to diverse modes of action, biodegradability, and lower non-target effects, they are considered superior. However, their field application has been limited by high volatility and instability. The transition of these botanicals in a formulated form with the addition of adjuvants provides the opportunity to surpass these limitations. *Pythium aphanidermatum* is a soil-borne fungal phytopathogen, causing pre and post-emergence damping-off in chilli. In the current study, two types of microemulsion formulations were developed using thyme essential oil (TEO) and aqueous extract of plant material (PAE). The two microemulsions, TEO-based and TEO-PAE-based, were prepared using the low-energy emulsification method. The particle examined using the dynamic light scattering method showed a particle size >30 nm for TEO formulation and >110 nm for TEO-PAE formulation. The polydispersity index of the TEO-PAE formulation has been found with better homogeneity than only the TEO formulation. Both of the microemulsions exhibited encouraging results in shelf-life testing at different storage conditions. The microemulsions were further tested for their antifungal efficacy against *Pythium aphanidermatum*. The TEO-PAE formulation exhibited improved antifungal efficacy over the TEO formulation. These formulations are being further evaluated for their in-vivo disease control efficacy. The data pertaining to the current study will be presented at the conference.

PP152(On)3C: Antagonistic activities of indigenous Trichoderma isolates on Fusarium oxysporum f.sp. ciceri

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Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops grown in the Indian sub-continent and is known to cope protein demand of the major vegetarian population of our country. Besides its significance, the crop faces prodigious ignorance due to a range of biotic and abiotic stresses. However, Fusarium wilt caused by *F. oxysporum* f. sp. *ciceri* is one of the significant catastrophes to chickpea cultivation in every Indian state. The present study was conducted to explore the potential of some indigenous *Trichoderma* isolates against two isolates of *Fusarium oxysporum* f.sp. *ciceri* viz., FOCUP1 (Uttar Pradesh) and FOCRJ1 (Rajasthan). Interestingly, all the tested *Trichoderma* isolates significantly inhibited the radial growth of both

Fusarium isolates. However, more inhibition of indigenous *Fusarium* isolates (FOCUP1) (ranged between 71.85 to 80.37) was recorded against all the tested *Trichoderma* isolates when compared to nonindigenous isolate, i.e., FOCRJ1 (ranged between 55.19 to 67.41). Among all the tested isolates of *Trichoderma* spp., the highest inhibition in FOCUP1 was exhibited by *T. viride* (80.00%), followed by *T. hamatum* (77.78 %). However, in the case of FOCRJ1, *T. hamatum* (67.41%) was superior to other tested *Trichoderma* isolates, followed by *T. viride* (62.96%). This *in-vitro* study gives a clue to further exploitation of indigenous bioagents to mitigate losses incurred by this pathogen at a large scale.

PP153(On)3C: Studies of antibacterial activity and molecular docking of potential bioactive compounds of plant extracts against KdgR protein of Dickeya dadantii

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Dickeya dadantii, the causal organism of bacterial stalk rot of sorghum, is a disease that is widely spread and destructive in India. As a result, it was aimed to explore some sources of natural bactericides for the alternative approaches of integrated disease management. The disc diffusion method was used to evaluate methanolic and aqueous extract at different concentrations (5, 10, 15, and 20%) of twenty plant extracts to *D. dadantii*. Among the selected plant species, *Eucalyptus globulus* and *Aegle marmelos* depicted the highest zone of inhibition in the range (1.67- 2.00cm) at 20% concentration. Antibacterial impacts of the most effective extract of *E. globulus* and *A. marmelos* were analyzed by the existence of bioactive compounds identified by GC-MS. Additionally, the study employs computational screening to determine the antibacterial activity of 155 compounds (ligands) identified using GC-MS against *D. dadantii* target pectin degradation repressor protein KdgR. The docking software AutoDock 4 was used to screen these identified chemicals. The target protein's high-quality 3D structural model was obtained using the I-TASSER programme, and the ligands' structures were obtained using PubChem. The total ten compounds (*E. globulus* and *A. marmelos*) showed high binding affinity (-7.5 to -8.6 Kcal/mol) with and without forming hydrogen bonds with KdgR in computational study. These selected compounds may be utilized as natural bactericides against *D. dadantii* and other plant pathogenic bacteria. The research involved using a SEM to explore the potential effect of plant extract on morphological changes in the cell wall of treated bacteria.

PP154(On)3C: Evaluation of agro-insecticide and plant extracts against yellow vein mosaic virus disease of okra

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Okra (*Abelmoschus esculentus* L. Moench) is a popular summer and rainy-season vegetable crop that is widely produced across the world for its immature nutritious fruits. Okra production is threatened by several biotic and abiotic causes. Okra yellow vein mosaic virus (OYVMV) is a devastating disease of okra, caused by monopartite and bipartite begomovirus and transmitted by whiteflies (*Bemisia tabaci* Gen.). Yield loss due to this virus is quite high, up to 80-94 per cent is reported under heavy infection. The field experiment was carried out to evaluate the effect of insecticide (malathion 50 EC) alone or with plant extracts (Faba bean seed extract and Sarpagandha leaves extract) for the effective management of yellow vein mosaic disease of okra during the *kharif* 2018 at research farm, Department of Plant Pathology, CCS HAU, Hisar. Three sprays of insecticide and plant extracts were taken at 15 days intervals. The result revealed that Among all the treatments malathion 50 EC (2 ml/litre) + sarpagandha leaves extract (10%) had recorded significantly less terminal PDI (15.55%) which was followed by malathion 50 EC (2 ml/litre) + faba bean seed extract 10 per cent (22.22%) and the fruit yield was also recorded highest (3833.20 kg/ha) in treatment malathion 50 EC (2 ml/litre) + sarpagandha leaves extract (10%) as compared to control (1811.15 kg/ha) and other treatments. The spray of malathion 50 EC (2 ml/litre) alone was also effective in lowering the PDI and in increasing fruit yield as compared to control.

PP155(On)3C: Silver myconanoparticles: Synthesis, characterization, antifungal activity and phytotoxicity

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In the present study silver myconanoparticles were synthesized extracellularly from biocontrol agent *Trichoderma harzianum*, where cell free extract of the fungus was used as reducing and capping agent and silver nitrate as precursor in the process of nanoparticles synthesis via autoclave method. Visual observation of colour change from colorless to greyish black preliminarily indicated the silver nanoparticles production. UV-Visible spectroscopy (UV-Vis) showed maximum absorption at 435 nm. Mean diameter of 53.1 nm of the nano silver particles was confirmed by Particle size analyzer (PSA). Scanning electron microscopy (SEM) revealed the formation of spherical shape nanoparticles with size range of 25-200 nm. Face centered cubic symmetry of synthesized myconanoparticles with average crystalline size of 19.15 nm was revealed by X-ray diffraction (XRD) analysis. Fourier transform infrared spectroscopy (FTIR) showed strong bands at 1635.04, 1384.45 cm-1 (Amide groups with -C-N- vibrations) and 3408.67 cm-1 (Hydroxyl group with -OH stretching) and these groups in secondary metabolites of the extract were found to be responsible for reduction and encapsulation of the synthesized myconanoparticles. The antifungal activity of the silver myconanoparticles were evaluated against *Alternaria solani* causing early blight of tomato at different concentrations (1-170 ppm) and it was found that cent percent inhibition of spore germination was observed at 2 ppm. Per cent inhibition of mycelial growth increased with increase in concentration of nanoparticles. Silver myconanoparticles at 170 ppm showed effective antifungal activity with 57.08 per cent mycelial growth inhibition and 28.31 per cent reduction in disease over control. The synthesized myconanoparticles showed no phytotoxicity symptoms on tomato seedlings.

PP156(On)3C: Efficacy of copper myconanoparticles against Alternaria solani and their phytotoxicity on tomato seedlings

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Early blight of tomato caused by *Alternaria solani* (Ellis and Martin) Jones and Grout is one of the most widespread and exterminatory disease prevalent throughout the tomato growing areas around the world. The present investigation was carried out to evaluate the efficacy of copper myconanoparticles against *A. solani*. Copper myconanoparticles were synthesized using copper sulphate (CuSO4.5H2O) as precursor and *Trichoderma harzianum* extract as reducing and capping agent. Copper myconanoparticles were evaluated against spore germination and mycelial growth at different concentrations (1-2000 ppm). Complete inhibition of spore germination was observed in copper nanoparticles at e”25 ppm, however they failed to inhibit the spore germination at 1 and 10 ppm. Per cent inhibition of mycelial growth increased with increase in concentration of copper nanoparticles. Copper myconanoparticles had shown the effective antifungal activity with 58.21 per cent mycelial growth inhibition and 16.98 per cent reduction in disease over control at 2000 ppm. Copper myconanoparticles showed no phytotoxic symptoms on tomato seedlings at all the tested concentrations (1-2000 ppm) however, CuSO4.5H2O (Precursor) showed complete death of lower leaves and necrosis of the margin of leaves seven days after spraying.

PP157(On)3C: In vitro evaluation of minimum inhibitory concentration (MIC) of fungicides against Rhizoctonia solani f. sp. sasakii Exner causing banded leaf and sheath blight disease in maize

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Minimum inhibitory concentration (MIC) is defined as the minimum concentration of a compound that will result in the inhibition of growth of a microorganism. These are principally used to confirm resistance in chemical fungicides, but most often as a tool to determine the *in vitro* activity of new fungicides as well as antibiotics. In this study, four fungicides viz. Carbendazim 50 % WP, Azoxystrobin 11% + Tebuconazole 18.30 % SC, Tebuconazole 50 % + Trifloxystrobin 25% WG (at 1, 2, 4, 6, 8 and 10 ppm conc.) and Azoxystrobin 18.2 % + Difenoconazole 11.4 % SC (at 10, 12, 14, 15, 20, 25 and 30 ppm conc.) were evaluated against *Rhizoctonia solani* causing banded leaf and sheath blight (BLSB) in maize for determining their minimum inhibitory concentrations (MICs) *in vitro* using poison food technique. All the fungicides showed variable response in inhibiting the colony growth of the pathogen. Among all the tested MICs fungus proved highly sensitive to Carbendazim 50 % WP at 6 ppm concentration, Azoxystrobin 11% + Tebuconazole 18.30 % SC and Tebuconazole 50 % + Trifloxystrobin 25% WG each at 10 ppm concentration and Azoxystrobin 18.2 % + Difenoconazole 11.4 % SC at 14 ppm concentration with 100% growth

inhibition. Such studies can be helpful in exploring *R. solani* for determing its resistance development to specific fungicides and thereby devising suitable management strategy against BLSB in maize.

PP158(On)3C: Efficacy of plant protection chemicals against pathogen Alternaria solani causing early blight of tomato (Solanum lycopersicon L.)

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Tomato is one of the most important vegetable crops grown throughout the world. India is the second largest producer of tomato after China despite its large-scale production, the growers of the tomato across the India facing challenges due to biotic and abiotic stresses. Among the diseases, early blight is the most devasting disease by causing severe economic losses by reducing yield of tomato. It is important to manage the disease by using effective fungicidal application. An *in-vitro* study was conducted to test the efficacy of systemic as well as non-systemic fungicides for the control of early blight pathogen through poison food technique. Among systemic fungicides, Propiconazole and hexaconazole showed cent percent inhibition at all the tested concentrations followed by Azoxystrobin+Difenconazole@ 0.05% and Trifloxystrobin+Tebuconazole@ 0.1% by significantly inhibiting radial mycelial growth of the *A. solani* up-to 88.0 per-cent at eight days after inoculation. Whereas as among non-systemic fungicides Chlorothalonil @ 0.15 % showed inhibition of 57.80% and copper oxy chloride@ 0.25% concentration showed mycelial inhibition of 60.52% when compared to control. All the tested fungicides showed greater efficacy in managing early blight pathogen at their higher concentrations. Systemic fungicides found to be more effective compared to contact (non-systemic) fungicides.

PP159(On)3C: *In-vitro* efficacy of silver nano particles (AgNp) against *A. solani* causing early blight of tomato (*Solanum lycopersicon* L.)

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Tomato is one of the most important vegetable crops grown throughout the world. India is the second largest producer of tomato after China, despite of its large-scale production the farmers India facing challenges in tomato production because of biotic and abiotic stresses. Among the diseases, early blight is the most devasting disease causing severe economic losses by reducing yield of tomato. It is important to manage the disease by using effective disease management strategies. Nano particles can be utilised to manage numerous plant infections in a reasonably safe manner compared to synthetic fungicides. An *in-vitro* study was conducted to test the efficacy of silver nanoparticles (AgNp) for the control of early blight pathogen (*A. solani*) through poison food technique. Silver nano particles at three different concentrations *viz*., 10, 15 and 20 ppm were tested against the pathogen under laboratory conditions. Among all the tested concentrations, AgNp @ 20 ppm concentration has showed stronger antifungal activity by inhibiting mycelial growth 82.2 per-cent followed by AgNp@15 and

10% concentration which inhibited radial growth of mycelium up-to 27.10% and 16.00% respectively when compared to control. Hence silver nanoparticles might be a good alternative to chemical fungicides as they are fully capable to suppressed the growth of *A. solani* even at lower concentrations.

PP160(On)3C: Pseudomonas fluorescens: Bio control agent against anthracnose of sorghum caused by Colletotrichum graminicola

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Sorghum (*Sorghum bicolor* L.) ranks fifth, among the world's cereal crops in the order of wheat, maize, rice and barley. It is attacked by several pathogens which cause different types of leaf spot diseases like anthracnose, rectangular leaf spot and gray leaf spot. Among these, Anthracnose incited by *Colletotrichum graminicola*, is one of the most destructive diseases, causing yield losses of up to 70% and considered as one of the most serious disease. This disease affects stem, leaf, peduncle and inflorescence that ultimately affect crop productivity and quality. Keeping in view of environmental pollution and ecological imbalance caused by the use of chemical fungicides, the use of the biocontrol agent to combat sorghum disease has proven to be an environment friendly alternative approach to chemical pesticide. Among the various *Pseudomonas spp*., *P*. *fluorescens* have received particular attention as biocontrol agent because of its biocontrol activity through direct antagonism against phytopathogens and induction of disease resistance in the host plant. A variety of antimicrobial secondary metabolites has been reported that helps in host recognition and controlling pathogens. It also inhibits spore germination and mycelial growth of *Colletotrichum graminicola*. Plant growth-promoting characteristics such as nitrogen fixation, phosphate solubilization, iron chelation and phytohormone synthesis are also prominent. *P. fluorescens* as a bio control agent has good prospectus in the future as it gives very high cost-beneût ratio and helpful in developing integrated disease management strategies for the control of anthracnose disease of sorghum.

PP161(On)3C: Studies on the Nematicidal effect of Ammonium bicarbonate and Lime against Meloidogyne incognita on Tomato (Lycopersicon esculentum)

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Meloidogyne incognita, a plant parasitic nematode, causes a huge reduction in yield and affects the quality of the tomato. While tomato, full of nutrition, can be taken as raw used in various recipes. The use of chemical nematicides to manage this nematode has several negative impacts on the environment, biodiversity and human beings when used at a large scale which leads to a total restriction. Plant parasitic nematodes are directly related to any modification in the soil environment and thus leads to change in their population. Ammonia and lime change soil pH, improve soil structure and hence affects nematode populations. The present investigation was aimed to evaluate the efficacy of Ammonium Bicarbonate (NH4HCO3) (AB), Lime Ca (OH)2 (L) and a combination of both Ammonium Bicarbonate and Lime (AB+L) as a potential nematicide against *Meloidogyne incognita* infecting tomato variety Pant T-3 (*Lycopersicon esculentum*) under glasshouse condition with changes in the chemical properties of the soil. Under glasshouse conditions, AB+L were found most effective at 3.0g /kg of infected soil followed by AB+L @ 2.250g/kg of infected soil showing an increase in plant growth parameters and reducing final nematode population in comparison to others. AB at a concentration of 1.0g/kg of infected soil and lime @2.0 g/kg soil also showed the same pattern in comparison to check. It was observed that with the increase in the concentration of these compounds there is a remarkable decrease in nematode population and number of galls and an increase in various plant growth parameters. AB+L at all the concentrations increased the soil pH, organic carbon and nitrogen. AB showed an increase in nitrogen and organic carbon both whereas, in the case of L only soil pH increased. However, all the compounds at all the concentrations suppressed the nematode population as compared to the check. From the investigation, it can be concluded that *Meloidogyne incognita* infects tomato variety Pant T-3 (*Lycopersicon esculentum*) with threshold inoculum level of 2000 J2 per kg of soil showed reduction in its initial population, number of galls and increase in plant growth parameters in AB+ L at 3.0g /kg of infested soil (AB@ 1.0+ L@ 2.0) and was found exhibiting nematicidal effect. These results may explore the efficacy of these compounds as an alternative method for nematode management which sounds to be ecologically safe.

PP162(On)3C: Protective and curative effects of a new fungicide molecules against sheath blight of rice

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Rice (*Oryza sativa* L.) is second most important crop among all the cereal crops and staple food consumed by 50 % of the world's population. In Chhattisgarh state rice is the major crop and cultivated under 70 % of net sown area. Rice disease sheath blight, caused by *Rhizoctonia solani,is* most economically important in the worldwide.Chemicals have ability to provide protection against the disease and therefore is an attractive option for the farmers. Fungicides also complement genetic disease resistance in management practices. A new fungicide molecules(Isopyrazam 12.5% + Azoxystrobin 20% (325SC),was found effective following protective sprays. The new fungicide reduced the rate of disease development when it was applied as protective spray.

PP163(On)3C: Isolation and characterization of fluorescent Pseudomonas from laterite soil

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Fluorescent *Pseudomonas* strains were isolated from weed host collected from laterite soil from different regions of Chhattisgarh. Fluorescent *Pseudomonas* is the gram-negative, motile, rod-shaped bacterium with polar flagella present everywhere and are known for their extreme versatility and adaptability. In the present investigation, twenty-six isolates out of 110 fluorescent *Pseudomonas* isolates were selected based on their efficacy to produce siderophore. Biochemical screens helped us to identify the isolates as *P. fluorescens* (P10, P12, P57), *P. putida* (P109), *P. aeruginosa* (P16, P18, P21, P45, P50, P53, P63, P75, P77, P83 & P88) and rest were categorized as fluorescent *Pseudomonas.*

PP164(On)3C: Comparative Efficacy of Fungicides, Phyto-extracts and Bioagents against Collar rot of groundnut under laboratory Conditions

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Groundnut is an economic important edible oilseed crop. Seed and soil borne pathogens are the major constraints in production of groundnut, causing poor germination and early mortality of seedling. Collar rot is one of the most destructive diseases of groundnut. To develop effective management strategies for this menacing disease using Seven fungicides, Seven phyto-extracts and five bioagents were evaluated by poison food technique and dual culture technique under laboratory conditions against *Aspergillus niger*. The result revealed that *in vitro* Saaf [Carbendazim (12%) + Mancozeb (63%)], Nativo [Tebuconazole 50% + Trifloxystrobin 25%] and Tilth [Propiconazole] showed 100 per cent mycelial growth inhibition at all the concentration (250, 500, 750 & 1000 ppm) While Taqat [Hexaconazole (5%) + Captan (70%)] gave mediocre effect in inhibiting the mycelial growth (65.83, 74.13, 88.11 & 90.13 %) at 250, 500, 750 and 1000 ppm concentrations, respectively. Among phyto-extracts, datura leaf extract was most effective and inhibited mycelial growth by 84.06%, followed by tulsi (79.18%) and neem seed kernel extract (77.05%) when applied at 10% concentration of the extracts. The least inhibition was observed due to Salvadora extract (35.85%). Among bioagents, *Trichoderma harzianum* inhibited mycelial growth by 77.67%, followed by *Trichoderma viride* (72.92%).

PP165(On)3C: Exploring the Combination of Antibiotics and Phyto-extracts for Combating Antibiotic Resistance in Bacterial Blight of Cotton

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Xanthomonas citri pv. *malvacearum* (ex Smith) Schaad *et al.* (*Xcm*) causing bacterial blight in cotton is amongst the major biotic factors, affecting cotton during all growth stages contributing to devastating yield loss worldwide. Different species belonging to the genus *Xanthomonas* can colonize around 400 hosts. In India, the highly virulent pathogen causes crop loss of up to 42 percent annually. The emerging issue of development of resistance to antibiotics in *Xcm*, attacking the high-yielding commercial cultivars, has catered to the need of developing a cost-effective, sustainable approach to address the problem to manage the disease. Therefore, this study focuses on assessing the efficacy of antibiotics, botanicals, and their combinations in different concentrations. The tests were performed using the disk inhibition method on confirmed *Xcm* strains isolated from cotton leaves and bolls. The antibiotic activity of Tetracycline hydrochloride showed maximum inhibition zone. The combination of Copper Oxychloride (COC) along with Tetracycline hydrochloride (2500ppm + 100ppm) at a comparatively low concentration

showed an inhibitory zone of 23.80mm. The combined efficacy of Tetracycline hydrochloride + *Manilkara zapota* and Tetracycline hydrochloride + *Aegle marmelos* at 100ppm + 1000ppm concentration exhibited zones of 32.20mm and 34.00mm respectively after 24h incubation. The antibacterial activity of plant extracts in combination with a minimum concentration of Tetracycline hydrochloride depicted remarkable results. The brief statistical analysis of the study serves as a precursor to discussing the effectiveness of using botanicals in combination with antibiotics to suppress the increased antibiotic tolerance in the pathogen and provides us with the scope to experiment with different combinations of botanicals and chemicals to manage the disease sustainably.

PP166(On)3C: Role of antagonistic fungal endophytes from cotton in disease management and plant growth promotion

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Fungal endophytes isolated from two cultivated cotton species namely *Gossypium hirsutum* and *G. arboreum* were evaluated *in vitro* for their antagonisity against leaf spot causing pathogen *Corynespora cassiicola*. Based on the preliminary results, efficient fungal endophytes were shortlisted for *in vivo* evaluation against *Macrophomina phaseolina*. Germination study in two cotton cultivars Suraj and Phule Dhanwantary revealed that germination percentage was high in endophyte treated plants. Further, endophyte seed treatment reduced the root rot incidence in plants artificially inoculated with *M. phaseolina* wherein low incidence of root rot was seen in *Diaporthe longicolla*-CEL 48 (10%) as against untreated control (>40%). Besides, endophytes were also evaluated against natural incidence of wilt/ root rot diseases during 2020-21. Cotton seeds were treated with talc-based formulation of endophytes along with *Trichoderma* sp. as check and untreated seeds as control. Results revealed that, in case of Suraj, least disease incidence was seen in *D. longicolla*-CEL 48 (2.66%) followed by CFL 34, whereas maximum disease incidence was seen control (10.29%). Moreover, effect of endophytes on growth promotion parameters like total soluble protein, total sugar and reducing sugar was also tested in cotton and other non-host crops like wheat, sorghum, cowpea and chick pea. It was found that these were also enhanced in cotton and other crops upon endophyte treatment. Total sugar content ranged from 5.46 to 7.54 mg/g F.W in cotton. Therefore, endophytes improve the growth of the plants and play a potential role in inhibiting major plant pathogens, and thus become promising biocontrol agents in future.

PP167(On)3C: In vitro and in vivo evaluation of fungicides against Rhizoctonia solani f. sp. sasakii causing banded leaf and sheath blight (BLSB) of maize

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A total of 11 fungicides (each @ 0.05, 0.1 and 0.15 %) evaluated in *in vitro* against *R. solani* f. sp. *sasakii and* the results on mycelial growth inhibition of the test pathogen were described as

below. All the evaluated fungicides were significantly inhibited the mycelial growth of the test pathogen, except Pencycuron 250 EC (ineffective) and Dimethomorph 50 % WP (least effective) over control. The fungicides *viz.,* Carbendazim 50 % WP, Propiconazole 25 % EC, Tebuconazole 250 EC, Metiram 55 % + Pyraclostrobin 5 % WG,, Fluopyram 17.7 % + Tebuconazole 17.7 % SC, Iprovalicarb 5.5 % + Propineb 61.25 %, Carboxin 37.5 % + Thiram 37.5 % WP and Tebuconazole 50 % + Trifloxystrobin 25 % WG (each @ 0.05, 0.1 and 0.15 %) resulted with cent per cent mycelial growth inhibition, followed by Fenamidon 10 % + Mancozeb 50 % WG, with 46.95, 56.95 and 100 per cent mycelial growth inhibition @ 0.05, 0.10 and 0.15 per cent, respectively. Based on *in vitro* evaluation results, the most effective and economically viable combi-product fungicides *viz.,* Carboxin 37.5 % + Thiram 37.5 % WP (for seed treatment) and Fluopyram 17.7 % + Tebuconazole 17.7 % SC (for spraying) and systemic fungicides *viz.,* Tebuconazole 250 EC, Propiconazole 25 % EC and Carbendazim 50 % WP (for spraying) were used for *in vivo* evaluation. Among them, the treatment Carboxin 37.5 % + Thiram 37.5 % WP seed treatment @ 0.15 % and two sprays of Tebuconazole 250 EC @ 0.1 % resulted in minimum disease index of 32.26 and 32.14 per cent during the year 2018 and 2019, respectively and was found most effective in managing maize BLSB disease under *in vivo*.

PP168(On)3C: Impact of Strobilurin fungicides, Melanin Inhibitors and Green synthesized nano particles on collar rot pathogen of lentil caused Slerotium rolfsii Sacc.

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Lentil (Lens culinaris M.) is an important" Rabi crop and accounts up to 7% of the total pulses production in the country. Lentils are earliest known crop to be "cultivated and archaeological" evidences dating back to "7000 years have been found in the Middle East and from Iberian Peninsula (Zapata et al., 2004)". The origin of lentil was considered to be as Central Asia. It "is one of the first foods" to "have been cultivated and" have "been an important food since prehistoric times" (Sarker and Erskine 2006). "Lentils have been used as a staple food during lent" in many Catholic countries. It had become "a very important part of the diet in many parts of the world, especially South Asia which has a large vegetarian population (Singh, 1999)". They were introduced into India before the 1st century AD and still lavishes as a high regard traditional cuisine made of spiced lentil known as dhal. *Sclerotium rolfsii* Sacc. is very fast spreading and non specialized soil borne fungal pathogen having worldwide importance and has a host range of over 500 species, includes ornamental plants. The experiment was conducted to study the impact of strobilurin fungicides (Azoxystrbin, Azoxystrbin+Difenconozole and Pyraclostobin+ Epoxiconazole) melanin Inhibitor (Tricyclazole) and green synthesized nano particles from different medicinal plants on mycelial growth of *Sclerotium rolfsii* Sacc. under *in vitro* conditions. Among Strobilurin fungicides, Azoxystrbin+Difenconozole was found the most effective at all tested concentrations of 250ppm, 500ppm, 750ppm and 1000ppm with an mycelial inhibition of (30%, 45%, 62% and 100%). Melanin inhibitor Tricyclazole was also found effective against the *Sclerotium rolfsii* at different tested concentrations (150ppm, 250ppm, 350ppm, 450ppm, 700ppm 900ppm). Maximum inhibition was recorded at 700ppm and 900ppm with an inhibition of 67% and 89%. The green synthesized nano particles from different medicinal plants were used at

0.04 and 0.06mg concentrations. Among them, nano particle from Apocynaceae family was found effective in inhibiting the mycelia growth with inhibition of 87percent under *in vitro* conditions. The study reveals that the strobulin fungicides, melanin inhibitor and green synthesized nano particles were effective against *Sclerotium rolfsii* Sacc. and they can be integrated for management under field conditions.

PP169(On)3C: Efficacy of fungicides in-vitro against the leaf spot of ginger caused by Phyllosticta zingiberi Ramakr.

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Phyllosticta zingiberi Ramakr*.* causing leaf spot of ginger is considered to be destructive, appearing in mild or severe form in all ginger growing tracts of the country. Chemical management is one of the most effective and economical ways in managing the disease. Therefore, the efficacy of different contact fungicides, systemic fungicides and fungicides combi products at different concentrations were tested against the pathogen and were evaluated by poison food technique *in vitro*. Among the six contact fungicides evaluated at different concentrations (500, 1000, 1500, 2000, 2500 and 3000ppm), mancozeb 75%WP recorded highest mycelial inhibition of 100.00 per cent at the least concentration tested (500ppm) followed by followed by Copper oxy chloride 50% WP (100.00%) at 2000ppm. Among the seven systemic fungicides at four different concentrations (500, 1000, 1500 and 2000ppm) evaluated, Propiconazole 25%EC, Tebuconazole 25%EC and Difenconazole 25%EC recorded highest mycelial inhibition of 100 per cent at least concentration tested (500ppm) followed by Hexaconazole 5% SC (100.00%) at 1000ppm. Among the six fungicidal combi products tested at six concentrations (500, 1000, 1500, 2000, 2500 and 3000ppm), Carbendazim 12% + mancozeb 63%WP recorded highest per cent mycelial inhibition of 100.00 per cent at the least concentration tested (500ppm) followed by Cymoxanil 8% + Mancozeb 64% WP (100.00%) at 1000ppm. Thus the present findings reveal that Mancozeb 75%WP, Propiconazole 25%EC and Carbendazim 12% + mancozeb 63%WP are effective in inhibiting the fungal growth and therefore can be used for the management of the disease, once tested under field conditions.

PP170(On)3C: Bio-efficacy of Organic Inputs against Collar Rot of Chickpea caused by Sclerotium rolfsii

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The collar rot is an important disease of Chickpea which causes reduction in plant population result in significant yield losses. The present research was conducted during Rabi 2020-21 organic farm block of ARS, Kota in order to find out bio-efficacy of organic inputs against collar rot of chickpea caused by *Sclerotium rolfsii*. Efficacy of different organic inputs against collar rot of chickpea disease was tested by seed treatment under field experiment. All organic inputs showed significant increase in seed germination, decrease in collar rot incidence and increase in seed yield of chickpea as compared to untreated control. Maximum percent germination of chickpea was observed when seeds were treated with Beejamrit (91.11 %) followed by seed treatment with *T. viride* @ 6g / kg (90.00 %) as compared to control (76.67 %). The minimum collar rot incidence 13.59 % was observed when seeds were treated with *Trichoderma viride* followed Beejamrit seed treatment for 5 hours with collar rot incidence 14.59 % as compared to collar rot incidence 31.80 % in untreated control. The maximum see yield of chickpea (22.19 q / ha) was observed under seed treated with *Trichoderma viride* followed by seed treatment with Beejamrit (21.14 q/ha) which was significantly higher over untreated control (17.10 q/ha).

PP171(On)3C: Reduced sensitivity of naturally occurring Alternaria porri to fungicide in-vitro

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Purple blotch of onion (*Allium cepa* L.) caused by *Alternaria porri* (Ellis) Cif . is a disease of world - wide importance and is favored by warm and humid environments (Maude ,1990 ; Miller & Lacy,1995), causing up to 59% losses in onion bulb yield (Gupta & Pathak,1988), and significant reduction in seed and bulb yield , with seed losses of up to 100 % (Abo Elousr et al., 2014). *Alternaria* is an important fungal genus with a worldwide distribution.This hyphomycetous ascomycete is diagnosed on the basis of production in chains of dark colored multi-celled phaeodictyospore. Growers rely on applications of fungicides with site specific modes of action such as the SDHI, quinone outside inhibiting (QoI) to manage disease but fungicide resistance is a major threat for such fungicides. We first proved the reduced sensitivity of naturally occurring *A. porri* spore to Difenconazole 12.5% and to premixed combination product of Pydiflumetofen 7.5% + Difenconazole 12.5% w/v (200SC) but not against Pydiflumetofen 20% SC. But agar disc containing *A. porri* mycelial growth expressed reduced sensitivity to different concentrations Pydiflumetofen 20% SC.

PP172(On)3C: Management of chickpea dry root rot caused by Rhizoctonia bataticola through bioagents and fungicides

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Chickpea (*Cicer arietinum* Linn.) is an important crop grown throughout the world. The crop is attacked by many pathogens. Dry root rot caused by *Rhizoctonia bataticola* (Taub.) Butler is an important limiting factor of the yield among all pathogens causing different diseases to the crop. Present investigations were carried out to evaluate three different fungicides along with *Trichoderma harzianum* with different combinations for the management of the disease under field conditions *Rabi* 2019-20 and 2020-21. Among all the treatment combinations treatment Carboxin 37.5% + Thiram 37.5% used as seed treatment @ 2gm/kg seed + soil application of *T. harzianum* @ 5 kg/ha. along with FYM provided maximum disease control (3.45%) followed by the treatment Carbendazim 50% WP used as seed treatment @ 2gm/kg seed + soil application with *T. harzianum* @ 5 kg/ha. along with FYM. Both these treatments also yielded highest grain yield. These treatments were also found effective in increasing dry weight, shoot length and root length of chickpea plants on the basis of two year pooled data analysis. Whereas, rest the treatments were found least effective against dry root rot of chickpea.

PP173(On)3C: Efficacy of new generation fungicides against rice sheath blight caused by Rhizoctonia solani Kuhn

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Rice (*Oryza sativa* L.) is one of the important cereal crop of the world. About 40% of the total food grain production is contributed by rice. It is primary food source for more than a third of the world's population. More than 92% of world's rice is produced and consumed in Asia. Sheath blight caused by *Rhizoctonia solani* Kuhn is potential and devastating fungal disease which occurs in all temperate and tropical rice production regions of the world. Till date there is no available resistance germplasm hence the most preferred option to manage the disease is use of fungicides. Due to continuous development of fungicide tolerance in fungal population, it is inevitable to search for a new group of fungicide with different mode of action so that new information on diverse fungicides with different modes of action can be offered to farmers. A field experiment was conducted in College of Agriculture, V.C Farm, Mandya during *Kharif* 2021 to evaluate the efficacy of new generation fungicides against sheath blight of rice. The experiment was laid out in RCBD with nine treatments wherein different fungicides were sprayed twice at 30 and 60 days after transplanting. Among the nine treatments the fungicide Azoxystrobin 18.2 + Difenconazole 11.4 SC was most effective in supressing the disease which showed highest per cent disease reduction with maximum yield (57.39% and 6,400 kg/ha) over control followed by fungicide Azoxystrobin 11+Tebuconazole 18.3SC (50.43% and 6,286 kg/ha) and Propiconazole13.9+Difenconozole 13.9EC (48.02% and 6,240 kg/ha). Also, the treatment Azoxystrobin 18.2 + Difenconazole 11.4 SC showed the least chaffiness 8.33 per cent compared to all other treatments which ranged from 8.67 to 15.17 per cent. The fungicide Tebuconazole 25.9EC recorded lowest per cent disease reduction with least yield (22.54% and 5253 kg/ha) when compared to control.

PP174(On)3C: Evaluation of Biochars efficacy against Fusarium oxysporum f.sp. radicis-cucumerinum and Their Impact on Growth Parameters of Cucumber in Pot Condition

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The present study was conducted under greenhouse conditions to evaluate the efficacy of biochars prepared from different plant parts against the pathogen *Fusarium oxysporum* f.sp. *radicis-cucumerinum* causing root and stem rot of cucumber.. Three types of raw materials were used to prepare the biochars (Eucalyptus wood, citrus wood, green house waste). The prepared biochar were collected and filled into pots at four concentrations (1%, 2%, 3% and 4% W/W). All biochars were effective in reducing the incidence of disease up to 3% concentration with minimum mortality (4.17%) obtained with Eucalyptus wood (EW) + Citrus wood (CW) + Greenhouse waste (GHW). The biochars also positively influenced the plant growth parameters like seed germination, root length and shoot length. Maximum shoot length 7.73 cm and root length 12.10 cm was observed with 3% Eucalyptus wood(EW) + Citrus wood(CW) + Greenhouse waste(GHW) biochar treated seeds.

PP175(On)3C: In vitro studies on assessment of variability in *Colletotrichum* spp.

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Colletotrichum (teleomorph *Glomerella*) is an important plant microbe that affects agricultural and plantation crops across the world. It adheres to the hemi-biotrophic mode of feeding, in which both biotrophic and necrotrophic stages occur sequentially. Seedling blight or damping-off, leaf spot or dieback, and anthracnose or fruit rot are the three most prevalent stages of the anthracnose disease. Pathogenic variability among *Colletotrichum* species affecting various crops as Mango (anthracnose), strawberry (fruit rot), Chilli (anthracnose), turmeric (leaf blight), soybean (pod blight), Bean (Die back) and sugarcane (Red Rot). These crop where taken from different growing regions of Chhattisgarh. The isolates where identified based on there conidial and morphological characterization. Various Colletotrichum species namely *C. gloeosporioides, C. truncatum, C. acutatum, C. capcisii*, *C.lindemuthianum* and *C. falcatum* shows characteristic difference in colony color mycelium growth , conidial growth and shape .The three isolate morphologically similar with C.*acuatum* produce fusiform conidia,and developed grey colony color with formation of acervuli whereas C.*gleosporoidies* ,*C.lindemuthianum* and C.*capsici*(non acervuli foming) with cylindrical conidia making it differentiable.The confrontation assay with *Trichoderma viridae(*79.8%*)*, *Pseudomonas flourosence(38%)* and *Bacillus subtilis(34%)* showed a clear inhibition zone along with the amount of pigment produced with *C gloeosporiodies* was significantly reduced on dual assay with *Pseudomonas*. The assay with three fungicide namely chlorothalonil, Difenoconazole, Azoxystrobin and tebuconazole+ Trifloxystrobin were checked at four concernteration 50,100 ,250 and 500 ppm with all the fungal culture and effective amount of control was observed especially with tebuconazole+Trifloxystrobin(72.73%) group of fungicide.

PP176(On)3C: Effect of different concentrations of culture filtrate of Trichoderma isolate on Meloidogyne graminicola causing root knot disease in basmati rice

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Rice root knot nematode (*Meloidogyne graminicola*) is the major soil borne pest of rice with worldwide distribution. This nematode has been reported in different rice growing environments like rain fed upland soil, shallow flooded soil and continuous flooded soil. *M. graminicola* infect and causes serious damage to cereals, especially in rice in many countries. *M. graminicola* affected rice plant shows stunting and chlorosis due to the characteristics terminal hooked galls on the roots which ultimately result in severe reduction in growth and yield. Number of eco friendly management technologies against *M. graminicola* have been developed and demonstrated, including the use of bio agents for minimizing the losses due to rice root knot nematode. For the purpose of isolating an effective native isolate of *Trichoderma* for the management of rice root knot nematode, 34 isolate of *Trichoderma* were isolated from different locations and they were tested against root knot nematode for their efficacy under lab and pot conditions. Out of 34 isolate one isolate S-32 was found more effective against root knot nematode. An experiment was conducted to test the efficacy of metabolites (culture filtrate) of *Trichoderma* isolate S32 at different concentrations *viz*, 100 %, 75 %, 25 %, 10 % and 5 % against larval mortality and reduced the egg hatching of *M. graminicola*. Among different concentrations, maximum (80%) larval mortality and minimum (18.33%) egg hatching was recorded at 100 % concentration after 72 hrs of inoculation. Minimum (15.00%) larval mortality and maximum (30 %) egg hatching was recorded at 5% concentration whereas, in case of untreated control (5 %) larval mortality and (70 %) egg hatching was recorded after 72 hrs of J2 inoculation.

PP177(On)3C: Management of sugarcane diseases by organic amendment in sugarcane-growing soils

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A field trial was conducted at CCS HAU, Regional Research Station, Karnal, Haryana to assess the effect of different bio-manures on soil physico-chemical and microbial properties in plant ecosystem. Soil amendment with different organic amendments was evaluated in field experiments for the effect on different sugarcane diseases and growth of sugarcane. Materials included composts prepared from farmyard manures (FYM) and bio-fertilizers in inter row spaces in two different varieties *viz*; CoH167 and CoH 160. The setts were treated with bio-fertilizers *viz;* Azotobacter/Acetobacter + PSB (Phosphorus solubilizing bacteria) for enhancing phosphorus availability to the crop and *Trichoderma viridae* before sowing. Three treatments of different doses with farmyard manure (FYM) @ 20, 25 and 30 t/ha was applied at the time of ratoon initiation. Zero budget technique was also compared with Recommended dose of fertilisers. The effect of different doses of FYM and bio- fertilizers on sugarcane yield, cane quality, and changes in soil physico-chemical and microbial properties in plant–eco system was observed. Among all the three different treatments of FYM, results were found more significant in the treatment 25 t/ha. The incidence of Pokkah boeng disease was found significant more in variety CoH 167 (6.4%) compared to variety CoH 160 (4.6%) whereas the incidence of eye spot disease was upto 9.8 % in variety CoH 160 and upto 11.7 % in variety CoH 167. However, incidence of red rot and wilt of sugarcane was not observed in all the treatments.

PP178(On)3C: Status of spot blotch of wheat and its management under agro climatic conditions of Central Indian

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Wheat (Triticum spp. L.) is one of the most widely produced and consumed cereals, providing around 20% of total energy and protein to the world's population. During the 2018-19 crop year, India produced 101.20 metric tonnes (mt) of wheat from a land area of 29.55 million hectares (mha) Uttar Pradesh typically ranks first in wheat production, with a total record output of 31.99 mt (32 percent) on a 9.79 mha area, followed by Punjab (17.61 mt (18 percent) and Madhya Pradesh 15.19 mt (18 percent).India is the world's second-largest wheat producer Bipolaris sorokiniana (Sacc.) Shoem causes wheat spot blotch disease. The wheat crop in Madhya Pradesh suffers from a number of fungal diseases, among which Bipolaris sorokiniana causes spot blotch. The pathogen attacks at all the growth stages of the crop, starting from the seedling to maturity of the plant, so it is indeed a desirable idea to work on management of spot blotch disease. During the rabi season of 2020, an intense roving survey was undertaken to assess the spot blotch of wheat incidence in the agro-climatic condition of central India. The average disease incidence varied from 15.77 to 23.55 per cent, according to the results of the field study. The maximum PDI (23.55%) was recorded in Mandla district, whereas the minimum PDI (15.77%) was recorded in Narsinghpur district in Madhya Pradesh. For the study of cultural and morphological variation among spot blotches of wheat isolates, pathogenic diversity among pathogen populations may give information into infections ability to cause disease in a certain location. Various bio agents and chemical fungicides are tested for efficacy against the pathogen. The concentrations of bio agents and fungicides are reduced to test their efficacy against the pathogen.Bio agents and fungicides reduce the spot blotch of wheat disease incidence and disease severity by seed treatment and foliar application. Pseudomonas fluorescens (1.00%) was found to be a highly effective bio agent in seed treatments, reducing disease incidence by 62.25 percent.The most effective fungicide among all the tested fungicides was propiconazole (0.15%). It inhibited 86.58% of disease incidence. In foliar application of different bio agents and fungicides, Pseudomonas fluorescens was found to be a highly effective bio agent against the spot blotch of wheat. Disease incidence was lowest in Pseudomonas fluorescens treated plots, compared to other bio-agents, which inhibited 49.19% of disease incidence. In chemical, propiconazole fungicide was the most effective fungicide among all the tested fungicides. Propiconazole treated field plots inhibited 67.80% of disease incidence and also reduced the severity level. In terms of in-vitro efficacy of fungicides and bio agents against Bipolaris isolates, propiconazole (0.15%) treated plates had 100% growth inhibition after 7 days of inoculation. The bio agents were found to be highly effective in inhibiting the growth of Bipolaris isolates, inhibiting 40.43 percent of their growth. Revealed that the mean incidence of spot blotch of wheat was significantly positively correlated with maximum temp.(0.766), minimum temp.(0.728) and rainfall (0.170). During the flowering stage of the crop, rainfall has a significant impact on the development of disease. Bipolaris sorokiniana, associated with spot blotches of wheat, is favored by high temperatures.

PP179(On)3C: Status and Screening of wilt Disease of Lentil and its Management under Kymore Plateau and Satpura Hills

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Lentils (Lens culinaris M.) have gained importance in various parts of the Madhya Prasesh as a potential legume crop and are grown in different areas of the M.P. It suffers from many diseases, among which vascular wilt of lentils caused Fusarium oxysporum f.sp. lentis has become a major problem in Madhya Pradesh and in other parts of India where lentils are grown. The gradual, sometimes sudden yellowing, wilting and drying out of the whole plants or most of it, is the most striking symptoms of wilting disease. A survey was undertaken for recording lentil wilt incidence in 10 districts of Madhya Pradesh namely Jabalpur, Katni, Seoni, Balaghat, Umaria, Sagar, Narsinghpur, Damoh, Dindori and Mandla During Rabi season 2020-2021. Maximum incidence (19.8%) of wilt was recorded in Katni District Followed by Umaria district (19%), Sagar (16.4%) Narsinghpur (14%), Damoh (13.8%), Dindori (12.6%), Seoni and Jabalpur (12%), Balaghat (11.6%) and Mandla (9.4%). Based on cultural and Morphological characteristics, the pathogen was identified as Fusarium oxysporum f.sp. lentis. The result of the study showed that in culture isolate from Sagar 90 mm, while the minimum diameter (42 mm) was recorded in the Fusarium isolates from Umaria. The color of the isolates was milky white, pinkish and dull white in color. Isolates collected from Jabalpur, Mandla, Seoni and Balaghat show dull white color with dark brown pigmentation, isolates collected from Katni, Umaria, Damoh and Narsinghpur showed milky white colour with purple pigmentation and isolates of Dindori and Sagar were pinkish in colour with pink pigmentation. During the microscopic study the maximum size of Macro and Micro conidia was recorded as 24.36 × 3.14 μm In the fusarium isolate from Jabalpur, while the minimum size of macroconidia was recorded 9.56 × 3.74 μm in the fusarium isolates collected from Balagaht and the size of micro were 7.74 × 3.12 μm from Mandla was maximum and 4.26 × 2.61 μm minimum frequency of micro conidia found in isolates collected from Katni. Among the seven Fungicides Carbendazim + Mancozeb suppresses 99.76% of the growth of Fusarium oxysporum mycelium. The effectiveness of nine fungicides and Bioagent was evaluated in the field. Trichoderma harzianum was found to be the best treatment for the best germination rate. Plant height (cm), number of pod per plant, number of seed per pod, number of branches per plant and yield. Screening work done in 10 district of Jabalpur division different genotype were taken for the field screening and from which in jabalpur four genotype(RVL 11-6, IPL 31, JL 1 and JL 3) were taken for screening and all the genotype were found susceptible. In Katni District RVL 31 found susceptible, variety IPL-316 found mordarately resistance in Mandla district, Variety IPL- 316 found susceptible in Dindori, Seoni, Balaghat and Umaria District, Variety IPL-316 found resistance in Damoh and Sagar district and variety RVL 13-5 and IPL-534 are found susceptible and IPL-321 found resistant in Narsinghpur district.

PP180(On)3C: Evaluation of fungicides against Pyricularia oryzae under in vitro conditions

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Rice blast caused by Pyricularia oryzae is the most important pathogen, which also affect the other graminaceous hosts. The major symptoms include seedling blight, leaf blast, node blast, neck blast and grain spot. A study was conducted to evaluate different fungicides against P. oryzae at Main Rice Research Station, AAU, Nawagam, Kheda (Gujarat). Effect of fungicides on radial growth of the test fungus was evaluated by using poisoned food technique with ten different treatments, each at two concentrations (100 and 200 ppm). The radial growth of colonies in each of the treatments was measured in four directions length and width wise (mm) and mean was calculated. The observations were recorded from 2nd to 14th day after inoculation and compared with the control. The results showed that highest per cent inhibition of mycelial growth over control 79.44% at 100 ppm and 92.78% at 200 ppm was recorded in tebuconazole 50% + trifloxystrobin 25% WG followed by azoxystrobin 18.2% w/w + difenoconazole 11.4% w/w SC (78.61 and 91.94%, respectively), whereas the lowest inhibition of mycelial growth was observed in Hexaconazole 5% EC (61.38 and 78.33%, respectively).

PP181(On)3C: Integrated disease management of Paddy Blast

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Rice is the most important food crop for about half of the world's population. India occupies the world's largest rice cultivated area and ranks second in its production. The crop being cultivated in varied climatic and most diverse ecological conditions faces various biotic and abiotic stresses. Among the biotic stresses, paddy blast is the most important disease in rainfed ecologies, causing severe loss in yield. A field experiment was conducted to evaluate the IDM modules for their effectiveness in reducing leaf blast of rice under rainfed unfavourable upland conditions. A total of five IDM modules were formulated involving use of local strain of *Trichoderma harzianum* (Th-CRURRS-9), biocontrol agent, intercropping of rice with pigeon pea, optimum use of nitrogenous fertilizer, pre- and post-emergence application of herbicide and need based application of Tebuconazole 50% + Trifloxystrobin 25%WG. The results revealed that all IDM modules significantly reduced the leaf blast incidence and weed biomass as well. But the IDM module 4 [(Mechanical seed separation (MSS) with Brine Solution + ST with *Trichoderma* @5g/kg seed + Pre-emergence application of Pendimethaline + Need based post emergence weedicide application (35-40 DAE) + Intercropping with pigeon pea (8:1) + N:15+30 +15 (kg/ha) + need based application of Tebuconazole 50% + Trifloxystrobin 25% WG] was most effective in minimizing leaf blast incidence, weed infestation and corresponding yield increase of paddy, followed by IDM module 5 [MSS with Brine solution + ST with *Trichoderma* @5g/kg seed + pre- emergence application of Pendimethaline + Need based PE weedicide application (40 DAE) + IC of pigeon pea (4:1) + N:15 + 30 + 15 (kg/ha) + Need based application of Tebuconazole 50% + Trifloxystrobin 25% WG].

PP182(On)3C: Eco-friendly management of Fusarium wilt of Linseed (Linum usitatissimum L.) by altering the date of sowing

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The experiment has been conducted at the Department of Plant Pathology of Chandrashekhar Azad University of Agri. and Technology Kanpur. It was carried out in wirehouse with Randomised block design (RBD). A total number of eleven cultivars (Jeevan, Shweta, Parvati, Surbhi, Shekhar, NDL-2004-05, Kiran, RLC-92, Indira Alsi, Dipika and Chambal) were sown at 7 different dates starting from 8 October 2020 to 15 December 2020 of 7 days interval each. The incidence of disease and seed yield were recorded. Out of eleven cultivars tested, a minimum percentage of wilting was recorded in cultivar RLC-92 (6.64 percent) followed by Jeevan (8.85 percent) and Indira Alsi (9.70 percent) respectively. Maximum seed yield of 1170.25 kg/ha was recorded in cultivar RLC-92 followed by Dipika (935.48 kg/ha) and NDL-2004-05 (908.67kg/ha). Maximum wilting of 63.55 percent was recorded at the date of sowing on 8th October which was decreasing gradually with delayed sowing. Minimum disease severity of 40.34 percent was recorded in 15th December, sown crop. The maximum seed yield of 572.67 kg/ha was recorded at the date of sowing of 13th November followed by 495.000 kg/ha sown on 21st November.

PP183(On)3C: Isolation, Identification of Antagonistic Endophytic Bacterial Strains obtained from Chickpea (Cicer arietinum L.) and their In-vitro Evaluation against Fusarium oxysporum

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Plant growth promoting rhizobacteria (PGPR), are associated with roots and root nodules can directly or indirectly enhance the plant growth. In this study endophytic bacterial strains were isolated from roots and root nodules of chickpea which were collected from different chickpea growing areas of Ri-Bhoi district of Meghalaya. PGPR were isolated, screened and characterized. Fiftyfour isolates of endophytic bacteria were isolated and four (T54, TS-15, TP-5 and EMP-3) were characterized. The antagonistic activity of all the isolates against *Fusarium oxysporum* was done and production of indole acetic acid (IAA), ammonia, HCN and P-solubilization was evaluated. The strains TS-15 and TP-5 were found to be positive in producing IAA, Ammonia as well as P-solubilization while strains T54 and EMP-3 were found positive for Ammonia and P-solubilization. Furthermore, twenty isolates showed antifungal activity against *Fusarium oxysporum*. The endophytic bacterial strains T54, TS-15, TP-5 and EMP-3 were used as bio-inoculants that might be beneficial for chickpea cultivation as the endophytic bacterial isolates possessed the plant growth promoting characters i.e., IAA production, ammonia production and phosphate solubilization. In *in vitro* tests, *Burkholderia* spp., *Enterobacter* spp., *Pseudomonas* spp. and *Bacillus* spp. inhibited the mycelial growth of the *Fusarium oxysporum*. All the four strains also significantly increased (30-40%) seed germination, shoot length, root length of the chickpea. The incidence of fungi was reduced by the colonization of RHA and RPG which enhanced the seedling vigor index and seed germination. These endophytic bacterial strains appear to be efficient plant growth promoting as well as effective biocontrol agent against *Fusarium oxysporum*.

PP184(On)3C: Management of blast disease of rice through biosynthesized gold nanoparticle and its effect on soil physicochemical properties

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Nanotechnology, the fascinating science refers to the technology of rearranging and processing of atoms and molecules to fabricate materials to nano specifications such as a nanometre (1 - 100 nm). A key requirement in the area of nanotechnology is the growth of reliable and environment friendly process for synthesis of metallic nanoparticles. Development of reliable and eco-friendly process for synthesis of metallic nanoparticle is an important steps in the field of nanotechnology. An experiment was conducted for biosynthesis of gold nanoparticles from entomopathogenic fungi *Metarhizium anisopliae*. Chloroauric acid was added as precursor for the synthesis of gold nanoparticles. Biosynthesized gold nanoparticles was characterized by UV-Vis spectrophotometer, Dynamic Light Scattering (DLS), Fourier transform infrared spectrometer (FTIR), Zeta Sizer and Transmission Electron Microscope (TEM). Formation of gold nanoparticles were confirmed by UV-VIS spectroscopy study with absorption peaks at 550 nm. FTIR study showed that synthesized gold nanoparticle has all the required functional groups like OH, N-H, C-H and COO- . Study on surface properties of nanoparticles by using zetasizer resulted that gold nanoparticle from *Metarhizium anisopliae* was found to be negative and were stable in nature with zeta potential value of -20.7 mV. DLS analysis showed that the average size of the biosynthesized gold nanoparticles is 32.54 nm with polydispersity index of 0.560. TEM study showed that shape of the biosynthesized nanoparticle is from triangular to quasihedral and the size range from 9-54nm.Study on in vitro efficacy of biosynthesized gold nanoparticle from *Metarhizium anisopliae* was tested against *Magnaporthe grisea* at three different concentrations (50, 100 and 150ppm) comparison was made with Tryclozole @ 600 ppm. The result showed that the gold nanoparticles at 150 ppm significantly inhibit the mycelia growth of the pathogens as compared to the Tryclyozole @ 600 ppm. Again, a pot experiment was conducted for studying its effect on soil physico chemical and biological properties by different methods of application like seedling dip treatment, foliar spray and soil application and incidence of blast disease. A positive effect was found on soil physico chemical and biological properties when rice seedling was treated as seedling dip treatment + foliar spray + Soil application of biosynthesized gold nanoparticles @ 150ppm.

PP185(On)3C: Screening of Endophytic bacteria for antagonistic activities against Xanthomonas oryzae pv. oryzae under in vitro

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Endophytes are bacteria that survive inside the host plant without producing illness or having a detrimental effect, and they are known to be able to fight plant diseases. Biological plant disease management, which involves the employment of hostile microbes to battle numerous illnesses in most crops, has recently emerged as a useful tool of organic, eco-friendly, and sustainable agriculture. Biological management has been shown to be the most effective method for protecting crops from infections and controlling the target organism while posing no risk to humans or other beneficial creatures in natural environments. Endophytes play a crucial role in the host plant's functioning by influencing Physiology and developmental processes. By releasing antimicrobial metabolites, synthesising phytohormones, siderophores, competing with pathogens for space and nutrients, and modulating the plant resistance response, bacterial endophytes are known to confer tolerance or resistance to the host plant from various biotic and abiotic stresses. Because BLB of rice is a severe hazard to rice farming and chemical control strategies are impractical, using endophytic bacteria to manage BLB is a must. *In vitro*, I isolated 80 bacterial endophytes and tested them against *Xanthomonas oryzae* pv. *Oryzae,* bacterium that causes bacterial leaf blight in paddy. Five bacterial isolates were found to be antagonistic to *Xoo.*

PP186(On)3C: Antagonistic efficacy of different botanicals against Alternaria leaf spot of ber (Zizyphus mauritiana Lamk.)

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Indian ber (*Zizyphus mauritiana* Lamk.) is one of the most important fruit-crop grown in wide range of tropical and subtropical regions as well as in Mediterranean regions. Ber is a good source of carbohydrate, essential minerals, ascorbic acid, iron, calcium, phosphorus, etc. Ber crop is attacked by many fungal, bacterial and viral pathogens. Out of the fungal pathogen *Alternaria alternata* (leaf spot) causes maximum damage to the crop. Formerly *Alternaria* leaf spot was a minor disease, but due to climatic changes, it emerged moderately too severe in form. The disease leads to formation of irregular brown spots on the upper surface of leaves followed by dark brown to black spots on the lower surface. In present investigation, total nine botanicals were tested at 10%, 15% and 20 % concentration against *Alternaria* leaf spot of ber. Among all the tested botanicals, maximum mycelium growth inhibition percentage was observed in Garlic extract (77.25 %) followed by Ginger (7.00 %) and Neem (74.92 %), while minimum inhibition was found by *Parthenium* (43.31%) followed by Dhatura (58.14 %) at 20 % concentration after 7 days of inoculation. On the basis of present investigation we concluded that the tested botanicals have shown potential antagonistic effect against *A. alternata* causing leaf spot of ber.

PP187(On)3C: Integrated management of banded leaf and sheath blight (Rhizoctonia solani kuhn f.sp. sasakii Exnr) on maize under north Indian conditions

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Banded leaf and sheath blight (BLSB) of maize caused by *Rhizoctonia solani* is saprophytic soil borne pathogen and has wide host range. Experiments on devising integrated disease management (IDM) strategies included sowing dates, nitrogen levels, spacing, sowing method and fungicides application were studied during *Kharif* 2018 and 2019. Disease severity, area under disease progressive curve (AUDPC) and relative AUDPC (rAUDPC) were found maximum in crop sown on June 30th and minimum in crop sown on May 30th. Mean disease severity was observed highest (64.30%) at 150 kg/ha while lowest (33.80%) at 90 kg/ha. The hybrids PMH1 and PMH5 were sown at spacing of 60 cm x 20 cm and 60 cm x 15 cm. Disease severity was observed more in closer spacing of 60 cm x 15 cm rather than 60 cm x 20 cm. Mean disease severity was recorded in PMH5 was 57.1% in flat sowing and reduced to 44.2% in ridge sowing. Azoxystrobin 250 g/l+ difenoconazole 125 g/l and trifloxystrobin 25% + tebucon-azole 50% @ 0.05 % gave maximum disease control under *in vivo* conditions. Only five weeds (*Acrachne racemosa*, *Dactyloctenium aegyptium, Echinochloa colonum, Eleusine indica* and *Cyperus rotundus*) showed typical symptoms. Maximum disease incidence was observed on *E. colonum* followed by *C. rotundus*. Maximum disease incidence and severity was found in *E. colonum* infested plot followed by *C. rotundus* infested plot under field conditions. The cultural, chemical and field sanitation components in IDM could serve to blend strategies for efficient and economic management of BLSB in maize.

PP188(On)3C: Synthesis, characterization and antifungal activity of copper nanoparticles against early blight disease of tomato

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Tomato crop is affected by a number of diseases of which early blight incited by *Alternaria solani* is an economically important disease. The present study was carried out by using copper nanoparticles (CuNPs) and fungicides against *A. solani*. Synthesis and characterization of CuNPs from different plant leaves i.e., *tulsi*, *neem*, *bael* and chemical methods i.e., aqueous solution reduction and precipitation were carried out. The average particle size(diameter) of CuNPs from *neem* were the smallest i.e., 246.5nm while that from aqueous solution reduction were the largest i.e., 1,537nm. *In vitro* efficacy of CuNPs, fungicides, and deionized water stored in copper container were evaluated against *A.solani by* poisoned food technique. CuNPs from *neem* proved to be most effective in inhibiting mycelial growth i.e., 60.24% at 300ppm and 75.9% at 500ppm. Aqueous solution reduction method showed the lowest growth inhibition of 40.96% at 300 ppm and 62.65% at 500 ppm indicating that smaller CuNPs had better antifungal efficacy compared to the larger ones at both concentration doses. Carbendazim 50 WP which was used as check exhibited much lower mycelial growth inhibition. Therefore, CuNPs in ultra smaller dose were much efficient than regular fungicides. Among different fungicides treatment , Kasugamycin 3% SL@0.2% was found most effective in inhibiting mycelial growth (84.34%).Water stored in Cu container for 120hours duration among various treatments resulted in highest mycelial growth inhibition whereas water boiled in Cu container exhibited no growth inhibition suggesting nil Cu content in it.

PP189(On)3C: Effect of seed coating bio polymer in combination with fungicide and biocontrol agents on the vigour and stem rot incidence of groundnut under in-vitro condition

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Seed treatment with one or more components is the most economical and efficient way to protect seed from these seed and soil borne diseases of groundnut and improve seed quality. Because of the high risk in synthetic pesticides, biological control of plant pathogens with bio-pesticides are profoundly supported. Chitosan is notable natural polymeric substances which is nontoxic, biodegradable and biocompatible properties. To determine synergistic benefits of chitosan in combination with beneficial microbes and fungicides can be combined in a strategic manner and applied through seed coating. The experiment was conducted with a combination of effective fungicide, potential biocontrol agents and seed coat polymer (biopolymer chitosan) with different concentrations and their combinations along with untreated seeds as a control were used for coating groundnut seeds. The pathogen was inoculated on each treated and untreated seeds and the maximum per cent of germination, 94.00% was obtained in treatment T5 having double layer combination of (Chitosan @5ml+ Penflufen 13.28% w/w + Trifloxystrobin 13.28% w/w FS @7.5ml+ *Trichoderma harzianum,* Th4d @0.1g) + (Chitosan @5ml+ Rhizobium @0.5g) which showed higher vigour index I and II (3162, 88.36) and minimum disease incidence of 10.72%. Whereas untreated seeds have shown low germination per cent of 66.66, vigour index I (1693.79) and vigour index II (46.38) with maximum disease incidence of 75.24%.

PP190(On)3C: Trichoderma: A promising biological control agent for Plant Disease Management

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Plant Disease Management using traditional methods i.e., chemical method is not considered to be an eco-friendly approach as the chemicals cause environmental pollution by accumulating harmful residues when used. To overcome such a problem, the use of biocontrol agents has been fascinating for many researchers for sustainable disease management. *Trichoderma* is an opportunistic, avirulent, mainly asexual fungus found in most agricultural soils. It acts as an antagonistic and parasitic fungus against many phytopathogens. *Trichoderma spp*. is also a decomposer of cellulosic waste materials. Recently, researchers have shown that *Trichoderma spp.* not only acts as a biocontrol agent but also stimulates plant resistance, plant growth, and development resulting in better crop production. *Trichoderma spp.* has been shown to improve the growth of lettuce, tomato, and pepper plants. *Trichoderma harzianum* strain T-22 has proved to be beneficial in improving the growth of maize plants. The biocontrol activities include mycoparasitism, antibiosis, and competition for nutrients and space. *Trichoderma* strains detect other fungi, grow straight towards them, and produce hydrolytic cell wall degrading enzymes. *Trichoderma* attaches to the host, and coil hyphae around it, form appressoria on the host surface, penetrate the host cell and collapse the host hyphae. *Trichoderma spp.* produce several secondary compounds, including antibacterial and antifungal antibiotics such as polyketides, pyrones, and terpenes. *Trichoderma spp.* also induces defence responses or systemic resistance responses in plants. For example, tomato plants colonized by *T. hamatum* induced systemic changes in plant physiology and disease resistance. The ability of *Trichoderma* to successfully manage the interaction between the host plant and pathogen has been well established leading to a successful biocontrol program.

PP191(On)3C: Trichoderma enriched spent mushroom substrate of Pleurotus sajor-caju as mulch for the management of rhizome rot complex disease of ginger

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A study was taken up to investigate *Trichoderma* enriched spent mushroom substrate (SMS) of *Pleurotus sajor-caju* for the management of rhizome rot complex disease in ginger (*Zingiber officinale*) under field condition. Fungal and bacterial microflora were isolated from SMS, collected from 6 different locations of Kerala, on three different periods *viz.,* March-April, June-July and November-December. The antagonistic efficiency of these isolates was evaluated against the five pathogens *viz., Pythium aphanidermatum, Fusarium oxysporum, Rhizoctonia solani, Sclerotium rolfsii* and *Ralstonia solanacearum* under *in vitro* conditions. All the isolates from SMS showed antagonistic property against one or the other soil borne pathogens, with varying degree of inhibition. Most efficient antagonists were identified as *Trichoderma viride, T. koningii, T. harzianum, Bacillus safensis, B. methylotrophicus* and *Burkholderia gladioli*. Since SMS could be effectively used as a medium for the mass multiplication of microorganisms, it was enriched separately as well as in combination with these fungal and bacterial antagonists. The resultant enriched and biosoftened SMS were used as mulch in ginger. From field evaluation it was found that the SMS softened with *T. viride* recorded the lowest disease incidence. Results were on par with the SMS softened with consortium of antagonists, *T. koningii* and *T. harzianum.* The study concluded that the SMS softened with *T. koningii* and *T. harzianum* can be used as mulch in ginger additionally this was found equally effective for the management of soil borne diseases as well as enhancement of rhizome yield.

PP192(On)3C: Plant growth, yield response of Soyabean to different NPK-bio fertilizers and MPKV consortia

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Bio fertilizers are typically microbial formulations in organic carrier materials that improve soil health and crop growth and development .A field experiment was conducted to investigate the effect of a different NPK, fixing bacterial bio fertilizers with their MPKV consortia on soyabean (*Glycine max* (L.) for plant growth, yield and other yield attributed characters at oilseed research station ,Jalgaon(M.S., India) in the year Kharif 2021-22.In the result revealed that germination %,Plant stand/m2 ,No .of branches per plant and plant height,was found numerically superior in the treatment T6(MPKV *Rhizobium*, PSB and KMB consortium+75%RDF) have (99.00%,42.00,7.97,68.07) respectively. Significantly superior 1000 grain weight (gm) and yield q/ha. was found in the treatment T4(MPKV *Rhizobium*, PSB and KMB consortium+100% RDF)i.e. 190.33gm,26.69 and treatment T6 (MPKV *Rhizobium*,PSB and KMB consortium+75% RDF) i.e.179.67gm.,26.48 respectively found at par with it. For no. of nodule/plant in respect of all the treatment, significantly superior result was found in the treatment T7 (*Rhizobium* + 75% N + 100% RD P & K Rhizobium +75% N +100% RD P &K)i.e. 43.00 and treatment T4 (MPKV *Rhizobium*, PSB and KMB consortium +100% RDF)i.e.42.93 and T3(MPKV *Rhizobium*,PSB and KMB consortium)42.33 found at par with it. The study revealed that with saving of chemical fertilizers, without environment pollution and biosphere safety the MPKV,biofertilizers consortia(talcum based) help for maximize the yield of soybean as use them for seed treatment.

PP193(On)3C: Effect of Planting Date and Cultivar on Grain Yield and Disease Intensity of Foliar Blight in Madhya Pradesh

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Foliar blight disease caused by complex fungal pathogens *Bipolaris sorokiniana* and *Alternaria triticina* is an important disease of wheat in Madhya Pradesh. The effect of sowing date has a significant impact on disease development and crop yield, and understanding this aspect is critical when developing a disease control strategy. This study was conducted conducted during the rabi season in the year 2020-21 at the Research farm of JNKVV, Jabalpur. to determine the best planting date to avoid infection with fungus. Five varieties with genotypes namely GW 322 (CZDOS 401), HI 1544 (CZDOS 402), HI 8713 (CZDOS 403), GW 513 (CZDOS 404), and HI 1636 (CZDOS 505), and two dates of sowing 15th November for timely sown and 6th December for late sown were employed in a split plot design with 3 replicates. Dates of sowing were randomized first followed by randomization of cultivars within a date of sowing. Observation revealed that less disease score, more yield, more earhead / m² was recorded in timely sown wheat genotype than late sown wheat genotype. The variety HI8713 showed the least disease score (11) more earhead / m² (471), more grains / earhead (22.1), and highest yield (47.4 q/ha) in both timely and late sown conditions. From the experiment, it is concluded that variety HI8713 sown in a timely (15th November) performed better as they were resistant/tolerant to foliar blight and heat stress.

PP194(On)3C: Exploration of Different Strategies in Integrated Sheath Blight Disease Management for Rice Mat Nursery

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Rice is a very Crop of India as well as west Bengal. In rice mat nursery farmers are facing the problem of sheath blight disease in a huge extent as the humidity is increased here because the trays where seedlings are prepared has to be covered by polythene for 14 days. Our findings provided ,The pathogen *Rhizoctonia solani* is the the causal agent we proved Koch's postulates and under humid conditions this pathogen found to be escaping from soil to canopy And we found canopeo based automated disease quantification methodology found to be accurate and effective and it was found that 100 gram seed density found to be less effected by *Rhizctonia solani* lowest disease severity 29.72% corresponding to 534.95 cm2 of affected area of 1800cm2 ,in search for best agent to control this pathogen we secerned variety of biotic and abiotic agents and their combinations to to found best one in inoculated treatments highest FGCC and 69.81% and lowest canopy temperature (26.63%) found in cucl2 treatment (T5) biochemical defence enzyme expression shown peroxidase (54%) and polyphenol oxidase (52%) and super oxide dismutase has (67%) negative correlation with disease incidence and they(defence enzymes) also had very high positive correlation with each other ,in root system reconstruction analysis studies revealed most of the root system characteristics found to be best in *Trichoderma viridae* treated seedlings 56% negative corelation found between second order root length and disease severity , in histopathological study some amount of infection cushions found on most of the treatments however in *pseudomonas fluorescens* and riboflavin treated seedling no infection development observed ,87% corelation found between disease scoring by FGCC and IMAGEJ methodology so CANOPEO based methodology was adopted for disease scoring and treatment screening as this is quick and accurate and it was found PF+TRICHO+PSB combination is the best as it produced lowest (7.4%)disease severity this treatment is followed by SSP+MOP+CUCL2 +PF+TRICHO+PSB (9.86%) .

3D: Biosecurity, Quarantine & Biosafety

PP195(On)3D: Plant quarantine: an effective practical approach in plant disease management

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The quantum of import and export of plant commodities have been increased during the recent years, there is a distinct possibility of moving insect pests and diseases from their original native habitation to new location. Late blight of potato pathogen (*Phytophthora infestans*) from Europe, coffee rust and banana bunchy top virus from Srilanka, downy mildew of grapes from Europe are some exotic diseases introduced into our country and cause extensive damage. So to prevent the introduction of exotic pests, diseases and weeds from foreign countries or within country, legal restrictions are enforced commonly known as Quarantine. Plant quarantine is defined as the legal enforcement of the measures aimed to prevent pests from spreading or to prevent them from multiplying further in case they have already gained entry and have established in new restricted areas. The word quarantine is derived from Italian word - quarantina means (forty days). Plant quarantine activities in India are carried out under the Destructive Insects and Pests Act (DIP Act) of 1914 and the rules and regulations framed from time to time there under by the Govt. of India. The import of agricultural commodities is presently regulated through the Plant Quarantine (Regulation of Import into India) Order; 2003. The specified planting materials for propagation require growing under Post Entry Quarantine (PEQ) for a specified period. The internationally accepted methods require Pest Risk Analysis (PRA) as a defensive method. The pest risk analysis is mandatory for all the plants/plant material prior to its import into India as per PQ Order, 2003. Inspection of agricultural commodities meant for export as per the requirements of importing countries under International Plant Protection Convention (IPPC) 1951 of FAO which's now replaced by revised text of IPPC as per the model certificates prescribed under IPPC and issue Phytosanitary Certificate. The export inspection involves sampling and detailed laboratory tests in case of seeds and planting material for propagation. Quarantine is accomplished through prohibition, interception, and elimination of pests, diseases and weeds at pre entry, entry and post entry points of consignment. All out efforts are, therefore, required to at least through proper management of crops and an effective implementation of plant quarantine regulations can help in strengthening national programme of pest management in India without risking environmental safety and ecological balance which in turns helps in maintaining the productivity of crops.

SESSION 4:
Commercial plant pathology

4B: Smart agriculture with precision plant protection

PP196(On)4B: Management of Root-knot Nematode (*Meloidogyne incognita*) through Integrated Approaches in Tomato (*Solanum lycopersicum* L.)

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The research trial was carried out for three years at different locations Agricultural Research Station (ARS) Navgaon-Alwar during Kharif 2018 & 2019, Rajasthan Agricultural Research Institute, Durgapura-Jaipur Rajasthan during Kharif 2021 on Tomato. In this research trial applied two fungal bio-agents and one chemical as nursery treatment. Okra (Abelmoschus esculentus) was used as trap crop except untreated check for the nematode trapped at initial stage and okra plants were uprooted after 18 days from date of germination. Fungal bio-agents viz. Paecilomyces lilacinus and Trichoderma harzianum @ 5.0 and 10 g /m2 doses were applied of each respectively and one chemical Carbofuran 3G @ 2.5 and 5.0 g /m2 were applied untreated check (control) was maintained. Research findings of the research trial was Paecilomyces lilacinus @ 10g/ m2 area in nursery treatment was found best fungal bio-agent for the management of root-knot nematode, Meloidogyne incognita. Paecilomyces lilacinus @ 10g/ m2 area plant parameters recorded highest shoot length pooled of the three years (72.56 cm), root length (28.61 cm), shoot weight (528.94 g), root weight (49.36 g) and tomato yield were recorded (249.46 q/ha). Nematode reproductive parameters were recorded minimum, number of females (galls) / plant pooled of the three years (4.00), number of egg masses / plant (1.78), number of eggs and larvae / egg mass (165.56) nematode population / 200 cc soil (157.78) and final nematode population (461.78). Tomato growth and yield was improved and nematode population was decreased. KEY WORDS: Bioagents, Chemicals, Meloidogyne incognita, Okra, Trap crop and Tomato.

PP197(On)4B: *In vitro* efficacy of plant extracts against mycelial growth inhibition of *Fusarium solani* f. sp. *pisi*

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Efficacy of six plant extracts tested under laboratory conditions through poisoned food techniques against root rot of pea at three concentrations viz., 5, 10 and 20 per cent. All the tested plant extracts showed significantly higher mycelial growth inhibition over control. Among these, clove plant extracts were found superior. clove extract was recorded mycelial growth inhibition of 88.67, 92.33 and 100 per cent at 5, 10 and 20 per cent concentrations, respectively. Neem leaf and Turmeric extracts inhibited mycelial growth 76.75, 79.13 and 80.08 per cent and 74.25, 75.70 and 70.45 per cent at 5, 10, and 20 per cent concentrations, respectively. Tulsi extracts were found moderately effective against *Fusarium solani* f. sp. *pisi* **(**60.50, 65.40 and 69.60 %) inhibition of growth at 5, 10 and 20 per cent concentrations, respectively. Eucalyptus and Giloy extracts were observed least effective to control the mycelial growth of *Fusarium solani* f. sp. *pisi* (26.50, 32.75 and 49.67%), (22.18, 25.20 and 30.06%) 5, 10 and 20 per cent concentration, respectively. The data presented that mycelial growth inhibition in the case of the plant extracts was maximum in clove followed by neem, turmeric, tulsi, Eucalyptus and giloy.

PP198(On)4B: Soil Biological Properties as Influenced by Organic and Inorganic Source of Nutrients in Wheat (*Triticum aestivum* L.)

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A field experiment was conducted during *rabi* 2020-21 and 2021-22 at Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur (Rajasthan), to study evaluate the impacts of organic and inorganic source of nutrients on soil biological properties.The treatments comprised four levels of enriched compost (EC), i.e. control, EC @ 2.0, 4.0 and 6.0 t/ha and four levels of inorganic fertilizer (kg/ha) i.e. control, 50% RDF + foliar spray of nano Zn @ 0.5%, 75% RDF + foliar spray of nano Zn @ 0.5% and 100% RDF + foliar spray of nano Zn @ 0.5%, respectively. The experiment was laid out in a factorial randomized block design with three replications. Significant improvement in different soil biological properties, i.e. alkaline phosphate activity, dehydrogenase activity and soil microbial biomass carbon was observed with increasing levels of enriched compost and inorganic fertilizer up to 6 t/ ha and 100% RDF + foliar spray of nano Zn @ 0.5%, respectively after harvest of the wheat (*Triticum aestivum*) crop during both the years as well as in pooled analysis. In case of inorganic fertilizer, however, the microbial populations in soil after harvest of crop increase was significant up to 75% RDF + foliar spray of nano Zn @ 0.5% which was found statistically at par with 100% RDF+ foliar spray of nano Zn @ 0.5%. the application of enriched compost @ 6 t/ha and 100% RDF + foliar spray of nano zn @ 0.5% along with the recommended dose of fertilizer results in significantly higher biological properties of soil under typic haplustepts.

PP199(On)4B: Zinc Oxide Nanoparticles as the biocontrol agents against phytopathogens- Adavantages and challenges

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Nanotechnology is the one of the fastest growing field of the 21st century. Around the world, extensive research is being conducted to manufacture nanoproducts due to their unique properties and used in most of the industries and these nanoparticles are used in the field of agriculture. The metallic oxide nanoparticles like Zn, Cu, Fe, Ag, and Au are most demanding due to their extensive applications. Zinc oxide nanoparticles (ZnO NPs) also have exceptional optical, physical, and antibacterial properties, making them ideal for agricultural use.Several chemiscal methods, such as precipitation, vapor transfer, and the hydrothermal process, can be used to make ZnO NPs but the byproduct

release during the formation of nanoparticles causes' deleterious effect in various groups of organisms including humans and the environment. The biogenic synthesis of ZnO NPs is very common in the present time. The biogenic method is cost-effective, environmentally safe, and effective nanomaterial for biological sciences applications. It has been found in various studies that nanoparticles are excellent bio-control agents against phyto-pathogens. ZnO nanoparticles may effectively use for the control of various genuses like *Fuserium, Candida, Aspergillus*, *Erythricium Rhizoctonia etc.* Although these *invitro* studies are providing promising results but still there are several aspect are remain unexplored for example the size and relative toxicity of non targeted species, cost of production and market value and self life of the nanoproducts. So a lot work is still required to convert lab research into field product in the form.

PP200(On)4B: Seasonal incidences of major insect pests on indian bean, *Lablab purpureus* var. *typicus* (l.) sweet in relation to weather parameters

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Indian bean, *Lablab purpureus* var *typicus* (L.) Sweet belongs to family Fabaceae, is one of the important pulse cum vegetable crops grown in fields as well as in kitchen gardens throughout the tropical regions in Asia and Africa. The crop provides silage, green manure and excellent source for Nitrogen fixation in the soil. It is also grown for medicinal and ornamental purposes. It helps in relieving constipation and weight loss due to good fibre content (Bose *et al.*, 1993). An insect pest viz., aphid, *Aphis craccivora* (Koch); leafhopper, *Empoasca fabae* (Harris); stem fly, *Ophiomyia phaseoli* (Tryon.); pod borer, *Adisura atkinsoni* (Moore); gram pod borer, *Helicoverpa armigera* (Hubner); spotted pod borer, *Maruca vitrata* (Geyer) and pea pod borer, *Etiella zinckenella* (Treitschke) are one of the major constraints attributing low productivity (Govindan, 1974; Reddy *et al*. 2017; Chouragade *et al*. 2018). The incidence of insect pests is varied due to change in agro-climatic conditions. The study on the influence of weather parameters responsible for population fluctuation on a particular crop may assist in prediction of insect pest occurrence in a given area which may be helpful in developing pest management strategy. In the present the investigation aphid, *A. craccivora,* leafhopper, *E. fabae* and whitefly, *B. tabaci*, spotted pod borer, *M. vitrata* and gram pod borer, *H. armigera* were appeared as major insect pests during the crop season *Kharif*, 2019. Among natural enemies lady bird beetle, *Menochilus sexmaculatus* Fab and syrphid fly, *Xanthogramma scutellare* Fab. were observed feeding on these pests. The infestation of the aphid started in the third week of August (34th SMW) and leafhopper and whitefly in the second week of August (33rd SMW). The peak population of aphid (196.8 aphids/ plant) was recorded in the second week of October (41st SMW), leafhopper (20.4/ three leaves) in the fourth week of September (39th SMW) and whitefly (27.2/ three leaves) in the first week of October (40th SMW).The maximum and minimum temperatures showed a positive significant correlation with leafhopper and whitefly population (r= 0.604 & 0.847 and r= -0.502 & 0.691) and non-significant correlation with aphid population. The relative humidity showed negative significant correlation (r= -0.735) with aphid population and non-significant correlation with leafhopper and whitefly population. The rainfall showed non-significant correlation all the pests. The incidence of spotted pod borer, *M. vitrata* and gram pod borer, *H. armigera* started in the second week of August (33rd SMW). The peak population of spotted pod borer, *M. vitrata* (9.80 larvae/ five plants) was recorded in the second week of September

(37th SMW) and gram pod borer, *H. armigera* (7.90 larvae/ five plants) in the third week of September (38th SMW). The minimum temperature showed a positive significant correlation with the population of both spotted pod borer and gram pod borer (r= 0.87 & 0.81 respectively). The other meteorological parameters, *viz*., maximum temperature, relative humidity and rainfall had non-significant correlation with population of the two pod borers.

4C. Advances in Mushroom Technology

PP201(On)4C: Mushroom diversity and marketing in tribal area "Bastar" (Chhattisgarh)

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In Chhattisgarh, Bastar is the southernmost district and covers around 6596.90 sq km which has a variability of mushrooms in its forests area. The present study was carried out and surveyed in 2021 for documentation of natural forest mushrooms from the Bastar plateau region. During monsoon season extensive surveys for many mushrooms were done taking precautions in view of covid. Mushrooms were collected from the forests which were mycorrhizal, parasitic, *Termitomyces*, and saprophytes. The most important mycorrhizal mushroom is *Aestreus hygrometricus*, a highly-priced mycorrhizal mushroom associated with the tree species sal (*Shorea robusta*). Edible mushrooms i.e. *Astraeus hygrometricus* (albino white), *A. hygrometricus* (niger black), *Boletus* sp. (*Jam phutu*), *Russula xerampelina*, *R. rosea*, *R. congoana*, *R. emetica*, *R. albonigra*, *Lactarius piperatus, Lactarius* sp., *Volvariella volvacea*, *Volvariella* sp., *Termitomyces eurrhizus*, *T. heimii* (white), *T. heimii* (Greyish), *Termitomyces* sp., *Cantharellus subalbidus* (*Baans phutu*) were found in this survey which was also sold in their local market, especially by tribal women's over there.

PP202(On)4C: Evaluation of compatible crosses of *Agaricus bisporus* and their genetic characterization

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Industrial mushroom production optimization depends on improving the culture process and breeding new strains with higher yields and productivities. Few systematic studies of genetic breeding of Agaricus bisporus strains have been reported. Hybridization is one of the effective methods to combine characteristics from different strains and create variability in the existing germ plasm. Despite difficulty in hybridization between the infertile isolates it has been reported to be a reliable approach towards strain improvement with development of two successful strains U-1 and U-3 of A. bisporus. In the present study, we used a hybridization method for hybrid production from cultivated Button mushroom. For this, 500 single spore isolates were raised from button mushroom (Agaricus bisporus), out of which 16 single spore isolates (nine from U3 and seven from A15) having slow appressed mycelial growth (d"1.2 mm per day) were selected and put to fruiting test in order to confirm their identity as homokaryons for crossing purpose. Out of one hundred thirty-eight (138) crosses, only five crosses were found compatible and put into fruiting test for confirmation of hybrids. These compatible crosses were named as Hb-1 (SU-18 x SA-7), Hb-2 (SU-31 X SA-2), Hb-3 (SU-31 X SA-7), Hb-4 (SU 11 X SA-31) and Hb-5 (SU-39 X SU-40). Among five hybrids, Hb-2, produced highest average yield (22.2 kg/ 100kg compost) and also exhibited better morphological characteristics as compared to parent U3 and A15 strain which produces 18.10 kg/100 kg and 9.50 kg/100kg compost respectively within six weeks harvesting period. RAPD studies showed that the percentage of polymorphism detected in hybrids was 50.00 per cent and maximum number of bands was produced by OPO-02 in different hybrids. Based on 73 alleles amplified by RAPD markers a dendrogram was generated using NTYSc 2.1 software that clustered total hybrids into two main groups in which Ia comprises four isolates viz., Hb-1, Hb-3, Hb-4, Hb-5 whereas Ib comprise single isolate Hb-2. In all total of five hybrids were differentiated into five variants at 73 per cent similarity coefficient.

PP203(On)4C: Evaluation of lions maine mushroom (*Hericium erinaceus)* strains during 2018 to 2019 under Haryana conditions

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Lion's mane mushrooms (*H. erinaceus*) are white, globe-shaped fungi that have long, shaggy spines. It is being used for both culinary and medicinal purposes. It is also taken as a supplement and available in different forms like capsule, liquid, tablet, powder etc. The literature reports that it has antioxidants which may help in enhancing the immunity, reduces inflammation, improved cognitive, heart health etc. The studies have been reported on animals but it is safe to eat the mushrooms in moderate quantities. It is popular in Asia because of its taste, nutrition, medicinal importance and it can be grown on agro-wastes under laboratory conditions. The Directorate of Mushroom Research, Solan supplied nine strains during 2018 and four strains during 2019 to test their performance at AICRP (mushroom) centre, Hisar. During 2018, the saw dust was used as a substrate for their cultivation while during 2019, the wheat straw was used. The substrates were thoroughly soaked in water overnight, then dried in shade and then supplemented with wheat bran @ 20% on dry weight basis. The supplemented wet wheat straw was filled @ 2.0 kg /polypropylene (PP) bag and autoclaved at 121° C for 2h. The autoclaved bags were cooled and spawned asceptically @ 3% on wet weight basis. The inoculated bags were kept in incubation room at 23-25°C for spawn run and 18-20°C for fruiting. There were five replications and 5 bags/replication and randomized properly as per RBD design. The observations on yield kg/100 kg dry straw and time taken for first harvest (days) were recorded. During 2018, the highest yield of 23.7 kg/100 kg dry substrate was obtained from strain HE 18-08 followed by HE 18-01 (20.5 kg/100 kg dry substrate) which differed significantly from other strains. The time taken for first harvest was significantly minimum (29.4 days) in HE 18-08, HE 18-09 and maximum in HE 18-02 (34.6 days). In the year 2019, the four strains tested and it was found that the maximum yield of 40.95 kg/100 kg dry straw was given by strain HE 19-02 followed by 34.67 kg/100 kg dry straw in strain HE 19-07 which differed significantly from other strains. The strain HE 19-04 produced significantly lowest yield (26.17 kg/100 kg dry straw). The time taken for first harvest was significantly minimum (34.40 days) in strain HE 19-02 as compared to other strains and maximum (39.60 days) in strain HE 19-04.

Central Zone: Special Satellite Symposium

Presidential Lecture (CZ)

Sub lethal heating as a tool for improving control of soilborne plant pathogens

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Soilborne plant pathogens cause heavy losses in commercially important crops grown world-wide. A number of management strategies have been advocated to minimize losses due to these pathogens based on several research findings. Organic amendments alone or combined with bio control agents, soil solarization, soil steaming, and fumigation have been suggested as important management approaches used in different parts of the world. Unfortunately, use of single management strategy has not been found effective in completely eradicating propagules of soilborne plant pathogens at soil depths where propagules of these pathogens survive. In the last two decades, studies were conducted world-over to improve pathogen control by exposing resting structures to sub lethal doses of heating. These doses incidentally eliminate only a part of inoculum, may also affect the surviving and possibly weakened propagules of soilborne pathogens. If any effective management strategy is subsequently applied after a requisite weakening is achieved may require less dose, duration and money for improving the pathogen control. Effects of different intensities of sub-lethal doses were studied in many parts of the world under field and laboratory conditions on different pathogens. These have demonstrated that the weakening effect achieved by sublethal doses of any stress has reduced survival of pathogenic propagules and caused a pronounced effect on remaining viable but weakened propagules, which in turn reduced disease incidence on crops. Several mechanisms have been studied to investigate cause of the weakening effect. These include direct heat, heat shock proteins, toxic volatiles, cracking in spores, dehydration, and loss of energy, delayed germination and mortality. This caused increased microbial antagonism, which was considered as the most important mechanism, which operated singly or in a sequence for further exerting an irreparable effect on resting structures of soilborne plant pathogens. This tool provide a novel approach for improving pathogen control in those regions where adequate sublethal heating or any other method of stress is possible due to hostile climatic conditions. Studies conducted at CAZRI on effectiveness of prior weakening on different soilborne plant pathogens and mechanisms involved are reviewed in this paper.

Nematode management in vegetables through biopriming

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Phytonematodes (PPNs) are ubiquitous browsers on crop plant. Among 3000 parasitic nematodes identified so far, about 90% feed on roots and rest 10% feed on aerial parts of plant. These parasites cause about US dollars 125 billion (12-15%) loss both quantitatively and qualitatively globally. In India during 2007, monetary loss of Rs. 2100 crore annually in 24 crops covered under AICRP on Nematodes in Agriculture was estimated but to gather with other crops, it can come to Rs. 12000-

15000 crore. Among root-knots, cysts, stunt, reniform, burrowing, lance, lesion, etc., root-knot nematodes attack almost all agricultural and horticultural crops, more horticultural crops in India. Several researchers have worked on different methods of management of nemic diseases but unfortunately, of several effective chemicals, only carbofuran and its derivate carbosulfan are available to the farmers. However, carbofuran has been banned and even otherwise nematodes have created resistance against carbofuran. Hence, bio logical agents such as *Trichoderma viride* (Tv), *T. harzianum* (Th), *Paecilomyces lilacinus* (Pl) (*Purpureocillium lilacinum*), *Pochonia chlamydosporium* (Pc), *Pseudomonas fluorescens* (Pf), *Bacillus subtilis* (Bc) and even bio fertilizers like N fixing Azotobacter, P, K, ZN, Fe, & S solubilising and mobilizing bacteria helped to manage nematodes by having their PGR properties to suppress nematode infection. But practically no much work has been done bio priming for nematode management in crops as revealed from literature scanned. Out of 3 different bio agents viz., Tv, Th & Pf tried as seed treatment at 5, 7.5 & 10g/kg seeds in cowpea indicated that seed coating with all three bio agents at 10g/kg seeds significantly improved plant growth characters with reduction in no. of galls/plant & eggs/egg mass and total *M. incognita* population over control. In okra, Tv, Th, Pc, Pl & Pf tried as seed coating @ 20g/kg seeds reduced no. of galls & egg masses/ root system and total soil population over control. Pl was more effective and was at par with carbofuran. Pl used as seed treatment @ 20g/kg seeds+ nursery bed treatment with 50g/m2 and transplanting treated seedlings in field after application of 5 tons FYM enriched with 5 kg Pl (1% WP) had minimum RKI (2.3 & 2.2) and increased tomato fruit yield (18.2 & 17.4%), minimum root population (22 & 20/10g root) and 67 & 70% egg parasitism by Pl in 1st & 2nd season over control. Two years poled data indicated that among four different seed treatments with different combinations of bio agents, combination of BA: Bio All (Mixture of Azotobacter, Azospirillum,, Phospho Solubilizing Bacteria(PSB) & Potash Solubilizing Bacteria (KSB)) + BM: Bio Micro (Zinc, Ferrous,& Sulphur Solubilizing Bacteria + ND: Nicoderma 1 % WP (*Trichoderma viride*) + BN: Bioniconeema 1% WP (*Purpureocillium lilacinum*) + PA: Power All 1% WP(*Pseudomonas fluorescens* each @ 20ml or gm/kg seeds increased seed germination, seedling growth & height, production of transplantable seedlings and decreased root-knot disease to the tune of 53.7,57.5,75.2, 117.9 & 34.1% in tomato cv. Abhinav (ICBR 1: 335) and 60.5,37.6,38.3,130.4 &25.9 in chilli cv Nisha (ICBR 1:324) respectively over control. Bio fertilizers would have made the seedlings more stout and healthy to resist RKN infection. Moreover, ND, BN & PA being fungal & bacterial parasites would have checked nematode infection and thereby enhanced seedling growth and production. Even in field also, all four bio agents treatments were superior over control but same combination of B A + BM + ND + BN+PA recorded significantly less RKI (2.87) with significantly higher fruit yield (393.9 q /ha) (ICBR 1:39.1) in tomato and RKI (2.40) with significantly higher fruit yield (194.4 q/ha) (ICBR 1:30.2) in chilli over other treatments including control. Thus there is a need to undertake more studies on seed bio priming of vegetables in nursery and crops of short duration with bio agents for eco friendly management of nematodes and other soil borne pathogenic organisms to enhance crop production.

Potential bacterial biocontrol agents for management of diseases in vegetables crops

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Vegetables are an important item of human diet throughout the world and to ensure nutritional security, the level of vegetable production in a country is required to increase significantly. A positive factor in cultivation of vegetables is that most of the vegetables are short-duration crop. As a result, they can be produced in succession, on the same plot. More than fifty varieties of vegetables are grown on an area of about four million hectare in India, major vegetable crops of the country include potato, onion, peas, cauliflower, tomato, brinjal, okra, cabbage and cucurbits. However, the vegetable crops suffer from biotic stresses caused by pathogenic organisms such as fungi, bacteria, viruses, viroids and nematodes. The plants produce different type of symptoms of the disease depending on its cause, nature, and the location of the impact site. The symptoms of plant diseases include wilting, spotting (necrosis), mold, pustules, rot, hypertrophy and hyperplasia (overgrowth), deformation, mummification, discoloration, and destruction of the affected tissue. The plant diseases have become an increasingly significant factor affecting crop yield and economic efficiency. Despite of various methods available for the management of black rot disease such as spray of antibiotics, copper fungicides, crop rotation and control of cruciferous weeds, the disease remains the most important disease of vegetable crops worldwide. Moreover, development of antibiotic resistant mutants and health hazardous pesticides should be discouraged. Hence, the availability of alternative protective strategies has been reassessed and consequently the development of eco- friendly approaches and presently, food hygienically safe plant protecting methods based on biological approach particularly bacterial antagonists has been greatly emphasized to control vegetables diseases. Hence it is necessary to select a potential bacterial strain poses both antagonistic as well as have ability to promote plant growth. Disease suppression by using microbes in biological control is the result of complex interactions among the antagonist, the pathogen, the host and its associated microbial community and the physical environment. Several genera of bacteria are associated with biological control of various vegetable diseases among them species of *Bacillus* and *Pseudomonas* play a significant role to improve over all plant health. They have ability to produce different types of bioactive compounds like antibiotics, volatile and growth promoting substances, which help plants to cope up with the diseases. However, further research on plant growth promoting, antagonistic and biodegradation activities through these bacteria is utmost require if these strategies are to be implemented for betterment of plant and soil health for sustainable production of vegetables crops.

Enhancing Export Potential by Mitigating Biotic and Abiotic Stresses in Arid Legumes: Guar

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Guar is extremely drought hardy, deep rooted summer annual legume with great economic and adaptive significance. The crop can sustain almost for 30-40 days in the field with mercury mounting more than 42°C in arid rain fed situations. It requires less inputs and minimum care. It can be grown in any type of soil situation barring there is no water logging. Biotic stress in plants is caused by living organisms, especially fungi, bacteria, viruses, nematodes etc. adversely affect growth, development of crop. In the Indian context, fungal and bacterial diseases are the major constraints in the production and productivity of guar. It however, suffers from Bacterial Leaf Blight, Alternaria Leaf Spot, Dry root rot and Powdery Mildew diseases. Seed treatment and foliage sprays are available which are quite effective to minimize losses due to diseases, one should identify the diseases and conditions that favour disease development and prepare management strategies that are effective, practical, safe, and economical. Of the total global production of more than 15-20 lakh tones annually, India is the most important guar producer in the world contributing almost 75%- 82% global guar grain production. Annually almost 75% of guar gum including its few derivatives like refined splits, gum powder and guar meals are exported from India. However, in 5-7 years before, Indian exports have shown high volatility in both volume and value. Exports from almost 4.04 lakh ton worth Rs.2811.93 crore during 2010-11, rose dramatically to almost 7.07 lakh ton in 2011-12, worth Rs. 16523.87 crore. In 2012-13, it dipped to 4.06 lakh ton worth Rs. 21287 crores, eventually picking up again in the year 2013-14, to almost 6.02 lakh ton worth Rs. 11734.5 crores. In order to prepare a status report of the sector, prioritize requisite R&D and prepare an action plan towards boosting exports, we often interact with the different major sector stakeholders including Institutions like CAZRI, Jodhpur, CCCSHAU, Hisar, NIAM Jaipur; ONGC, WSS, Ahmadabad; FRI, Dehradun; IICT, Hyderabad and from Guar Gum Manufacturers Association, Jodhpur, exporters, besides officials of Ministry of Commerce and APEDA. We have reported the status, potential, and prospects of guar and its products. In view of the emerging and fast changing market scenario, this work highlights the challenges especially the technical ones, which needs to be addressed in a composite manner, so that our country is able to consolidate and expand our presence and reach in the market. Finally, we report action plan and strategy, both in the short and long term to tap the market potential to the maximum extent. The recommendations are categorized in two distinct categories: dissemination of best practices and trajectory of R&D efforts. The dissemination of best practices include recommended specific varieties of seeds for sowing and sowing methods in areas of differing rainfall situations. The R&D Efforts include needful breeding of seeds, introducing appropriate machinery for advanced processing, guar derivatives etc.

Advances in detection and diagnosis of diseases in oilseed brassica for enhancing export potential

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India is the largest producer of oilseeds in the world and the oilseed sector occupies an important position in the agricultural economy of the country. Oilseeds are among the major crops that are grown in the country apart from cereals. Among the nine annual oilseeds cultivated in India, the share of Rapeseed-mustard is about 25% of the total area and 27% of total production. With the share of 39% in total vegetable oil production, Rapeseed-mustard stands at the first position. Rapeseed-mustard is the major source of income, especially to the marginal and small farmers in rainfed areas which are about 25% of the total cultivated area under Rapeseed-mustard. During the last 5 years, the compound annual growth rate (CAGR) of Rapeseed-mustard production and productivity at the National level increased by 10.42 and 8.46%, respectively. Rapeseed-mustard production and productivity (2014-15) were 6.28 mt and 1083 kg/ha which increased to 9.26 mt and 1511 kg/ha (2019-20), respectively. India exports edible oils in small quantities to meet expatriate demand. Otherwise, edible oil is India's third-biggest import item after crude oil and gold. The country exported 80765 tonnes of various edible oils valued at Rs 955.51 crore in which mustard oils 3881 tonnes were mainly exported to the UAE (963 tonnes) and the US (445 tonnes) in 2019-20. Though the yield potential of Indian mustard has been realized up to 3.0 t/ha at experimental fields, it failed to perform at farmer fields due to input insufficiency (soil and water) or rhizospheric disparities. Abiotic stresses cause yield losses up to 30-40% while in biotic stresses due to insect-pests (Painted bug, aphid), diseases (Sclerotinia stem rot, white rust, Alternaria blight), and weeds, cause yield loss up to 30% in different regions of the country. Plant diseases are considered as risks because they constantly contribute to significant yield, economic, and environmental losses worldwide. Therefore, the early and accurate detection, monitoring, and assessment of plant diseases are important and necessary for farmers, managers, and decision-makers.

Advances in Detection and Diagnosis of diseases in Pearl millet

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Pearl millet, Pennisetum glaucum (L.) R.Br. is an important crop grown widely in semi-arid arid tropics of Asia and Africa for the purpose of its grain and fodder. Pearl millet is having very good nutritional value in terms of higher levels of protein, zinc *etc*. Demand for pearl millet is expected to exceed the projected increase because of the lower productivity of the crop in India. Many biotic stresses result in economic losses to the crop by way of yield reduction. Green ear disease / downy mildew, ergot, rust, leaf blast and smut are the major pearl millet diseases responsible for lower production of pearl millet in India. The diseases of pearl millet need immediate attention so that they can be managed properly and economic yield of the crop can be harnessed. In present lecture, the advances in detection and diagnosis of pearl millet diseases will be discussed to disseminate the knowledge for proper understanding of all aspects of diseases and proper management of the diseases. The early and accurate detection of pathogens is essential for the proper diagnosis and management of the diseases. Identification of pathogens results from the chain of events involving culturing techniques, microscopy (optical and electron microscopy), serological techniques like immuno electrophoresis, monoclonal antibodies, immune-gold labelling and molecular tools *etc*. During last few decades due to spectacular development in the field of biotechnology, a wide range of molecular techniques viz., gel electrophoresis, Fluorescent in situ hybridization (FISH), multiplex PCR, RT-PCR, BIO-PCR, microarray, microbiome profiling, massive parallel DNA sequencing, molecular typing of pathogens, mass spectrometry *etc.* have been used for detection, classification, characterization, identification and diagnosis of pathogens. RT-PCR is used for the quantification of the pathogen in the target sample at the early stage. In the current era, the use of significant molecular tools and techniques deserve due consideration for the detection, diagnosis and management.

Identification of pearl millet genetic resources having resistance against leaf blast caused by *Pyricularia pennisetigena* for hot and arid environments of Western India

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Pearl millet is an important rainfed crop cultivated to meet food and fodder requirements in hot and arid environments of Western India. Productivity of the crop has dramatically enhanced in the region by adoption of early hybrids having resistance against downy mildew disease. In recent years, incidence of blast has increased in hot and arid pearl millet growing regions of western India. Till date, Leaf blast has been reported to be caused by *Pyricularia grisea,* but in recent studies causal agent is found to be *P. pennisetigena* in hot arid parts of Rajasthan. Hybrid program depends upon

Central Zone: Special Satellite Symposium the disease resistance levels of both seed and restorer hybrid parental lines to develop disease resistant hybrids. During rainy season of 2019, 215 pearl millet hybrids developed using 20 male sterile lines and 29 restorer parents were evaluated at Jodhpur, Rajasthan, India under rainfed conditions. The crop received more than 500 mm rainfall which created highly congenial humid environment for the expression of leaf blast disease. Disease severity was very high and uniform in the trial, data for disease severity was recorded on 0-9 standard scale at post-flowering stage in each hybrid. Based on performance of hybrids, parental potential for blast resistance was analysed. Male sterile lines ICMA 15222 and ICMA 08555 showed high resistance to the blast disease followed by ICMA 06888, ICMA 16666 and ICMA 16222, whereas ICMA 04555 and ICMA 08333 were highly susceptible. Among the restorer parents, CZI 2017/8 showed very high resistance to the blast disease followed by CZI 2014/3, CZI 2013/8 and CZI 2005/22. In the subsequent rainy season of 2020, the identified resistant parental lines and their hybrids were evaluated in rainfed conditions. Again, leaf blast incidence and severity was high, the identified resistant lines showed leaf blast resistance, confirming their genetic potential for disease resistance. These identified lines are valuable genetic resources for breeding blast resistant parents and hybrids adaptive to hot arid regions of Western India.

Occurrence of Cercospora leaf spot of Mothbean (*Vigna aconitifolia* (Jacq.)) in Bikaner District of Rajasthan

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An Intensive survey was conducted in three *tehsil* of Bikaner district during 2019 *kharif* season to know the severity of Cercospora leaf spot disease of mothbean. Higher severity of leaf spot was observed in Gusainsar village of Bikaner *tehsil* (32.65 %) during survey, followed by Norangdesar village of Bikaner *tehsil* (28.72 %) and least in Parwa village of Nokha *tehsil* (21.28 %).

Screening of different plant extracts and bio-agents against early leaf spot pathogen (*Cercospora arachidicola*) of groundnut (*Arachis hypogaea* L.)

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Groundnut (*Arachis hypogaea* L.) is an important oilseed and supplementary food crop of the world. The crop is suffered from several biotic factors such as fungal diseases like early leaf spot that limit its production and productivity. Early leaf spot caused by *Cercospora arachidicola* Hori. is most destructive disease in all the groundnut growing areas of Rajasthan. To explore the possibility of substituting fungicides with other more eco-friendly products, extracts of ten different plants (garlic, ginger, merigold, NSKE, neem leaf, datura, onion, turmeric, tumba and tulsi) and antagonistic potential of two fungal and two bacterial bio-agents were tested against the pathogen. All the tested plant extracts suppressed the mycelium growth of of *C. arachidicola*. At 15% concentration, maximum per cent growth inhibition of *C. arachidicola* was observed in *Allium sativum* (58.25%) followed by *Citrullus colocynthis* (55.24%) and *Datura stramonium* (51.75%). All the fungal and bacterial bio-agents were significantly inhibited the mycelial growth of pathogen. The maximum per cent growth inhibition of *C. arachidicola* was observed in *T. harzianum* (72.13%) followed by *T. viride* (61.47%), *P. fluorescens* (34.26%) and *B. subtilis* (28.36%).

Assessment of Pathogenic variability of various isolates of *Alternaria sesami* causing Alternaria blight of sesame

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This investigation was carried out during the year 2020 under pot condition using Alternaria blight susceptible sesame cultivar (RT-46). Twenty eight isolates were obtained from various districts of Rajasthan *viz*., Pali, Sawai Madhopur, Jodhpur, Karauli, Bikaner, Ajmer and Jaipur and used to evaluate pathogenic variability of different isolates of *Alternaria sesami*. Collected isolates were coded as AsPA1, AsPA2, AsPA3, AsPA4, AsSM1, AsSM2, AsSM3, AsSM4, AsJD1, AsJD2, AsJD3, AsJD4, AsKR1, AsKR2, AsKR3, AsKR4, AsBK1, AsBK2, AsBK3, AsBK4, AsAJ1, AsAJ2, AsAJ3, AsAJ4, AsJP1, AsJP2, AsJP3 and AsJP4. To assess pathogenic variability among the test isolates, the observation on per cent disease intensity were recorded after one week of inoculum spray (1×10^6/ml). Results revealed that, all the isolates were found pathogenic to sesame and able to produce all characteristics symptoms of the disease as small isolated light brown to dark brown circular spots (1-2 mm dia.) on the lower leaves, which gradually spread to upper leave. Maximum per cent disease intensity was observed in AsJP1isolate (63.29 %) followed by AsJP2 (61.28%), AsJP3 (59.75%) and AsJP4 (58.28%). The minimum per cent disease intensity was recorded in AsBK4 isolate (18.28%) followed by AsBK2 (19.29%), AsBK3 (21.78%) and AsBK1 (22.17%).

Biopesticides for the management of soil-borne diseases of medicinal & aromatic plants: Current scenario and future prospects

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Like other plants, medicinal and aromatic plants (MAPs) are prone to many diseases caused by fungi, bacteria, viruses, phytoplasma, and nematodes. Out of several diseases reported on MAPs, soil-borne diseases caused by fungi cause considerable loss in productivity and quality of the produce. Biopesticides based on living microbes and their bioactive compounds have been promoted as replacements for synthetic pesticides for the control of plant diseases. However, lack of efficacy, inconsistent field performance, low shelf life, and strict regulatory requirements by CIBRC have generally relegated them to niche products. Significant increases in market penetration have been made, but biopesticides still only make up a small percentage of disease control products. Thiry four microbes have been included in the schedule to the Insecticide Act 1968 for the production of microbial-based biopesticides. While working with some important antagonistic microbes (*Trichoderma* spp.), we have documented the biocontrol ability of these organisms not only at laboratory level but also at field level as well as up to the extent of commercialization. We have started promoting the usage of biopesticide formulations as a component of integrated farming practices involving farmers of eastern Uttar Pradesh. The research on biocontrol agents (BCAs) can be fruitful only when we commercialize and register the product based on superior strains. Biopesticide registration requires data on technical and formulation-related information such as biological characteristics, pathogenic contaminants, other microbial contaminants, bioefficacy, toxicity, container compatibility, self-life, etc. To achieve this, certain norms specified by Central Insecticides Board are to be followed. To date, about 970 microbial-based biopesticides products are registered with CIBRC (http://cibrc.nic.in/bpr.doc) under sections 9(3B) and 9(3) of the Insecticides Act, 1968 Government of India). None of the biopesticides registered in India have the level claim of controlling the diseases of MAPs.

Microbes for suppressing nematodes and enhancing plant secondary metabolites in medicinal and aromatic plants

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The past few years have witnessed a steep rise in the cultivation of medicinal and aromatic plants (MAPs) in limited area for higher net returns and greater demand. But at the same time the havoc caused by root-knot nematode has increased tremendously in arable soil and this may be due to the continuous cultivation of root-knot nematode susceptible crops. The major medicinal and aromatic plants which suffer root-knot nematode infestation are: Ashwagandha (*Withania somnifera*.), Qinghao, (*Artemisia annua*.) Brahmi (*Bacopa monnieri*.) , Mints (Mentha spp.), Basil (*Ocimum* spp.),and musli (*Chlorophytum borivillianum*). The scope of chemical armory to combat with nematode pest is showing a decreasing trend due to its adverse impact on human and environmental health. Consequently, it has become inevitable to manage these pests through non-chemical methods. Though, several non-chemical management tactics like fallow, flooding, changes in time of sowing / planting material, tillage practices, crop rotations, use of antagonistic crops, trap crop/ cover crop, use of nematode free planting materials or seeds, solarization and organic amendment are available, efforts are also directed towards the use of microbes to minimize the phytonematode population and to make soil more suppressive to nematode diseases. Organic soil amendments have also been explored by a large number of researchers especially in Asian countries to manage phytonematodes but the large quantities required per unit area renders the strategy largely inapplicable in large scale farming enterprises. The assault on the environment through the use of chemical nematicides as well as unreliable results from cultural methods of nematode management has necessitated the search for sustainable, effective and environmentally acceptable nematode management options. Rhizosphere is the site of intensive interaction between plant and diverse rhizospheric microbes. Rhizospheric flora possesses immense potential for soil and plant health. But this all depends on the density and diversity of microbes. Useful microbes like PGPR, mutualistic fungi, and other nematode antagonists disfavor the multiplication and development of root-knot nematode population in soil, enhancing the growth/yield of medicinal and aromatic plants. For example when nematode population density reaches a certain level, host crop yields suffer greatly as few host plant support faster multiplication of nematodes and others do not. For sustainable cultivation of medicinal and aromatic plants effective management of root-knot nematode is essential. As my group deals with rhizospheric and endophytic microbes, most suitable for growth promotion and biocontrol potentials, we started developing a better understanding of the complex ecologies of soils and agricultural ecosystems, with enhanced strategies for exploitation of various microbes for the management of root-knot nematode and also sustainable production of plant secondary metabolites.

Diversifying dry land farming involving Medicinal and Aromatic Plants: Microbial ways to enhance yields

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Crop diversification provides a greater choice in the selection and production of various crops in a particular region to enlarge production-related activities with reduced risk. Crop diversification is also considered a great option for widening the crop diversity for expanding production-related activities improving ecosystem services. Crop diversification helps reducing the impact and risk on environmental resources, besides exploiting global markets and also reducing imports helping establishing new crop-based industries and thereby generating huge employment opportunities. Ecosystems with better diversity, both crop and microbial, are generally highly stable and are able to withstand ecological disturbances and can recover faster than less diverse systems. It is very well established that higher diversity among plants, animals, and soil-borne organisms inhabiting cropping or farming system may lead to more diverse populations of beneficial organisms managing pests and diseases. Problems that need immediate attention regarding diversification under dry land agriculture: Some of the significant problems that need quick attention for diversifying into medicinal and aromatic crop cultivation may greatly help the marginal farmers · Water scarcity, · Soil Erosion, · Smaller Land holdings, · Threat from wild life, · Market Reach. Medicinal and Aromatic Plants: With increasing industrialization and urbanization, there had been a considerable increase in industrial turnover of aromatic and medicinal plants, essential oils/aroma chemicals, and a growth in use of aromatics in the food, flavors, cosmetic and pharmaceutical industries. Growing consumer incomes and greater mindfulness related to health benefits associated with these plants may favor this swelling market. Also, increased consciousness about the benefits of essential oils and growing inclination towards aromatherapy and spa has resulted in an upthrust to the market. According to an estimation, the world's demand of essential oils was around 230 kilotons in 2018 worth US$ 8008 million. It is projected to expand at a CAGR of 8.6% from 2019 to 2025 and may touch a value of US$ 15620 million in 2026. Vigorous growth of end-user industries like food & beverage, cosmetics, personal care and aromatherapy has translated into a higher demand of essential oil-based products. In India, area under medicinal and aromatic plants is more than 4,00,000 ha with annual production of about 40,000 metric tonnes of essential oil. In addition, the cultivation of aromatic crops offers hope for enhancing farmers' income despite global warming and climate change. The Council of Scientific and Industrial Research (CSIR), by implementing AROMA and PHYTOPHARMA MISSIONS in 2017 has contributed significantly in the development, nurturing and positioning of phytopharmaceutical and essential oil-based aroma industry in the country. These plants are not expected to create any adverse environmental effect. On the contrary, these crops would be beneficial in remediation of contaminated soils, checking soil erosion, enhancing Carbon sequestration, reclamation of waste- and degraded lands, greening of uncultivable lands, utilization of lands/areas prone to weather extremes (flood, tsunami, cyclone affected areas) etc. Medicinal and aromatic crops are important because of their secondary metabolites which are extensively used in aroma and pharma industries. The quality of these plants is governed by the qualitative and quantitative traits of these secondary metabolites. It has been shown that the quantity and quality of these can be modulated by microbial flora present in the rhizosphere or inside the plants. Plants suitable for dry lands, having the ability to bring decisive and transformative change in the rural economy, market dynamics and growth opportunity this sector, and ways to enhance their yields through microbial interventions would be discussed.

Changing dynamics of pesticides in India

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The FAO estimates that up to 40% of food crops are lost due to plant pests and diseases annually. Complexity of pests is likely to increase, with more frequent pest outbreaks. Climate change is a potential threat. Use of crop protection chemicals can increase crop productivity by 25-50%, by mitigating crop loss due to pest attacks. At present, only 25-30% cultivated area is covered by the crop protection umbrella. The domestic market has enormous growth potential because of low pesticide use, which is among the lowest in the world. India's per hectare consumption of pesticide stands at 0.6kg/ha against the global average consumption of 3kg/ha. India is the fourth-largest producer of crop protection products globally after the United States, Japan, and China. Domestic market was estimated at Rs 23,200 Cr for 2020. It is projected to reach a value of Rs 31,600 Cr by 2024, growing at CAGR of 8.1 % during 2019-2024. Domestic market, insecticides have a 44 per cent share while fungicides and herbicides almost have an equal share of around 22% each. The balance 12% is represented by plant growth regulators, bio-stimulants, seed treatment segments. While insecticides dominate the Indian crop protection market forming the highest share, fungicide and herbicides are emerging as the fastest-growing segment. Total pesticide consumption is the highest in Maharashtra, followed by Uttar Pradesh, Punjab, and Haryana. At present 1175 molecules are available globally but about only 292 are registered in India. Only about 75 molecules and their combinations are being used to protect 140 million hectare of diverse Indian agricultural crops. Increase in pesticide consumption and bringing hitherto untapped areas of cultivation under its umbrella will help to boost agriculture productivity and feed our increasing population. Indian farmers need far greater range of newer molecules to fight the battle against pests, diseases, weeds and other attacks. Diverse and growing portfolio provides farmers with the latest technologies and a wide range of choices for their crop protection needs. The solution is not in shunning chemical pesticides but in educating farmer about judicious use and consistently spending on research to come out with safer and more efficient products.

Role of *Trichoderma* spp. in mitigating moisture stress in black pepper (*Piper nigrum* L.) through antioxidative defence system

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Major factors limiting growth and yield in crops are biotic and abiotic stresses. Amongst the abiotic stresses, drought causes significant reduction in yield. Several species of *Trichoderma* have the innate ability to induce tolerance in plants against abiotic stresses especially drought and moisture stress. The present study was conducted to understand the mitigation of moisture stress by *Trichoderma* isolates *viz*., *T. asperellum* (NAIMCC 0049), *T. erinaceum* (APT1), *T. atroviridae* (APT 2), *T. harzianum* (KL3), *T. lixii* (KA15), and *T. asperellum* (TN3) in black pepper plants. Single node stem cuttings of black pepper (variety: - IISR Sreekara) raised in polybags were subjected to four levels of moisture *viz*., field capacity (FC), 75 percent FC, 50 percent FC and 25 percent FC. After imposing moisture stress the plants were inoculated with different *Trichoderma* isolates. The biochemical parameters *viz*., proline, protein, phenol, lipid peroxidation, chlorophyll, relative water content (RWC), and growth parameters were recorded at the time of inoculation, 10, 20, 30, 40, 50, and 60 days after inoculation (DAI). Under moisture stress, the proline content of plants increased, whereas the plants inoculated with *Trichoderma* showed an additional increase in proline. The plants inoculated with the isolate *T. atroviridae* (APT2) showed the highest protein content, while in uninoculated plants, there was a significant reduction. The plants inoculated with the isolates NAIMCC 0049 and APT2 showed the lower rate of reduction in RWC, even at 25 percent moisture stress. Among the six isolates tested, the isolates *T. asperellum* (NAIMCC 0049), and *T. atroviridae* (APT2) have the potential to induce tolerance to drought stress by enhancing the root and shoot growth and also by triggering protective mechanisms, which in turn prevented oxidative damage. The study showed that the *Trichoderma* isolates hold great promise in mitigating moisture stress in black pepper.

Effect of plant protection chemicals on the survivability of *Phytophthora* spp infecting Black Pepper (*Piper nigrum* L.)

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Foot rot caused by *Phytophthora* spp is an important soilborne plant disease that causes economic losses in black pepper (*Piper nigrum* L.). Primarily, *Phytophthora* spp survive in soil in the absence of the hosts as resting mycelia, encysted zoospores, overwintering zoosporangia, chlamydospores, or oospores. The aim of the present study was to evaluate the effect of plant protection chemicals commonly used for soil drenching and fumigation in black pepper gardens and nurseries on the survivability and viability of *Phytophthora* propagules. Three isolates of *P. capsici* (05-06, 18-01, 20-01) and one isolate of *P. tropicalis* (98-93) isolated from black pepper were used for the study. The molecules tested included, fungicides -Metalaxyl Mancozeb, Propamocarb+Flupicolide, Copper oxy chloride, nematicide -Fluopyram and soil fumigant – Formaldehyde at recommended doses. 30 g each of double autoclaved potting mixture (equal volume of sand: soil: organic manure) were taken in 50 ml glass vials and to that 6ml stock solution of respective chemicals were added. These

vials were inoculated with two mycelial discs of 72 h old sporulating cultures of each isolate. Soil samples were taken from treated and untreated vials at monthly intervals for a period of one year. The qualitative assessment for *Phytophthora* viability was tested using leaf baiting technique and quantitative estimation by soil dilution plating. The results of the study showed that irrespective of different plant protection chemicals, all the test isolates were able to survive in soil one year after inoculation. Mean survivability of *P. capsici* isolate (20-01) and *P. tropicalis* (98-93) was found to highest among tested isolates under all treatments and it ranged from 2.4- 19.5 x 10 3 cfu/g soil to 0.45 -9.85 x 10 3 cfu/g soil respectively, one year after inoculation. The study indicated that *Phytophthora* spp have the potential to survive in soil for at least a year even in the presence of plant protection chemicals and therefore, long-term studies on survival need to be undertaken so as to develop effective foot rot disease management strategies in black pepper.

Assessment of Integrated Management modules for Management of MYMV disease of Greengram in Kumore Plateau and Satpura Hills Agroclimatic Zone of Madhya Pradesh

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The study on assessment of IPM module for the management of Mungbean yellow mosaic disease of Greengram in Singrauli district of Madhya Pradesh which comes under Kymore Plateau and Satpura Hills Agroclimatic Zone of Madhya Pradesh was carried out in three consecutive years during kharif in Greengram farmers fields of Singrauli district. The experiment was conducted in 2000 M2 area each year with active participation of farmers with an objective to assess the integrated management module for the management of MYMV in Greengram. Mean of MYMV incidence in IPM module and farmer practice was 6.95 and 21.43 percent respectively. Mean yield of IPM module was 643.02 kg/ ha with net returns of Rs. and C: B ratio of 15709.42 Rs ha-1 and 1:2.13, respectively. Whereas, farmer practice recorded mean yield of 472.28 with net returns and C: B ratio of 7798.96 Rs ha-1 and 1:1.6, respectively.

In-vitro Evaluation of Herbicides and Botanicals against Stem Rot of Wheat Caused by *Sclerotium rolfsii* Sacc.

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Stem rot caused by *Sclerotium rolfsii* Sacc. has been observed to cause rapid mortality in wheat field. Saccardo named the fungus *Sclerotium rolfsii* in 1911, and it causes 25-50 % loss by infecting herbaceous woody plant seedlings, fleshy roots, bulbs, and fruits.Two experiments were conducted in a complete randomized design (CRD) with three replications to evaluate the efficacy of some Herbicides and Botanicals against stem rot of wheat. Among five herbicides *viz.*(Metribuzin 70% WP and Oxadiargyl 80% WP), systemic herbicide *viz.* (Pyrazosulfuron Ethyl 10% WP and Metsulfuron Methyl 20% WP) and one combo herbicides *viz.* (Bensulfuron Methyl 0.6% + Pretilachlor 6% GR) and five plants leaf extract viz., Neem, Methi, Aak, Kaner and Parthenium at 10 % concentrations were evaluated against *S. rolfsii.* The result revealed that among the five herbicides metribuzin showed 80.00 % growth inhibition, succeeded by Pyrazosulfuron ethyl (51.85%) and Bensulfuron methyl + Pretilachlor (45.92%).Out of five botanical extracts evaluated, neem leaf extract (6.3%) @ 10 % concentration was found promising antifungal for restricting the growth of *S. rolfsii* in solid media.

Management of foliar blight of Wheat (*Bipolaris sorokiniana* and *Alternaria triticina*) through the application of Fungicides and plant extracts

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Wheat (*T. aestivum* L.) is an important cereal crop of India that contributes greatly to the country's food security. Foliar blight is one of the most common diseases of wheat that lead to significant crop loss. In the present work, management strategies are developed against the disease using botanical and fungicides under *in vivo* conditions. Six fungicides namely Propiconazole, Pyraclostrobin, Azoxystrobin, Difenoconazole, Propineb, and Thiophenate methyl, and six combination fungicides namely Luna (Fluopyran + Tebuconazole), Sofia (Hexaconazole + Carbendazim), Azoxy super (Azoxystrobin+ Tebuconazole), Azoxy top (Azoxystrobin + Difenoconazole), Vitavax power (Carboxin + Thiram) and Nativo (Tebuconazole + Trifloxystrobin) were evaluated against foliar blight. Among single fungicides, two sprays of Propiconazole (1ml /L) and among the combination fungicides two sprays of Nativo (Tebuconazole + Trifloxystrobin) (1g /L) proved the most effective treatment with the least disease score (02) and (01) and highest grain yield (6.57 t/ha) and (6.77 t/ha) recorded. Six different plant extracts viz. Garlic, Neem, Ashwagandha, Datura, Ginger, Tulsi (Table- 3.2) and their combinations were evaluated against the disease. Garlic extract (5%) and a combination of Ginger + Garlic extract (2.5%+ 2.5%) found the most effective treatment in which the least disease score (13) and (11) and highest grain yield (6.62 t/ha) and (6.76 t/ha) were recorded.

Effect of solid culture media and cultural or morphological variability among different isolates of *M. phaseolina* causing Stem and Root Rot of Sesame (*Sesamum indicum* L.)

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Five isolates of *Macrophomina phaseolina* namely, AUMP-1, AUMP-2, AUMP-3, AUMP-4 and AUMP-5 were isolated and identified morphologically. Variability among these isolates of *M. phaseolina* was determined using growth parameter and sclerotial body formation criteria. Based on the virulence study on susceptible host (VRI-1) it was identified that AUMP-1 was the most virulent with (53.60 % of disease severity) and AUMP- 2 was the least. Optimum growth of the *M. phaseolina* was observed at 30ºC temperature and observed maximum mycelial growth (90.00 mm) under *in vitro* conditions.
Cultural and morphological studies revealed that mycelium of *M. phaseolina* initially appeared as dirty white then turned to fluffy white to black with minute dark black sclerotia on PDA medium. The hyphal branches were at dense and feathery angles with constriction of hyphal branches at their

point of origin with closed septum. The microsclerotia were dark black in colour and varied in size with 70.27 – 99.00 ¼m. The highest radial growth and excellent sclerotial formation was obtained on PDA media (90.00 mm) and proved best for growth followed by Richard's Agar media (83.63 mm) for growth of *M. phaseolina.*

Eco-friendly Approaches for management root rot of fenugreek incited by *Rhizoctonia solani*

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Fenugreek (*Trigonella foenum-graecum* L.) is vernacularly known as *'Methi'* in India and it belongs to family *Fabaceae*. It has multipurpose significance in the human life as food and medicine. Root rot of fenugreek, caused by *Rhizoctonia solani* has become a severe menace in Rajasthan state and other parts of India and causes qualitative and quantitative losses. Considering the value of fenugreek, the present study aimed at management the root rot disease using organic amendments and cultural practices. Different dates of sowing, plant spacing and organic amendments *viz.*, groundnut cake, mustard cake, neem cake, poultry manure, wool waste and human hairwere evaluated for two consecutive years in the field. Among the date of sowing highest disease reduction (40.26%) was recorded in late sown crop (20th Nov.) with 26.91 per cent increased yield in comparison to standard recommended date of sowing (6th Nov.). In case of plant geometry, 36.67 per cent higher seed yield and 26.82 per cent disease reduction were recorded in narrow spacing (20 cm x 10 cm) as compared to recommended wider spacing (30 cm x 10 cm). The highest per cent of seed yield (66.13%) was found for neem cake with reduced disease incidence 63.39% among all the treatment. The application of wool waste and human hairs into the field are new for managing plant diseases, as these have proved effective with encouraging response by dual action, one by reducing disease (36.67 and 13.01)and another by increasing yield (40.36 and 20.69%).

Pathogenicity of Ascochyta blight of pea caused by *ascochyta pisi*

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Pea *(Pisum sativum* L.) is an annual, cool-season legume native to northwest to southwest Asia. Two types of field peas are generally cultivated one is the field pea (*Pisum sativum* L. var. *arvense*) or called dry pea and other is garden pea (*Pisum sativum* L. var. *hortens*) called table pea. Field pea is generally used as a pulse crop and garden pea as vegetable crop. Ascochyta blight of pea devastating in areas where cool, cloudy and humid weather (15-250C and more than 150mm rainfall) occurs during the crop season the infected field pea plant tissues collected from farmer field presented typical ascochyta blight symptoms purplish black to brown spots or lesions on stems, leaves and pods. Black spore- producing structures may from on these lesions. pod lesions may become sunken. Early symptoms (purple-brown irregular flecks) are first observed under the plant canopy on lower leaves stem and tendrils, where conditions are more humid For proving the pathogenicity of the fungus through Koch's postulates pea seedling of 5-week local variety was taken. This seedling was grown with surface sterilized healthy seeds in pots that was containing pre sterilized soil in it. for inoculating the seedling fungal spore suspension prepared by taking 14-day old culture in sterilized distilled water. The population of fungal spore. Suspension was adjusted to 1× 105 conidia ml-1 of sterile water. the suspension of spore was sprayed on to the plant through atomizer. The moisture in the plants were maintained by regular misting and for maintaining high level of humidity plant were covered with plastic. Disease symptoms observations were recorded after 7 days of inoculations and were recorded till 30th days on alternate days. Then after appearance of the disease symptoms pathogen was reisolated, purified and thus Koch's postulate was confirmed and prove. To compare the disease symptoms on uninoculated plants was maintained as check.

Assessment of yield losses due to Alternaria leaf spot of coriander

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Coriander (*Coriandrum sativum* L.) is an important spice crop belonging to the family *Apiaceae*. It's all the tender aerial parts, stem, leaf, flower, fruits are used due to aromatic flavour. The crop is grown in almost all the states of the country but Rajasthan, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Orissa, Uttar Pradesh and Uttarakhand are the major coriander growing states. The crop suffers due to a number of biotic and abiotic stresses which are detrimental to plant health and seed quality. Several disease causing pathogens are seed borne. They are associated with seeds externally, internally, extra embryal, intra embryal, as contaminant and inert matter as well as associated with inert matter. To test the pathogenicity, coriander plants were inoculated by spray with spore suspension of *Alternaria alternata*. Six week old coriander plants were inoculated by spraying the mycelial spore suspension with the help of an automizer. And control also maintained by spraying sterilized water only and maintaining relative humidity. Symptoms were visually observed and compared with control plants. The pathogen was reisolated from inoculated plants and the culture was compared with original to confirm identity of pathogen. Alternaria leaf spot (*Alternaria alternata*) is a major disease of coriander. Alternaria blight which causes on average 32-57% yield losses. Characteristic symptoms of this disease are appearance of brown or dark brown spots, outlined by concentric lined inside the spots on tender stem and pods. The *Alternaria alternata* genus is characterized by uniform conidia that is longitudinal and transverse septa. The multicellular pigmented conidia are produce in chain. The conidia are broader near the base and tapered into elongate beak. The pathogen seems to have adaptability to higher temperatures and the disease occurs during February-April and it is particularly severe at flowering and post flowering stages and produces a very low quality.

Evaluation of different Novel chemicals against Panama wilt of Banana incited by *Fusarium oxysporum* f. sp. *cubense* TR4

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Total six novel chemicals viz., Carbendazim (Bavistin), Hexaconazole (Convax plus), Tebuconazole (Folicur), Tebuconazole50%+ Trifloxystrobin 25% (Nativo), Fosetyl-Al (Aliette) and Fluopyram 17.7%+

Tebuconazole17.7% (Luna) were evaluated against *Fusarium oxysporum* f. sp. *cubense* TR4 at 50, 100, and 150 ppm concentration. Data revealed that the 100% inhibition was recorded in Tebuconazole50%+ Trifloxystrobin 25% even at 50 ppm followed by Fluopyram 17.7%+ Tebuconazole17.7% and Tebuconazole with 100% inhibition over control at 150 ppm. The Minimum inhibition was found in the Carbendazim with 43.05% inhibition over control at 150 ppm. Same chemicals were tested at 0.2% concentration against Panama wilt of banana under pot condition in poly house. Among the novel chemicals, Tebuconazole 50% + Trifloxystrobin 25% was found most effective against *Fusarium oxysporum* f.sp. *cubense* TR4, in which wilt symptom was not observed up to 78 days after inoculation (DAI) in cv. Grand naine followed by Tebuconazole in which wilt disease was not found before 55 DAI while in Hexaconazole 52 DAI, Fosetyl-Al 50 DAI, Carbendazim 48 DAI whereas in Fluopyram 17.7%+ Tebuconazole17.7% wilt symptoms were appeared in 47 DAI. In control where no treatment was applied wilt symptom was seen in 21 days with a 96% wilt index. Maximum 77.09% inhibition over control was recorded in Tebuconazole 50% + Trifloxystrobin 25% followed by 52.09% in Fluopyram 17.7%+ Tebuconazole17.7%, 50.00% in Tebuconazole, 48.96% in Hexaconazole, 45.83% in Carbendazim and minimum 29.17% in Fosetyl-Al.

Trichoderma viride for management of early blight in potato

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Early Blight is one of the most serious diseases of Potato. The efficacy of bio-agents was studied and revealed that all four *Trichoderma* species significantly reduced the mycelial growth of the pathogen over the control by the dual culture method. Significantly maximum inhibition of mycelial growth was obtained with *T. viride* (57.08%) followed by *T. azospirillum* (50.00%), *T. harzianum* (43.26%), and *T. virens* (37.08%) of the pathogen after 48hours of incubation. In the present study, *T. viride* was observed inhibitory against *A. alternata*. In-field conditions, among the bioagents, both methods of tuber treatment through application of *Trichoderma viride* and *Pseudomonas* were equally effective against early blight as compared to control. Whereas, maximum disease control and minimum disease intensity were recorded in *Trichoderma viride* @8gm/lit per 20 kg of tuber treatment combined with two foliar spray *Trichoderma viride* @5ml/lit of water. However, maximum disease intensity was recorded in the control. Among the media tested, the potato leaf agar and potato broth medium were the significantly superior and most effective medium for growth as well as dry mycelial weight followed by PDA. However potato leaf agar medium was also superior for sporulation of *A. alternata*. In the present study, potato leaf agar was found superior for the growth of pathogen as well as sporulation.

Effect of micronutrients and systemic acquired resistance activators on powdery mildew of Indian mustard incited by *Erysiphe cruciferarum*

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Studies with micronutrients and systemic acquired resistance activators were performed in field to assess their potential in managing powdery mildew of Indian mustard (*Brassica juncea*) incited by *Erysiphe cruciferarum*. This biotic stress has become a severe menace to the growers of Rajasthan in India and in general causes economic losses under changing climatic scenario. During this study, six micronutrients (Zn, B, Cu, Mn, Fe and Mg) and six systemic acquired resistance (SAR) activators (salicylic acid, isonicotinic acid, ethylene, fosetyl Al, ²-amino butyric acid, gamma-amino butyric acid) were evaluated under field conditions. Two foliar applications of copper sulphate (0.5%) were proved the most effective in reducing disease intensity (45.31%) and in increasing yield (33.07%) followed by borax. In SAR activators, two foliar application of salicylic acid (200 ppm) were found superior in reducing intensity (54.57%) and in increasing yield (43.43%) followed by isonicotinic acid (@150ppm). The results of this study indicates that foliar application of copper sulphate and salicylic acid has great potential to be used to manage disease effectively and eco-friendly for the betterment of the end users. In lieu of consumer health, findings may be helpful for growers.

Assessment of Various Inoculation Techniques to Prove the Pathogenicity of *Choanephora* Fruit Rot of Cucumber in Rajasthan

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The purpose of this study was to evaluate the effects of different inoculation methods (Pinprick method of inoculation technique, spore suspension inoculation technique and single mycelial disc inoculation technique) of pathogenicity on cucumber plant under cage house condition as well as laboratory condition. Artificial inoculation was done by inoculating fungal spores suspension (1 × 106) by spraying to run-off level and also used fungal mycelial disc on 45 days old cucumber plant (artificially wounded immature and mature fruits) under cage house conditions as well as laboratory condition on susceptible variety Hilton during 2019. Observations on development and progression of *Choanephora* fruit rot on inoculated cucumber fruits and time taken for development of symptoms & complete rotting of cucumber fruits under pot condition (days) as well as under *in vitro* conditions (hrs.) day after inoculation were recorded. The overall goal of this study was to identify a cost- and time-efficient method that might reflect the pathogenicity of *Choanephora cucurbitarum* (Berk. & Ravenel) Thaxter occurring on cucumber. After inoculation, the fruits were kept in plastic covers in order to maintain humidity and incubated at room temperature for 24 – 48 hrs till the appearance of symptom on the inoculated fruits under *in vitro* condition. The results revealed that under cage house condition typical symptoms of the fruit rot appeared at 3-5 days after inoculation on cucumber fruit (Single mycelial disc inoculation technique), 7-10 days (Pinprick method of inoculation), 8-12 days (Spore suspension inoculation technique) and under laboratory condition, typical symptoms of the fruit rot appeared at 3-4 days after inoculation on cucumber fruit (Single mycelial disc inoculation technique), 5-7 days (Pinprick method of inoculation), 5-8 days (Spore suspension inoculation technique). The fungus was re-isolated from the diseased cucumber fruits. Koch's postulates were proven by re-isolating the fungal pathogen in a pure culture.

Management of powdery mildew of ber (Oidium erysiphoides f.sp. ziziphi) through natural products

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Ber (Ziziphus mauritiana Lamk.) is an old and important fruit of Indo-China region. Ber is a tropical fruit tree spp. belonging to the family Rhamnaceae. Powdery mildew of ber incited by Oidium erysiphoides f.sp. ziziphi, Yan and Wang is the most important disease that causes maximum reduction in yield and quality of ber fruits. Powdery mildew disease is easily recognized by the presence of white floury patches appearing mostly on leaves and young and immature fruits. In modern era, it is considered that food items produced organically are very less destructive to human health, eco-system and are full of nutritive values. Looking to the increasing awareness of people, natural products were tried to manage the disease through cow urine and Panch gavya. Different levels of two natural products (cow urine 10%, 20% and 30%; Panch gavya 10%, 20% and 30%) were sprayed twice under natural conditions in orchard. Two foliar applications of Panch gavya (@30%) at 15 days interval starting from disease initiation was recorded highly effective with minimum disease intensity (18.63%) followed by cow urine 30% (19.57%), Panch gavya 20% (22.20%) and cow urine 20% (22.77%). These present findings may be helpful for growers to earn income by producing organic ber fruits in lieu of consumer health consciousness.

Prof. M.J. Narasimhan Academic Award Contest (CZ)

Strategic management options for leaf curl of chilli

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To establish leaf curl disease and vector population dynamics in chilli for SEIR and SI model and predict seasonal vector abundance based on autoecological and weather parameters on population development and to identify key parameters for interventions to keep low or minimum disease intensity. A field trial was conducted at CAZRI research farm for two successive years, 2019 and 2020. Chilli variety HPH-1041 of Syngenta was sown and observation on presence of virus in the nursery/ transplanting stage, weekly observation in field to determine I (infectious category), and seasonal incidence of whitefly and weather data recorded. It was observed that there was no disease symptoms/ incidences in nursery stage, transplantation stage and till harvesting stage in main field. Although, chilli leaves and vector whitefly samples shown positive PCR reaction for virus in samples collected only afterwards December 16, 2019 and November 02, 2020 in respective years and confirms CLCV infection. None of the former field samples recorded positive for PCR reactions. Observation on weather data, seasonal data, disease incidences, whitefly movement, plant growth and plant growth stages, yield attributing characters was recorded in respective years. Management trials were also conducted in year 2020 against CLCV infection and strategies implicated as follows- Insecticidal spray of Imidacloprid 0.05% in three distinct manners i.e. 4 sprays in T1, 8 sprays in T2 and 12 sprays in T3 for initial one, two and three months respectively; Similarly water spray i.e. 15 sprays in T4, 30 sprays in T5, 45 sprays in T6 for initial one, two and three months respectively and a complete border of whitefly-proof cover (at least 1.5 m height) i.e. Polypropylene Non-woven Fabric 17 GSM or sheet (net 200 mesh) in T7, T8 and T9 around the field with no interruption (neither water or insecticide spray) for initial one, two and three months respectively. Samples for PCR reaction were collected from control plot i.e. T10 with no interventions (neither water or insecticide spray nor border cover). Management trials reported effective disease suppression (12.5%) in the treatment T9 with lowest disease incidence (1.2%) when compared with control which may attribute to vector-movement barrier around plots. In terms of yield which however recorded highest in treatment T7 i.e. complete whitefly-proof border for initial one month only may attributed to the profuse plant growth after removing of cover. Management with insecticide treatment reported low disease incidence and greater production whereas water spray treatments were average in disease management however recorded low yield than control. As per data available the insecticide treatment is more economical and feasible to manage the disease, however, for organic agriculture the barrier for the movement of vector is effective.

Integrated Disease Management Approaches for Early Blight Disease of Tomato caused by *Alternaria solani*

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Early blight disease in tomato is one of the most widespread and destructive diseases in major tomato-growing areas. The only use of synthetic fungicides to manage early blight disease in tomato pose serious risks to human health and safety; and now a day's trend shifting towards healthy, safe and IPM of plant disease. In present study evaluated *in vitro* efficacy of six phytoextracts, four bio agents and seven fungicides were tested in the lab against *A. solani* mycelial development. In plant extract, garlic clove extract was found effective inhibiting mycelial growth 71.23% followed by neem (64.06%), datura (53.10%) and Tulsi (43.10) while, aloevera was found least effective with least mycelium inhibition (38.18%). In case of bioagent, *T. harzianum* was found most effective inhibiting mycelial growth 71.15% followed by *T. viride* (66.35%). Among the fungicides tested, hexaconazole 4% + zineb 68% inhibited 100% mycelium growth of the fungus at 250 ppm concentration, while pyraclostrobin 133 G/L + epoxiconazole 50 G/L SE was the second best fungicide, inhibiting 89.62% mycelial growth at 250 ppm concentration and 100% mycelial growth at 500, 750, 1000 ppm concentrations, followed by kresoxim methyl 44.3 SC @ 0.044%.

Predicting relationship with weather attributes and yield losses due to stem and root rot of sesame caused by Macrophomina phaseolina

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Relationship assessment with different weather parameters of stem and root rot of sesame are essentially needed to increase our understanding about this disease and predict the yield losses. Therefore, correlation coefficient of per cent disease incidence with different meteorological components was calculated and regression equation was drawn. The results indicated that disease incidence was considerably influenced by the prevailing weather conditions. In epidemiological studies, results revealed that stem and root rot of sesame is highly favoured by high temperature, low relative humidity and low rainfall conditions. Stem and root rot of sesame favoured by high temperature and low relative humidity. Disease incidence was maximum (11.33 and 14.34%) as weekly per cent disease incidence during 2018 and 2019 cropping seasons, respectively. Disease was declined during last week of September and showed significantly positive correlation with maximum temperature and sunshine hrs. Minimum temperature, relative humidity and rainfall showed negative correlation during 2017 and 2018 crop seasons. A correlation of multiple determinations (R2) showed that 73.50–89.30% disease incidence was based on weather variables during 2018 and 2019, respectively. Likewise, results of pot culture study with susceptible highly susceptible variety (VRI-1) on sick soil revealed that the disease incidence was 54.16 and 55.83 per cent in unprotected plot during 2018 and 2019, respectively with an average yield loss of 60.33%. Findings of our study may help in development of sustainable management strategies against stem and root rot disease to minimize of yield consequences in sesame

Clusterbean dry root rot management by Integrating different control measures

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Clusterbean [*Cyamopsis tetragonoloba* (L.)], is a deep-rooted annual legume crop known for its drought and high-temperature tolerance. The production of the clusterbean crop has been stagnant because of its cultivation under rainfed areas, marginal and sub-marginal lands, low soil fertility, and biotic stresses. Among various biotic threats, dry root rot disease has become a major biotic threat

which is caused by *Macrophomina phaseolina* (Tassi) Goid. Clusterbean is generally raised under moisture stress conditions and high temperature, which is also conducive to developing dry root rot disease. The objectives of this study were to find sustainable management strategies to control the soil borne pathogens. In order to control this devastating pathogen, a field experiment was conducted during *kharif* seasons of 2019-2020 at the Research farm in RARI, Durgapura, SKNAU, Jobner, Rajasthan. Integration of various control measures were attempted including plant extract, biocontrol agents, organic amendments and fungicides as seed treatment, soil application and their combinations. The results of this study revealed that integration of disease management practices significantly reduced the disease incidence over the control during both the years under pooled basis. Among the tested treatments, the seed treatment of carboxin 37.5% + thiram 37.5% @ 2g/kg seed + soil application of *Trichoderma harzianum* @ 2.5 kg in 100 kg FYM/ha + soil application of *Pseudomonas fluorescens* @ 2.5 kg in 100 kg FYM/ha), found most promising one which exhibited the lowest disease incidence, highest root, shoot length and grain yield.

Study on pathogenicity factor of Early Blight of Tomato (Solanum lycopersicum Mill.) Incited by Alternaria solani

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Tomato (Solanum lycopersicum L., syn. = lycopersicon esculentum Mill.) is a regular kitchen component of Indian diet which comes under the family Solanaceae. The most important fungal disease of tomato prevalent in tomato growing areas of India including Rajasthan is early blight of tomato caused by Alternaria solani it is regarded as one of the limiting factors for victorious cultivation of tomato. The diseased leaves were collected from farmer's field of nearby Jobner, Kaladera (Jaipur) and fungus associated was isolated and multiplied on Potato Dextrose Agar medium. Purification of the fungus was done by single spore technique and fungus was identified as Alternaria solani on the basis of its phylogenic, morphological and colony characters. Pathogenicity was proved on healthy leaves of tomato. The characteristic symptoms of the disease appeared after 10 days of inoculation. Initially, the symptoms of this disease comprised minute yellow dot like circular, bright yellow colored spots on leaves. After that, spots enlarged, transformed into brown to dark brown, necrotic spots having bright yellow halo and less prominent concentric rings. Spots intermingled and surrounded larger area of leaf. The fungus was found to be pathogenic to tomato producing typical symptoms and results showed that the fungus was pathogenic with 66.45% disease intensity.

Induced Systemic Protection in Groundnut against Collar Rot Disease (*Aspergillus niger*) Through Systemic Acquired Resistance Activator

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Groundnut (*Arachis hypogaea* L.) is an important legume and cash crop of tropical and sub-tropical areas of the world including India. Collar rot caused by *Aspergillus niger* van Teighem is one of the most limiting diseases that affects groundnut crop. The objective of the present study was to evaluate the effect of seed soaking and foliar applications of salicylic acid on disease progression on groundnut crop. The field experiments were conducted for two consecutive years (2019 and 2020) to evaluate the field performance of salicylic acid applied through seed soaking with different concentrations (50,100,150 and 200 ppm) for 30 minutes and then single foliar application of varying concentrations of salicylic acid (50,100 and 150 ppm) on every seed soaking concentrations at 20th day of crop sowing. Field trials showed that seed soaking and one foliar application of SA reduced the disease incidence significantly in comparison to check. The lowest disease incidence (20.70%) and the highest pod yield (22.55 q/ha) were recorded by seed soaking in 200 ppm solution and 20 days after sowing as compared to untreated check (50.85% incidence and 15.27 q/ha pod yield). In conclusion, the use of the synthetic elicitors (SA) can be considered as a tool complementary for the commercial management of collar rot in areas where this disease is gaining importance and becoming a limiting factor. This is the first report of SA application on groundnut for protecting it against collar rot by acting as systemic acquired resistance inducer under field conditions.

APS-IPS Travel Sponsorship Award Contest (CZ)

Survey and Identify the Source of Resistant against Early Blight Disease of Tomato Caused by *Alternaria solani*

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Early blight disease is painful nerve to tomato growing farmer because it causes huge economic loss to the farmer every year. Roving surveys were conducted in tomato growing areas of different tehsils of Jodhpur district, Rajasthan to assess the intensity of early blight diseases. Among them the highest intensity of early blight of tomato was observed in Tinwari tehsil (32.35%) followed by Osian (28.25%). Whereas, the minimum early blight intensity was observed in Bilara (12.04%) tehsil. The overall average disease intensity of the Jodhpur district was (23.10%) based on total 125 fields surveyed in *kharif* 2020. In an another experiment, field screening of tomato cultivar against early blight disease was taken up during *Kharif* 2020. Ten tomato cultivar were evaluated under natural epiphytotic conditions. Among them two cultivars Pusa Ruby and Arka Rakshak were showed 1-10% disease intensity and considered as resistant. Three cultivars Pusa Rohini, Arka Abhed and Arka Samrat, were showed 11-25% disease intensity and considered as moderately resistant. One cultivar Arka Apeksha, were showed 26-50% disease intensity and considered as moderately susceptible, whereas Arka Vikas and VL- Tamatar 4 were showed highly susceptible reaction.

Integratet Disease Management Approaches for Alternaria Leaf Blight of Carrot Caused by *Alternaria alternata*

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The carrot suffers from several diseases among those Alternaria leaf blight is one of the most horrible diseases are causing considerable quantities and qualitative losses in carrot. Application of chemical fungicides are often cost prohibitive and hazardous to environment and human health. Keeping this in view, use of IPM for plant disease management. The efficacy of six plant extracts and four bio-agents were evaluated against the *A. alternata* incite carrot leaf blight under *in vitro* condition. Among the all botanicals, the garlic extract (68.33% & 80%) was observed to be all most effective inhibiting the mycelial growth, followed by neem extract (60.44% & 73.98%) at 5% and 10% concentrations. Among the all bio-inoculants highest per cent mycelial growth inhibition was recorded in *T. viride* (77.13%) followed by *T. harzianum* (70.41%) and *Pseudomonas fluorescence* (57.79%) after 7 day of incubation, along with control were tested *in vitro.* Among the fungicides difenoconazole 25% was inhibited the 100% mycelial growth at 250 ppm concentration, the next best treatment was tebuconazole 50% + trifloxystrobin 25% inhibited the 96.11% & 100% mycelial growth at 250 ppm & 500ppm concentrations, respectively.

Management of Sesame (Sesamum indicum L.) Phyllody through Date of Sowing and Inter cropping

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Sesame (Sesamum indicum L.) belongs to family pedaliaceae, which have basic chromosome number 2n =26 and originated in IndiaThe crop is affected by sesame phyllody disease and transmitted by leaf hopper (Orosius albicinctus Dist.). The effect of dates of sowing on leaf hopper population and disease incidence were revealed that, leaf hopper population was minimum when crop sown on 30th July, with disease incidence 6.83 per cent with respect to other hand maximum leaf hopper population recorded on when crop sown on dated 20th July, with disease incidence 21.40 per cent. Effect of inter crops on leaf hopper population and incidence of phyllody disease in sesame at maturity stage of crop was studied. The maximum number of leaf hopper was recorded when mung bean used as inter crop (Sesame + Mung bean 2:1) with 2.15 vector population per leaf with 27.02 per cent disease incidence, where as the minimum. The minimum leaf hopper population was recorded when cowpea used as inter crop (Sesame + cowpea 1:1) with vector populations 0.86 per leaf showed minimum disease incidence i.e 10.33 per cent, respectively.

Activation of disease resistance in Early Blight of Tomato through salicylic acid

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Tomato (Solanum lycopersicum L., syn. = lycopersicon esculentum Mill.) is a regular kitchen component of Indian diet which comes under the family Solanaceae and it is native of Tropical America. In the era of 16th century it spread throughout the world from the center of origin. After potato, it is second most important vegetable whereas processing point of view it ranks first among vegetables. The pathogen of early blight disease of tomato i.e. Alternaria solani is a soil inhabiting and air borne in nature. Study of Salicylic acid under in vitro condition resulted that SA at 200 ppm (68.45%) concentration was most effective in inhibiting mycelial growth followed by 150 ppm (46.98%) concentration. For activation of defense mechanism of plants, salicylic acid was evaluated through interaction between root dipping and foliar spray. Salicylic acid was proved to be most effective in treatment combination (root dip of 200 ppm and foliar spray of 150 ppm) against Alternaria solani and recorded minimum per cent disease intensity i.e., 17.41%, 20.43% at 45 DAS and 60 DAS, respectively.

Management of Early blight of tomato (Lycopersicon esculentum Mill.) incited by Alternaria solani through Date of Sowing and Use of Biopesticide

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Tomato scientifically known as Solanum lycopersicum L., (syn. = Lycopersicon esculentum Mill.) it is originated in Peru of South America. In searching for natural plant products (botanical pesticides) and use of resistant varieties that can be used as important sources for the control of plant diseases out of thirteen hybrids none of the hybrids found free from disease. Among these hybrids, only cherry tomato (4.21 %) was found highly resistant. Two hybrids i.e. chenaya (8.40 %), F1 gold current cherry tomato (11.21 %) were resistant and five hybrids i.e. abhiraj (14.37 %), tomato oblate yellow (16.30 %), Deep-s-22 (18.15 %), satyam (20.03 %), local hybrid- 4 (21.30 %) were moderately resistant. Three hybrids were moderately susceptible i.e. tomato S yellow pear (28.67 %), local hybrid-1 (43.66 %), local hybrid-2 (49.40 %) while two hybrids i.e. F1 hybrid tomato sachriya (55.53 %) and selection-22 (58.65 %) shown susceptible reaction. In in vitro test, Minimum mycelia growth was recorded in Calotropis gigantean (32.67 mm) whereas maximum mycelail growth (80.33 mm) was observed with Cynodon dactylon.

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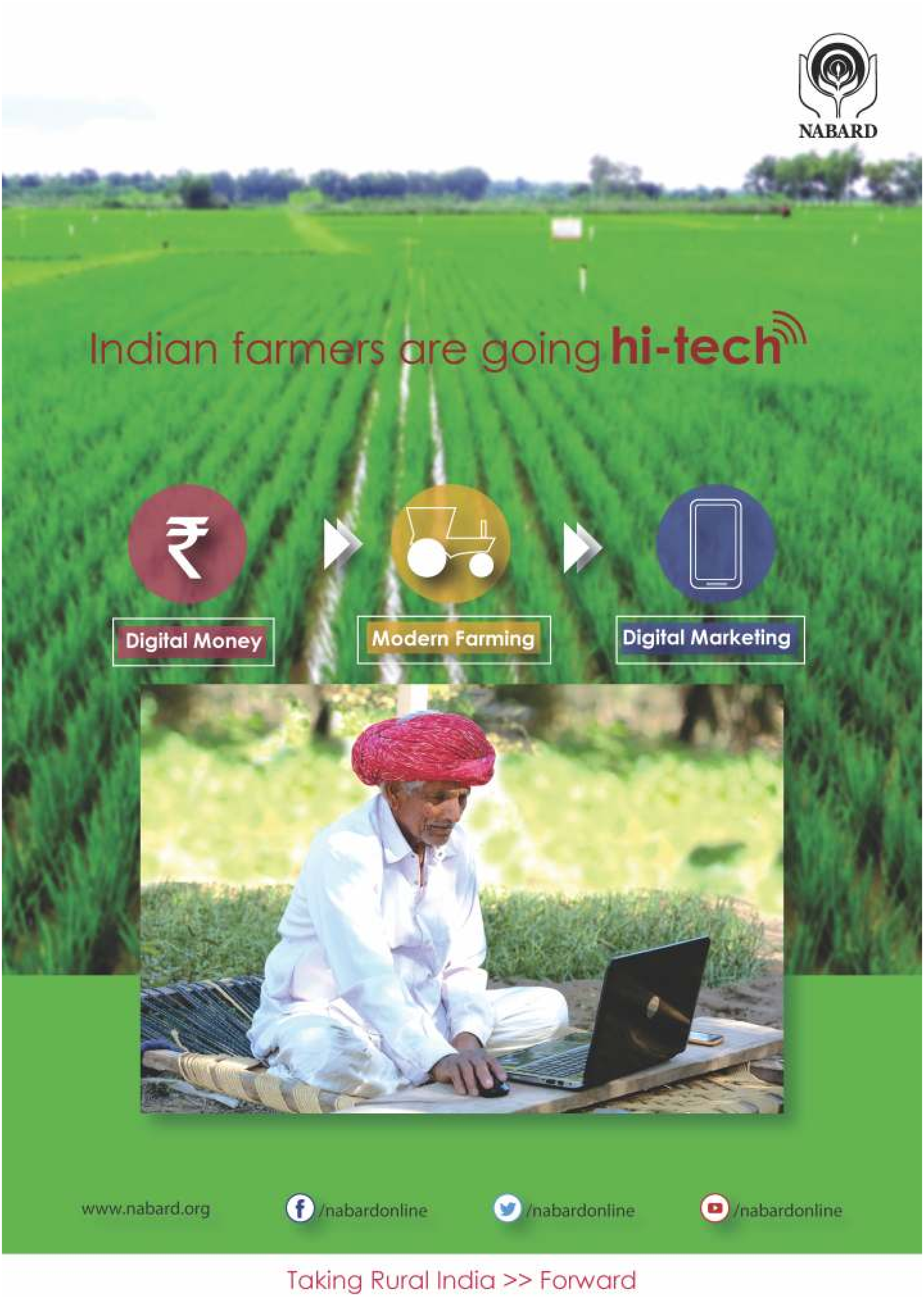
Notes

Note

Note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