70th Annual Meeting

INDIAN PHYTOPATHOLOGICAL SOCIETY

New Delhi

SOUVENIR CUM ABSTRACT

National Symposium

Plant Health Management: Embracing Eco-Sustainable Paradigm

at Assam Agricultural University, Jorhat

February 15-17, 2018

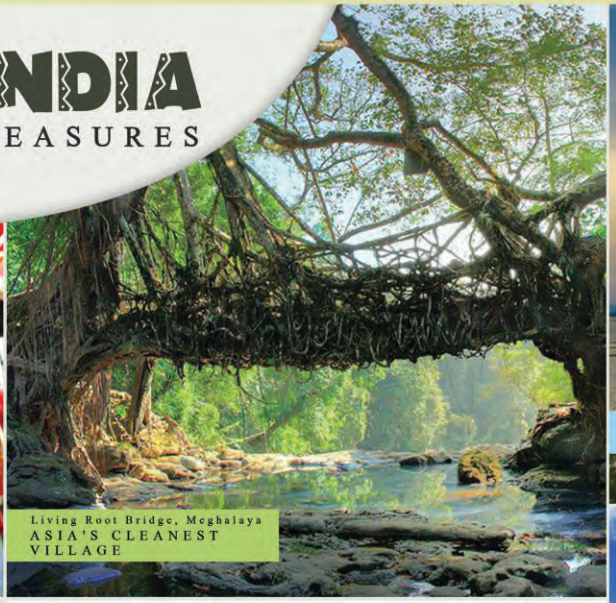
Organized by

Indian Phytopathological Society, New Delhi, India
and
Assam Agricultural University, Jorhat, Assam, India

NORTHEAST INDIA

DISCOVER NATURE'S TREASURES

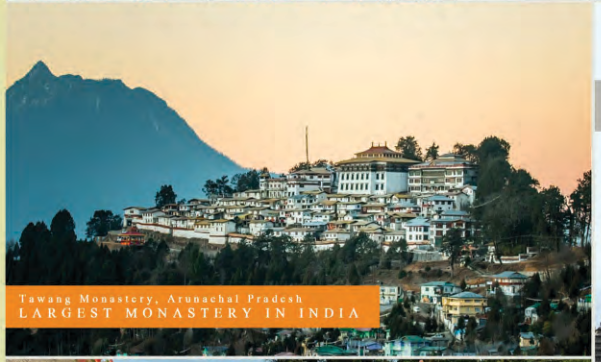
Hornbill Festival, Nagaland
CULTURALLY RICH



Living Root Bridge, Meghalaya
ASIA'S CLEANEST VILLAGE

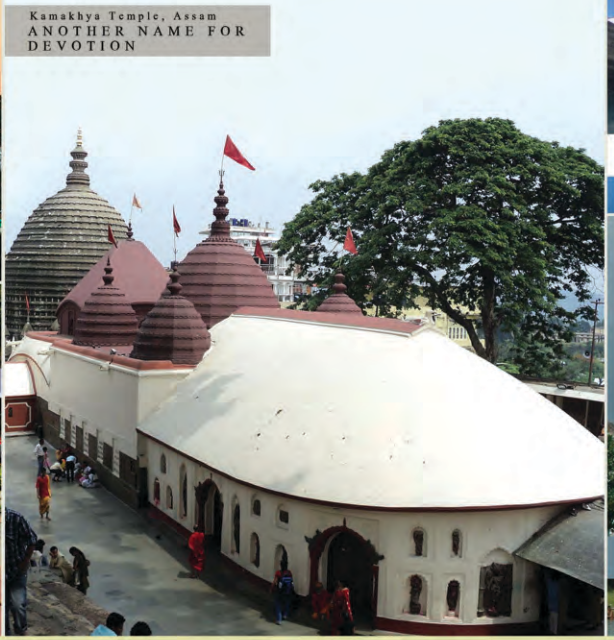
NORTH EASTERN COUNCIL
Ministry of DoNER

Loktak Lake, Manipur
WORLD'S ONLY FLOATING NATIONAL PARK



Tawang Monastery, Arunachal Pradesh
LARGEST MONASTERY IN INDIA

Mizo Traditional Bamboo Dance, Mizoram
WHERE GRACE AND CULTURE MEET



Kamakhya Temple, Assam
ANOTHER NAME FOR DEVOTION

The Himalayas, Sikkim
THE MAJESTIC MOUNTAIN

Ujjayanta Palace, Agartala
HERITAGE HAS A NAME

70th Annual Meeting

INDIAN PHYTOPATHOLOGICAL SOCIETY (IPS)

NEW DELHI

National Symposium on

Plant Health Management:

Embracing Eco-sustainable paradigm

15-17 Feb, 2018

Organized by

Indian Phytopathological Society, New Delhi

and

Assam Agricultural University, Jorhat, Assam

Venue :

Assam Agricultural University

Jorhat, Assam

Souvenir cum Abstracts :

70th Annual Meeting and National Symposium on
"Plant Health Management: Embracing Eco-sustainable paradigm
15-17 Feb, 2018

Organized by

Indian Phytopathological Society, New Delhi, India &
Assam Agricultural University, Jorhat, Assam ,India

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Prof. Jagdish Mukhi

RAJ BHAWAN
GUWAHATI

MESSAGE

It gives me immense pleasure to learn that the 70th Annual Meeting of the Indian Phytopathological Society, New Delhi is being held at Assam Agricultural University, Jorhat during February 15 to 17, 2018 along with a national symposium on "Plant Health Management: Embracing Eco- Sustainable paradigm". A commemorative souvenir is being published to mark the event.

I believe agriculture has a key role to play in pushing forward our economic growth curve. However, managing plant pest and diseases without the use of harmful inorganic agents has been an issue which needs to be addressed. I hope the 70th Annual General Meeting and the national symposium will set an agenda for charting out a modus operandi for a judicious management of the plant health.

I convey my best wishes to the organiser and the editorial team of the souvenir all success in their endeavour.

Dated : February 9, 2018

(Prof.Jagdish Mukhi)
Governor of Assam

Sarbananda Sonowal

सत्यमेव जयते

Chief Minister, Assam
Guwahati

Dispur
24th January, 2018

MESSAGE

I am happy to know that the 70th Annual Meeting of the Indian Phytopathological Society, New Delhi is being organized at Assam Agricultural University, Jorhat from February 15 to 17, 2018 alongwith a national symposium of the topic 'Plant Health Management: Embracing Eco-sustainable Paradigm'. A Souvenir cum Abstract is also being published to mark the occasion.

In the present era of chemical pollution of the environment, the national symposium organized in connection with the Annual Meeting of the Indian Phytopathological Society is very commendable. An organic approach for disease management seems to be the answer to many associated problems related to use chemical pesticides. I am hopeful that the plant pathologists participating in the symposium will come up with eco-friendly solutions to the problems of plant health management.

I wish all success of the Meeting and the Symposium.

(SARBANANDA SONOWAL)

ATUL BORA
Minsiter
Agriculture, Horticulture & Food Processing
Animal Husbandry & Veterinary, UDD and T&CP
Government of Assam

सत्यमेव जयते

ADVANTAGE ASSAM
India's expressway to ASEAN

MESSAGE

I am very glad to know that the 70th Annual Meeting of the Indian Phytopathological Society, New Delhi along with a National Symposium on 'Plant Health Management : Embracing Eco-Sustainable Paradigm' will be organized at Assam AgriculturalUniversity, Jorhat from 15th to 17th February, 2018.

I feel it is indeed a great honour and privilege for the Assam Agricultural University for getting the opportunity to host the Annual Meeting and National Symposium of this esteemed Society, I believe there will be effective deliberations in the convergence of various speakers and experys. The Souvenir being published will also commemorate this occasion very well.

In this era of shrinking land and water resources for agriculture and burgeoning global population, there has been everdependence on chemicals to increase crop production. As a result, the problems of soil health,residues, human hazards, resurgence, secondary disease outbreaks etc. have cropped up. Therefore, ecological considerations have gained importance in disease management also nad plant protection scientists will have to play a major role in increasing food by protecting the crops in a sustainable eco-friendly manner. I am sure that the interactions and deliberations of the National Seminar will enable fruitful exchange of ideas and certainly come up with answers to the problems of disease management that will sustain the ecological harmony.

I take this opportunity to convey my best wishes to the University and wish the Annual Meeting and National Symposium a grand success.

(ATUL BORA)

Ground Floor, Block-C, Janata Bhawan, Dispur, Guwahati-6, Assam 0361-2237008

त्रिलोचन महापात्र, पीएच.डी.
एफ एन ए, एफ एन ए एस सी, एफ एन ए ए एस
सचिव एवं महानिदेशक

TRILOCHAN MOHAPATRA, Ph.D.
FNA, FNASc, FNAAS
SECRETARY & DIRECTOR GENERAL

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कृषि अनुसंधान और शिक्षा विभाग एवं
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INDIAN COUNCIL OF AGRICULTURAL RESEARCH
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MESSAGE

I am happy to learn that the 70th Annual Meeting of the Indian Phytopathological Society, New Delhi along with a National Symposium on 'Plant Health Management: Embracing Eco-Sustainable Paradigm' is being hosted by the Assam Agricultural University, Jorhat, Assam from 15 -17 February, 2018.

Assam Agricultural University is the oldest and premier institute in the Northeastern India and has rightly been chosen for holding the Annual Meeting as well as the symposium with a very befitting theme important not only for the North East but also for the country as a whole. Government of India and Indian Council of Agricultural Research have already given a major thrust in this area to transform the Northeastern states into hubs of organic agriculture. Greater emphasis on organic agriculture and eco-sustainability would benefit Indian agriculture in many ways. I sincerely hope that the ensuing symposium will deliver fruitful recommendations to march ahead in this direction.

I wish all the success to the annual meeting and the symposium.

(T. MOHAPATRA)

Dated the 7th February, 2018
New Delhi

DR. K.M. BUJARBARUAH
ARS, PhD. FNAAS, DSc(Hc)
VICE-CHANCELLOR

ASSAM AGRICULTURAL UNIVERSITY
JORHAT - 785 013
ASSAM (INDIA)

(Receipient of Sardar Patel Outstanding Institution Award)

MESSAGE

I am happy to know that the 70th Annual Meeting of the Indian Phytopathological Society, New Delhi is being organized at the Assam Agricultural University, Jorhat from February 15-17, 2018 and quite aptly along with an associated symposium on " Plant Health Management : Embracing Eco-Sustainable Paradigm'. Hazardous effect of chemicals on human as well as animal health and the environment is a matter of concern for all of us which is why the issue has been covered in the Sustainable Development Goal (SDG) of the United Nations. Further the NE Region has also to gear itself up to transform its agriculture into organic mode where eco-sustainable management of production resources will be very vital and crucial. In that sense the current symposium is of vital relevance not only to Assam but also to the North East. I hope that the outcome of the symposium will facilitate drawing a road map towards evergreen revolution.

I wish all success of the meet and the symposium.

(K.M. Bujarbaruah)

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राम मुईवा, आई. ए. एस.
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उत्तर पूर्वी क्षेत्र विकास मत्रांलय
भारत सरकार

सत्यमेव जयते

RAM MUIVAH, I.A.S
SECRETARY
NORTH EASTERN COUNCIL
MINISTRY OF DEVELOPMENT OF
NORTH EARTERN REGION
GOVERNMENT OF INDIA

Dated : 29th January, 2018

MESSAGE

I am delighted to know that the 70th Annual Meeting of the Indian Phytopathological Society and also a Symposium in being organised during 15th to 17th February, 2018 at Assam Agricultural University, Jorhat. To commemorate this auspicious occasion, publication of Souvenir is a mirror to focus the Plant pathology, agricultural development and extension activities in the North Eastern Region. I am sure this occasion will provide an opportunity to all the farmers and entrepreneurs about the new research in the areas of plant health management and other resource conservation technologies.

I convey my compliments and best wishes to the organizers and all members of the Indian Phytopathological Society family for their hearted efforts in organizing such an important event for the farmers of the North Eastern Region.

I wish the event a grand success

(Ram Muivah)

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Date 18th January, 2018

MESSAGE

I am happy to know that the 70th Annual Meeting of the Indian Phytopathological Society, New Delhi is being organized at Assam Agricultural University, Jorhat from February 15 to 17, 2018. I am informed that a Souvenir cum Abstract is also being brought on the occasion. It is also heartening to know that National Symposium being organised during this period is thematically directed towards organic agriculture. In present day agriculture, it is a great challenge before the plant protection scientists to manage plant health problems in eco-friendly manner. I hope the deliberations in the Symposium will help in formulating suitable recommendations for sustainable organic mode of plant health management.

I wish the symposium and the meet all success.

(K. K. Mittal)

From

Dr. C.D. Mayee,

Formerly, Chairman ASRB, New Delhi and
Agriculture Commissioner Govt India

MESSAGE

I am extremely happy to learn that the Indian Phytopathological Society New Delhi , of which I have been a life member since last 50 year, is organizing the National Symposium on "Plant Health Management" at Assam Agriculture University, Jorhat. Let me first congratulate the organizers of the IPS to have chosen the most appropriate venue for the symposium as I know the way the University has flourished over the last 8 years under the dynamic leadership of Dr K.M.Bujarbaruah, the Vice Chancellor. The delegates will have the glimpse of the educational Institute that they will be visiting as a model of what can be achieved with dedication and foresight.

Crop disease management over the years is changing its routine track of chemical and host resistance management systems because the over all development of allied sciences are shaping the course of plant pathology. Environmental Sciences, biotechnology, nanotechnology ,space research, meteorology, diagnostics, statistics/mathematics and even sociology are influencing the course of plant health management systems. It is therefore most logical to stress on eco-sustainability paradigm as the theme of the symposium. Today instead of farmers alone the non farmers have now have a say in what we do in the name of research and development. Public opinion matters more in using the chemical route or the genetic engineered path of disease suppression. Hence it is pertinent that we need explore other options of plant health management.

I am sure the symposium will through new out-of-box ideas in this area. Let me also congratulate Dr Bhattachraya,the local organizing secretary who has taken lead at the University in Jorhat to organize this symposium.. I wish the event a grand success.

Dr C.D.Mayee

Prof. A.N.Mukhopadhyay
Ph.D., D.Sc., FNAAS, HFIFS, HFMSI
Formerly
Vice Chancellor, AAU
Director General, Tea Research Assoc.

MESSAGE

I am happy to know that the 70th Annual Meeting of the Indian Phytopathological Society, New Delhi and a National Symposium on 'Plant Heath Management : Embracing Eco-Sustainable Paradigm' is going to be held at the Assam Agricultural University, Jorhat. Evolving eco-friendly management practices for plant protection is a necessity in the context of food safety and environmental concerns. In this regard responsibility lies on the plant protection scientists to bring about a change in the chemical driven crop protection and food production. I am sure that the forthcoming meeting of the Society and the symposium will deliberate on the issues in a practicable manner.

Assam Agricultural University is a remarkable institution & I consider it as a Jewel in the crown of Agric. Universities in the country. Plant Pathologists of AAU have made immense contributions over the years. I have had the opportunity to review their progress while I served AAU two decades back as Vice Chancellor. I admire & appreciate the efforts of all including Prof Buzarbaruah, V.C., Dr. Puzari, Head, & Dr.Bhattacharya, Convenor for holding 70th Annual Meet of Indian Phytopathological Society.

I extend my best wishes for all success of the meeting and the symposium.

Prof. A.N.Mukhopadhyay

भारतीय कृषि अनुसंधान परिषद
Indian Council of Agricultural Research
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Dr. P.K. Chakrabarty, *PhD., FNAAS*
Adjunct Professor, UF
Asst. Director General
(Plant Protection & Biosafety)

Dated: February 07, 2018

MESSAGE

It is a pleasure to know that the Assam Agricultural University is going to host the 70th Annual Meeting of the Indian Phytopathological Society New Delhi and the National Symposium entitled 'Plant Health Management: Embracing Eco-Sustainable Paradigm', from February 15-17, 2018.

Spectacular progress has been made by India towards ensuring food security buoyed by an unprecedented production of 275 million tons of food grains and 300 million tons of horticultural commodities during 2016-17. A voluminous gap still seems to exist between per unit area productivity in agriculture in India compared to the western world. Unless sustainability of the growth in food production is insured through continuous improvement in yields from the limited land, it would become extremely difficult for the country to ensure food security for the whopping population of 1.5 billion people by 2050. One of the challenges includes threat due to chronic as well as emerging plant diseases on the sustainability of agricultural crop production throughout the world. Plant diseases on an average are estimated to cause yield reductions of 15-20 per cent in the principal food and cash crops.

The present symposium would serve to address major important issues like biodiversity and biosystematics, plant-microbe Interaction, omics and genetic engineering applications, molecular diagnostics of plant diseases, fungicides/bactericides-a global perspective from industries, bio-Inoculants and biological control agents, impact of climate change on plant diseases, disease complex/IDM approaches, regulatory and policy issues and industrial linkages/extension plant pathology, to achieve sustainability in food production.

I am happy that the Assam Agricultural University, Jorhat, one of the premier and finest academic Agricultural organizations of the country that has led several advancements in the fields of Plant Pathology has taken up the task of shouldering the responsibility to organize this important National symposium. The symposium will provide a good platform for the plant health specialists and molecular biologists from both academia and industry to come together, discuss and deliberate to devise strategies to contain the threats posed by plant diseases and to ensure food security.

I convey my best wishes to the organizers and participants hoping for the event to be a grand success.

(P K Chakrabarty)

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Prof. B.N. Chakraborty
FPSI, FISMPP, FNRS, FISPC,FMSI,FIMS, FAScT, FRSC(London),FNAAS, FNABS
President, IPS

Indian Phytopathological Society

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MESSAGE

It gives me great pleasure to be associated with 70th Annual Meeting of Indian Phytopathological Society and National Symposium on "**Plant Health Management: Embracing Eco-Sustainable Paradigm**"organized by Assam Agricultural University, Jorhat, Assam during February 15-17, 2018. This Society has successfully completed its journey of 70 years with keen involvement of past presidents, secretaries, zonal presidents and councillors, executive council members as well as contributions made by each member to achieve an International status linking with American Phytoapthological Society. One of the key achievements has been the upgrading of the Journal "***Indian Phytoapthology***" by linking with Springer publications.

Sustainable plant health management is the key issue of global development with regards 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 the plant pathogens, still the technologies towards the management of plant viruses, bacterial and fungal pathogens has 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 believe that this Symposium would provide a useful platform for deliberation by the learned delegates, fruitful discussions and interactions among scientists, agriculturalists and farmers; sharing their scientific knowledge on latest development and technologies in management of crop diseases and significant planning for valuable recommendation to make agriculture more profitable and eco-sustainable.

I extend heartiest welcome to all the delegates and my best wishes for the grand success of the event.

(B.N. Chakraborty)

January 25, 2018

Dr. Dinesh Singh
Secretary

Indian Phytopathological Society

Division of Plant Pathology
Indian Agricultural Research Institute
New Delhi 110012, INDIA
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MESSAGE

The Indian Phytopathological Society (IPS) is a professional forum for promoting the cause of Phytopathology. The Society provides information on the latest developments and research advances in plant health science through its journals and participates in the exchange of plant health information with public policy makers, and the larger scientific community. It provides opportunities for scientific communication, collaboration, and professional development.

The Society recognizes the need to look to the future to best position the discipline to meet future needs of Society and scientific opportunities. In this context, the contribution of the Society in bringing to focus the area of research on diverse aspects for sustainable plant health management. Keeping this in view, the Society is organizing National Symposium on **"Plant Health Management: Embracing Eco-Sustainable Paradigm"** during February 15-17, 2018 in collaboration with Assam Agricultural University, Jorhat, Assam.

This symposium would serve as a forum to deliberate on different aspects such IDM, protected cultivation, biosafety and biosecurity, nano and biotechnological approaches, taxonomy of microbes, mushroom and woody fungi, special session on wilt diseases of crops, and strengthening HRD in Plant Pathology, etc. will be discussed. To put things into perspective, I hope the deliberations in the symposium will focus on these aspects to fulfill the future requirement for sustainable crop production.

I wish the symposium a grand success.

February 01, 2018

(DINESH SINGH)

Contants

Presidential Lecture

Molecular recognition of Fungal pathogens and Activation of Plant Immune response

B.N.Chakraborty
Former Professor, Department of Botany, University of North Bengal, Siliguri-734013
Email: bncnbu@gmail.com

One of the most difficult and intriguing aspects in the study of biology is understanding of the significant events of the interaction between a plant and a pathogen at the cellular and subcellular level. In fact, if one considers the multitude of microorganisms to which plants are being continuously exposed in nature, the significance of specificity becomes more apparent. Until and unless the mechanisms whereby a host and pathogen 'recognize' the potential for establishing a compatible or incompatible relationship are identified, and the devices whereby specificity for that relationship is established, it cannot be claimed that a full understanding of host-pathogen interactions has been achieved. Interaction between higher plants and microorganisms are often thought of as being either symbiotic or pathogenic but these are in fact only two aspects of a co-evolutionary struggle for survival, which may take different forms. The success or failure of infection is determined by dynamic competition and the final outcome is determined by the sum of favourable and unfavourable conditions for both the pathogen and host cells. A basic requirement for proper functioning of even a simpler cellular system is communication between its components. Numerous signals are thought to be exchanged between the host-fungal partners during both compatible and incompatible interactions. Many of the signals produced during early stages of infection induce a hypersensitive reaction (HR) in the plant which is usually associated with the expression of chemical and molecular markers such as salicylic acid and PR proteins leading towards synthesis of phytoalexin for plant defences. Defense gene expression is to be a great extent regulated through the production of metabolites which act as signals. Pathogens may often generate metabolites which suppress plant defences and cause disease symptoms. Activation of inducible defence responses is likely to be based upon recognition of pathogen-associated molecular patterns (PAMP),which bind to plant receptors. A multitude of PAMPs have been shown to trigger receptor-mediated defence responses in non-host plants. Recognition of such signals is very likely to activate defence responses in natural plant–microbe encounters**.** During evolution, plant species resistance was overcome by individual races or strains of a given pathogen species through the acquisition of virulence factors, which enabled them either to evade or to suppress plant defence mechanisms. PAMP-induced defence in susceptible host plants is insufficient to stop infection; nonetheless, it is referred to as basal resistance. Selective pressure on host plants exerted by virulent pathogens has resulted in the co-evolution of plant resistance R genes, which specifically recognize pathogen strain- or race-specific factors and allow for the establishment of pathogen race/plant cultivar-specific disease resistance**.** The potential use of acquired and induced immunity has been explored in strengthening strategies for crop disease management. Agriculturally important microorganisms have been shown to induce resistance in cereals, pulses, oil seed, plantation and horticultural crops. This may lead towards efficient bioinoculant formulation and delivery system which could become important inputs leading to a resilient agriculture.

Life Time Achievement Award

Integrated Pest Management for Sustainable Crop Protection: The Way Forward

C. D. Mayee
Former Chairman, ASRB , New Delhi & currently Adjunct Professor
IARI , New Delhi
Email Id: charumayee@yahoo.co.in

Integrated Pest Management (IPM) has been one of the classical strategies developed and adopted by Plant Protection scientists to combat the menace of pests, diseases and weeds and reduce the losses induced by them. The wisdom to adopt this technology has come from the very fact that no single method of pest control was useful in containing the losses and those like chemical use had created problems of residue, resurgence and resistance in the pests. IPM aims at using all the available options, their integration at ground level to achieve the desired economic and ecological benefits while reducing the losses caused by the pests of all kinds.

It is estimated that the overall losses due to diseases alone in India range from 15 to 20 per cent. Even considering an average annual loss of production, the country is loosing around 25 million tonne of food grains and equal quantity of fruits and vegetables which when added to the current production figures are targets of achievements by 2025. Therefore crop protection including the disease management assumes high significance in the overall food security of the country in the years to come.

In India several IPM modules have been developed. However, these need location specific validation on large scale. The ground reality is that the actual IPM use is only 7 -8 per cent and in the immediate future it must reach a respectable position .Except cotton and to some extent rice the adoption of IPM in other crops is low to negligible .In fact IPM should by now the backbone of the entire crop protection umbrella but still awaiting the due attention in field that it deserves. The way forward is to replicate some of the achievements in IPM such as; Ashta project, FFS concept and IRM success in cotton. Further the way grape disease management has shown through the monitoring program, a substantial reduction in the chemical use can be achieved without any residue problem. These technologies can effectively be replicated in oranges, pomegranate, apple, several vegetables where chemicals become an integral part of IPM as they cannot be avoided totally. To increase the reach of IPM amongst the farmers it is also essential to invest in developing forewarning technologies for epidemiologically potential pests. Similarly, strengthening the surveillance mechanisms and educating the farmers through the transfer of technologies shall be of great help in adoption of IPM in future.

Birth of Plant Pathology in India vis-à-vis Indian Phytopathological Society

Robin Gogoi
Division of Plant Pathology, ICAR-Indian Agricultural Research Institute
New Delhi-110012
Email Id: r.gogoi@rediffmail.com

In the present times India has been able to produce enough agro products. It is able to look forward to export of food commodities and food products after domestic consumption. This has become possible due to the tireless and excellent works of plant pathologists of the country since long back.
An organized agricultural research and education in India was developed through some historical events. After establishment of the British East India Company in Bengal in 18th century, Lord Clive expanded the British rule in Begnal and Bihar. The company acquired a land in Pusa Bihar and established a horse breeding and stud farm in 1784. But this farm was closed in 1889 because of the epidemic of cattle plague or rinderpest and shifted to Pune. Coincidentally, Robert Koch, an eminent German Bacteriologist (known for Koch's postulates) visited India during this period as a consultant to investigate rinderpest. According to his advice the Imperial Bacteriology Laboratory (now Indian Veterinary Research Institute) was shifted from Pune to Mukteswar of Kumaon Hills in 1893. But the recurrence of famines in the country attracted attention of the Government of India and then Imperial Department of Agriculture was established in 1881. It was running without research support till 1889 and then the post of an Imperial Agricultural Chemist, an Imperial Cryptogamic Botanist (who also served as Mycologist) and an Imperial Entomologist was created. In 1901, the post of an Imperial Mycologist was created. Of these departments, agricultural botany and mycology were headed by European officers and thus the importance of mycology and plant pathology was emphasized as early as 1889.

Lord Baron Curzon, Viceroy and Governor General of India, was serious about the famine of 1889-90 and played a crucial role in the development of agriculture. In April, 1905, Government of Bengal proposed to use an estate at Pusa Bihar for an agricultural research institute. An American philanthropist Mr. Henry Phipps of Chicago, USA gracefully donated £30,000. Hence, in the honour of the donor, the main building was named "Phipps Laboratory" and the institute was named "Pusa Institute". The local people called the building "Naulakha" as the cost of the building was Rs. 9 lakh in those days. The institute started with major five sections namely Agriculture & Cattle Breeding, Botany, Chemistry, Economics, Entomology and Mycology. Three scientists of Imperial Department of Agriculture were transferred to the Agricultural Research Institute (ARI) and two additional posts were created. In 1907, a new section of Bacteriology was started. The institute (ARI) was renamed twice as the Imperial Institute of Agricultural Research in 1911 and the Imperial Agricultural Research Institute (IARI) in 1919. In 1934, the institute was badly affected by an earthquake that was beyond repair. The government of India took a decision to shift the institute from Bihar and re-built at New Delhi in 1935.The first Indian Director of the institute Dr. B. Vishwa Nath held responsibility of transferring entire set up including employees, cattle and equipments. In 1936, Lord Linlithgow, the Viceroy of India inaugurated the institute's new campus. The status of 'section' was upgraded to the Divisions in 1944-45, and the Section of Mycology was named as Division of Mycology. In 1947, the Imperial Agricultural Research Institute was renamed as Indian Agricultural Research Institute and the Division of Mycology was designated as the Division of Mycology and Plant Pathology. This name was changed to the Division of Plant Pathology in 1994.

During the British rule, the Natural History Society recorded that a medical officer of Indian army, Lt. Col. K.R. Kirtikar, was perhaps the first person to study *Agaricus ostreatus* in 1885. But the foundation of mycological study was laid by a group of European botanists in the mid of 19th century. In 1901, systematic study of fungi began with the creation of a post of Cryptogamic Botanist. Sir Edwin John Butler was the first person to occupy this post, who was earlier working at the Botanical Survey of India, Calcutta. The post was redesignated as Imperial Mycologist in 1905.

It is obvious that the work in the field of plant pathology (Fungal Pathology) received a momentum in 1905 at Pusa Bihar with the establishment of Mycology Section at the Imperial Agricultural Research Institute (IARI). The first ever survey of Indian fungi was conducted by E. J. Butler. He collected a large number of fungi from across the country. Based on the collection, IARI established one of the world's leading herbarium internationally renowned as "Herbarium Cryptogamme Indiae Orientalis" (HCIO). Even being a non Indian, Butler embraced the field of plant pathology of India, became the founder and single handedly detailed about fungal diseases of various crops. The HCIO proved a valuable repository and the first book on fungal flora entitled "Fungi of India" authored by Butler and G. R. Bisby was published in 1931. Munshi Inayat Khan, an Indian, who worked with Butler was given the charge of the herbarium. As an assistant, Azmatullah Khan joined the team of Imperial Mycologist and later he was appointed as Assistant Mycologist at Murray, Pakistan. In this team, another important figure was Rohini Ranjan. Two supporting staffs in the Mycology Section namely Abdul Hafiz Khan and L. S. Subramanium were very closely associated with HCIO and helped the Imperial Mycologist. It is worth mentioning that the above supporting staff was not qualified but acquired the spirit of research from their chief.

The Division was headed by five English Plant Pathologists during the British rule. Butler was the first Imperial Mycologist and Head of the Mycological Section of the then IARI from 1905 to 1920. Later he held the position of Director. Butler left India in 1920 and then F.J.F. Shaw became Imperial Mycologist for one year only (1920-21). After Shaw, the position was occupied by W. McRae from Madras till 1933. L. D. Galloway, an industrial mycologist of England held the position during the period of 1934 to 1937. Subsequently, G. W. Padwick came from England and served the Imperial Mycologist between 1937 and 1945. Later, J. F. Dastur, an Indian Assistant to Butler, was appointed as the Imperial Mycologist and the Head of the Division of Mycology and Plant Pathology till 1947.

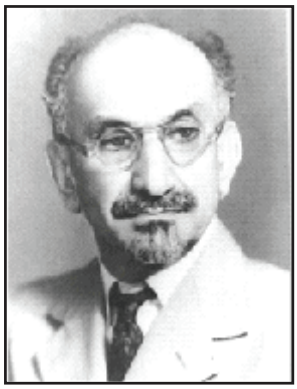
A few qualified Indian Mycologists and Plant Pathologists were trained during the British rule. They remained isolated and lacked necessary facilities for pursuing research. However, in the later time, Indian scientists established a strong base of plant pathological research in India. Among them, Manoranjan Mitra and B. B. Mundkur are most notable figures. Butler selected Mitra before he left India; unfortunately he passed away prematurely. Mundkur was devoted to fungal taxonomy and he had been a major contributor to plant pathological research of India.

In true sense, E. J. Butler remained as the path finder of the Indian Plant Pathology. For his enormous contributions, Butler is regarded as the Father of Indian Plant Pathology. The first disease he investigated was late blight of potato caused by *Phytophthora infestans*, which appeared in the humid areas of Assam, Bengal, the eastern Himalayas and the Niligiris. He investigated about pigeon pea wilt (*Fusarium udum*) and also wheat rusts. He realized the importance of wheat rust problem in 1906 and published a research paper along with J. J. Hayman by emphasizing the fact that wheat rust problem in India required a holistic approach and could not be dealt with from the static point of work accomplished elsewhere. In 1906, Butler along with Sydow published a series of paper by describing many Indian fungi. Important contributions of Butler are a monograph on the genus "*Pythium*" (1907), association of a nematode in ufra disease of rice (1913), downy mildew of jowar and bajra (1907), downy mildew of maize (1913) in Pusa Bihar. His work with Abdul Hafiz (1913) on red rot disease of sugarcane was very significant. The classic book "Fungi and Diseases of Plants" was published in 1918 prior to his departure from India to England in 1920.

Pioneer and Path Finders of Plant Pathology of India

E. J. Butler

B. B. Mundkur



J. F. Dastur

R.S. Vasudeva

S. R. Bose

M. J. Narasimhan

K. D. Bagchee

R. K. Saksena

Indian Phytopathological Society: Custodian of Plant Pathological Research in India :

The Indian Phytopathological Society (IPS) was instituted as a professional society to promote the cause of science of plant pathology. Dr. Bhalchandra Bhavanishankar Mundkur laid the foundation of IPS in 1947. Since then its head quarter is located in the Division of Plant Pathology (then the Division

of Mycology & Plant Pathology).It started functioning under the chairmanship of Dr. S. R. Bose. A small sub-committee comprised of Professor J. F. Dastur, Dr. S. R. Bose, Dr. B. N. Uppal, Dr. A. N. Sattar and Dr. R. S. Vasudeva was formed to start publication of a journal "Indian Phytopathology". Initially there were twenty members in the society and now IPS ranks third among the phytopathological organizations of the world (Anon., 2005). Periodically it conducts scientific symposia, conferences, seminars, workshops, lectures, etc. in India at national level. IPS so far has organized four international symposia at ICAR-Indian Agricultural Research Institute. The 1st, 2nd, and 3rd International symposia were held in 1967, 1981 and 1991, respectively. The 4th International conference on "Integrated Plant Disease Management for Sustainable Agriculture" was organized during Golden Jubilee of the society in 1997. With the theme "Plant Pathology in the Globalized Era", the 5th International conference was held in 2009. Keeping the tradition, in this year (2016), the society organized 6th International conference on "Plant, Pathogens and People" with the mission **"Challenges in Plant Pathology to Benefit Humankind"** at Delhi during 23-27 February.

As per the constitution of the society Annual General Meetings would be held during the annual session of the Indian Science Congress Association. This practice has been maintained for these 20 years, except for one unavoidable lapse and another due to national emergency in 1964. At these meetings, the business of the Society is transacted, the Secretary-Treasurer presents his report, election results are announced and resolutions passed. The retiring President delivers his address. During the Science Congress session there are concurrent meetings and crowded programme and very little time was available for holding the society meetings and the attendance was generally thin. In recent years, therefore, the Society has held its meetings a few days before the commencement of the Science Congress and this has reflected in a bigger attendance and better scientific discussions. In honour of late Dr. B. B. Mundkur, the Society had resolved to institute Mundkur Memorial lectures to be delivered by senior plant pathologists. The First lecture was delivered by Prof. J. F. Dastur in February, 1963. Prof. M. J. Narasimhan and Dr. K. D. Bagchee have been other speakers in the series and the next speaker is Professor R. K. Saksena. These lectures are printed in the regular issues of Indian Phytopathology. The society has been running with the following objectives:

1. Advance the cause of Mycology and Plant Pathology in India.
2. Encourage and promote mycological and plant pathological study and research in the country.
3. Disseminate the knowledge of mycology and plant pathology.
4. Facilitate closer association and relations among member and other scientific workers in India and abroad.

The IPS is working for diverse global community of agricultural scientists. It provides credible and beneficial information related to plant health; advocates and participates in the exchange of knowledge with the public, policy makers, and the larger scientific community; and promotes and provides opportunities for scientific communication, career preparation and professional development for its members. With these righteous mottos, the society has made some of the notable advancements in the recent times, those are:

v **APS-IPS Collaboration: A** memorandum of understanding was developed in October, 2015 between the American Phytopathological Society (APS) and the Indian Phytopathological Society (IPS). It was signed during 6th International Conference (February, 2016) to facilitate mutually beneficial interactions through scientific exchanges and increased sharing of science by joint memberships and professional interactions.

v **APS Travel grant: In order to** encourage young researchers to have global exposure, t**his grant is awarded to IPS student members for participation in APS Meeting in USA.**

v **Springer Collaboration** An agreement has been signed with Springer for publication of the journal Indian Phytopathology from 2018 onwards and the first issue of the journal is ready for publication on this international platform.

v **Publication of books:** The society has taken initiative to publish books on various aspects of plant pathology. Till date many books have been published and their contents are available on the society's website.

Key Note Lecture

KNL-01

Trichoderma for plant disease management a reality or myth

Dr. A. N. Mukhyopadhyay
Former Vice-Chancellor, Assam Agricultural University, Jorhat, Assam

Key Note Lecture

KNL-02

Food Security, Food Producton and GM Crops

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Food is universally a fundamental human right however still about one sixth of global population is undernourished and every year about 15 million deaths occur due to hunger and over 200 million suffer from acute deficiencies. The World Food Programme Survey places India at 100th rank in global hunger index with rampant under and malnourishment. At present rate of population increase, for food security of 2.5 billion, India needs to double the food production by 2050 when the present food production system is suffering from post green revolution problems resulting low profit agriculture and dwindling share of agriculture sector in country's GDP. Green Revolution a miraculous event of twentieth century saved millions of people from starvation. But it caused fast depletion of natural resources besides reduced genetic diversity, increased vulnerability to pest and diseases and genetic erosion. There is need to enhance production, productivity, diversify agriculture and discourage indiscriminate use of natural resources.

Climate Change will be major impediment in achieving food security in the 21st Century. With warmer baseline climate, heightened exposure to weather extremes and the scarcity of capital for adaptation measures the developing countries are more vulnerable to the ill effects of climate change than developed countries. With changing weather parameters plant pathogens may attribute tendencies to evolve new variants at higher rate, multiplication behaviour and parasitic fitness ability thus shifting prevalence and occurrence of disease spectrum. It will also impact multiplication, virulence, survival and dispersal, life cycle, physiology of pathogenesis and disease cycle. It requires formulating plant disease management strategies supported by developing early warning systems and decision support system for timely application of control measures.

Food security is multidimensional issue involving government policies related to food from farm to plate as well as enhancing food production to meet the ever increasing demand for food. There is need to accelerate efforts for achieving productivity enhancement since there is huge gap between productivity levels in India and other countries. This can be achieved by overcoming problematic constraints, which have no solutions since long, with conventional technologies. Many countries have adopted biotech crops to achieve higher production. India has benefited greatly by introducing Bt cotton, the first GM crop however is shy of introducing edible GM crops so far. It is necessary to employ modern molecular tools to break the stagnancy in food production level. In this context adoption of safe genetically modified crops conforming to safety norms , after rigorous testing can be best option to fill the productivity gaps to meet the future demands of food.

KNL-03

Can Indigenous Soil Microbiomes Deliver the Promise of Biocontrol?

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The science of biocontrol has had a long and rich history and yet has delivered few field-based successes for soilborne diseases. Intractable nature of many soilborne diseases, diminishing control options and increasing public concern about pesticide residues call for disruptive research that will enable sustainable and environment-friendly cultural practices. Can we make biocontrol for pathogens effective and reliable so that it becomes an integral part of soilborne disease management? This question is as old as the field of biocontrol itself and the reasons for this apparent mismatch between the promise and reality are varied and numerous. The talk will discuss some of these reasons, and delve into the emerging alternative models being proven as a viable strategy. The ability to harness native soil microbiomes to manage plant pathogens is a promising but relatively unexplored area, which recently has received increased attention as an alternative to prevailing soilborne disease management strategies. Our studies have focused on substrate-mediated changes in soil prokaryote communities with the goal to convert Verticillium wilt-conducive soils to Verticillium wilt-suppressive soils. These studies involved input of broccoli and chitin to soil, and were replicated in soils with distinct land use histories. Regardless of the soil type, the applied inputs significantly reduced *V. dahliae* microsclerotia and wilt incidence and severity on eggplants in the greenhouse, and these reductions were correlated with an increase in the proportion of known fungal antagonists. Prokaryote communities identified were distinct in the wilt-suppressive soils as compared to the wilt-conducive soils. Three cycles of inputs nearly eliminated the pathogen in all three soil types. These results were further validated in a 12.2 ha grower's field. Identification of locally adapted beneficial inputs remains a challenge but explorations for such inputs undoubtedly will lead to new success stories for soilborne disease management.

KNL-04

Isolation and Utilization of Arabidopsis Nonhost Resistance Genes in Enhancing Disease Resistance in Soybean

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Soybean is considered worldwide to be one of the most valuable crops. Soybeans are rich in both protein (40%) and oil (20%) contents. Unfortunately, soybean is susceptible to many pathogenic organisms. In the United States, the annual yield suppression from various diseases are valued over five billion dollars. Growing of disease resistant soybean cultivars is the major method of controlling many of the diseases. Complete resistance is however unavailable against many pathogens. Transfer of nonhost resistance genes conferring immunity to multiple soybean pathogens could be an ideal approach in controlling some of the diseases. In order explore this possibility, we conducted a genetic screen for loss of immunity mutants against two soybean pathogens and identified 30 *Phytophthora sojae* susceptible (*pss*) mutants , *pss1* through *pss30*, of which 14 are susceptible also to the fungal pathogen *Fusarium virguliforme*. This forward genetic study led us to cloning*PSS1, PSS5, PSS6, PSS21, PSS25* and *PSS30* genes.*PSS1* encodes a glycine-rich protein and *PSS30* a folate transporter. Overexpression of these two genes enhanced resistance of transgenic soybean against *F. virguliforme*.*PSS30* enhanced immunity also against the soybean cyst nematode. Investigation of *pss30* mutants or mutants with reduced folate contents showed loss of nonhost and host resistance in *Arabidopsis* suggesting a critical role of folate in plant immunity. Our study also suggests that nonhost resistance is complex and governed by multiple mechanisms, incorporation of which could provide durable and broad-spectrum disease resistance in crop plants against multiple pathogens.

Prof. S P Raychaudhuri Memorial Award Lecture

Advances in Insect Vector and Plant Virus Research in India

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Crops suffer heavily from the infestation of insect pests causing both quantitative and qualitative loss that runs into billions of dollars loss across the globe, annually. Among the various insect pests, sap sucking insects such as thrips, aphids, mealy bugs, whiteflies, leafhoppers, psyllids (Hemiptera) pose twin threat either through direct damage and vectoring many plant pathogens like tospovirus, begomovirus, criniviruses etc. The later is assuming serious proportions, as India has recently witnessed virus disease outbreaks on chilli, capsicum, melons, brinjal, cucurbits etc. Of late, we are witnessing host range expansion both by the insect vector and arthropod-borne viruses. Reasons are many, but few understood to explain this phenomenon. This could be rendered by high levels of resistance to insecticides, altered genetic constitution of endosymbionts, higher fecundity & post embryonic development and mutation enabling the virus to infect/adapt more crops. The threat of increased crop loss due vector borne virus diseases is looming large in the impending scenario of climate change. This warrants an immediate attention and action to contain possible catastrophe in near future. Towards this, chemical control is often ineffective in the management of insect vectors and virus diseases due to the increased dispersal of the vectors resulting in enhanced spread of the disease for e.g. aphid borne viruses such as potyviruses that are transmitted in a non-persistent manner. Regarding designing an effective management strategy of insect vectors, correct species identity, prevalence of cryptic species/genetic groups are important but generally lacking. In this regard, DNA Barcoding, a development stage non-limiting identification for a quick and accurate species diagnosis and to understand prevalence of cryptic species/genetic groups in the case of thrips, whiteflies, mealy bugs, leafhoppers, aphids, psyllids in India is noteworthy. Similarly, we have also developed next generation pest management methods based on RNA interference (RNAi) popularly called gene silencing brought about either by exogenous application of cognate double stranded RNA (dsRNA) or in planta expression of cognate dsRNAs for *Aphis gossypii, Bemisiatabaci, Helopeltisantonii* and for tospoviruses (Asokan*et al*., 2014; Chaitanya*et al*., 2016). We have also demonstrated the utility of artificial micro RNAs (amiRNAs) in the management of various insect vectors (Rebijith*et al*., 2017). We were first to report the prevalence of the dreaded Western Flower Thrips (WFT) in India based on the work carried out under ICAR Outreach Programme on the management of sucking pests in horticultural crops. Further, genomic approaches such as whole genome sequencing, transcriptome, genome editing and finally gene drive are being contemplated for developing ecofriendly, effective insect vector and plant virus management strategies. Host-plant resistance offers the best ecological and economically viable solution in mitigating the damage by plant viruses. Unfortunately, neither resistance is discovered to mitigate all viruses nor is often permanent. Many problems today especially in vegetables is break down of resistance to plant viruses. An ecological understanding of the complexities of arthropod borne plant virus/pathogen epidemics supported equally by molecular advances is needed for sustainable management of plant viruses and phytoplasma. The problem is serious but understanding and financial support for such research is limited. What is surprising is we have a fewer pathologists and even less when it comes to addressing problems such as these.

Mundkur Award Lecture

Strategic Management of Plant Diseases to Ensure Crop Biosecurity

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Plant Protection and Biosafety
Indian Council of Agricultural Research, New Delhi

Traditional Principles of Plant Disease Control include- Avoidance, Exclusion, Eradication, Protection, Resistance and Therapy. While these principles are as valid today as they were a century ago, in the context of modern concepts of plant disease management, they have some critical shortcomings. First of all, these principles are stated in absolute terms (e.g., "exclude", "prevent", and "eliminate") that imply a goal of zero disease. Plant disease "control" in this sense is not practical, and in most cases is not even possible. Indeed, we need not eliminate a disease; we merely need to reduce its progress and keep disease development below an acceptable level. Instead of plant disease control, we need to think in terms of plant disease management.

Each of these 6 cardinal principles of disease control must be strategically employed to manage disease through:

1. Reduction of the initial plant disease inoculum.
2. Reduction of the infection rate and,
3. Reduction of the duration of the epidemic.

Use of reliable tools to precisely detect plant diseases and forecast disease epidemics, are undoubtedly the cornerstones of disease management. In general, PCR, with all its variants, is currently a basic tool in diagnosis, alone or preferentially in combination with other techniques e.g. Co-operational PCR uses three/four primers simultaneously in simple reaction with additional sensitivity and low usage of reagents. Multiplex PCR does simultaneous detection of two or more DNA or RNA targets in a single reaction with specific primers. RT-PCR is used for the detection of plant viruses due to its high sensitivity and specificity as the majority of them are RNA viruses. Microarrays are composed of thousands of specific probes spotted onto a nylon solid surface which are used for gene expression studies.

Development of disease can be avoided by reducing the initial inoculum or by selecting a season or a site where the amount of inoculum is low or where the environment is unfavourable for infection. Deep ploughing after the harvest of the crop or Soil-solarization prior to planting is an effective strategy that can help in reduction of soil borne pathogens Crop rotation and adjustment of sowing or planting dates are the other cultural methods that aim at interfering with the infection cycles of soil borne diseases. Reducing the introduction of inoculum from external sources during the course of the epidemic involves the principle for Exclusion for Plant disease control. Domestic quarantine or transboundary movement of pathogen propagules serve to exclude the introduction of inoculum from external source thereby reducing the rate of infection. Disease eradication aims at reducing the production of initial inoculum by destroying or inactivating the sources of initial inoculum by practicing field hygiene and sanitation through removal of reservoirs of inoculum, removal of alternate hosts, rogueing of infected plants, etc. Protection of crops from onset of diseases can be achieved through reduction in the levels of initial infection by means of seed treatment, soil treatment other barrier to infection like prophylactic application of safe pesticides with the onset of favorable weather conditions. Employing host resistance is the best bet to management of plant diseases. use of crop cultivars with superior resistance and/or tolerance to diseases can reduce the rate of inoculum production, the rate of infection, or the rate of pathogen development providing the most economic and safe method for plant disease management. Biological control agents (BCAs) may be effective either upon introduction by application or through strengthening their natural

occurrence. In general, their effectiveness requires specific, conducive environmental conditions. If appropriate temperature and moisture are not consistently available, BCA populations may fail to reduce disease incidence and severity, and may not recover as rapidly as pathogen populations when conducive conditions recur. Integrated Disease Management is a holistic approach to sustainable agriculture that focusses on managing diseases through combination of cultural, biological and chemical measures that are cost effective, environmentally sound and socially acceptable. IDM thus includes responsible use of crop protection and plant biotech products.

Advances in molecular biology have opened up a plethora of opportunities of identifying and isolating any gene from an organism and expressing it in a different organism. RNAi technology has been evaluated in a number of host-pathogen systems and effectively used to enhance the resistance in plants against plant diseases especially, plant viruses. Unlocking new alleles with a clear understanding of host-pathogen interaction forms the basis of resistance breeding. Identification of molecular markers and tagging genes for disease resistance is an exciting area of plant disease resistance that has made marker assisted selection and breeding a real success for conferring tolerance against a number of plant diseases. Transgenic plants to combat diseases has been successful mostly against viruses.

Crop plants are under greater threat than ever before and ensuring biosecurity is a key function of crop protection specialists. There has been a long-term trend of increasing volume and speed of movement of plants and other material traded from an increasing variety of sources. This increases the chances of exotic pests arriving with imported goods and travelers, as well as by natural means. 'Emerging infectious disease (EID)' is the term coined in literature to define the introduction of a pathogen to areas beyond the boundaries of its native origin. The main goal when a new pathogen is detected is its ultimate eradication. For precise detection, diagnostic infrastructure of the country needs to be comprehensive to ensure early detection of EID pathogen. While traditional symptom-based and morphological diagnostics remain important, nucleic acid and protein based technologies have greatly increased the accuracy of detecting the pathogens. Successful eradication involves concerted complex of detection, risk assessment, adoption of the appropriate strategy and careful execution of all the control procedures. Prior to eradication, prevention of the pathogen at its inception should be carried out by means of strict quarantine, pest-free seed and transplants. If the pathogen is already introduced, in to the new area, efforts must be made to reduce the initial inoculum of the invaded pathogen and prevent its spread. Finally, secure communication systems are a mandate to ensure biosecurity vis-a-vis food security. Communication should encompass early warning systems and the implementation of rapid response plans. A global connectivity needs to be developed that will transcend political boundaries, geography and economic vitality, so as to achieve crop biosecurity for the country.

M.S. Pavgi Award Lecture

Managing abiotic stresses in rice in South Asia using climate resilient rice varieties and potential to combine microbes with host gene(s) for more effective management at farmers' fields

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Rice is a staple food for more than half of the humanity. More than 90% of the world's rice is produced and consumed in Asia. South Asia constitutes 37% of total rice area, half of that is rainfed. which frequently suffers from abiotic stresses like flood, drought and/or soil salinity/sodicity. Out of 57.8 million ha rice area in India, Bangladesh and Nepal, almost 26 million ha area is frequently affected by flood, drought and/or soil salinity. Problem of abiotic stresses like flood, drought and salinity are getting exacerbated due to climate change. Quite often in same season crop may suffer from both flood and drought at different points of time. These abiotic stresses are major yield limiting factor in rainfed areas of South Asia. These areas were not benefited by first green revolution which was inputs intensive and confined to irrigated areas.

International Rice Research Institute identified and characterized flood tolerance gene, *SUB1A*, and transferred the same to six mega rice varieties from South and South-East Asia using marker-assisted backcross (MABC) breeding. Five of these (Swarna-Sub1, Samba Mahsuri-Sub1, Ciherang-Sub1, CR1009-Sub1 and BR11-Sub1) are recently released for commercial cultivation in South Asia. Varieties carrying the *SUB1* gene are capable of tolerating flash flood for 2 to 3 weeks. They had the same agronomic, yield and quality traits as their non-Sub1 counterparts when grown under non-flooded conditions, but showed yield advantages of 1 to 3 t ha^{-1}, depending upon severity of submergence, at farmers' fields.

Sub1 varieties are excellent for the flash flood condition where water recedes within 2 to 3 weeks. However, if > 25 cm water stagnate beyond 3 weeks these varieties are not useful. However, in recent years IRRI has identified QTLs for the stagnant flood tolerance and have combined them with *SUB1* gene. New rice lines with tolerance to both stagnant and flash flood are being evaluated in South Asia including India.

SUB1 gene expresses in seedling under transplanted condition. It is not effective under direct seeded condition if field undergoes water before the germination of the seed. For such situation IRRI has identified gene for the anaerobic germination (AG) and combined it with *SUB1* gene. New lines with both *AG* and *SUB1* genes are being field evaluated. They are good for both direct seeded and transplanted condition.

So far 14 QTLs have been identified for the drought tolerance out of which 5 are able to express in multiple background. Both through conventional and MABC breeding during the last 6 years 26 drought tolerant rice varieties have been developed and released for the cultivation in South Asia. Two of these – Sahbhagi dhan and DRR dhan 44 have shown excellent performance across the region. They offer 0.5 to 2.0 tons yield advantage over normal varieties under severe drought condition.

Through conventional breeding several salt tolerant rice varieties were developed and released in South Asia for the cultivation in salt affected soils. *SALTOL* 1 gene was introgressed into a number of

high yielding mega varieties from South Asia, which are being evaluated under field condition. So far 17 salt tolerant varieties are released in India and Bangladesh out of these only two are for sodic soil and remaining for saline soil.

Considering the fact that quite often a rice crop may face more than one stress within same crop season, in recent years, a lot of emphasis is being given to develop multiple stress tolerant rice varieties. Only during 2017, 4 multiple stress (submergence + drought) tolerant rice varieties have been released for the cultivation in India and Nepal.

With financial support from the Bill and Melinda Gates Foundation, IRRI launched a project entitled 'Stress tolerance rice for Africa and South Asia (STRASA)' in October 2007. By sharing the ownership and aligning the project objectives with the national priorities of target countries, STRASA developed an innovative model system which addressed the entire seed chain including seed policy issues for rapid out scaling of stress tolerant rice varieties in South Asia. In this model IRRI played a catalytic but central role and the entire work was carried out by national partners with strong physical, financial and policy support from national systems. Project developed a large network (~ 700) of national partners involving research institutions, agricultural universities, federal and state governments, mega schemes/projects addressing food security, climate change or disaster management, NGOs, public sector seed corporations, private seed companies, small and medium seed producers, farmers organizations, mass media, other international organizations etc. Most of the partners participated using their own resources. Most of the seed companies/corporations and small and medium seed producers are moving the stress tolerant rice varieties (STRVs) in business mode. They are playing active role not only in seed production and business but also awareness creation. Due to these efforts and strong support from national system, stress tolerant rice varieties have moved at unprecedented speed in South Asia covering >4 million ha area. These climate resilient rice varieties have potential to usher green revolution in eastern India and rainfed areas in South Asia.

Many microbes, including biocontrol agents, are reported to induce plant root growth and enhance tolerance of plant to abiotic stresses. These microbes may not be effective enough to work them as standalone treatment for the management of abiotic stresses. However, they offer high potential once combined with host gene (i.e. stress tolerant varieties) due to their synergistic /additive action.

K.C. Mehta and M. Mitra Award

Dealing with biotrophs and hemibitroph pathogens of wheat in warmer and humid climate of India in an eco-sustainable way- A success story-

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Wheat (*Triticum aestivum*) is cultivated in warmer and humid climate of North-eastern plains zone (NEPZ) of India at nearly 8.82 million ha with productivity of 2.7 tonnes/ha with a yield gap of nearly 0.5 tonnes/ha compared National productivity and 2.5 tonnes/ha as compared to wheat productivity in North-western plains zone NWPZ. The temperature remained higher right from sowing till maturity in NEPZ and therefore it invites diseases like brown or leaf rust and spot blotch in a greater intensity than in NWPZ. However it is only potent zone for increasing the wheat area due to availability of surplus land after rice and plenty water availability. However, during nineties, the wheat varieties bread for traditional wheat growing area of NWPZ when grown in NEPZ were infected heavily by spot blotch and up to some extent by brown rust and thus yielded poorly. As a result dividend received in terms of rust resistance was neutralized by spot blotch. Since then efforts are going on to find out the resistant sources for biotophic pathogen of brown rust (*Puccinia triticina*) as well as hemibiotrophic pathogen of spot blotch (*Bipolaris sorokiniana)*. Stripe rust is not a major problem in NEPZ. Through regular collection and analysis of blighted wheat leaf samples over years it has been now established that *B. sorokiniana* is the major cause of leaf blight and *Alternaria triticina* is no more a major pathogen associated with leaf blight complex of wheat. *Pyrenophora tritici repentis* occurs only in minority. Regular watch on brown rust pathotypes is being kept and these are used for evaluation of pipeline varieties at hot spot location to test their status of resistance and only brown rust resistant varieties are evolved. Since 2000-01, the station trial entries of wheat formally contributed in Initial rust screening nursery (IRSN) are now screened against three rusts and spot blotch under new nursery namely Initial Plant Pathological Nursery (IPPSN). The virulent isolates of *B. sorokiniana* are mass multiplied and sprayed in field on infector lines in PPSN block besides brown rust. The rating scale for spot blotch for seedling and adult stage has been evolved. The recording of spot blotch is done at in 0-9 double digit rating scale by taking per cent blighted area of flag (F) and F-1 leaves. The categorization was done as: Highly Resistant (HR): average disease score range 00-13 with highest score up to 35, Resistant (R): average score 14-35 and highest score up to 57, Moderately Resistant (MR): average score 36-57 with highest score up to 69, Moderately Susceptible (MS): average score 58-69 and highest score up to 79, Susceptible (S): average score >69 and highest score up to 99 Highly Susceptible (HS). The score of leaf blight was up to 99 on the infector, Raj 4015. The following genotypes and varieties were found highly resistant to moderately resistant category. The varieties found resistant to spot blotch were DBW 39, HD 2733, HD 2888, K 0307 and K 8027 whereas HD 2967 was moderately resistant. As result of vigorous screening against spot blotch and brown rust, the entries carrying good level of resistance to brown rust (ACI up 15.00) and spot blotch has increased considerably. The varieties have been released with resistance to both biotrophs and hemobiotrophs. The varieties, HI 1612 (I), DBW 39, HD 2733, HD 2888, HD 3171, K 8027, K 0307, K 1006 and K 1371 are found having resistance to brown rust along with resistance to spot blotch and now in cultivation in NEPZ. The wheat yields in states like Eastern

UP, West Bengal and Bihar have increased considerably due to resistance to these pathogens and farmers are growing wheat successfully since past one and half decade. In addition to these pathogens, the occurrence of wheat blast in Bangladesh caused by *Magnaporthe oryzae* pathotype *Triticum* has again posed a threat to wheat of NEPZ and efforts are going on to prevent and establishment of this pathogen in India from Bangladesh. A total of 140 Indian wheat varieties have been sent for screening in Bolivia, USA and Bangladesh and those found resistant to wheat blast will be deployed in West Bengal, Assam and other Eastern states.

Sharda Lele Memorial Lecture Award

Aerobiology, Epidemiology and management strategies in apple scab - Science and its applications

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Integrated spray schedule used in Gangotri valley of Uttarakhand apple orchards in 1993 to 2017 for management of the most important foliar diseases are described, such as Scab (*Venturia inaequalis* (Cke.) Wint), Powdery mildew [*Podosphaera leucotricha* (Ellis and Everhart)] and Apple blotch [*Marssonina coronaria* and *Alternaria mali*]. These diseases have plagued apple cultivation in Uttarakhand Himalayas. Special attention is paid to the control of apple scab using warning services, and the biological control of diseases. Several pesticides spray schedules were evaluated for their efficacy on controlling the apple diseases under cool, wet weather conditions. Urea @ 5% concentration had a significant effect on breaking of the life cycle of *V. inaequalis* in overwintered leaves. The number of cumulative degree-days for 50 and 95 per cent ascospore discharge was approximately 426 and 826 (R^2 =0.943), respectively for orchards situated at 1900-2200 m asl and > 1272 (95% ascospore discharge; R^2 = 0.968) for orchards situated at >2200 m asl. Thus, seasonal variation of ascospore discharge during experimental years differed at different locations in the region. More than 20 year study on epidemic progress of apple scab was conducted at Gangotri valley, Uttarakhand, India, in 1992 to 2017. The environmental conditions varied from location to location, and Mills infection periods ranging from 19–47 were recorded from April to September every year revealed that number of infection periods varied from year to year depending upon the weather conditions. The observation revealed 2 day (light infection), 1 day (moderate infection) and 1 day (severe infection) delay in symptom expression under orchard conditions. Potential ascospore dose is a useful tool for predicting the total amount of inoculums in an orchard and has been shown to effectively improve apple scab management. PAD values were 50 times higher in the poorly managed orchards than in the integrated orchards. However, integrated orchards were considered well-managed in the investigated years and showed that the epidemic risk was low and medium, while it was very high in the poorly managed orchards on the basis of PAD. The number of applications will vary with the frequency of PAD. The completely management of scab by applying no more than 3-4 fungicide and 2% urea spray at the time of leaf fall in some years. The warning services are based on weather stations, grower and private consultant information and traps. Warnings are issued mainly via a call in telephone, SMS, WhatsApp, Agriculture Govt. department, and broadcasted through radio stations. In addition, growing season kisan mela, press releases and newsletters are issued via the extension workers of University and Govt. department. The Indian Council of Agricultural Research, NATP, UCOST, NAIP and University help to develop monitoring methods and test development models. The possibility of an integrated approach to control the diseases menaces would be discussed.

A.K. Sarbhoy Memorial Award Lecture

Biodiversity, Taxonomy, Conservation and Documentation of fungi of India

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The fungi are the second largest group of organisms in the world after insects and hence require greater attention with regard to biodiversity and global ecology. The diversity of fungi refers to the genetic or taxonomic variability within a specific area or region is immense. Out of 1.5 million species estimated to exist, so far only 80,000 species have been described *(Hawksworth, 1991)* More recent estimates based on high-throughput sequencing methods suggest that as many as 5.1 million fungal species exist.(Blackwell 2011)

One third of fungal diversity of the globe exists in India and are essential to such crucial activities as decomposition, nutrient cycling, and nutrient transport and are indispensable for achieving sustainable development (Palm and Chapela, 1998). As habitats are being degraded and destroyed each year, hundreds or thousands of species are being lost even before they are known. The preservation of fungi in a viable yet stable state for long periods has always been important to maintain the vigor and genetic characteristics of a pure culture, as these fungi can serve as standards for identification of new and quarantine taxa. The continuing emergence of molecular biology will develop novel gene-based bio industries as a result of the rich diversity and the culture collections worldwide are encouraged to create novel and better techniques for bio-prospecting of novel microorganisms, carry out molecular sequence analysis, define phylogenetic relationships, execute taxon-based research on population structure of natural consortia, and pools of microorganisms.

The Herbarium Cryptogamae Indiae Orientalis (HCIO) and The Indian Type Culture Collection (ITCC) are the oldest national fungal collections established in 1905 and in 1936 respectively at Indian Agricultural Research Institute, New Delhi to conserve, catalogue, identify and furnish the knowledge on specimens and living fungi. ITCC is an affiliated member of World Federation of Culture Collection (WFCC) and is registered with world data centre for microorganisms (WDCM) and recognized as a national repository by National Biodiversity Authority (NBA), Ministry of Environment and Forests, Govt. of India. Studies on DNA Barcoding through multigene analysis and Development of molecular markers for identification of fungi, bioprospecting of fungi and descriptions of new fungi are the main research activities of these centres apart from the documentation of the specimens and living fungi through digitization.

J.F. Dastur Memorial Award Lecture

Present Status and Future Research dimensions of soybean diseases for sustainable productivity of soybean in India

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Diseases take heavy toll in soybean production and productivity. This paper mainly outlines the work done detection, diagnosis of soybean diseases by modern tools, variability and race pattern of soybean rust pathogen, host plant resistance and also integrated disease management strategies (2010-2016) carried out at the University of Agricultural Sciences, Dharwad which has released first ever rust resistant variety DSb 21 in the country.The work carried out on soybean diseases over one decade are presented in this paper which will be a real tribute Prof.J.F.Dastur, a great Phytopathologist of the country.

M.K. Patel Memorial Young Scientist Award

Dynamics and sustainable approaches for the management sheath blight disease of rice in India

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India is the largest rice grower, consumer and exporter. Rice is grown in most of the states in India, in an area of 43 mHa producing 105 mt, contributing about 42% to the country's food grain production and livelihood for over 70% of population in the traditional rice growing regions. The first incidence of sheath blight disease of rice in India was reported by Paracer and Chahal (1963) in Punjab. Since then, this disease is considered as one of the major constraints for rice production in India (Ram Singh and Sunder 2012) and also worldwide. The severity of the disease depends upon the age of the plant, the time of infection, etc. and the yield loss is about 70% (Venkat Rao *et al*., 1990; Naidu, 1992). Heavily infected plants produce poorly filled grains, and additional losses result from aggravated lodging of the plants. The disease also affects quality of straw, limiting its value as fodder. It is one of the major biotic constraints that affects rice production and contributes to severe yield reduction threatening the socio economic status of rice-farmers in India.

In order to understand the spread of sheath blight of rice disease in the country, data was collected over the past twenty five years (1990-2017) from production oriented survey (POS) reports of AICRP on rice (Annual Report 2015-2016). Results revealed that the disease has spread widely in terms of both occurrence and intensity over the period of time and has occurred predominantly various regions of rice cultivation. Currently, it is a major production constraint in the many states of the country *viz*., Punjab, Haryana, Uttarakhand, Eastern Uttar Pradesh, Bihar, West Bengal, Odisha, Jharkhand, Chhattisgarh, Andhra Pradesh, Tamil Nadu, Karnataka and Kerala. With the introduction of dwarf, high yielding cultivars, increased use of inorganic fertilizers and intensive mono-cropping, the disease problems have aggravated.

As the pathogen is majorly saprophytic and has a wide host range, the identification and utilization of host plant resistance is difficult as well as not very effective. However, analyzing the distribution of genetic diversity within and among the pathogen (*R. solani*, *R. oryzae* and *R. oryzae-sativae*) populations helps to determine historical patterns of migration and subsequently identify the centres of diversity. Sheath blight disease samples of rice were collected from different rice ecosystem in India and 120 isolates of *Rhizoctonia solani* were purified and characterized. *R. solani* isolates from Karnataka (20), Chhattishgarh (42) and Telangana (35) states were characterized through phenotyping, pathotyping and genotyping. The virulent spectrum of these isolates was identified and the anastomosis group was confirmed.

The major constraint in the development of sheath blight resistant rice cultivars is the non-availability of donors having high degree of resistance to the pathogen. It has been reported that resistance to rice sheath blight is a complex, quantitative trait, governed by several minor genes. Targeted resistance breeding for sheath blight was not done in the past primarily because of lack of donor parents having high level of resistance. Therefore the variety/cultures with high degree of sheath blight resistance are not available even though ~1100 lines in Advanced Varietal Trails (AVTs) and ~4000 lines in Initial

Varietal Trials (IVTs) were screened at hot spot areas in the past six years (2012-2017). Besides, about 3000 germplasm, wild rice and breeding materials were also screened through typha bit method of artificial inoculation at field condition.Eventually, four sheath blight tolerant lines (Gumdhan, WazuhoPhek, Ngonolasha and Phougak) were identified from land races of North Eastern India through field screening. As resistance breeding for sheath blight is hindered due to lack of resistant donors, cultural practices combined with use of fungicides is the most viable option for sheath blight disease management. Different combination products were tested against the disease under -field condition with artificial disease pressure. In various trials in different seasons, the combination products of fungicidal molecule *viz*., trifloxystrobin 25%+tebuconazole 50% (0.4 g/l), tetraconazole 7.46%+azoxystrobin 9.32% (3.0 ml/l), mancozeb 68%+hexaconazole 4% WG (2.0 ml/l) and ICF-110 (tricyclazole 45%+hexaconazole 10% WG-1.0g/l) were significantly effective in reducing the severity of sheath blight under field conditions. Biological control with the help of fungi Trichoderma spp., and *Penicillium oxalicum* and bacteria *Pseudomonas fluorescens* and *Bacillus subtilis* have shown encouraging results in both *invitro* and *invivo* trails against sheath blight. Use of entophytic strains of *Trichoderma* improves both the initial vigour of the plant and also helps in the defense of the plants against *R. solani* infection. Besides, essential oils *viz.*,Citronella, Cedar wood and Eucalyptus were found most efficient for disease suppression.

Integrated management of an emerging disease-bakanae of rice

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The bakanae disease of rice is incited by *Fusarium fujikuroi* Nirenberg (sexual stage: *Gibberella fujikuroi* (Sawada) Wollen worth). The disease is becoming a serious threat to cultivation of rice specially basmati rice in India and other rice growing nations. The disease is characterized by production of various kind of symptoms like crown or foot rotting, lanky, tall slender elongated culms with pale yellow flag leaves and sterile grains. The disease causes upto 40% losses in the yield. Most of the aromatic rice varieties are susceptible to the disease. Biocontrol agents were evaluated against the disease and *Talaromyces flavus* was identified effective against the disease. Further, fungicides were evaluated in different combination for the seed, drenching, seedling and spray treatment and Carbendazim was identified most effective. Five modules were designed for the management of bakanae disease and tested in field conditions. Lowest disease incidence was observed in module no. 5 (Seed and seedling treatments with Carbendazim and two sprays of Trifloxistrobin + Tebuconazole) followed by module no. 1. Testing of module in farmers field condition indicated that module is highly effective for the management of bakanae disease in North-West plain zone of India.

Prof. M. J. Narashimhan Merit Academic Award

S-MJN/NSIPS/O-1

Eco-friendly Management of Fruit Rot of Brinjal with Botanicals

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Fruit rot is one of the most destructive disease of brinjal causing considerable losses to the fruits in field, storage, transit and marketing. The commercial cultivation of the crop is under serious threat in Assam due to the disease. The incitant pathogen was identified and confirmed as *Phoma exigua* (Id No. - 8221.16 of the National Centre of Fungal Taxonomy, New Delhi), which constitute a new host record from Assam. Antifungal potential of aqueous extracts of fifteen botanicals at 25% concentration were evaluated *in vitro* for their efficacy against *Phoma exigua* by "poisoned food technique". Highest inhibition on mycelial growth of the pathogen was recorded in *Allium sativum* (90.24%) followed by *Allamanda cathertica* (87.80%), *Lawsonia inermis* (79.67%), *Laurus nobilis* (73.28%) and *Lasia spinosa* (70.15%) which were further tested at 5, 10 and 15% concentration. *A. sativum* at 15% showed highest inhibitory effect (88.03%) on mycelial growth of the pathogen, followed by 10 and 5% of *A. sativum* (78.51% and 74.33%). Next was *A. cathertica* (73.51%) and *L. inermis* (73.28%) at 15%, the effect of which were statistically *at par* with *A. sativum* at 5%. Least inhibition was recorded in 5% concentration of *L. spinosa* (57.14%). Phytochemical profiles of these five botanicals were also estimated and results revealed significantly higher alkaloid (g/100g) and phenol content (mg/g) in case of *A. cathertica* (2.764 ± 0.100; 55.50 ± 0.800) followed by *L. inermis* (2.550 ± 0.262; 49.68 ± 0.386), *A. sativum* (2.192 ± 0.034; 30.6 ± 0.165), *L. nobilis* (1.450 ± 0.042; 26.95 ± 1.001) and *L. spinosa* (0.086 ± 0.006; 3.71 ± 0.051)

S-MJN/NSIPS/O-2

Biosynthesized Chitosan Nanoparticle has the Ability to Enhance the Biocontrol Potentiality of *Trichoderma asperellum*

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Chitosan, a cationic polysaccharide (partly de-acetylated form of chitin) present in microorganisms can be used for synthesis of nanoparticles. In the present study, chitosan nanoparticle was synthesized from fungus belonging to four different genera. Synthesized nanoparticles were characterized by using UV-VIS Spectroscopy, Zetasizer, Dynamic Light Scattering (DLS) and Transmission electron microscope (TEM). Average size of the chitosan nanoparticles synthesized from *Fusarium oxysporum, Metarhizium anisopliae, Beauveria bassiana* and *Trichoderma harzianum* were found as 273.20 nm, 172.50 nm, 78.36 nm and 89.03 nm respectively. Compatibility of the nano chitosan with fungal biocontrol agent (*T.*

asperallum) at different concentration when tested by poison food technique showed chitosan nano particle was found to be compatible with *T. asperallum* at 0.01, 0.02, 0.03 per cent. Combined effect of *T. asperallum* and chitosan nanoparticle was tested against three soil borne plant pathogens viz., *Fusarium oxysporum*, *Sclerotium rolfsii* and *Rhizoctonia solani* and found that the combined effect of *T. asperallum* and chitosan nanoparticle was superior in inhibiting the mycelial growth of the tested pathogens as compared to the recommended chemical at 0.1 per cent. Nanochitosan based liquid formulation of *T. asperellum* prepared by adding SDS @ 0.01 M showed significantly effective results against all the three pathogens alone with increasing result of plant growth parameters. This study showed encouraging result of combined use of nanoparticle and biocontrol agent for the management of soil borne plant pathogens and it paves the way of possible way of reduced use of synthetic pesticides.

S-MJN/NSIPS/O-3

Genetic Variations among *Alternaria* spp Collected from Different Host Plants

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The genus *Alternaria* is indigenous and pathogenic to economically important agricultural crops causes early blight symptoms. Growth and colonization varied with duration and exposure in a suitable natural and synthetic growth media. The studied isolates were collected from cumin, sesame, tomato brinjal, onion, cauliflower, chilli, datura and potato.

Variations among different *Alternaria* species were identified on the basis of protein and Random Amplified Polymorphic DNA (RAPD) banding pattern. Molecular characters were varied to some extent when they were grown on PDB and compared with protein pattern in different *Alternaria* species. A total of 80 protein bands were observed with different molecular weight ranged from 3.0 KD – 29.0 KD. Highest (17) bands were found in *Alternaria burnsii*, *Alternaria alternata* and *Alternaria solani* with higher variation in proteins, whereas minimum (one) was found in *Alternaria brassicae* followed by two bands in *Alternaria tenuissima.* A total of 20 RAPD primers were used to analyze genetic variability among *Alternaria* species. Out of them only eight were found to be suitable for amplification. Primers OPH-02 and OPH04 amplified the highest six bands with all samples, while, OPH-06 and OPH-09 amplified five bands with two polymorphic (60%) each. Among all primers only OPH-02, OPH-06 and OPH-09 were able to amplify polymorphic banding pattern. *Alternaria* spp isolates were grouped into two clusters i.e. one major and one minor when dendrogram generated based on Jaccard's similarity coefficient using UPGMA cluster analysis. The major cluster consisted eight isolates while minor cluster contained only one isolate.

S-MJN/NSIPS/O-4

In-silico Analysis of BLB Resistance Gene(s) Xa4, Xa7, Xa21 Provides the Basis for Fine Mapping of Introgressed gene(s) in Karma Mahsuri

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Bacterial leaf blight (BLB) of rice caused by *Xanthomonas oryzae pv. oryzae* (Xoo) is one of the most serious production constraints of rice worldwide. Chhattisgarh one of the leading rice producing state in India has 37.73 lakh hectare area under rice cultivation with the production of 60.28 lakh tones. One of the major production constraints of Karma Mahsuri is its susceptibility to bacterial leaf blight which can only be managed through host plant resistance. We report herein in phenotyped resistant genotypes the MAS based introgression of two (Xa7+Xa21) and three (Xa4+Xa7+Xa21) gene pyramids. Foreground selection markers are required for precise placement of gene(s) of interest and also quickly and reliably select desirable material, and eliminates individuals that contain deleterious alleles is critical to the success of a plant breeding program. By identifying BAC or PAC clones that simultaneously contained a hit from the marker in silico, it has been reported herein a high resolution molecular marker map for Xa4, Xa7 and Xa21. Map generated from a targeted region will help us to select appropriate combinations of markers for foreground selection, precise placement of a gene(s) of interest and analysis of regional and sub-regional rates of recombination.

S-MJN/NSIPS/O-5

Characterization of *Uromyces appendiculatus* Races and Identification of French Bean Lines with Slow Rusting Components in Himachal Pradesh

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Rust (*Uromyces appendiculatus*(Pers.) Unger) is one of the most devastating diseases of French bean (*Phaseolus vulgaris* L.) occurring worldwide and its pathogen is highly variable. The

present studies were carried out with the objective to characterize *U. apeendiculatus* races occurring in Himachal Pradesh and to identify different cvs./lines with slow rusting components. Systematic surveys of French bean growing areas of five districts of the State viz., Solan, Shimla, Sirmour, Kullu and Mandi were conducted and leaf tissues with rust pustules were collected. Ten single pustule isolates were raised and maintained on highly susceptible Cv. Falguni. The associated pathogen on the basis of urediniospore characteristics, standard keys and ITS was identified as *Uromyces appendiculatus*(Pers.) Unger. Ten single pustule isolates were then inoculated on 12 bean rust International Differential Set obtained from South Africa. According to new International classification system and the binary nomenclature, these 10 isolates were grouped into 5 different races, most of which affected the Andean gene pool. Sixty six different germplasm lines/cvs./local selections were screened against the disease under natural epiphytotic conditions and out of which 39, 5 and 11 were found highly resistant, resistant to moderately resistant and susceptible to highly susceptible, respectively. These cvs./lines were further evaluated under artificial inoculation conditions and 29, 6 and 26 were found highly resistant, resistant to moderately resistant and susceptible to highly susceptible, respectively. Slow rusting is a kind of resistance that appears to be race non-specific and more durable than major gene resistance. Studies were, therefore, conducted to determine if any slow rusting components like incubation period, latent period, uredia size and number of uredia/cm2 exist among different cvs./lines having varied degree of resistance/ susceptibility to the pathogen. Only five lines viz., EC-755318, EC-400442, EC-400406, EC-400390 and EC-405210 demonstrated slow rusting characteristics like longer latent period, much smaller uredia, fewuredia/cm2 than highly susceptible cv. Falguni. However, line EC-400411had only small size uredia.

S-MJN/NSIPS/O-6

Impact of Weather Factors in the Development of Phomopsis Blight of Brinjal in Kashmir

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Phomopsis vexans causes leaf blight of brinjal and is one of the major constraints in the cultivation of the crop. Climate not only affects the crop but also affect the pathogens that decrease the crop yield. Due to industrial emissions, concentration of CO_2 and temperature would increase leading the world towards global climate change. The effect of weather parameters *viz*. temperature, relative humidity and rainfall on the development of *Phomopsis* blight of brinjal was therefore investigated under prevailing environmental conditions on susceptible cultivar Pusa Purple Long during 2015 and 2016. The data regarding per cent disease intensity was recorded at fifteen days intervals from May- October. Data obtained was correlated with the mean maximum and minimum temperature, mean maximum and minimum relative humidity and mean rainfall during the corresponding period. The data revealed that in 2015 the disease initiated under field conditions in the second week of June on leaves and last week of June on twigs. The per cent disease intensity increased slowly and reached as high as 59.48 and 39.97 on leaves and twigs respectively, during the last week of October. However, on fruits the disease symptoms were first observed during last week of July when the mean atmospheric temperature both maximum and minimum were 29.03^{o}C and 17.84^{o}C, respectively and mean relative humidity both maximum and minimum were 86.73 and 65.60 per cent, respectively and reached as high as 60.90 per cent in the last week of October. The maximum rate of disease progress (0.0722, 0.0779 and 0.0712) was observed during the

second week of August, last week of August and second week of September on leaves, twigs and fruits, respectively which coincided with the favourable temperature and relative humidity for its progress. The minimum infection rate of 0.0058, 0.0066 and 0.0053 was recorded in the last week of October when the maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity and rainfall during the previous week were 18.03, 6.53, 89.13, 67.73 and 5.93, respectively. Epidemiological studies further revealed that the relationship between disease intensity on leaves and weather factors indicated significant positive correlation with maximum relative humidity, significant negative correlation with maximum temperature, minimum temperature and minimum relative humidity while as it showed non-significant positive correlation with rainfall. In case of stem blight, the relationship showed positive and significant correlation with minimum temperature and maximum relative humidity, significant and negative correlation with maximum temperature and minimum relative humidity and non-significant negative correlation with rainfall. For fruit rot, the relationship indicated significant and negative correlation with maximum temperature, minimum temperature and minimum relative humidity, significant and positive correlation with maximum relative humidity and non-significant but positive correlation with rainfall.

S-MJN/NSIPS/O-7

Molecular Characterization and Management of *Fusarium solani* (Mart.) Sacc. causing Dry Rot of Potato Tubers

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Fusarium dry rot of potato is devastating postharvest disease worldwide and is caused 25 to 60 per cent yield loss in India. Among the fungicides screened *in vitro*, carbendazim completely inhibited the mycelial growth of *F. solani*. The result of *in vivo* study revealed that the dry rot severity was not observed in tubers treated with carbendazim. Complete mycelial growth inhibition of *F. solani* was recorded in aluminum acetate and aluminum chloride salts. Further no dry rot severity was recorded in tubers treated with aluminum acetate. Red Kaner found significantly superior in inhibiting the mycelial growth (69.17%) of *F. solani.* Significantly lowest dry rot severity was noticed in tubers treated with Red Kaner (0.60%). *Trichoderma asperellum* found most efficient antagonist in inhibiting the mycelial growth of *F. solani* (93.99%) in *in vitro* and *in vivo*. Variation in cultures was observed among 25 isolates in growth, pigmentation and conidial size. The primer OPA-6, OPA-7, OPA-11and OPA-13 showed the highest percentage (100%) of polymorphism. Highest similarity was observed between FS-10 and FS-13 (0.86). The dendrogram exhibited one big cluster of twenty four isolates, while only one isolate FS-6 was separately situated with similarity matrix of 0.349 with FS-1.The PCR amplification with fuminosin mycotoxin specific primer FUM1 showed that all isolates have a potential to produce the toxin fuminosin except FS-6, FS-13 and FS-14. Potato tubers when inoculated with *F. solani* showed progressive decrease in total soluble sugar (2.90%), total reducing sugar (1.02%), non reducing sugar (1.88%) and starch (3.41%), while the total phenol (3.74%) was increased as the incubation period is increased.

S-MJN/NSIPS/O-8

Management of Finger millet (*Eleusine coracana* L. Gaertn.) Blast (*Pyricularia grisea* (Cke.) Sacc.) on the Basis of Screening of Germplasms for Resistance to Blast and Seed Treatment as well as Foliar Spray

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Finger millet blast caused by *Pyricularia grisea* (Cke.) Sacc. is serious disease of finger millet under south Gujarat condition and causes severe losses in yield. In order to manage this disease, the experiments were carried out at Hill millet Research Station, Rajendrapur, Navsari Agricultural University, Waghai, Gujarat. Biochemical parameter exhibited antimicrobial properties that inhibit the growth and development of the pathogen in the plant. The mechanism of resistance revealed that the higher amount of total phenol in finger millet resulted lower disease incidence. The finger millet genotypes GN-5, GPU-28, GPU-48, KOPN-235, KMR-204 and MR-6 are having maximum amount of total phenols. Correlation between total phenol with disease severity at different growth stages shows that there was a negative correlation in all the finger millet genotypes. Among all the tested fungicides and bioagents, seed treatment with carbendazim, 2g/kg seed + 2 sprays of tricyclazole, seed treatment with carbendazim, 2g/kg seed + 2 sprays of tebuconazole and seed treatment with *Pseudomonas fluorescence*, 10g/kg seed + 2 sprays of *P. fluorescence* found superior for the control of blast disease of finger millet as well as for getting higher grain and fodder yield.

S-MJN/NSIPS/O-9

Selection of a Compatible Biocontrol Consortium for the Management of *Fusarium* Wilt of Tomato

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Fusarium oxysporum f.sp. *lycopersici* (FOL), an incitant of vascular wilt of tomato, needs to be contained through efficient sustainable management practice to boost the yield and quality of marketable produce. To enhance the consistency and degree of disease control offered by individual antagonists, effective strain mixtures consisting of *Pseudomonas putida* (TEPF), *Bacillus subtilis* (S2BC-1), *Trichoderma harzianum* (S17TH) and *Chaetomium* sp (CG-A) were designed based on growth, antagonism and antifungal enzyme and gene expression assays. In pot experiments, seed treatment and soil applications of suspension cultures of 5 different strain mixtures were assessed for their efficacies in vascular wilt control over individual strains upon challenge inoculation with FOL under polyhouse conditions. In general, the biocontrol strain mixtures greatly reduced vascular wilt incidence besides

promoting tomato plant growth in comparison to the pathogenic and untreated controls. However, the biocontrol performance of the consortium housing all the four strains was lesser than the strain mixtures containing three strains. Among the treatments, application of a strain mixture comprising TEPF+CGA+S17TH under challenge inoculated conditions resulted in significantly lower incidence (71.4% reduction) of *Fusarium* wilt and increased root and shoot length of 135.5% relative to the pathogen control without biocontrol agents. In further studies on elucidating the role of defence genes of tomato plants in vascular wilt suppression by the biocontrol consortia, though strong expressions of *PR3b* and *PR5*, the marker genes for salicyclic acid modulated pathway and *gluB*, the marker gene for ethylene modulated pathway were observed over the pathogenic and untreated controls, in the treatments, S2BC-1+CGA+S17TH and S2BC-1+TEPF+S17TH, a reduction in expression was observed for the best performing strain mixture, TEPF+CGA+S17TH. The reduced expression indicated that novel genes other than the candidate ones might be playing a role in the resistance induction. Further, plant growth promotion by the consortia could be attributed to the suppression of the pathogenic fungi besides other mechanisms that need to be explored in detail. The identified consortium has the potential as a preferred input in integrated disease management systems once formulated and tested under field conditions.

S-MJN/NSIPS/O-10

A Geminivirus Betasatellite Encoded âC1 Protein Interacts with PsbP and Subverts PsbP-Mediated Antiviral Defense in Plants

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Geminivirus disease complexes potentially interfere with plants physiology and cause disastrous effects on wide range of economically important crops throughout the world. Diverse geminivirus-betasatellite association worsens the epidemic threat for global food security. This study provides the first evidence of chloroplast localization of a DNA virus encoded protein which in turn affects the ultrastructure and function of the chloroplast. *Radish leaf curl betasatellite* (RaLCB) encoded âC1 protein gets localized into the chloroplasts of the infected *N. benthamiana* plants and causes damages to the OEC of PSII. The antiviral response against virus systemic infection is known to be majorly associated with chloroplast function. Conversely, plant viruses primarily target and exploit chloroplasts to establish viral pathogenesis and symptom induction. In this present study, the virus-chloroplast interaction in the scope of viral pathogenesis as well as plant defense response was explored. Interaction between host encoded PsbP protein with RaLCB-âC1 protein was confirmed both in vitro and in vivo. Host PsbP protein binds to geminivirus DNA both in-vivo and in-vitro. Transient silencing of *PsbP* in *N. benthamiana* plants greatly enhances symptom induction and viral DNA accumulation. Over-expression of PsbP impedes disease development during the early phase of infection, suggesting that PsbP generates defense response during geminivirus infection. In addition, âC1-PsbP interaction hampers binding of PsbP to the geminivirus DNA. Taken together, these findings suggest that betasatellite encoded âC1 protein accomplishes counter-defense by physical interaction with PsbP and by interfering with ability of PsbP to bind geminivirus genome to ensure the establishment of viral pathogenesis.

S-MJN/NSIPS/O-11

Combination of Copper-Chitosan-*Trichoderma* Mediate Defence Induction in Potato against Late Blight Pathogen

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Late blight disease is a serious threat for the production of important horticultural crops like potato and tomato. Due to aggressive nature of pathogen and explosive nature of the development, it is important to develop innovative methods for management of this disease. Although copper (Cu), chitosan (Chi) and *Trichoderma* (Tri) individually have been widely used to protect plants from a variety of pathogenic diseases, their combination has been found to significantly reduce late blight disease of potato at field level. Though action of the physical mixture of the three ingredients suggests an integration of defence induction mechanism with fungicidal protection yet the mechanism behind the triple combination induced resistance needs to be understood. The aim of this research was to assess the effect of combination of Cu-Chi-Tri on defence induction in potato against *Phytophthora infestans infestans*.

Experiments were performed using susceptible potato variety Kufri Jyoti and experiments were conducted under field as well as glass house conditions for establishing reproducibility of results. Technical grade CuOH (Spiess Urania, Germany), Chitosan 651 (Mahtani chitosan Pvt. Ltd, Veraval, Gujarat) and talc-based formulation of copper tolerant and chitosanolytic *Trichoderma* (TCMS 36 strain) prepared in the Biocontrol lab, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar was used singly as well as in dual and triple combinations. A total of 10 treatments were evaluated under controlled and natural conditions. Under glass house conditions treatments were given using a hand sprayer and plants were challenge inoculated by *P. infestans* 24 hours after treatments. In glass house, 24 hr after treatments, the potato plants were challenge inoculated with *P. infestans* zoospore suspension. In field experiment, natural inoculum was assured by growing the susceptible potato varieties. Under glasshouse conditions, disease was recorded 98 hr post inoculation by measuring the percentage infected leaf area (PLA). Under field conditions, disease severity was observed before and after application of the treatments and increase in disease severity was calculated. Microscopic quantification of trichomes was performed using Olympus IX81 motorized inverted differential interference contrast (DIC) microscope with magnification of 40x. Biochemcally SOD was estimated by the procedure of Beauchamp and Fridovich (1971) and $H_2O_2$was estimated by the method of Alexieva et al. (2001). Proline content was determined by the method of Bates et al. (1973).

In the present study it was observed that a triple combination comprising of Cu-Chi-Tri was effective in controlling the late blight disease and slowed down its progress. Based on the estimation of the disease severity, it was found that triple combination was effective in controlling the progress of the disease both under field and glass house conditions, compared to other treatments evaluated in the study. It was observed that leaves treated with the triple combination had shiny leaves with dense growth of trichomes, compared to other treatments and control. Therefore, it is speculated that triple combination might be strengthening physical defense in potato plants by increasing the no. of trichomes and thus inhibiting penetration and spread of the late blight pathogen, which requires high humidity on the leaf surface for germination and penetration. On estimating biochemical markers of defense induction, it was observed that proline concentration increases in plants treated with triple combination. Proline makes the plants tolerant to abiotic stresses and is recently reported to be involved in initial defense induction against pathogens (Qamar *et al*., 2015).

Increase in concentration of proline suggest that, in plants treated with triple combination defense reactions are initiated which stop/ inhibit spread of the pathogen. This observation is further supported by observed increase in concentration of SOD and H_2O_2. Both SOD and H_2O_2 are involved in the initial defense reactions and induction of hypersensitive response (Lakimova *et al*., 2005) against pathogens. The observation that SOD and H_2O_2 increase by triple combination supports the hypothesis that triple combination may induce ROS and hypersensitive response for inducing defence against *P. infestans* invasion. The result from glass house and field trial suggest that oxidative burst might be the intial mechanism for checking the entry of the pathogen, which triggers the down stream biochemical mechinery for defence induction. Thus, decrease in disease severity in plants treated with triple combination may be due to increase in number of trichomes as first line of defence, followed by induction of biochemical pathways and hypersensitive response for restricting entry of the pathogen.

Results suggest that triple combination of Cu-Chi-Tri evaluated in this study is effective in managing late blight of potato by inducing the general defence pathway in potato plant. Further, due to reduced dosage of Cu used in the combination, it will be environment friendly and less phytotoxic. The combination involves copper (fungicide), chitosan (plant strengthner) and *trichoderma* (a well known biocontrol agent), suggesting that the components of the triple combination will have different mechanisms for disease management. Due to multiple sites of action this combination may provide a durable and long lasting management strategy for late blight pathogen.

S-MJN/NSIPS/O-12

Potential of *Brassica juncea* as Biofumigant for the Management of Damping Off in Tomato

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Damping off is one of the serious most diseases in vegetable nurseries. In tomato, 72.3 to 100 per cent incidence of damping off disease is reported by many researchers. Fungicides though are the most common means to check the disease in nursery, frequent and intensified use of these chemicals is hazardous to humans and environment. Alternative disease management strategies, thus, are being emphasized with an objective of reducing crop losses besides minimal ecological implications. Among different alternatives to chemical control, biofumigation i.e. suppression of soil borne pests and diseases by glucosinolate containing plants arising from the biocidal properties of hydrolysis products of glucosinolates especially isothiocyanates, released from incorporated tissues of *Brassicaceae* plants, has been considered to be most promising eco-friendly management option for the soil borne plant pathogens. Keeping this in view, the present investigation was carried out to evaluate the potential of three *Brassica juncea* varieties viz., Kranti, Varuna and Divya as biofumigant alone and also in combination with Pant Biocontrol Agent-3 (consortium of *Trichoderma asperellium* and *Pseudomonus fluoroscens*) for the management of damping off disease in tomato.*Pythium aphanidermatum* was isolated from infested soil following bait technique and *in vitro* toxicity of the volatiles released from the *B. juncea* varieties against soil borne pathogens was evaluated using head space technique. To evaluate *B. juncea* as biofumigant for the management of damping off in tomato in glass house conditions, *B. juncea* varieties were chopped at 50 per cent flowering stage and were incorporated into the pots containing *P. aphanidermatum* inoculated soil. Pots were covered with 100 micron polythene sheet for 14 days and after uncovering the pots, those were kept as such for 3 days. Thereafter, tomato seeds

(var. S-21) were sown in the pots as per treatment. In the field conditions, *B. juncea* varieties were grown up to 50 per cent flowering stage and were incorporated into the soil after chopping. Plots were covered with 100 micron polythene sheet for 14 days and after uncovering the pots, those were kept as such for 3 days. Thereafter, tomato seeds (var. S-21) were sown in the plots as per treatment. Quantification of sinigrin was done through high performance liquid chromatography.

At 100 mg per plate dose of crushed leaf powder, *Pythium aphanidermatum* showed highest sensitivity to Kranti variety with growth inhibition of 81.05% followed by Varuna (65.21%) and Divya (54.79%). *Rhizoctonia solani*, *Fusarium oxysporusm*, *Sclerotinia sclerotiorum* and *Sclerotium rolfsii* were most sensitive to the volatiles released from Kranti variety follwed by Varuna and Divya. Per cent growth inhibition from Kranti was found to be 90.41, 92.08, 91.66 and 92.88 % over control for *R. solani*, *F. oxysporusm*, *S. sclerotiorum* and *S. rolfsii*, respectively. Incidence of pre-emergence damping off was found minimum in the treatment Kranti+PBAT-3 in both glasshouse and field conditions (4.47% in glasshouse and 11.67% in field) as compared to control (42.20% in glasshouse and 37.67% in field). Post-emergence damping off incidence was recorded to be lowest in the treatment Kranti+PBAT-3 in glasshouse as well as in field (6.98% in glasshouse and 5.47% in field) as compared to control (26.98% in glasshouse and 14.56% in field). Maximum shoot length and root length were attained in the treatment Kranti+PBAT-3 in both glasshouse and field conditions (36.67 cm shoot length and 10.08 cm root length in glasshouse; 35.62 cm shoot length and 10.05 cm root length in field). Maximum fresh weight of shoot and root were recorded in the treatment Kranti+PBAT-3 in glasshouse as well as in field conditions (6.10 g shoot weight and 1.87 g root weight in glasshouse; 6.12 g shoot weight and 0.63 g root weight in field). Dry weight of shoot and root were also found to be highest in the treatment Kranti+PBAT-3 in glasshouse and also in field condition (1.27 g shoot weight and 0.46 g root weight in glasshouse; 0.98 g shoot weight and 0.15 g root weight in field). Highest plant vigour index was attained in the treatment Kranti+PBAT-3 in glasshouse as well as in field condition (4466.03 in glasshouse and 4034.03 in field). Maximum Sinigrin content was found in Kranti (21.17 μM/g) followed by Varuna (15.37 μM/g) and Divya (9.74 μM/g) through High Performance Liquid Chromatography. It justified the results of the previous experiments.

Thus, from the results of different experiments, it can be concluded that *Brassica juncea* tissue degradation products containing higher concentrations of biocidal compounds like isothiocyanates have greater potential in managing damping off disease in tomato and also other soil borne plant pathogens. Combination of *Brassica juncea* biofumigant with the application of biological control agents effectively control tomato damping off disease and enhance plant growth parameters. Among the different *B. juncea* varieties Kranti has emerged as potent biofumigant as it resulted in the minimum incidence of pre and post-emergence damping off. Therefore, biofumigation with Kranti and seed biopriming with PBAT-3 could be a handy option to manage damping off disease of tomato in nursery.

S-MJN/NSIPS/O-13

Influence of Weather Indices on Spot Blotch Disease of Wheat in North Eastern Plain Zone of India

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The second most important food crop of the country is wheat. The productivity of wheat in India is low (2.95 t/ha) as compare to China (5.34 t/ha) in 2015-16. Biotic stresses play an important role for significant yield loss, among them *Bipolaris sorokiniana* is one of the most destructive diseases,

which attacks wheat plant at most crucial growth stage. Yield losses due to spot blotch disease in wheat are reported to range from 15.5% to 100% under favorable weather condition. Environmental factors play crucial role for initiation and spread of the disease. Results revealed that maximum spore germination was recorded at 30°C temperature followed by 25°C temperature, whereas, highest length and width of new borne secondary conidia and conidiophore was recorded at 15°C followed by 20°C temperature. Formation time of new borne secondary conidia and conidiophore was shorten at 25°C temperature followed by 20°C. Under light condition at varying temperature no sporulation was observed. Under field condition, vegetative phase of both the cultivar (UBW-9 and Sonalika) was reduced with delayed sowing. Reproductive phase of the crop between days to flowering and days to physiological maturity was recorded with delayed planting. The late sown crop has less plant height than normal sowing. The numbers of grain per spike of both the cultivars were more in timely sown plant than the late sown. In cultivar UBW-9 grain per spike (49.06) was always higher than the Sonalika (35.11). The relation between thousand grain weight and date of sowing indicates that thousand grain weight was more in early sown as compared to late sown crop in both the cultivars. The Area Under Disease Progress Curve (AUDPC) was significantly higher in 4th, 5th and 6th date of sowing. Rate of increment of disease in susceptible variety was 10.08 AUDPC per day in contrast to resistance genotype with only 3.66 AUDPC per day with delayed planting from 16th November. At the same time it was also observed that a susceptible variety losses 45.5 kg of yield per hectare per day where as a resistance variety losses 37.5 kg per hectare per day with delayed planting from 16th November. The effects of Canopy temperature on plant yield were found to be significant at first date of sowing than delayed sowing. The AUDPC/degree-days increased significantly as a function of sowing time from 26th November to 16th December. Highest chlorophyll content (650.86) was recorded in UBW-9. In Sonalika Chlorophyll contain was always lower than the UBW-9 because in Sonalika disease severity was much higher. Weather indices like minimum temperature, minimum & maximum relative humidity are highly correlated with disease development. From the field data, step wise multiple regression models were developed keeping disease severity as dependent variables and weather variables as independent variables for prediction of disease development for both susceptible and resistant cultivars, where in both cases variability can be explained to the extent of 92 % and 81% respectively.

S-MJN/NSIPS/O-14

Studies on Variability, Epidemiology and Management of Twig Blight Disease of Chili caused by Choanephora cucurbitarum

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Chili (*Capsicum annum L.*/Solanaceae) is the universal spice in India. It is affected by as many as 26 diseases, at different stages of crop growth among which "Twig blight" is one of the major disease and agro-lock situation suffered by chilli cultivars, in monsoon season par year. Based on this recent agro climatic situation our research objective is sub-divided into five key objectives - I] morphological and pathological variability of *Choanephora cucurbitarum*. II] Studies on host range of *Choanephora cucurbitarum*. III] Effect of temperature and wetness duration on spore biology IV] Studies on the effect of weather variables on twig blight disease severity and V] Studies on the effect of different fungicidal molecules on management of twig blight disease of chilli. For the fulfillment mentioned key

objectives we have followed several strategies like survey and surveillance of disease specific domains of Gangetic alluvial region, estimation of disease severity, isolation and morpho-cultural characterization of the pathogen by using different methods, molecular detection and variability study among different isolates, detection of most influencing factor for disease spreading, estimation of meteorological factors compare to previous weather condition for the detection of increasing disease rate, managemental approach of the pathogen through bio-control and fungicidal molecules, construction of epidemiological modeling for disease prediction.

Results revealed that among the 26 different tested media CEPDA (chilli extract potato dextrose agar) (4.74) and 30°C temperature supported (7.9) the highest radial growth rate and suitable for sporulation, pH 5 was observed to be best for growth of *C. cucurbitarum* (2.37 cm) followed by pH 5.5. Our investigation on host range first times explores some unknown hosts of this pathogen from India. Temperature range between 28-30 °C along with 70-90% moisture level and 16 hours minimum surface moisture triggers the mycelial growth as well spore germination. Molecular detection of rDNA region was further confirmed by ITS sequencing (using ITS-1 and ITS-4 primers) and get 98-100 % homology with NCBI available data base. Simultaneously variability study with comparative analysis was done among collected isolates and *C. cucurbitarum* isolates of different geographical locations in NCBI-Genbank database by intra and inters grouping cladistics. *Pseudomonas fluorescence* the most potent biocontrol agent and two chemical fungicide Nativo (25% Trifloxystrobin and 50% Tebuconazole) and TATA contaf (Hexaconazole 5% EC) are very much effective for disease suppression and control measures. Disease prediction with three different epidemiological modeling (linear regression, binary logistics, and canonical discriminant analysis) of field data helps to construct a brief knowledge about the disease nature. Among which binary logistic model is best fitted for prediction of disease risk/non risk period. The present research signifies at its own and opens a new direction by adding some new information regarding disease nature, host indexing, disease management and establishing disease prediction model.

S-MJN/NSIPS/O-15

Isolation, Characterization and Evaluation of Fungal Endophytes as Potential Biocontrol Agents on *Sclerotium rolfsii* sacc. Infecting *Capsicum annuum* L.

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Increased usage of plant protection chemicals in the management of plant diseases lead to the development of resistance strains among pathogens, environmental pollution and finally fall in benefit-cost ratio due to increased cost of cultivation. To combat these issues, evaluation of biocontrol agents against soil borne pathogen *Sclerotium* sp. infecting chilli was carried out using hidden world organisms called fungal endophytes. Fungal endophytes are living microorganisms present inside the plant tissues imparting tolerance against abiotic and biotic stress, in turn getting food and livelihood from plants. Exploration of fungal endophytes as potential biocontrol agents against *Sclerotium* sp. infecting chilli was made by conducting *in- vitro* studies. Fungal endophytes isolated from selected plants with antimicrobial activity *viz., Hibiscus rosa sinensis*, *Phyllanthus acidus*, *Catharanthus roseus*, *Phyllanthus amarus* and *Solanum torvum.* Total 66 fungal endophytes were obtained from 165 processed tissue segments, morphologically categorised into 25 Operational Taxonomic Units (OTU's) and evaluated

against *Sclerotium* sp infecting chilli by dual culture technique. Out of 25 OTU's, 5 OTU's showed greater than 50 per cent and 20 OTU's showed 1-50 per cent inhibition. Endophytic OTU HI2 from *H. rosa sinensis* showed highest per cent inhibition (65%) of *Sclerotium* sp. was taken for further studies. Molecular characterization of *Sclerotium* sp. infecting chilli and endophytic OTU HI2 by amplifying Internal transcribed spacer (ITS) region (ITS1 and ITS4 primers) revealed *Sclerotium* isolate as *Sclerotium rolfsii* and OTU HI2 as *Trichoderma asperellum*. To decipher the mechanism involved in inhibition of *S. rolfsii* by *T. asperellum* broth culture study and double plate assay for diffusible and volatile metabolites were conducted. The metabolite profile of high pressure liquid chromatography (HPLC) analysis showed that the metabolite content of the endophyte was eluted between 21-39 min retention time. Major peaks were observed between 21 to 25 min and 36 to 39 min retention time. In case of pathogen the metabolite peak was eluted at 24 min of retention time. Few metabolite peaks observed individually for pathogen and endophyte were absent in the samples processed from interaction between pathogen and endophyte. However, two peaks were obtained at 37.5 and 39.4 min retention time, which were not observed in the samples with pathogen or endophyte alone. In double plate assay the volatile organic compounds (VOC's) generated by the endophyte inhibited the mycelial growth of pathogen (56.46 %) significantly over control. Analysis of antimicrobial VOC's produced by *T. asperellum* by Gas Chromatography-Mass Spectrometry showed varied peaks. Total thirty-four VOCs were obtained from the potato dextrose agar media (control), endophyte, pathogen and interaction (endophyte and pathogen) in double Petri dish assay treatments. Fourteen tentative VOC's are specific to *T. asperellum* and four VOC's specific to *T. asperellum* and *Sclerotium rolfsii* interaction were detected (Epizonarene, Guaiol, á-Eudesmol and Verticilla-4 (20), 7, 11-triene). In host colonization assay *T. asperellum* successfully colonized in chilli stem and root tissues.

APS Travel Grant Fellowship contest

S-APS/NSIPS/O-1

Purification, Electron Microscopy, Antisera Production, Serodiagnostics and Molecular Characterization of *Potato Virus Y* (PVY) causing Severe Mosaic of Potato

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Purification was done from *Potato virus Y* (PVY) pure culture maintained on potato plants (*Solanum tuberosum*) following standard procedure to obtain purified viral protein from extracted leaves. Presence of viral protein was confirmed by transmission electron microscopy (TEM) of the purified material which showed flexuous filamentous particles. Rabbit immunization with purified viral antigen plus Freund's complete adjuvant and subsequent injections with Freund's incomplete adjuvant at alternate weeks followed by three booster doses after a rest period of 6 weeks was done to raise polyclonal antibodies. High quality antisera were collected one week post boosters (AS5b, AS6b and AS7b) and the IgG fractions were separated through ammonium sulphate precipitation method. The IgG fractions AS5b, AS6b and AS7b were tested for the detection of PVY by DAS-ELISA with universal anti- rabbit enzyme conjugate as secondary antibody which showed high specificity with the known PVY infected samples compared with the commercial DAS-ELISA kit (Bio Reba, AG, Switzerland). ELISA positive PVY samples were further confirmed by reverse-transcriptase polymerase chain reaction (RT-PCR) assay resulting a 328bp amplicon. Partial sequencing of RT-PCR product was done. Phylogenetic analysis revealed that the virus is closely related to *Potato virus Y* worldwide isolates.

S-APS/NSIPS/O-2

In vitro Evaluation of Fungicides against *Alternaria alternate* causing Foliar Blight of Turmeric

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In order to find out the effective fungicides against *Alternaria alternate* causing foliar blight of turmeric, five fungicides viz; mancozeb, carbendazim, copper oxychloride, hexaconazole and propiconazole, at half of the recommended dose and recommended dose of chemicals were evaluated under *in vitro* conditions, which revealed that all the fungicides significantly inhibited the growth of the pathogen over control. In case of half dose hexaconazole showed maximum inhibition over control (87.62 %) with colony diameter of 5.32 mm on 4th day and (88.41%) per cent inhibition with colony diameter 10.43 mm on 8th day. This was followed by propiconazole, which caused 84.88 per cent inhibition with colony diameter of 6.50 mm on 4th day and 86.25 per cent inhibition and colony diameter of 12.37 mm on 8th

day. Among group of traditional fungicides mancozeb showed inhibition (75.58%) with colony growth i.e., 10.50 mm on 4th day and 74.63 per cent inhibition with 22.83 mm colony growth on 8th day. Carbendazim showed the least effectiveness against the pathogen with 48.09 per cent inhibition and 22.32 mm colony diameter on 4th day and 53.0 per cent inhibition and 42.30 mm colony diameter. In case of recommended dose (100 ppm) the hexaconazole showed the maximum inhibion of 88.37 over control with the colony diameter of 5.13 mm on 4th day and (88.44%) inhibition with 10.40 mm colony growth which was statistically at par with the Propiconazole showing the inhibition of (87.90%) with 5.20 mm colony growth on 4th day and (88.32%) with 10.53 mm colony diameter on 8th day. Among older group of fungicides mancozeb showed maximum efficacy and carbendazim showed least effectiveness against the pathogen.

S-APS/NSIPS/O-3

Antioxidant-Mediated Survival Strategy in Primed Ragi Plants against Blast Disease

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Ragi blast caused by *Magnaporthae grisea* (Hebert) Barr. is a very severe disease with a subsequent annual loss of ~ 80% yield. It is highly virulent with a wide host range (rice, wheat, rye, barley, pearl millet). Many strategies have been used to manage the disease, of which, use of beneficial, soil microbes is an eco-friendly approach for induced systemic resistance (ISR). It is the state of the plant wherein the selected rhizobacterial strains enhance the ability of the plant to mobilize infection-induced cellular defense responses against the pathogen (priming). The synergism between the plant and rhizobacteria plays a crucial role in host-specific disease resistance by many of those mechanisms or signals. Inoculation of bacteria that protect plants through different mechanisms in pathogen-challenged plants, contributes to the increase in knowledge on plant- microbe interactions. Antioxidants act as signal molecules which subsequently enhances cellular patterns of the host, thus increasing resistance during the early hours of pathogen entry. The goals of the present study were (i) to analyse the performance of rhizobacteria for growth promotion and induce disease resistance under green-house conditions in ragi plants and (ii) to analyse the enhancement of disease resistance by measuring the antioxidant levels at different time (0, 6, 12, 24, 36, 48, 72, 96 hours post inoculation) intervals. Isolated rhizobacteria were identified as fluorescent *Pseudomonas* by partial 16sRNA sequencing. Two isolates, JUPC113 (GenBank ID. KX010601) and JUPW121 (GenBank ID. KX010602) were used in priming the ragi (Indaf 9) seeds. Plants challenge-inoculated with *M. grisea* spores ($5x10^4$ spores.mL^{-1}) showed reduced disease incidence in plants from primed-seeds, compared to the control. JUPC121 (92.03 ± 0.04%) showed enhanced disease protection rate with vigour index of 3064.00 ± 3.06, disease incidence was highest in control (2.67 ± 0.3) plants and vigour index of (2005.33 ± 3.71). Primed and control samples were analysed for various antioxidants, which showed increase in activities of superoxide dismutase (SOD), ascorbate peroxidase (APX), peroxidase (POD), glutathione reductase (GR), catalase (CAT). A decrease in malanoldialdehyde (MDA) and proline content was observed in plants from primed seeds, which was comparatively significant. The native PAGE showed alterations in the intensity of the isozyme bands in control plants. From these studies, the xymogram and enzymatic assays indicates the induction of disease resistance, thereby sinking the disease severity. Hence the microsymbiont, reinforce the disease resistance and protect the primed plants from *M. grisea* against the detrimental effect, a useful strategy for ragi production by sustainable agriculture.

S-APS/NSIPS/O-4

Study on Populations of *Candidatus liberibacter* asiaticus from North East India based on Genomic Locus of Short Tandem Repeat Variability

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Citrus Huanglongbing (HLB) is the most devastating, destructive, threatening and dreadful disease of citrus worldwide as well in India. It is also known as yellow shoot disease due to the appearance of patchy yellow in the new flushes. HLB infection causes severe economic losses more than 100 million citrus trees were estimated to have wiped out due to its infection. Average annual yield losses due to HLB infection in Asia were to the tune of 40-60%. It is the most emerging citrus disease in different citrus growing pockets of India in general, North East India in particular. The disease is caused by a phloem-limited, non-cultured, gram-negative bacteria *Candidatus* Liberibacter asiaticus (CLas). Although, the disease has been reported from some parts of North East India except Manipur, there is no systematic study and knowledge on the molecular variability of the pathogen. Present study focus on identification of short tandem repeat numbers (TRNs) at the genomic locus CLIBASIA_01645 in order to elucidate the check variability of CLas isolates from North East India. The genomic locus was characterized and categorized into five classes based on the tandem repeat number (TRN) viz. Class I (TRN d" 4), Class II (TRN > 5 d"10), Class III (TRN > 10 d"15), Class IV (TRN > 15 d" 20) and Class V (TRN e" 20). The present study conclusively revealed that TRN CLas isolates from North East Region ranged from 4-21. The CLas population consisted predominately of strains with a TRN 9 at a frequency of 36.40 % followed by TRN 5 with 23.00 %. A few sample from Nagpur region were also characterised which showed TRN 9 with the samples from Arunachal Pradesh which had TRN ranging from 9-12. On the basis of cultivar analysis, it can be interpreted that CLas isolates infecting Khasi mandarin cultivar had TRN 9-12 with the highest frequency in TRN 12 and acid lime cultivar had TRN 4-6 dominated by TRN 4 and 5. Most interestingly a Citrus spp. from Manipur got highest TRN 21 which is the highest TRN reported till date. The present study conclusively revealed that Clas bacterium present in North East region is highly diverse at the genetic level compared to other parts of India.

S-APS/NSIPS/O-5

Pathogenic Characterization of *Albugo candida* Isolates the cause of White Rust Disease in Rapeseed-Mustard

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Rapeseed-mustard comprise the most importantedible oilseed crops in India. White rust incited by*Albugo candida* (Pers. ex. Lev) Kuntze. affectsthese crops in India as well as other countries and

isone of the major constraints for their lowproductivity. *A. candida* exhibits specialization ondifferent cruciferous species and on cultivars within species. Depending on the severity of infection, the yieldlosses caused by white rust or a mixture of whiterust and downy mildew, range between 17% to 60%. Most of theIndian cultivars are susceptible to white rust and there is lots of variability in *A. candidaaffecting* rapeseed mustard in different parts of India.The identification of *A. candida races is very difficult and there is no reliable and validated method available till now, most of the races have been designated on the basis of infectivity on different Brassica species. However, theoreticallyraces cannot be identify on the basis of species, it should be identify on the basis of isogenic lines/ genotypes/cultivars.* Therefore, the present investigation focuses onto carry out re-designation of *A. candida* races on the basis of infectivity of *A. candida* isolates on different genotype/cultivars of different *Brassica* species. For thispathogenic characterization of *A. candidaisolates (collected from major Brassicagrowing states/geographical areas of India), have done*during 2016-17 under controlled environment glasshouse facilities at GBPUAT, Pantnagar, Uttarakhand.Nineteen different genotype/cultivars of different *Brassica*species were taken for host differential study against fifteen different *A. candida isolates, at two different growth stage of the plants i.e. cotyledonary as well as true leaf stage. Studies conducted for the host differential as well as to find out most susceptible stage of different Brassica species against A. candida isolates. Disease reaction of all the isolates on different varieties of Brassica species were taken following 0-7 rating scale(Leckieet al., 1996).***At cotyledonary stage**, different genotypes such as Bhawani, Tobin, Candle, *Erucasativa*, Kiran, GSL-1, Donskaja, Cutlass, Bio-YSR, NRCDR-515 and *Raphanussativa* showed 'NN' disease reaction i.e. no sporulation with almost all isolates of *A. candida*.Genotypes such as Varunashowed S2-4/5 or S3-6/7and *Sinapisalba*showed S1-2/3 or S2-4/5 disease reaction as well as disease score with almost all the tested isolates (15 no.). Among the isolates Bangalore, Simour and Karnalwere found to be more virulent and showed different disease reaction with different genotypes. **At true leaf stage,** different genotypes such as Bhawani, *Eruca sativa, Sinapis alba*, Kiran, GSL-1, Sangam, Donskaja, Bio-YSR, NRCDR-515, *Raphanus sativa* and *Brassica oleraceae* showed 'NN' disease reaction i.e. no sporulation with almost all isolates of *A. candida*. Genotypes such as Varuna and Pusa bold showed S1-2/3 or S2-4/5 or S3-6/7 disease reaction as well as disease score with almost all the tested isolates (15 no.). Among the isolates Jammu, Kanpur, Bangalore and UDSC were found to be more virulent and showed different disease reaction with different genotypes. The same experiment will be conducted during 2017-18 for the confirmation of the results. Molecular characterization of the *A. candida* isolates are undergoing for the validation of host differential studies as well as identification of *A. candida* races.

S-APS/NSIPS/O-6

Effect of Soil Abiotic Factors and Cropping System on *Sclerotium rolfsii* Disease Conducive/Suppressiveness

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*Sclerotium rolfsii*Sacc. (telomorph: *Atheliarolfsii*(Cruzi) is a widespread soil borne pathogen in vegetable producing areas. It is a devastating soil-borne fungus and it infects more than 500 plant species belonging to 100 plant families in tropical and subtropical countries of the world. *Sclerotium rolfsii* represents both unity and diversity in fungi. It may be a plant pathogen, a parasite, a symbiont, or

a facultative parasite. Its pathogenesis is complex; and has heterogeneity of strains and diversity in host range. Temperature, moisture, pH and fungal nutrition, have shown a significant influence on disease caused by *S. rolfsii* on various hosts. The pathogen is difficult to manage due to the existence of high level of variability of the isolates, low inherent level of resistance of crop cultivars and wide host range of the pathogen, ability to survive in soil for a long time due to melanizedsclerotia and mycelial production and complex interaction of crop rhizosphere, soil environmental factors and microbiota influence the suppressiveness and conduciveness of soil towards soil-borne plant pathogen. Suppressive soil serve as an excellent agent for plant disease management. The most common hosts of this pathogen are the legumes, crucifers, cucurbits and crops of solanaceous family. Survival, population build up, successful parasitic relationship and rate of spread of *Sclerotium rolfsii* in soil-plant system depend on different types of crops in sequence, rhizosphere microbial diversities, soil physio-chemical and biological characteristics and abiotic stress factors like soil moisture and temperature. The thorough understanding of these factors with special emphasis on the influence of different rotational crops for declining of *Sclerotium rolfsii* population in rice/vegetable/jute based cropping system of West Bengal will help in managing the diseases incited by the pathogen on many crops. Cereal/ grass family dominated cropping sequence and grass and brassicaceae family rotated cropping sequence reduced sclerotial population and disease incidence of *Sclerotium rolfsii.* Cruciferous vegetable based cropping system i.e. Brinjal-Rice-Cabbage, Jute-Rice-Cabbage and cereal based cropping system like Maize-Rice-Rice and Maize-Rice-Tomato are the important cropping sequences of this region considering both for reduction in sclerotial population and disease incidence and also for harnessing higher economic return. Seasonal deviation and fluctuation of sclerotial population was noticed and population was found to be higher during Rabi and pre-kharif season, while very low sclerotial population was noticed in kharif season under rice based cropping system. Crop types, soil types, duration of submergence, soil physico-chemical and microbiological parameters along with weather and soil factors are conjointly influencing the sclerotial population of the soil

S-APS/NSIPS/O-7

Characterization and Expression of Fungicides Induced Novel Pathogenesis Related Protein 1 (PR1) Gene in Tomato (*Solanum lycopersicum*) cv. Pathar Kuchi

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Pathogenesis Related Protein gene family play important roles in the regulation of various biological processes such as the responses to biotic and abiotic stresses.In this work, we isolated PR1 gene from a tomato cultivar PatharKuchi, which was dependently expressed in leaves and PR5 gene was consistently expressed with or without application of inducing agents.Total RNA was extracted from leaves from untreated control and Salicylic acid (SA, Aspirin), Methyl Jasmonate (MeJA) and the fungicides viz. BenalaxylM and Valifenalate treated plants in the growth chamber and in MOPS buffer. M-MLV reverse transcriptase was used to synthesize cDNA from total RNA. PCR and qRT-PCR was conducted and 18S and Actin geneswere used as calibration control. Treatment of SA, MeJA, BenalaxylM and Valifenalate amplified the PR1 gene with specific primer pairs but the untreated control plants failed to induce.On the other hand, we also characterized the PR5under untreated or induced conditions and the

results showed that high independent expression of PR5 and 18S gene have occurred in tomato leaves. The consensus nt sequences of PR 5 and PR 1 have been gene bank accessed number ofLT855381 and LT856234 respectively. The current Tomato Genome version SL3.0 and Annotation ITAG3.10 [New] confirmed the location of the homologous PR 5 gene Solyc08g080670 [61,057,123 <61,057,875] (96.87 centisomes) and PR 1 gene (Solyc00g174330 and Solyc0g174340) on chromosome 8 of tomato genome which confirmed the temporal regulation of PR 5 gene in tomato plants but PR 1 gene in tomato was differentially regulated as PR 1 family gene.The qRT-PCR analyses also offered strong support that PR1 gene was expressed in Benlaxyl M (CT value 33.04) and Valifenalte (CT value 20.85) dependent manner whereas the negative control had no CT value. We speculated that expression profiling of PR1 gene may help to predict the functions of some specific fungicides involved in induction-mediated resistance as well as direct fungicidal activity to the invading pathogen like *P. infestans* in tomato conferring superior efficacy of the particular fungicides.

TECHNICAL SESSION - I

Integrated Plant Disease Management

Lead Lecture -01

S-1 /NSIPS/L-1

Biotic traumas of Crops and Future Climate in India

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Climate change has demonstrated differential influences on components of earth system. Impression of climate change has been least investigated into the biosphere and specially with the agricultural crops due to lack of complete knowledge of complex, multi-dimensional interaction between the factors of production and interplay with those of biotic stress under field condition. Concurrent, gradual changes in the crop plants, pathogen and insect-pests due to the exposure of changing climatic variables and possible multiple combinations of interactions have probed the future global food security. Some assessments have been carried out in a few places on fewer crops and specific pathogens or insect-pests to mitigate the present and future biotic stresses. Focus needs to shift from looking at impacts to adaptation and mitigation strategies as also possibilities thereof with indications on possible migrations and outbreaks. There is also matching need to revisit the efficacy of present and future pest management with emphasis on developing newer tools and techniques. Specific investigation needs to be undertaken on response of crop plants vis-à-vis their adaptations to changing climate and pest scenario with appropriate pest risk analysis done thereof to provide a future key with climate-analogous-site for disease and pest response of crops. There is also need to developed forewarning system to predict the severity of important pathogens, other pests of major crops in real-field conditions on climate change scenario. These changes have direct effect on growth and multiplication, spread and severity / infestation of many plant pathogens and insect-pests, which in turn are influencing the pattern of their infestation. The Indian scenario presents diverse climate suitable to grow and study diverse pest, their dynamics, which could help counter pest problems and related doubts on farmers' fields with ease.

Lead Lecture -02

S-1 /NSIPS/L-2

Role of conventional fungicides in preserving disease control potential of modern compounds: A retrospection

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After host resistance, fungicides serve as the second line of defense in our fight against plant diseases. For certain diseases, such as those caused by oomycetes, these are the chief means of containing disease attacks to avoid serious crop losses. During the pastnearly one hundred years, several classes of chemical compounds have been introduced as fungicides, starting from simple inorganic

salts to organic compounds having contact action as well as those with systemic properties. Starting from late 1960s and 1970s(benzimidazoles, dicarboximides, phenylamides, pyrimidines, triazoles and other EBIs), most of the fungicides developed till date are systemic and have site-specific modes of action. These have certainly helped much in managing manydevastating plant diseases more effectively than the protectant fungicides and led to substantial increase in crop yields.With the technological advances in fungicide discovery, several new compounds with different modes of action have been developed and introduced during the past 25-30 years. Important among these are QoIs, carboxylic acid amides, succinate dehydrogenase inhibitors, azolones, benzamides, quinolones, Qils, etc. that have the potential to manage diverse fungal diseases.

There is no denying of the fact that systemic fungicides have proved more effective than the contact fungicidesand have the advantage to control established infections due to curative properties. On the other side, soon after their introduction, these were confronted with the problem of resistance build up in the target pathogens. Fungicide resistance has now become a major challenge in their prolonged use due to their single-site mode of action in the fungal metabolic processes.The discovery and development of fungicides with new modes of action, no doubt, comes as a good help in combating resistance to the existing fungicide compounds, but most of the new compounds being site-specific in action themselves carry certain level of resistance risk.Most of the new fungicide leads also suffer from certain proneness to resistance build-up.

Contrary to this, contact or surface protectants viz. dithiocarbamates, copper compounds, phthalimides, chloronitriles, etc., the so called conventional fungicides developed during 1940-1970,have stood the test of time and no cases of resistance build up in practice have ever been reported against these fungicides. Due to their multisite action and broad spectrum disease control, these are often used as mixture partners with a number of site-specific fungicides as part of resistance management strategies.Such mixtures not only reduce the rate of evolution of resistance, but may also allow lowering the dose of the at-risk fungicide without compromising effective disease control. Few among these, such as mancozeb, also possess synergistic effects when used in mixtures with phenylamides for managing resistance build up in *Phytophthora* and other oomycete pathogens. The multisite mode of action and broad spectrum of activity of such contact fungicides has the advantage of acting against the sensitive as well resistant strains of the pathogens that emerged due to the sole use of a site-specific fungicide.

As a reliable resistance management tool, which prolongs the active life of otherwise highly effective and much needed novel action fungicides, these multisite protectant fungicides are expected to play a key role in plant disease management for several years to come. This will be more so in developing countries like India where dependence on these fungicides is likely to continue because of their broader spectrum of activity and relative cheapness.

Lead Lecture -03

S-1 /NSIPS/L-3

The Science of Omics for Enhancing Plant Disease Managemeent

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Growing population exerts pressure on highroductivity of crops and the onus to protect crops from diseases rests on the plant pathologists. Although resistance breeding is the high priority of breeders and pathologists the "arms race" among plants and the pathogens continues for ever. The problem becomes acute in case of soil borne pathogens and where there is no source of resistance. The modern tools provided by the "Science of Omics" offers opportunities to understand the molecular interactions among plants and pathogens and paves the way for interfering with the interaction to prevent disease development. Interfering with pathogenesis could be one of the attempts to disease management.

Among the OMICS, "proteomics" denotes the comprehensive study of entire proteins in a given sample, which includes the information on proteins, abundances, their variations and modifications, along with their interacting partners and networks. Although progress in plant genomics has been rapid, in reality it only provides a glimpse on what may occur as dictated by the genetic code but the insight on what is happening in the plant system in real time would be evidenced by proteomics.

Similarly, "transcriptomics" that encompasses set of transcripts from a cell or a population of cells, which include protein-coding mRNAs and non-coding small RNAs such as ribosomal, tRNAs and miRNAs. Traditionally, transcriptome profiling, or transcriptomics, has focused on quantifying gene expression. EST sequencing has been the core technology used for the discovery of reference transcripts. However, it has some inherent limitations, such as low throughput, high cost and a long experimental cycle. With the advent of Ultra high-throughput sequencing (UHTS) technologies, it is now possible to obtain highly resolved structural information of RNA populations on a high-throughput platform. This includes mapping transcript initiation and termination sites, splice junctions and post-transcriptional modifications. Such information will lead to a better understanding of the functional elements within the genome and the discovery of novel developmental or environmental regulatory networks. Whole-genome or whole transcriptome analyses have become a realistic option for genetic non-model organisms, even for individual laboratories, and will soon be standard practice in molecular studies.

The information generated using these tools in the pathosystem of Black pepper -*Phytophthora capsici*; Black pepper- Badna virus; Ginger and *Ralstonia solani* at Indian Institute of Spices Research Kozhikode, shall be highlighted in this lecture.

Invited Lecture- 01

S-1 /NSIPS/I-1

Integrated Plant Health Management: Needs for Paradigm Shift in 21st Century

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Rapid change in societal, environmental and economic situations during last three decades is generating various unforeseen threats in healthy livelihood of human beings all over the world. Climate resilience and agriculture sustainability are perhaps the most expectant domains need to be addressed in positive outlook. India being a developing country should adopt new technologies which have immense prospect in the field of agriculture at much faster rate than whatever exists today. Integration of interdisciplinary approaches aimed for overall plant health management will be needed to meet goals such as mitigating environmental degradation associated with the use of farm chemicals, and increasing productivity by reducing insect and disease damage to crops, and reducing competition from weeds rather adopting isolated effort of IPM, IDM, IWM and INM. Development of cropping system models will provide useful frameworks to address the interrelationships among plants, the pest complex, dynamics of beneficial microbes and the environment to determine the most appropriate management strategies. Improved techniques for managing pests, such as transgenic plants resistant to pests and diseases, new biological control agents, innovative cultural controls, biological pesticides, additional information to improve efficacy of traditional chemicals and introduction of new generation pesticides, will require weather data and forecasts in order to be used. Climatic change resulting in increased variability of production factors will require improved analyses that can be used to assess risks associated with existing and newly developed crop health management strategies and to gauge the impact of these techniques on productivity and profitability. Management recommendations will need to be evaluated for suitability in the farming system where they are to be implemented. Precision farming and information technology based decision support system will definitely ensue towards the agricultural sustainability that the country is expecting in 21st century.

Invited Lecture- 02

S-1 /NSIPS/I-1

Shaping the Future of Farming – Innovation and Sustainability in Plant Disease Management

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Bayer is more than 150 year organization and its dedication is innovation. We were founded by Innovators and we are still driven by Innovation. Bayer has around 15000 colleagues in research and development and invest around €4.4 billion. Bayer's Success is based on excellence in Research & Development.

Why innovation is needed? The global population is increasing and expected to be around 9.5Bn by 2050. This has implication to increase food production without extending the area of land set aside for agriculture. On the other hand there are challenges like climate change are posing difficulties to maintain and improve agricultural productivity. During the last food crisis Science had provided solutions - crop-breeding techniques, fertilizers and crop protection, to overcome it. During the Green Revolution of the 1960s crop yields were increased significantly. Can we do it again? Next Green Revolution must boost yields yet preserve the environment.

Bayer through its purpose "Shaping the future of farming" moving forward in innovation with sustainability. It is important while producing more food from the same area of land coupled with reducing the environmental impacts requires what has been called "sustainable intensification".

Until now Bayer has contributed with more than 60 of fungicide compounds globally and dozens of modes of action. In India also it has supported farmers with modes of action, formulation and compounds.

Bayer has adopted the process of bringing sustainability in very early stage of innovation. The approach is to conduct extensive toxicology and environmental safety screening assays. Innovation requires planning security and significant investments.

It has been seen that innovation is not only providing efficacy against diseases but also having favorable safety profile and additional benefits to farmers. Rapidly developing technology increases our knowledge about processes in the plants and biological organism. The objective is to arrive at a more complete picture of the living organism. There are challenges of systems biology and functional genomics to integrate proteomic, transcriptomic, and metabolomic information to give a more complete picture of living organisms. Therefore various new techniques and processes are used like computational chemistry, proteomics, epigenetics, etc

Implementation of sustainability is important at farmer level as well. There are various initiatives like digital Farming, enabling smallholders to produce food where it is needed most and helping farmers to produce food without harming the environment and putting the health of humans or animals at risk.

This is an exciting yet challenging time in ag , Innovation is the key to cope with existing and future challenges and will shape the future of farming. Innovation and Sustainability are linked together

S- 1/NSIPS/O-1

Management Studies on Rhizome Rot of Ginger Caused by *Pythium aphanidermatum* (Edson) Fitzp.

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Pythium aphanidermatum (Edson) Fitzp. is one of the important pathogen causing rhizome rot / soft rot in ginger. The management of disease is very important and cues heavy losses in the yield. The fungicides, bioagents and organic amendments play very important role in eco friendly management of this disease. All the treatments increased germination percentage thereby decreasing pre-emergence rhizome rot (PERR) over control it was ranged from 15.56 in *T. viride* and *T. harzianum* to 64.44 per cent in Thiophnate methyl + Mancozeb + *T. viride* + poultry manure treatments as against 33.33 per cent in control. The least post emergence rhizome rot (PESM) was recorded with the treatment *T. viride* (12.92%) it was (58.09%) in Thiophnate methyl+ Mancozeb + *T. viride* as against in control

(73.33%). The maximum per cent reduction in pre-emergence rhizome rot was recorded with the treatment *T. viride* and *T. harzianum* (76.66%) while it was least in treatment Thiophnate methyl + Mancozeb + *T. viride* (33.34%).

S-1 /NSIPS/O-2

Integrated Disease Management & Judicious Use of Crop Protection Chemicals

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Pesticides are legitimate and useful tools that can provide significant benefits to our society. To maximize these benefits we need to use pesticides in a safe and efficient manner; misuse of pesticides can cause harm to people and the environment. Integrated Management approach is the key solution to minimize pesticide hazard & sustainable farming. Integrated plant Disease Management (IDM) is a decision-making process for the optimal use of resources for plant disease control to improve Efficacy, Cost-effectiveness, Ecological soundness & Sustainability of crop protection.

Pesticide, given its intrinsic properties to kill pests, is toxic in nature. It must not be regarded as a panacea for all pest problems but should only be used in a judicious manner. As long as the pesticides will be used indiscriminately problems like pest resurgence, pesticide residues, secondary pest outbreaks, health hazards to humans and other environmental effects will be there.

S- 1/NSIPS/O-3

Performance of Different New and Commercially Available Fungicides in Managing Sheath Blight of Rice under Field Condition

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Sheath blight of rice caused by *Rhizoctonia solani* Kuhn {Teleomorph: *Thanatephorus cucumeris* (Frank) Donk} is one of the destructive diseases across the rice growing regions of the world, that causes significant yield loss and quality degradation (Lee and Rush, 1983; Manibhusanrao, 1989; Nagarajkumar *et al.*, 2004). This disease generally appears at maximum tillering stage and affects all the plant parts above water line. The yield loss due to this disease is reported to range from 5.2-50% depending on environmental conditions, crop stages at which the disease occurs, cultivation practices and cultivars used (Marchetti and Bollich, 1991).The incidence of disease has become rampant with the introduction of semi dwarf, heavy tillering ,early maturing and high yielding varieties. In the absence of suitable resistant donors, chemical control is the only alternative to check this disease. Chemical control of sheath blight disease is successful in field condition in majority of the cases (Kandhari and Gupta, 2003). Since the seriousness of disease warrants chemical protection, it is important to explore alternative chemical

molecule to avoid build-up of resistance in the pathogen. Fungicides with multiple effects on the pathogen like mycelial growth, sclerotial germination and reduction in spread of the disease will be most ideal. Most of the fungicides namely carbendazim, chloroneb, benomyl, captafol, mancozeb, zineb, edifenphos,iprobenfos, thiophanate methyl, carboxin etc. have been found effective for the control of sheath blight disease under field condition (Dash and Panda,1984; Kannaiyan and Prasad,1984; Singh and Sinha,2004).Several new fungicides have been recently developed which are known to possess good control against *Rhizoctonia solani*. In the present study an attempt has been made to evaluate the performance of six new and commercially available fungicides, namely Tricyclazole 20% + tebuconazole 16%SC @2.0ml/litre, Tricyclazole 20% + tebuconazole 16%SC @ 2.25ml/litre, Tricyclazole 75%WP @0.6g/litr,Tebuconazole 25% @1.5ml/litre, Hexaconazole 5%EC@2.0ml/litre and Carbendazim 50% WP 1.0g/litre, in managing the sheath blight disease in rice in a field trial under artificial inoculation condition.

One field experiment was conducted in National Rice Research Institute, Cuttack during kharif 2016 in R.B.D with 7 treatments including control and 4 replications. For conducting this experiment 25 days old seedlings of rice variety 'Tapaswini', being highly susceptible to sheath blight, were transplanted at a spacing of 20x15cm and plot size of 15sq.m. At maximum tillering stage the rice plants were artificially inoculated with the virulent isolate ShBSL4 of *Rhizoctonia solani* Kuhn by inserting the bids of mycelia along with five sclerotial bodies inside the leaf sheaths followed by wrapping with moist cotton above the water line. After 10 days of inoculation i.e, establishment and initiation of disease symptoms the fungicides at their above mentioned doses were sprayed thrice to the rice plants at an interval of 15days. In the untreated control, the rice plants were sprayed with water only. The data on disease incidence and subsequent spread were collected from the date of first incidence of the disease till 30days after final spray. The grain and straw yield were also recorded from each plot for logistic assessment of new and commercially available fungicides against the sheath blight pathogen.

Out of seven treatments including untreated control, the fungicide Tricyclazole 20% + tebuconazole 16%SC @ 2.25ml/litre caused 77.1% reduction in sheath blight disease severity and 77.0% reduction in sheath blight disease incidence over the untreated control. It was followed by Tricyclazole 20% + tebuconazole 16%SC @2.0ml/litre and Tebuconazole 25% @1.5ml/litre -the former reducing the disease severity by 72.3%, sheath blight disease incidence by 64.0% and the latter causing reduction in disease severity by 55.0% and sheath blight incidence by 51.6%. Grain and straw yield were the highest i.e, 5.67t/ha and 6.95t/ha respectively due to treatment with Tricyclazole 20% + tebuconazole 16%SC @ 2.25ml/litre followed by grain yield of 5.45t/ha, straw yield of 6.12t/ha due to Tricyclazole 20% + tebuconazole 16%SC @2.0ml/litre; 4.84t/ha grain yield, 5.8t/ha straw yield due to Tebuconazole 25% @1.5ml/litre, while grain yield of 3.36t/ha and straw yield of 4.64t/ha were obtained in untreated control.

Research findings suggest the chance of a pathogen developing resistance to a particular chemical increases with regular use over a period of time (Brent and Hollomon,1998; Zhang *et al*., 2009).The alternatives are to develop a new line of a chemical (fungicide) class that has no cross resistance to the chemical to which the pathogen developed resistance. From this experiment, the new combination fungicide molecule, Tricyclazole 20% + tebuconazole 16%SC at two different dosages 2.25ml/litre and 2.0ml/litre found more efficient in managing the sheath blight disease will be evaluated again for consecutive seasons for confirmation.

S- 1/NSIPS/P-1

Identification of Disease Resistant Hybrids and Sources against Turcicum Leaf Blight of Maize

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Maize is an important cereal crop grown in India. With changes in cropping pattern, cropping intensity, crop management and spreading of hybrids, turcicum leaf blight caused by *Exserohilum turcicum* has become a serious and widespread disease in India during Kharif season causing immense losses in yield. In recent years epiphytotic levels of turcicum leaf blight disease noticed thus indication of lower level of resistance in commercial hybrids. Large number of maize hybrids and inbred lines of different maturity groups along with speciality corn hybrids were screened under artificial inoculations in field conditions. In late maturity group, hybrids viz; AH-1602, CMH-12-686, DMH-192 and CMH-11-586 registered resistant reaction. Hybrids viz; GH-150141, GH-150125, LMH-1116 and JKMH-4103 were found resistant under medium maturity group. Among the early and extra early group, DMRH-1417, DMRH-1305 and DH-304 exhibited resistant reaction. The speciality corn hybrids QPMMH-27 and IMRQPM-1609 for quality protein maize: BSCH-6 and Mishti for sweet corn: IMHB-1532 for baby corn were registered resistant reaction. The inbred lines viz; BML-7, HKI-1128, V-345, LM-13, BGS-32, BGS-59 and UML-1210 found highly resistant to turcicum leaf blight. The identified resistant hybrids may be deployed in disease hot spot locations and sources of resistance can be utilised in further resistance breeding programme. The high level of resistance shown by the identified inbred lines for turcicum leaf blight disease may be governed by adult plant resistance/ minor genes. These minor genes are presumed not to put pressure on the pathogens for racial evaluation and may therefore provide durable resistance.

S- 1/NSIPS/P-2

Management of Rust and Pod Blight Diseases of Soybean using Trifloxystrobin + Tebuconazole 75WG in India

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Field screening of new fungicide molecules against soybean rust and anthracnose was taken up during kharif growing season 2014 and 2015 at the Main Agricultural Research Station, Dharwad. Seven treatments were tested under natural epiphytotic conditions of both rust and pod blight severity. The pooled analysis over two years revealed that among the treatments imposed, spraying with Trifloxystrobin + Tebuconazole 75WG @0.7g/L recorded minimum per cent disease index of 25.5 and 15.1 rust and pod blight respectively followed by 32.6 and 18.1 PDI in case of Trifloxystrobin + Tebuconazole 75WG @0.6g/L against rust and pod blight respectively. The positive check Hexaconazole @ 1ml/L recorded disease severity of 29.1 and 26.8 respectively. The maximum severity was recorded in untreated control (78.50 PDI Rust and 40.9 PDI Pod blight). The reduction in PDI, increase in seed

yield and B:C ratio was observed in above said treatments. Thus, two sprays with Trifloxystrobin + Tebuconazole 75WG @0.7g/L be recommended in management of rust and pod blight diseases in northern Karnataka.

S- 1/NSIPS/P-3

In Vitro Evaluation of Fungicides and Plant Extracts against *Alternaria helianthi* (Hansf.) Tubaki and Nishihara Causing Leaf Blight of Sunflower

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Alternaria leaf blight of sunflower caused by *Alternaria helianthi* (Hansf.) Tubaki and Nishihara is an important disease of sunflower causing yield loss of 50-60 per cent. The study was conducted on *in vitro* evaluation of new molecules of fungicides and plant extracts against *Alternaria helianthi*, causal agent of *Alternaria* blight of sunflower. *In vitro* evaluation of fungicides revealed that, among four systemic fungicides hexaconazole and propiconazole were highly effective in inhibiting the mycelial growth showing 100% inhibition at 200, 400, and 600 ppm concentrations followed by Thiophanate methyl (40.37%) and Carbendazim (39.07 %) at 600 ppm. Among non-systemic fungicides, the maximum inhibition of mycelial growth was found in Copper oxy chloride and Captan at 600 ppm showed inhibition of 84.07 per cent and 50.74 percent respectively, the least inhibition was recorded by Chlorothalonil (17.41%) at 100 ppm. Whereas, among the botanicals neem seed kernel extract at a concentration of 10 per cent showed positive effect of 43.74 percent inhibition of pathogen mycelium growth followed by neem leaf extract (25.26%) at the same concentration and the least was recorded by Chromolina leaf extract with an inhibition of 6.74 percent at the concentration of 2.5 per cent.

S- 1/NSIPS/P- 4

Solar Assisted IPM Techno-Package for the Management of *Meloidogyne graminicola* and *Rhizoctonia solani* Infecting Rice Nurseries in and around G.B Nagar

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As a remedial, safe and cost effective approach, the plant protectionist around the globe switched on to safer tactics utilizing solar energy clubbed with organic amendments and/or, botanical antagonists, fungal bioagents alongwith biofertilizer as a replacement of chemical farming. In continuance for searching

for the same the investigators concentrating towards evolving indigenous IPM packages for improving soil, plant and human health. The paper presents the application of soil solarization in enhancing the effect of sustainable pest management components like neem oil-seed cake, fungal bioagent, *Trichoderma harzianum* and a biofertilizer, AM fungus *Glomus etunicatum* against soil-borne fungi and root-knot nematode for the improvement of plant growth parameters. The observations of all the above management components integrated together carried out in different villages of Gautam Budha Nagar, in nurseries of rice where heavy infestations of both root knot nematode *Meloidogyne graminicola* and rot causing fungus, *Rhizoctonia solani* on the same crop rice Cv Basmati 1509, was recorded. The results of the above cumulative data gathered from all the identified hot spots clearly revealed outstanding performance in the treatments where the radiant sun's energy was trapped by polysheets in comparison to where no solar trapping was done in respect to plant growth parameters with reduction of both soil borne fungi and root knot nematode disease incidences. The VA mycorrhiza protected the entry of both fungi and root-knot nematode through vesicles and arbuscules occupying cortical tissue of the roots i.e. the zone of elongation. The oil seed cake, another IPM component is attributed to help in increasing the tolerance level of root while *T. harzianum* enriches the health of rice seedlings through its growth promoting properties. This solar assisted treatment comprising of neem oil-seed cake, biopesticide and a biofertilizer, is proved to be an ideal package in combating soil-borne maladies infecting rice at nursery level.

S- 1/NSIPS/P-5

Studies on Powdery Mildew of Chilli Caused by *Leveillula taurica* (Lev.) Arn.

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An experiment was undertaken for in vivo bio efficacy of fungicides, bioagents and botanicals in the field of Vegetable Research Center, VNMKV, Parbhani during kharif 2015 for powdery mildew of chilli. The results of disease management experiment through fungicides indicated that disease severity and incidence declined only after second and third spray. The disease incidence and severity after third spray ranges from 25.00 to 37.75 per cent and 16.35 to 27.13 per cent respectively. On the basis of effectiveness in controlling the powdery mildew of chilli most effective fungicide recorded in the order of merit Sulfex (63.03%), Penconazole (59.88%) and Hexaconazole (58.85%). Incidence and severity of powdery mildew disease on chilli after second botanical spray ranges from 41 to 51.37 per cent and 29.90 to 42.46 per cent. Among all the botanicals Garlic and Tulsi were superior over all the others. All bioagents effectively control the disease. After second spray disease incidence reduces in the range of 18.78 to 40.50 per cent. On the basis of effectiveness in controlling the powdery mildew of chilli most effective bioagents recorded in the order of merit *Trichoderma harzianum* (90.60%), *Trichoderma viride* (89.26%) and *Trichoderma koningii* (88.07%).

S- 1/NSIPS/P-6

Exploitation of Systemic Insecticide for Root Dipping Alternated by Spraying of Different Botanicals to Control Tomato Leaf Curl Virus (Tolcv) in Tomato

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White fly transmitted Tomato leaf curl virus (ToLCV) is an internationally important disease due to its devastating nature and known to cause up to 100% losses in tomato. The management of this disease has been offering serious challenges to the plant pathologist, since there has not been any single package perfected to the required level and this is a serious impediment in the productivity of this crop. However, several reports are available where attempts were made to manage the disease by controlling its vector with insecticides but it is the concern of environmental hazards and its residual toxicity, food safety and resistance to the pesticides that compelled the workers to find out other alternatives like minimal use of chemicals or eco-friendly products without affecting the ecosystem. Therefore, in the present study, efforts have been made to explore the effect of root dip of tomato seedling in Imidacloprid (@0.02%) and spraying of different botanical oils and the viricide (T.N. Gujcovircon).

The study was conducted at the University Instructional Farm, Jaguli, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during 2013-2014 and 2014-2015. The experiment was designed under randomized block design with eight treatment and three replications and one susceptible cv. Patharkuchi was chosen under natural epiphytotic condition. The details of the treatment were T1 = Root dipping of tomato seedling for 30 minutes before transplanting in imidacloprid solution (@0.02%), T2 = T1 + 3 spray of Imidacloprid (@0.02%) at 15 days interval T3= T1 + 3 spray of neem oil, T4 = T1 + 3 spray of koronja oil, T5 = T1 + 3 spray of citronella oil, T6 = T1 + 3 spray lemon grass oil, T7 = T1 + 3 spray of viricide and T8 = control.

The two years cumulative data revealed highest disease severity (PDI= 56.06% and 53.48% respectively) in the treatment T7 i.e root dipping in Imidacloprid (@ 0.02%) and three spray of viricide (Gujcovircon) and minimum disease severity was recorded (PDI= 17.23% and 17.99%) in the treatment T2 receiving root dipping in imidacloprid (@ 0.02%) before transplanting followed by 3 spray of Imidacloprid (@ 0.02%). In both the year, second lowest disease severity was observed in the T3 treatment where neem oil sprayed distinctly along with imidacloprid root dipping.

White fly population was found to have positive correlation with the disease severity and was statistically significant. During the year 2013-14 was highest population noticed in T7 (varied between 4 to8) and lowest (varied between 1 to 3) in T2.

Similarly, in the year 2014-15, maximum whitefly population (found to vary between 7 to 14) also coincide with the highest disease severity recorded in the treatment T7 and lowest disease severity and minimum whitefly population (varied between 1 to 2) was noticed in the treatment T2.

Pooled data revealed maximum yield (352.50 qha-1) was obtained from the plot T2 i.e treated with root dipping and three spraying of Imidacloprid followed by the plot T3 (350.25 qha-1) where root dipping in Imidacloprid (@ 0.02%) and spray of neem oil was done. Only root dipping in Imidacloprid (@ 0.02%) before transplanting and three spray of viricide T7produced the minimum yield (145.50 qha-1) but higher than the untreated control (102.75 qha 1).

Taking into consideration both minimum disease severity and whitefly population and in increase yield the experiment revealed that the root dipping in Imidacloprid and three consecutive spray of Imidacloprid is the best one.

S- 1/NSIPS/P-7

In Vitro Evaluation of Different Fungicides and Bio-Agents against Tomato Fruit Rot

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Tomato (*Solanum lycopersicum*) is one of the most important Solanaceous vegetable, ranking second in importance to potato in many countries, but the tomato crop have threat to their production because susceptibility of tomato to fruit rot disease which is incited by number of causal pathogens. As their importance it was therefore, thought necessary to study the occurrence and magnitude of commonly responsible causal pathogens for fruit rot of tomato and that is why the detailed investigations on fruit rot of tomato were carried out with regards to isolation of the organism, pathogenicity, symptomatology. Isolation carried out from the rotten fruits of tomato yielded fungal pathogens viz., *Alternaria alternata, Fusarium* spp., *Aspergillus niger* and *Curvularia lunata*. Fungal pathogens inoculated on healthy fruits of tomato confirmed the pathogenicity of the isolated organisms in the present investigations.

The symptomatology of fruit rots of tomato caused by *A. alternata, Fusarium* spp., *A. niger, C. lunata* are described in detail.

In vitro evaluation of different fungicides, *A. alternata* was most effectively controlled by Hexaconazole (0.1%), Metalyxl (0.25%) and Tebuconazole (0.1%) while in case of Fusarium spp. most effective control was obtained by Hexaconazole (0.1%), Tebuconazole (0.1%), Metalyxl (0.25%). In case of *A. niger*, most effective control was obtained by Carbendazim (0.1%), Hexaconazole (0.1%), Tebuconazole (0.1%), while in case of *C. lunata*, most effectively controlled by Mancozeb (0.1%), Tebuconazole (0.1%), and Metalyxl (0.25%).

In vitro evaluation of bio-agents, *Trichoderma harzianum* was found most effective against *A. alternata, Fusarium* spp. and *A niger* than *T. viride* while *T. viride* was found effective against *C. lunata* than *T. harzianum.*

S- 1/NSIPS/P-8

Induction of Resistance against Sheath Blight of Rice

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Sheath blight of rice caused by *Rhizoctonia solani* Kuhn. is a serious threat in all rice growing regions. Soil borne nature of the pathogen with ability to produce sclerotia make chemical disease management a distant possibility. Enhanced activities of defence enzymes have been suggested to have major role in induction of SAR and ISR in plants against pathogens. The role of non-traditional chemicals and botanicals in inducing resistance in susceptible variety. An attempt was made through a pot culture

study of rice using susceptible cultivar MTU 7029 (Swarna) with various non-traditional chemicals and bio-agents used as seed treatment, like salicylic acid, cyclohexamide, fecl3, Mnso4, Cucl2, coconut water and biocontrol agents (*Trichoderma* and *F. pseudomonas*) to study the induction of resistance and its bio-chemical basis. Challenge inoculation with *R. solani* to ascertain the effect of elicitors on defence related enzymes like Phenylalanine Ammonia lyase (PAL), Total phenol Content (TPC) , poly-phenoloxidase (PPO) was done.PDI at 5,9 and 13 days after inoculation (DAI) showed relative increase in disease index with time in all the treatments. Cupricchloride (Cucl2) exhibited significantly lower disease progress (28.45) followed by Cyclohexamide (53.50) against control (118.19). The biochemical attributes studied were measured at 0, 9, 18 and 24 hours after inoculation and correlated with disease development in plant under differential treatment. PAL at 18 hours of inoculation only showed a significant correlation (0.6443) with final disease at 13 DAI. So, biochemical basis of resistance may be uncovered by investigating the downstream of phenyl propanoid pathway after activity of Phenylalanine Ammonia Lyase.

S- 1/NSIPS/P-9

Studies on Leaf Spot Disease of Betelvine (*Piper Betle*. L) Caused by *Alternaria alternata* Kessler

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Piper betle L. commonly known as betelvine is a perennial dioecious creeper. It belongs to the genus Piper established by Linnaeus in 1753. Betelvine is known to be affected by several fungal diseases. Recently, the leaf spot disease of betelvine caused by *Alternaria alternata* has become severe affecting the leaf yields. Therefore, attempts were made on aspect of isolation, identification, efficacy of different fungicides in in vivo conditions. The causal organism was isolated from infected leaves of betelvine showing leaf spot symptoms. The pathogen was identified to be *Alternaria alternata*. The pathogenicity of the pathogen was confirmed on healthy leaves. The pathogen, *Alternaria alternata* caused leaf spot symptoms as oval, round to mination and vigour index irregular or angular, necrotic, surrounded with the concentric rings. Later these spots increase in size and coalesce covering larger leaf area with dark brown margin and yellow halo. The treatment T6 *Trichoderma* (3 kg/ha), mancozeb (0.25%) and Bordeaux mixture (0.5%), two sprays was found to be effective for management of *Alternaria* leaf spot of betelvine caused by *Alternaria alternata* along with higher growth, Leaf yield and quality. The highest Leaf yield of 28.96 lakh leaves/ha was obtained and gave the maximum benefit with a benefit cost ratio of 1:3.62 in the treatment of *Trichoderma* (3 kg/ha), mancozeb (0.25 %) and Bordeaux mixture (0.5 %) followed by *Trichoderma* (3 kg/ha), chlorothalonil (0.15 %) and Bordeaux mixture (0.5 %) with leaf yield 25.90 lakh leaves/ha and with benefit cost ratio of 1:3.23. The unsprayed control T13 showed minimum leaf yield.

S- 1/NSIPS/P-10

Effect of Post Harvest Treatment on Post Harvest Disease Management and Shelf Life of Mango

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Mango is one of the choicest fruit of tropical and subtropical region of Maharashtra in India. Kesar variety is the most popular cultivar of mango in Maharashtra. In Mango losses are observed due to fungal diseases are of prime importance which reduces the quality and quantity of marketable fruits leading to heavy losses to sellers as well as consumers about 30-40 per cent. Infected mango fruits recorded association of three fungi is affected by post-harvest diseases anthracnose (*Colletotrichum gloeosporioides*), die back (*Botryodiplodia theobromae*) and black rot (*Aspergillus niger*). Pathogenecity of all three isolates were proved. Nine post-harvest treatments were given as HWT, FWE, HWT+FWE, Yeast strain É, Yeast strain-ÉÉ, Garlic extract, Ginger extract, Carbendazim and Control. The study on effects of postharvest treatments on loss in weight (%) HWT+FWE treated fruits exhibited minimum losses in weight followed by Hot water treated fruits, while frutox wax treated fruits at par with fruit treated with yeast strain-É and control fruits show maximum losses in weight (%). Encouraging biochemical changes of fruits and their persistence was observed in Mango cv. Kesar. Maximum T.S.S was found in HWT+FWE treated fruits followed by hot water, frutox wax and yeast strain É. Higher per cent acidity and ascorbic acid content found in fruits treated with HWT+FWE followed by frutox wax, hot water and yeast strain-É. Maximum per cent sugar was found in hot water treated fruits followed HWT+FWE, while control treated fruits recorded minimum per cent sugar. HWT+FWE and hot water treated fruits exhibited minimum disease incidence followed by frutox wax and yeast strain-É treated fruits and maximum per cent disease incidence found on control treated fruits. Therefore HWT+FWE treatment can be used to increase 15 days the infection free shelf life of mango cv. Kesar.

S-1 /NSIPS/P-11

Study of Effect of Different Regimes of Nitrogen on Late Blight of Potato

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Late blight of potato caused by *Phytophthora infestans* (Mont.) de Bary is one of the most devastative diseases of agricultural crops. Most of the measures for managing the disease are based on chemicals but facts like environmental hazards due to chemicals, development of resistance in pathogen against fungicides and increased cost of cultivation direct towards the need of integrated approach of managing disease. So, along with chemical management practices other measures of disease management

should also be studied. In cultural management practices, fertilization plays an important role. Nitrogen being an essential constituent of protein and chlorophyll is important for growth and development of plants as well as yield. So in greed of more yield higher dose of nitrogen application is in practice. But nitrogen has both direct and indirect effect on plant making it susceptible to the pathogen. Direct effect is increased succulence of plant tissue so increased susceptibility. Indirect effects are bigger canopy which alters microclimate of plant making it favourable for disease establishment and distance- effect increases the spread of pathogen. So the optimum dose of nitrogen which can provide higher yield and should not make plant susceptible to the pathogen should be estimated. This study includes study of effect of different regimes of nitrogen on Late blight of potato. There were 6 doses of nitrogen ranging from 0 to 250 kg/ha out of which 150 kg/ha was found to be most suitable both in terms of yield as well as less disease severity.

S- 1/NSIPS/P-12

Evaluation of Amistar Opti 560 SC (Azoxystrobin 4.8 %+ Chlorothalonil 40 %) against Diseases of Cucumber

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A field experiment was conducted during 2014 and 2015 to evaluate the bio-efficacy of Amistar Opti 560 SC, a mixture of Azoxystrobin 4.8% and Chlorothalonil 40% w/w SC against powdery mildew (*Erysiphe cichoracearum*), downy mildew (*Pseudoperonospora cubensis*) and leaf spots (*Colletotrichum lagenarium* / *Cercospora* sp.) in cucumber. The test molecule was compared with the bio-efficacy of component fungicides (Azoxystrobin 23SC,

Chlorothalonil 75WP) along with conventionally used Cymoxonil 8% + Mancozeb 75WP and Zineb 75WP. The fungicide treatments were applied twice at 10-day intervals commencing immediately after appearance of the diseases. The disease severity at terminal point of disease record revealed that significant variations existed in each year although treatment variation was significantly prominent as evident from pooled analysis. The test molecule @ 0.3% exhibited significantly lower disease severity for powdery mildew (2.1%), downy mildew (5.2%) and leaf spot (3.4%) resulting in 83.5%, 84.2% and 80.0% reduction in disease severity, respectively. Further, increase in spray concentration to 0.4% showed 89.1%, 88.8% and 83.5% reduction in powdery mildew, downy mildew and leaf spot severity, respectively compared to untreated check without significant deviation from its immediate lower dose. Fruit yield was found to be increased by 56.6% - 62.9% due to application of Amistar Opti 560 SC applied @ 0.3-0.4%. Analysis of Area Under Disease Progress Curves (AUDPCs) revealed that no significant variation was found for the powdery mildew and leaf spot between two years but significant difference was noticed in case of downy mildew with higher AUDPC. Instead of such variation, treatments had significant effect on reduction of disease severity and strong negative correlation was found between AUDPC and fruit yield. Hence, Amistar Opti 560 SC may be considered as one of the best chemical options to combat the problem of resistance development in the concerned cucumber pathogens.

S- 1/NSIPS/P-13

Management of Stem Rot Disease of Paddy using Fungicides

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A field study was conducted during Kharif 2014 and Kharif 2015 to evaluate the bioefficacy of fungicides (both solo and combination products) against stem rot disease of paddy. Different fungicides were tested either as seed treatment (ST), seedling dip (SD), foliar spray (FS) or in combinations. Disease was measured in 0-9 standard evaluation scale and scores were transformed into percent disease index (PDI). PDI of Kharif 2014 and Kharif 2015 were pooled to get the mean PDI. Among the different treatments, ST with carbendazim at 2g/kg of seed + FS with Thifluzamide 24 SC (0.75 ml/l) has recorded lowest PDI of 15.15 (mean PDI) which was on par with another treatment comprises ST with carbendazim at 2g/kg of seed + FS with Thiophanate Methyl 70 WP at 1.5 g/l (mean PDI 18.7). Significant increase in grain yield (51.6 q/h) was observed in the plots having treatment combination of ST with carbendazim at 2g/kg of seed + FS with Thifluzamide 24 SC (0.75 ml/l) which was statistically on par with another treatment comprises ST with carbendazim at 2g/kg of seed + FS with Thiophanate Methyl 70 WP at 1.5 g/l (50.3 q/h) whereas, other treatments recorded the yield in the range of 34.8-44.6 q/ha.

S- 1/NSIPS/P-14

Evaluation of Fungicides against *Helminthosporium vignicola,* the Incitant of Target Spot Disease of Cowpea

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Helminthosporium vignicola, the incitant of target spot disease of cowpea (*Vigna unguiculata* (L.) Walp.) is a foliar fungal pathogen experienced for the first time during kharif- 2017 from AICRP On Vegetable crops, OUAT, Bhubaneswar and adjoining coastal tracts of Odisha. It causes 25-30% loss in yield in all the cowpea growing areas of Odisha. The efficacy of ten fungicides such as Hexaconazole 5%EC @0.05%, Zineb 75%WP @0.25%, Hexaconazole 68% + Zineb 4%WP @0.2% , Difenconazole 250SC @0.05%, Azoxystrobin 23%EC @0.1%, Tebuconazole 250EC @0.1%, Azoxystrobin11%+Tebuconazole 18.3%SC @0.1%, Mancozeb @0.25%, Cymoxanil 8% + mancozeb 64%WP @0.15% and Azoxystrobin8.3% + mancozeb 66.7% WG @0.15% were tried in vitro to assess the growth inhibition of the test fungus. All the fungicides inhibited the mycelia growth over control ranging from 22.53 to 97.05 per cent. The fungicide hexaconazole at 0.05% recorded maximum fungal growth inhibition of 97.05%. The next best growth minimization was observed in tebuconazole at 0.1% followed by hexaconazole + zineb at 0.2% recording 94.97% and 86.04% growth inhibition respectively.

S- 1/NSIPS/P-15

Fungicidal Management of *Colletotrichum gloeosporioides* (Penz.) causing Anthracnose Disease in Cashew

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Cashew is infected by more than 20 diseases worldwide. Among the diseases, anthracnose caused by *Colletotrichum gloeosporioides* (Penz.), perfect stage *Glomerella cingulata* (Ston.) Spauld. & Schrenk is a serious menace in cultivation of cashew causing economic loss in Odisha. The present investigation was carried out with an objective to study the efficacy of some new fungicides in in-vitro condition. Twelve fungicides such as Azoxystrobin(0.1%), Tebuconazole(0.05%), Azoxystrobin + Tebuconazole(0.1%), Mancozeb(0.2%), Azoxystrobin + Mancozeb(0.1%), Hexaconazole(0.1%), Zineb(0.25%), Hexaconazole + Zineb(0.2%), Difenoconazole(0.05%), Pyrachlostrobin(0.1%), Tebuconazole + Trifloxystrobin(0.06%), Cupper hydroxide(0.2%) were evaluated against the pathogen. The growth of the pathogen was significantly reduced by the fungicides included under investigation. Mancozeb recorded maximum mycelia growth inhibition of 96.33% followed by Azoxystrobin + Mancozeb (96.17%). However both the fungicides are at par. Cupper hydroxide recorded the least inhibition of 29.02%. Tebuconazole alone recorded 94.56% growth inhibition but combination of Azoxystrobin + Tebuconazole recorded 93.22% growth inhibition. Similarly Zineb alone inhibited 95.46% but in combination with hexaconazole recorded 94.5% of growth inhibition. The combination of fungicides proved less effective as compared to sole fungicides. However the testing of fungicides may be carried out under field condition for further confirmation.

S- 1/NSIPS/P-16

Management of *Uromyces viciae–fabae* (Pers.) J. Schrot. in *Pisum sativum* L. through Alteration in Sowing Time

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Experiment was conducted for crop seasons 2013-2014 and 2014-2015 to know the effect of alteration in date of sowing on rust severity and grain yield in field pea. The results of investigation indicate that, early sown crop in 31st October, 7th November and 14th November face lower disease severity (8.67-17.50 percent) with low area under disease progress value (81-198.67) and produce good yield (690.90-775.39 kg/ha) and test weight (162.34-175.34 g) whereas crop sown in 21st November, 28th November, 5th December and 12th December succumb to high disease severity (40-54.17 percent) showing high area under disease progress value (383.50-549.17) with low yield (429.06-581.95 kg/ha) and test weight (146.67-153.73 g). When disease severity at most susceptible stage (110DAS) in different

sowing dates were correlated with weather factors, it was found that maximum and minimum temperature were significantly positively correlated whereas relative humidity, rainfall and wind velocity showed negative correlation.

S- 1/NSIPS/P-17

Management of Bitter Gourd Yellow Mosaic Virus

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Bitter gourd Yellow Mosaic Virus (BGYMV) is a Whitefly transmitted geminivirus. BGYMV causes yellow mosaic disease in bitter gourd. *Bitter gourd yellow mosaic virus* (BGYMV) has been reported to infect bitter gourd naturally causing enormous losses in respect of yield and quality of fruits. Considering the economic importance of this disease occurring on bitter gourd therefore, management of *Bitter gourd yellow mosaic virus* (BGYMV) and the quantitative biochemical changes in host plant due to virus inhibiting chemicals, bio-control agents, antiviral principles (AVP) and insecticide are summarized. Virus inhibiting chemicals, bio-control agents, antiviral principles (AVP) and insecticide, treatment T7 (Salicylic acid @ 2.5 mM) and T4 (*Bougainvillea spectabilis* leaf extract @ 10% w/v) were found to be most effective in inducing resistance in Bitter gourd plant *i.e.* 66.67% at 60 DAS. The treatment T8 (Pegasus @ 0.2%) was also effective in reducing disease up to 55.56 by vector control; and the treatment T1 (Actinomycetes @ 10^{7} CFU/ml) was least effective with 33.33% PDC on 60th DAS. The activities of enzymes *viz.*, peroxidase, polyphenol oxidase, total phenol and total soluble protein content due to virus inhibiting chemicals, bio-control agents, antiviral principles (AVP) and insecticide was found to be correlated with the disease resistance. The activities were found to be increased due to treatment followed by inoculation with BGYMV. Thus the acceleration of enzymatic activity was the indication of its involvement in the development of resistance in bitter gourd to BGYMV.

S-1 /NSIPS/P-18

Chemical Management of Early Blight Disease in Potato

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Early blight of potato caused by *Alternaria solani* is a destructive foliar disease causing 30 to 90% yield loss throught India.The trial was conducted in experimental farm of Potato Research Project O.U.A.T.in the year 2013-14 and 2014-15 with six fungicides and four replications. The treatments were followed as such ,i.e.T1=Control,T2=Three sprays of Mancozeb 75 WP (0.25%) at 10 days interval *,T3=Three sprays of Chlorothalonil 75 WP(0.25%) at 10 days interval, T4=Three sprays of hexaconazole 5EC(0.05%) at t 10 days interval, T5=First spray of Mancozeb 75 WP (0.025%), second spray of Hexaconazole 5EC(0.05%) and third spray of Mancozeb 75 WP (0.025%) at 10 days interval, T6= First spray of Chlorothalonil 75 WP (0.025%), second spray of Hexaconazole

5EC(0.05%) and third spray of Chlorothaloni 75 WP (0.025%) at 10 days interval,.Among different treatments maximum yield (17.39) was obtained by spraying Mancozeb three times. There was no significant difference in yield (17.30 t/ha) with the treatment where first spraying was with Mancozeb 75 WP (0.025%), second spraying with Hexaconazole 5EC(0.05%) and followed by third spraying with Mancozeb 75 WP (0.025%) at 10 days interval.This treatment was followed by three sprays of hexaconazole 5EC(0.05%) at t 10 days interval, The lowest was observed in only spraying with Mancozeb (14.54 t/ha). Disease severity showed to be increased with the age of the plant. It was maximum in the treatment where no chemical was spraying (84%).

S- 1/NSIPS/P-19

In Vitro Efficacy of Fungicides and Bio Fungicides against *Pythium aphanidermatum* (Edson.) Fitzp. causing Rhizome Rot of Ginger

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Five systemic, four non systemic, one combo fungicide, three fungal and one bacterial antagonist were evaluated *in vitro* against *P. aphanidermatum* causing rhizome / soft rot of ginger. All fungicides and biofungicides were found fungistatic / fungicidal action against test pathogen. The systemic fungicides were evaluated at 1000 and 1500 ppm. The non systemic and combo fungicides were evaluated at and at 2000 and 2500 ppm concentration. The Thiophnate methyl and Copper oxychloride were found to be most fungistatic and recorded significantly highest mean mycelia inhibition (93.28 %) and least Propiconazole (35.05 %).The percentage mean mycelia inhibition of the test pathogen was found to be increased with increase in concentration. Amongst the bio fungicide used *T. viride* was found most effective and showed significantly highest mycelia inhibition (94.97%) while the bacterial biofungicide *Pseudomonas fluorescens* showed least inhibition (54.76%).

S- 1/NSIPS/P-20

Effect of Micronutrients and Antibiotics on Bacterial Titre of Citrus Greening Disease (Huanglongbing) in Andhra Pradesh

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Huanglongbing (HLB), also known as citrus greening disease, is one of the most destructive disease affecting Rutaceae plants in many parts of the world and it threatens citrus industry worldwide. HLB is associated with three species of '*Candidatus* Liberibacter' with *Ca*.L.*asiatius* (L*as*) being the

most widely distributed bacterium in Asia. HLB is a systemic disease, once a tree is infected; there is no established cure for this disease. In this study, the effectiveness of chemical treatments *viz.*, T_1: Di potassium hydrogen phosphate @ 5g/l, T_2: Manganese Sulphate @2g/l, T_3: Copper Sulphate @3g/l, T_4: Penicillin G-Potassium, T_5: Ampicillin Sodium, T_6: Oxytetracycline hydrochloride, T_7: Chloramphenicol, T_8: Rifampicin, T_9: Control all @ 500ppm were evaluated in Las-infected Sweet orange (*Citrus sinensis*) var. Sathgudi trees using quantitative real-time polymerase chain reaction. Total three foliar sprays of these treatments at one month interval were applied for the standing trees in field conditions. The results showed that Ampicillin and Rifampicin only shows some suppressive effect at 90 days after 1st spray on the bacterial population (Ct=25.41 and 23.62) and symptom expression of HLB disease while compare to other treatments. There is no effect of nutrition on bacterial population or symptom expression. At the time of visual scoring, maximum increase in symptom expression was observed at 30 days after first spray and least symptom expression was observed at 30 days after third spray, this was due to emergence of new foliage. This may provide a useful tool for the management of citrus HLB disease.

S- 1/NSIPS/P-21

Management of Leaf Blotch Disease of Turmeric

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Turmeric (*Curcuma longa* L.) known as *Haldi* and Indian saffron is an important and ancient spice of India. Among various diseases attacking turmeric, leaf blotch caused by *Taphrina maculans* (Butler) is the most devastating disease. An experiment was conducted at Dholi (Bihar) during 2012-13 to 2014-15 to evaluate the field efficacy of four fungicides *viz.*, Propiconazole 25% EC (0.1%), Bordeaux mixture (1%), Copper oxychloride 50% WP (0.25%) & Zineb 75% WP (0.25%) and two bio-control agents *viz.*, IISR *Trichoderma* liquid formulation (1%) & IISR *Pseudomonas* talc formulation (1%) through its rhizome treatment + foliar spray at 90, 105 & 120 days after planting (DAP) against leaf blotch disease of turmeric. Application of Zineb 75% WP (0.25%) resulted in least per cent disease intensity (13.34 PDI) and maximum disease reduction over control (71.74%). Propiconazole 25% EC (0.1%) was the most effective in achieving maximum yield (38.09t/ha) and consequently resulting maximum yield increase over control (47.80%). Best incremental cost benefit ratio of 1:22.22 was recorded under the treatment of Zineb 75% WP (0.25%).

S-1 /NSIPS/P-22

IPM as a Tool to Control Blister Blight in Tea

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Blister Blight (*Exobasidiun vexans*) is a fungal disease in tea which was first reported in 1868 from Assam from where it spread to Darjeeling in the early years of 19th Century. It has potential to cause a heavy crop loss in tea which requires cold and humid climate for development and damage.

Crop loss of as high as 40-45% in China has been reported. The pathogen requires only a short period to complete its life cycle which depends on ambient weather conditions and vary between 11 to 28 days. Since tea is cropped throughout the year, seasonal liability to the disease cannot be avoided. But the field programme can be adapted to allow the bush passing through its most vulnerable period with the minimum risk. Tightening cultural control measures like pruning, shade pattern and plucking play a significant role in controlling the disease. Since the pathogen infects only tender shoots, efforts were directed to reduce the disease severity by adopting early pruning and hand plucking. Dry weather pruning helped to reduce the disease incidence by letting the exposure of bushes to high temperature and low humidity. Plucking at closer interval and hard plucking are advantageous as these operations help to remove the lesions before sporulations, thereby interfering with the life cycle of the pathogen. Plucking at 6-8 days interval was found to be successful in suppressing blister blight to a permissible level. The disease can be efficiently controlled by formulations containing cyproconazole, bitertanol, hexaconazole and propiconazole. The efficacy was improved when triazoles were used in combination with copper oxychloride. Nickel chloride is a breakthrough in blister blight management as it possessed both antisporulant and eradicant action. Combination of Copper oxychloride and Nickel chloride give improved efficacy to their use independently and also reduced the phytotoxicity of nickel chloride.

S- 1/NSIPS/P-23

Integrated Management of Tomato Wilt caused by *Fusarium oxysporum* f. sp. *lycopersici*

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Wilt of tomato (*Lycopersicon esculentum* Mill.) caused by *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.) is considered as one of the most devastating disease of tomato, which cause considerable losses in yield of tomato. Present investigation was carried out at Plant Pathology Section, College of Agriculture, Nagpur during the year 2016-17. In present investigation bio-agents, neem cake and carbendazim were evaluated on different combinations and mode of treatments. Under *in vitro* condition, carbendazim at concentrations 0.1, 0.15 and 0.2 per cent found effective in inhibition of mycelial growth 100 per cent. Though at lower concentration of fungicide (0.01, 0.05 per cent), the test fungi do not found effective in 100 per cent inhibition of radial growth but have positive effect on inhibition of sporulation. Neem cake at 10 per cent showed maximum inhibition of growth of the pathogen (86.92 per cent) followed by neem 7 per cent concentration (75.82 per cent). Among bio-agents, *T. viride* and *T. harzianum* were recorded maximum inhibition against *Fusarium oxysporum* f. sp. *lycopersici* (57.00 and 52.80 per cent respectively) as compared to control. The different growth parameters i.e. root length, shoot length, germination and seedling vigor index were found maximum in treatment (T_6) Neem cake + *Trichoderma viride* + *Bacillus subtilis* by paper towel method. Wilt incidence was significantly reduced due to the integrated application of *T. viride, Bacillus subtilis* and neem cake (12.50 per cent) showing 85.71 per cent decrease in wilt incidence over control followed by *T. viride* and neem cake and carbendazim (16.67 per cent).

S- 1/NSIPS/P-24

Integrated Management of False Smut Disease of Rice caused by [(*Ustilaginoidea virens* (Cooke.) Tak.] and their Impact on Yield Attributes under Submergence Prone Ecology

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The present study deals with the field efficacy of bio-control agents and seed dressing fungicides in integration mode to management of false smut disease of rice. The false smut disease of rice caused by *Ustilaginoidea virens* has gained worldwide importance and its affects both quantitatively and qualitatively. Yield losses ranging from 0.2-49% reported from India (Ansari et.al., 1988). KVK Sitamarhi, Bihar conducted on farm testing trails from 2014 and 2015, under the project entitled "Improved Rice Based Rainfed Agricultural System". funded by International Rice Research Institute Philippines, Manila, to find out the effect of different chemicals and microbes alone or in combination on growth and yield of rice and cost effective method of false smut management in rice under flood prone ecology. The observation on different growth parameters of transplanted rice such as, disease severity (%), plant height at maturity stage, days after 50% flowering, days to maturity, tillers/m2, grain yield(kg/ha), straw yield(kg/ha), harvest index(%) and B:C ratio were undertaken. The plant height measured at maturity stages of the crop, varied significantly among the treatments. However, the highest plant height (82.7 cm) was recorded in treatment T4 (Trichoderma seed treatment @12g/kg seed + one spray of Copper oxychloride @ 2g/lt of at 50% panicle emergence) and treatment T7 [Chemical seed treatment (Tricyclazole @0.4g/kg seed) + one spray of Copper oxychloride (@ 2g/lt of water at 50% PE)]. Days to fifty percent flowering and days to maturity showed non-significant difference. The highest number of tillers per m^2 was measured in the treatments T4 and it varied significantly among the treatments. The minimum disease severity (22.40%), maximum grain (34.50 q ha-1), straw yield (36.05 q ha-1) and harvest index (%) were observed under treatment T4. It might be due to lower unfilled grain per panicles and lower infected spikelet per panicle in the treatment of *Trichoderma* seed treatment (@12g/kg seed) + one spray of copper oxychloride (@ 2g/lt of at 50% panicle emergence.

S- 1/NSIPS/P-25

Management of Sigatoka Leaf Spot Disease with Fungicides Petroleum Based Mineral Oil Formulations

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A field trial was laid out to find out the effect of various fungicides i.e. Mineral oil (1%), Propiconazole, Difenconazole, SAAF, Combine application of Propiconazole and mineral oil,

Carbendazim+mineral oil, Difenconazole +mineral oill on yellow sigatoka leaf spot of banana cv. GRAIND NAINE during 2013-15 at AICRP on Fruits. Horticultural Research Station O.U.A.T, Bhubaneswar. The experiment with eight treatments was conducted in Randomized Block Design with three replications. The plant to plant and row to row spacing was 1.5×1.5m. All the recommended agronomic practices for raising crop were followed. The treatment details were given below in Table A: The results of present investigation revealed that the application of 0.05 per cent propiconazole + 1 per cent mineral oil recorded its superiority in respect of disease control yield and quality of fruit than rest of the treatments studied. The least disease severity and disease free leaves(YLS) (1.29 & 7.7 respectively) The highest bunch yield (21.00 kg/plant) along with B:C ratio of 2.60 was recorded by treatment of spraying 0.05 per cent propiconazole along with oil based formulation *i.e.* 1 per cent mineral oil than control. Hence the spraying /s of 0.05 per cent propiconazole + 1 per cent mineral oil is recommended for effective control of sigatoka leaf spot disease of banana

S- 1/NSIPS/P-26

Management of Foliar Diseases of Bt Cotton through Chemicals

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Cotton is one of the most ancient and important commercial crops next only food grains and is principal raw material for a flourishing textile industry. The study was conducted on management of major fungal diseases of cotton *kharif* 2016 at Agricultural Research Station, Dharwad Farm, UAS, Dharwad. Among the fungal foliar diseases, economically most important are *Alternaria* leaf spot , Grey mildew and Rust. Different triazole group of fungicides, strobulin compounds and new combi molecules were tried to control major fungal foliar diseases of cotton. The efficacy study of these fungicides revealed that, maximum disease control with higher yield was observed in three sprays of the combi product Trifloxystrobin 25% + Tebuconazole 50% @2.0gm/lit followed by Payaraclostrobin 5%+ Metiram 55% @ 3.5gm/lit. The kapas yield of cotton was significantly superior in all tereatment as compared to untreated control. Maximum yield was recorded in Trifloxystrobin 25% + Tebuconazole 50% (2544.60 kg/ha) followed by Payaraclostrobin 5%+ Metiram 55% (2471.91 kg/ha), Captan 70% + Hexaconazole 5% (2438.73 kg/ha). The benefit cost ratio study revealed that, Trifloxystrobin 25% + Tebuconazole 50% was most to be effective chemical for the management of fungal foliar diseases of cotton and Payaraclostrobin 5%+ Metiram 55% was found to be the second best chemical.

S- 1/NSIPS/P-27

Efficacy of Metiram 55% + Pyraclostrobin5%WG (Cabrio Top 60%WG) against Alternaria leaf spot Disease in Bt Cotton

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Combi products of strobulin group of fungicides like Metiram 55% + Pyraclostrobin5%WG at., 1250, 1500 and 1750 g/ha, were evaluated for two seasons kharif 2011 and 2012 against *Alternaria* leaf

spot disease in Bt cotton. The efficacy of Metiram 55% + Pyraclostrobin5%WG was compared with commonly used chemicals like mancozeb, carbendazim and an untreated control. Metiram 55% + Pyraclostrobin5%WG at all concentrations was found significantly effective in reducing the disease and in increasing the yield as compared to carbendazim, Metiram and Pyraclostrobin alone, and control. In the first season, Metiram 55% + Pyraclostrobin5%WG treated plots recorded a PDI ranging from 13.4 to 21.20 and yield of 31.0 to 36.1 q/ha as compared to PDI of 35.7 and yield of 23.7 q/ha in control. In the second season, Metiram 55% + Pyraclostrobin5%WG treated plots recorded a PDI ranging from 30.7 to 39.0 and yield of 9.3 to 10.4 q/ha as compared to PDI of 72.9 and yield of 7.72 q/ha in control. Metiram 55% + Pyraclostrobin5%WG @ 1750 g/ha application found to be effective in control of *Alternaria* leaf spot disease in Bt Cotton and consequently higher yield was observed. Metiram 55% + Pyraclostrobin5%WG at 1250, 1500 and 1750 g/ha did not cause any phytotoxicity symptoms in terms of chlorosis, necrosis, wilting, scorching, hyponasty and epinasty.

S- 1/NSIPS/P-28

Pre-Planting Strategies for Management of Panama Wilt Disease of Banana in Bihar

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Banana (*Musa* sp.) is one of the important fruit crop and it ranks first in production and third in area among fruit crops, occupying 13% of the total area and 33% of the total fruit production in India. In Bihar, the Cavendish group of banana is mostly grown and contributes about 70 per cent. Recently, in the eastern part of Bihar, where banana crops grown widely, have been found severely affected with wilt disease. Fusarium wilt is one of major constraints of Bihar banana production. Soil management before planting was done to reduce *Fusarium* inocula in the soil and wilt incidence, and maximize banana growth. Experimental trials have been conducted from 2013 to 2016 at Katihar, which was naturally-heavily infested by *Fusarium oxysporum* f. sp. *cubense* in a randomized block design with four replications. Soil solarization: plots were covered with transparent polyethylene plastic for 10 months, Crop rotation with maize: plots were planted with two periods of maize, Bare: no crop for 10 months, and Control: continuous planting of banana were the four treatments. Baring condition and Maize rotation minimized the Fusarium population in the soil, but could not escape from Fusarium wilt of banana. Continuous planting of banana retained the population of Fusarium in the soil. Soil solarization increased temperature of the soil up to 52^{o}C, which consequently suppressed Fusarium population in the soil, and reduced Fusarium wilt incidence of banana. Fusarium wilt emerged at three months after planting on plot previously rotated with two periods of maize, bare for 10 months, and continuous planting of banana while soil solarization played an important role to delay the disease emergence until six months. The treatment soil solarization, resulted linear disease development until the end of observation while all the other three treatments performed logarithmic trend of disease development and reached optimum at seven months after planting. Soil solarization could be one of the best control measures to control the Fusarium wilt and increase the yield of Banana.

S- 1/NSIPS/P-29

Performance of Propiconazole 25 EC against False Smut of Hybrid Paddy in Farmers' Field of Barpeta

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False Smut of paddy, caused by *Ustilaginoidea virens* (Cooke) Takah, has become major problem in Barpeta district of Assam in the popular hybrid paddy PAC 837. False smut infection in the field is known to occur before heading stage and primarily affects quality since the fungus produces orange brown smut balls that contaminate rice grain at harvest. However, the, production of ustilotoxin, a mycotoxin produced by the pathogen, may be of concern to livestock and humans. There is an urgent need to monitor and control the disease effectively in hybrid summer paddy. The fungicides used by the farmers of Barpeta district, Carbendazim 50 WP do not provide effective control against the disease. An OFT was conducted in the farmers' field of Barpeta district against false smut of summer paddy hybrid PAC-837 in the year 2015-16 and 2016-17 with the technology developed by Director of Rice Research, Hyderabad (2012) i.e. spraying of Propiconazole 25 EC @ 1 ml/L at 50% P.E. stage and compared with the farmers' practice i.e. spraying of Carbendazim 50 WP @ 1 g/L at 50% P.E. stage in seven different locations. The pooled data showed the better performance of the fungicide Propiconazole 25 EC in reducing the per cent infected tillers (3.87), per cent infected grains (0.67) as compared to the farmers' practice (per cent infected tillers = 5.63 and per cent infected grains = 1.71) and control (per cent infected tillers = 16.11 and per cent infected grains = 4.27). The yield obtained in the technology was 73.89 q/ha with B:C ratio 2.41 as compared to the farmers' practice (yield= 71.47 q/ha, B:C ratio= 2.23) and control (yield= 62.83 q/ha, B:C ratio= 1.83). The fungicide Propiconazole 25 EC may be recommended against false smut of hybrid paddy.

S- 1/NSIPS/P-30

Management of Plant Diseases in traditional farming systems of Assam

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Traditional farming system is associated with primitive agricultural systems or peasant agriculture. It is usually based on agriculture that has been practiced for many generations. Most small and traditional farmers of Assam utilize agricultural practices that are to some degree traditional. The agricultural activities of traditional farmers are associated closely with the indigenous knowledge of the indigenous people inhabiting different geographical regions with their own language, culture, tradition, belief, rites and rituals. Eventually, this local knowledge in course of time gets socially accepted and validated which finally inters into the social life and subsequently become the indigenous traditional knowledge (ITK).

Indigenous knowledge system and technologies are found to be socially desirable, economically affordable, sustainable and involve minimum risk to rural farms and products. Many traditional farmers have successfully managed plant diseases, primarily with cultural practices. For plant disease management many traditional farmers dust their crops with ashes, spray them with fish water, and spray with cow urine or cow dung solution, seeds soaked in milk-water mixture. Crop rotation, intercropping, flooding, burning, multi-storeyed cropping, mulching, sanitation, light trap for insects-vectors, manipulation shade, don't sown or plough when the moon is full or the sun has a halo, *Akadashi, Amubashi* etc. are most commonly practised by traditional farmers of Assam for good crop health. Indigenous technical knowledge deserves more respect than they receive. Traditional farmers' knowledge regarding many aspects of agriculture is often broad, detailed, and comprehensive, although this is not always the perception among agricultural scientists and development extension workers. Traditional agricultural practices must be understood and conserved before they are lost with the rapid advance of modern agriculture. Extension Plant Pathologists can learn much from traditional farmers to elucidate principles and practices useful in management of plant diseases sustainable, organically viable and eco-friendly manner.

S- 1/NSIPS/P-31

Present Scenario of Brown Spot of Rice in India

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Brown spot disease is caused by the fungal pathogen *Helminthosporium oryzae* (Syn: *Drechslera oryzae*; sexual stage: *C. miyabeanus*), which causes significant yield loss in rice production (up to 90%). Fungus attacks the crop from seedling in nursery to milk stage in main field. The disease appears first as minute brown dots, later becoming cylindrical or oval or circular. Recent survey in Manipur showed increase on the incidence of brown spot of rice in Bishnupur and Imphal West. Some resistant varieties like Co4, Cauvery are under in commercial cultivation. Research during the previous two decades has led to the possibility of biological control as an increasingly realistic option for rice disease management, *Trichoderma* spp. has been shown to be effective for the control of brown spot disease and the increase of plant growth on rice. Biotechnological approaches like Real-time quantitative PCR (RT-qPCR) reports the quantitative expression of known defence genes in rice leaves upon B. oryzae infection. Effective control measures carrying by using the phenolic antioxidants substances on rice diseases. Mitogen-activated protein kinases (MAPKs) are ubiquitous and evolutionarily conserved enzymes connecting cell surface to intracellular regulatory targets activating various morphogenetic changes. The variability study of pathogen in Manipur is in progress.

S- 1/NSIPS/P-32

Incidence of Leaf Spot Disease caused by *Cercospora capsici* in IPM and Non IPM Plots of Chilli (*Capsicum annuum* L.)

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Field trials were conducted to determine the incidence of leaf spot disease of chilli in IPM and Non IPM plots during 2013-14 *kharif* in Regadaguduru Village, Velugodu Mandal, Kurnool District. The number of IPM interventions were 15 as against 22 numbers of interventions in Non-IPM plot for cultivar Devanur Deluxe, whereas in case of Super-10, it was 16 in IPM plots as against 20 in Non-IPM plots. Experimental findings indicate that the incidence of leaf spot was high in the month of October both in IPM and non IPM plots (farmers plot). The incidence varied from 9.68 to 18.71 (PDI) in IPM plot as against 14.68 to 31.36 per cent in Non-IPM plot. With the IPM Interventions, the incidence came down from 18.71 per cent to 17.74 per cent by the end of November and 9.68 % by February. In general the incidence of leaf spot was marginally higher in non IPM plots throughout the season and the average seasonal incidence was 14.14% in IPM plots as compared to 23.38% in Non IPM plot.

TECHNICAL SESSION - II

Protected Cultivation, PGPR, Mycoorhiza, Biological Control

Lead Lecture-01

S-2 /NSIPS/L-1

Trichoderma spp. as Bioagents and Decomposers in the Management of Stresses and Nutrients in Plants

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Trichoderma spp. have been proved beneficial for the management of biotic stresses i.e. seed and soil borne diseases of the crops particularly wilt (*Fusarium* spp.), root rot (*M. phaseolina, R. solani*), collar rot (*A. niger*), stem rot (*S. rolfsii*), etc. which cause huge qualitative and quantitative crop yield losses. *Trichoderma* spp. not only act as biocontrol agents, but also stimulate plant resistance to biotic and abiotic stresses and help in plant growth and development resulting in an increase in crop production.

The biocontrol activity involving mycoparasitism, antibiosis and competition for nutrients, also induces defence responses or systemic resistance responses in plants. Several mechanisms by which *Trichoderma* may influence plant development have been proposed, such as the production of phytohormones, the solubilisation of sparingly soluble minerals, reduction in pollutant toxicity (organic or heavy metal), and the regulation of rhizospheric microflora. These are also found as decomposer of waste organic matters.

Trichoderma spp. are asexual fungi that are soil-borne, green-spored ascomycetes that can be found all over the world in different eco-system and also in decaying woods and organic matters. *Trichoderma* spp. have tremendous potential for production of cell wall degrading enzymes *viz*. cellulase, protease, chitinase, xylanase, endoglucanase, etc.They have been studied with respect to various characteristics and applications and have been found as successful colonizers of their habitats, efficiently fighting with their competitors. Once established, they express their potent degradative machinery for decomposition of the often heterogeneous substrates at hand. Therefore, distribution and phylogeny, defense mechanisms, beneficial as well as deleterious interaction with hosts, enzyme production and secretion, sexual development and response to environmental conditions such as nutrients and light have been well studied in great detail worldwide with many species of this genus. *Trichoderma* is one of the best studied fungi with the genome of three species currently available. Efficient biocontrol strains of the genus are being developed as promising biological fungicides, and their weaponry for this function also includes secondary metabolites with potential applications as novel antibiotics. The cellulases produced by *Trichoderma reesei*, the biotechnological workhorse of the genus, are important industrial products, especially with respect to production of second generation bio-fuels from cellulosic waste. The article reviews the information on *Trichoderma* spp., and its biocontrol and decomposing activity in sustainable disease management programmes.

Amendment of compost with *Trichoderma harzianum* also accelerates agricultural wastes composting shortened the composting time to less than half of the conventional methods of composting and improved its diseases suppressive effect. Ordinary composting, which generally requires three months for complete decomposition, is too slow for farmers who plant two or three crops a year. The IBS rapid composting method developed by Institute of Biological Sciences at the University of the Philippines, Los Baños, speeds up the process with a compost fungus activator, *Trichoderma harzianum*.

The activator complements soil microbes as a source of waste cellulose decomposers, thereby increasing the number of decomposers and the rate of decomposition so that farmers can use the compost sooner.

Rapid composting requires carbon-rich materials such as rice straw, nitrogen-rich materials like animal manure and the activator *Trichoderma harzianum*. A combination of three parts carbon to one part nitrogen substrate is best. If animal manure is difficult to obtain, it may be replaced with leguminous plants such as *Azolla*, *Sesbania*, etc.

Income gains resulting from a healthy crop are the most immediate requirement to increase the income of the farmers. The soil benefits from continued use of compost in the long term. It improved soil texture and tilth, better aeration and water-holding capacity, increased fertility and less acidity. Because rice straw is composted and not burnt, less carbon dioxide is released into the atmosphere. Compost reduces the need for chemical fertilizers. Additionally, as farmers gain self-reliance they become less dependent on off-farm inputs.

Lead Lecture-02

S-2 /NSIPS/L-2

Biological Control of Bacterial Wilt Disease of Solanaceous Crops through Microbes

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Bacterial wilt of tomato incited by *Ralstonia solanacearum* (Smith) Yabuuchi is a very serious in solanaceous crops including tomato, potato, chilli and brinjal and occurs across the country mainly coastal areas, foot hills and lower altitude of hills. Biological control not only increases crop yield and suppresses disease but also avoids environmental pollution. It is important to develop methods for evaluating antagonistic microorganisms and incorporating them into successful disease management. Chemical and soil treatments, such as soil fumigation, application of stable bleaching powder, modification of soil pH, heat treatment by solarization, application of plant resistance inducer or phosphorous acid or use of suppressive soils have been shown to reduce bacterial populations or disease severity at the small experimental scale, but these methods are either environmentally destructive, expensive, or both, and still have to be validated in the field. Hence another optionto control bacterial disease is biological control using microbes which is not only increases crop yield and suppresses disease but also avoids environmental pollution. It is important to develop methods for evaluating antagonistic microorganisms and incorporating them into successful disease management. Research on microbial antagonists, such as *Pseudomonas fluorescens, P. glumae, Bacillus* sp. (*B. licheniformis B. cereus, B. subtilis, B. amyloliquefaciens), Stenotrophomonas maltophilia* and a Hrp-mutant of *R. solanacearum*, *Trichoderma harzianum*, *Candida ethanolica* and mycorrihiza are found to be relatively effective in the control of *R. solanacearum* populations under natural conditions. The pathogen is a soil inhabitant bacterium and found in different agro-climatic regions of India. Biological control of *R. solanacearum* through the antagonistic bacteria has been done, which reduces the incidence of bacterial wilt disease. In case of bio-efficacy of these strains of antagonistic bacteria, minimum wilt intensity (46.0%) in tomato cv. Pusa Ruby was found in treated with *P. fluorescens* DTPF-3 treated soil followed by DTBS-5 under glasshouse conditions. *P. fluorescens* showed significantly better wilt disease control than *B. subtilis* under moderate conditions. Integrated approach for management of bacterial wilt included bacterial antagonists and bleaching powder, minimum bacterial wilt intensity was found in bleaching powder (0.01%) + Bacillus treatment in both

cultivars Arka Abha (19%) and Pusa Ruby (29.6 %). Although, bleaching powder (0.01%) along with bioagents performed better than the applied separately. The disease incidence further may be reduced if it integrated with resistant cultivars of tomato. Biological control efficacy of both biocontrol agents was found maximum in bleaching powder + *B. subtilis* 37.29 and 36.06 % followed by Arka Abha and Pusa Ruby cultivars of tomato respectively.The minimum wilt disease incidence in tomato (22.13 %) was recorded in combination with *P. fluorescens*(DTPF-3) + *T. harzianum* with highest biological control efficacy (54.65%) followed by *P. fluorescens*DTPF-3(28.73) alone as compared to control 48.80 %. Integration of soil solarization for 8 and 10 weeks during March to May along with incorporation of antagonistic rhizobacteria i.e. *P. fluorescens* and *B. cereus* in soil prior to solarization reduces the disease significantly. Integrated approach for management of bacterial wilt included bacterial antagonists and bleaching powder, minimum bacterial wilt incidence was found in bleaching powder (0.01%) + *Bacillus* treatment in both cultivars ArkaAbha (19%) and Pusa Ruby (29.6 %)under glasshouse conditions. *Bacillus* spp. contain different type antibiotic producing genes like Iturin A, Bacillaene, Macrolactin and Difficidin of *B. amyloliquefaciens* (DSBA-11) which play important role in suppressing growth of bacterial pathogens. To study the role of these genes for reducing wilt intensity caused by *R. solanacearum*, cloned product genes (white colonies) along with parent *B. amyloliquefaciens* DSBA-11 and non - cloned product (blue colony) were treated tomato cv.Pusa Ruby by drenching against bacterial wilt caused by *R. solanacearum* under glasshouse conditions. Minimum 29.3 % of wilt disease intensity was recorded in parent *B. amyloliquefaciens* DSBA-11 treated plants with 57.72 % of biocontrol efficacy followed by cloned product of Dificidin gene (39.3 % with 43.23 % biocontrol efficacy, which was significantly higher than any cloned product of particular genes but lower than the parent. Biological control, based on use of *R. solanacearum* antagonists, has shown promising results at the small experimental scale, but still needs to be validated at a larger scale.

Lead Lecture-03

S-2 /NSIPS/L-3

Management of Plant Health using Mycorrhizal Biotechnology

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Relationships among different species are defined by the effect of interaction on each of the species. Mutualism is an association that benefits both the interacting species. Arbuscular mycorrhizal (AM) fungi (Phylum Glomeromycotina) are one of the beneficial soil borne microbial symbionts which are ubiquitous in nature. It is an intimate association between symbiotic soil fungi and the plant roots.

The host plant allocates photosynthate to the mycorrhiza and in exchange the host roots are linked by extra-radical hyphal network resulting in improved acquisition of limiting soil resources especially immobile nutrients *viz.*, P. They play a key role in nutrient cycling in ecosystem, and protect the host plant against environmental stress. Because of its beneficial effects on overall plant growth and health, it is accepted that AM symbiosis can reduce the usage of chemical fertilizers, thereby leading to the reduction of harmful impact of chemical substances on the environment. Thus, making AM fungi a vital component of terrestrial ecosystems including horticulture and agro-ecosystems.

This study discusses AM fungal inoculum production (traditional and monoxenic culture methods) and multiplication for utilization as bio-fertilizer.

Invited Lecture-01

S-2 /NSIPS/I-1

Exploration and Exploitation of Multi-Trait Bio-Control and Stress Tolerant *Trichoderma* spp. from Pulse Rhizosphere of India

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Trichoderma is a very versatile bio-control fungi which alleviate biotic, abiotic stress and have abilities to control multiple abiotic stress such as osmotic, salt, suboptimal temperatures which suggests a common mechanism through which the plant–fungus association enhances tolerance to a wide range of abiotic stresses as well as biotic stress. *Trichoderma* spp. has been known as biocontrol agents for the control of plant pathogens for decades which are capable of parasitising several plant pathogenic fungi. Therefore it is important to investigate the diversity of *Trichoderma* in the soil since such information can lead to the isolation of *Trichoderma* species having higher antagonistic efficiency and development of better biological control methods to manage plant pathogenic infections caused by pathogenic fungi through different mechanisms like competition, antibiosis, mycoparasitism, hyphal interactions and enzyme secretion especially extra cellular lytic enzymes such as chitinase and glucanases. Evaluation of bio-control potentials of native *Trichoderma* isolates from the rhizospheric soil of chickpea and pigeonpea were characterized through cultural, morphological and molecular methods. Antagonistic potentials of *Trichoderma* isolates from the pulse rhizospheric soils were evaluated against *Rhizoctonia bataticola*, responsible for dry root rot of chickpea. Result indicated that the *antagonistic* potential of 57 isolates of Trichoderma against *R. bataticola* were varied which *inhibited R. bataticola ranges* 31-88% *in vitro*. The salt tolerance was shown upto 10% by the isolates. Thus, the potential and well characterised saline tolerant strains of *Trichoderma*, could be used as potential bioagent in stressed soils.

Invited Lecture-02

S-2 /NSIPS/I-2

Trichoderma: Critical Issues in Research and Commercialization

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Most of the early research on biocontrol of plant diseases by *Trichoderma* spp. revolved around the direct ability of these fungi to interact with seed and soil borne plant pathogens. However, more recent findings indicate that a primary method of plant pathogen control by *Trichoderma* occurs through the ability of this beneficial fungus to reprogram plant gene expression by releasing chemical signaling molecules. Also, recent studies have established that the pathogen controlling ability of *Trichoderma* is only a small part of the gamut of benefits it offers to the plants including growth promotion, increased photosynthetic efficiency, nutrient availability, etc. In India, very limited research has been done to select the antagonists which have endophytic root colonizing and broad spectrum activity. Not much is known about the abiotic stress tolerance abilities of these strains and thus their successful establishment

in the soil under different stress conditions, their role in promotion of plant growth and amelioration of abiotic stresses. *Trichoderma* commercial products available in India are having limited bioefficacy, tested locally against a disease in a crop and not in different agroclimatic regions of the country and that has resulted in inconsistent performance of these products when they were used in different regions in a variety of crops. Though there are more than 150 registered producers of these agents in India, the formulated product available for farmers for seed treatment is about 5000 MT only. To treat at least 10% of seed produced by government agencies in the country we need to produce a lakh tonne of *Trichoderma* formulations. It is also necessary that easy, rapid and accurate test methods be developed to identify the genuineness of the formulations supplied in terms of both the qualitative (presence or absence) and quantitative (cfu per unit of formulation). To have increased demand and acceptance by farmers, there is a need to identify *Trichoderma* that are; growth promoting root endophytes, survive in saline soils and tolerate abiotic stress conditions including drought, high temperature and able to induce defense response against biotic/abiotic stresses. Apart from this, efficient delivery system by seed coating in conjunction with seed coat polymers leading to seed enhancement and mitigation of moisture stress owing to climate change events (erratic rainfall pattern, uneven distribution, high soil temperatures during seed germination) in dry land crops is very important. Delisting *Trichoderma* from Insecticide act or further simplifying registration requirements pertaining to toxicology with more stringency on bioefficacy and establishing guidelines to maintain and test the quality of formulations should be given a thought. Mere dependence on private sector will not help in the spread of this wonder fungus to farmers and therefore there must be serious efforts to enhance production by involving KVKs, SAUs, and also by establishment of regional production centres by DAC, MOA & FW, GOI.

Invited Lecture-03

S-2 /NSIPS/I-3

Biocontrol by Yeast: Indian Perspectiv

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Yeasts, the unicellular forms of fungi are well known and explored as agents for alcoholic fermentation since ancient times. Their role as post harvest plant disease bio-control agent is established recently during late twentieth century.

Postharvest diseases cause significant levels of economic losses ~ 20–25% in industrialized countries and ~50% in developing countries like India. Chemical control is the most used method to control post-harvest diseases in fruits and vegetables by directly applying synthetic fungicides to the product to be consumed. Contamination of fresh fruit and vegetables with pesticides residues has been under the spotlight of the consumers, health and regulatory authorities during the past three decades.

Management of postharvest decay of fruits, vegetables and grains using antagonistic yeasts has been reported by several researchers as one of several promising alternatives to chemical fungicides, the use of which is facing increasingly more stringent regulation. Yeast species have been isolated over the past two decades from a variety of sources, including fruit surfaces, the phyllosphere, soil and sea water, and their potential as postharvest biocontrol agents has been investigated (Droby *et al*., 1993; Lima *et al*., 1997; Wisniewski *et al*., 2007, Sten, 2014, Zhimo *et al*., 2016, 2017). The most effective are *Cryptococcus laurentii*, *Candida sake*, *C. oleophila*, *C. tropicalis*, *Metschnikowia* spp. and yeast-like fungus *Aureobasidium pullulans*, which are able to reduce or inhibit the growth of fungi such as e.g. *Botrytis*,

Colletotrichum spp, *Penicillium* and *Rhizopus* causing rots of fruit and vegetables or act on other field phytopathogens. Several mechanisms have been proposed as responsible for their antagonistic activity, including competition for nutrients (mainly N, Fe) and space, parasitism of the pathogen, secretion of antifungal compounds, induction of host resistance, biofilm formation, and most recently, the involvement of reactive oxygen species (ROS) in defense response.

The use of antagonistic yeasts has been especially emphasized since the production of toxic secondary metabolites (antibiotics) is generally not involved in their inhibitory activity (Wisniewski and Wilson, 1992), moreover, some yeast are able to synthesize vitamin-B beneficial for the consumers. Yeasts are becoming increasingly important in the "biotechnological revolution" by virtue of both their features and their very long and safe use in human nutrition and industry as well as in biological control of plant pathogens.

The new paradigm shift proposed in the bio-control research includes the integrative strategies for control of postharvest diseases include effectively inhibiting pathogens growth, enhancing resistance of hosts and improving environmental conditions resulting favourable to the host and unfavourable to the pathogen growth. The possibility of integrating the different effective strategies to achieve higher level of control of postharvest pathogens and to minimize or replace the use of synthetic fungicides has to be explored in certain host–pathogen systems.

Yeast based technologies and products (e.g Aspire® containing *Candida oleophila*, Yield Plus® containing *C. albidus*) for post-harvest disease management of fruits are already developed and practiced in Europe but in India we are lagging behind with respect to research and yeast based product development. Thus we in India need to put emphasis on research on the isolation and selection of potential bio-control yeasts from natural sources, their biology, stress tolerance capacity. The issue of yeast based product development may be addressed by industry-academia collaborative research. Public-private partnership (PPP) funding model for research and development needs to be initiated in India to explore the vast potentiality of yeast to minimize the post harvest losses of fruits and vegetables.

Invited Lecture-04

S-2 /NSIPS/I-4

Identification of *Colletotrichum truncatum* causing Anthracnose Disease on Dragon Fruit and the Efficacy of Some Biological Tools on the Mycelial Growth of the Fungus and Disease Control

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One of the most severe fungal diseases on dragon fruit (*Hylocereus undatus*) (DF) is anthracnose caused by *Colletotrichum gloeosporioides*. During a disease survey on DF in March and December 2015, fifty isolates of *Colletotrichum* were recovered from DF in the main growing areas in the South of Vietnam. Based on the morphological characteristics of colony, color, appearance, shapes of conidia and sequences of ITS regions, *C. truncatum* was identified as another causal agent of anthracnose on DF. The favorable temperatures for colony growth on PDA medium were of 25 to 37ºC and the pH of

4.5 to 7.5. On the evaluation effect of seven fungiciedes, the result shown Difenoconazole, Propiconazole + Difenoconazole, and Azoxystrobin + Definoconazole were the most inhibitory to fungal growth at 50 ppm and 100 ppm, percentages of the inhibition was up to 83.75; 93.75 and 93.75 % respectively. Among three plant extracts of *Impatiens balsamina*, *Pachyrhizus erosus*, and *Caulis opuntiae*, the extract of *I. balsamina* at 2.0; 3.0 or 4.0% was the most efficacy on inhibition of mycelial growth of the fungus, up to 93.7%. The other PDA medium test using *Streptomyces* isolate TG12, TG 17, the result shown that TG12 could control well *C. truncatum* upto 60.37% and TG17 to *C. gloeosporioides* at 71.33%. Under glasshouse and field conditions, the Difenoconazole, Axoxystrobin + Difenoconazole, Propiconazole + Difenoconazole và *Impatiens balsamina* extract, *Trichoderma* and *Streptomyces* solutions could control well the development of *C. truncatum* on both lesion diameter and serverity.

S-2 /NSIPS/O-1

Management of White Rust Disease in Indian Mustard by Non-Chemical Agents

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White rust (*Albugo candida*) is the most widespread and destructive disease of Indian mustard (*Brassica juncea*) causing up to 28% yield loss in India. In recent times non-chemical agents are being propagated for management of plant diseases to replace the harmful effect of chemicals. In view of this, an experiment was planned and carried out at ICAR-NCIPM, New Delhi during *Rabi* crop season 2016-17in split-split plot design with main treatments of soil application of *T. harzianum* (IIHR-Th-2) strain with well decomposed FYM before sowing and without application of *Trichoderma* (control). Further, sub-treatments of foliar sprays of bio-agent (*T. harzianum*), botanical (*Allium sativum*), standard fungicides (carbendazim + mancozeb) & water spray and sub-sub treatments of seed treatments (*T. harzianum*, metalaxyl-M, *A. sativum* & untreated) were undertaken. The results showed that soil application of *Trichoderma*, decreased the intensity of white rust over the control and increased the seed yield, whereas in sub treatments the seed yield was best in garlic bulb extract spray plot. In sub-sub treatment, seed treatment with *Trichoderma* or garlic bulb extract were found superior over metalaxyl -M. In combination, white rust was found better managed with soil application of *Trichoderma*, seed treatment with *Trichoderma* or garlic bulb extract followed by foliar spray with garlic bulb extract and gave maximum seed yield. This combination also provided maximum incremental benefit cost ratio (IBCR) as compared to other treatment besides being eco-friendly management of white rust.

S-2 /NSIPS/O-2

Eco Friendly Management of Phytophthora Diseases in Citrus

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Citrus occupies an important place in the horticultural wealth and economy of India as the third largest fruit industry after mango and banana. Citrus production in the country is 8.7 million tonnes at present with world ranking at sixth position after China, Brazil, USA, Spain and Mexico. Many fungal, bacterial and viral diseases that threaten citrus crops but some fungal diseases caused by *Phytophthora* spp. are the most devastating in central India. *Phytophthora parasitica* causing root rot / collar rot disease in Citrus jambhiri commonly spreads through the supply of disease planting material. Soil samples were collected from nurseries of Vidarbha region in India. The *Phytophthora* spp. *includes P. parasitica, P. citrophthora* and *P. palmivora* are responsible for root rot, and gummosis and collar rot in citrus of central India. Some potential biological agents investigated for control of these dangerous diseases. *Trichoderma* spp., *Pseudomonas fluorescens* and *Bacillus subtilis* were found effective in management of these diseases.

A thorough investigation was carried out and survey was undertaken where almost all samples collected from nurseries and in orchards of citrus were found associated with *P. parasitica* (28-46 cfu/ g soil) when tested on PARPH medium. Population level was found higher where; nurseries were raised on same location years together. Root stocks have significant role in managing the disease. Rangpur lime was found tolerant root stock whereas, *Citrus jambhiri* was found susceptible to the disease. The ability of *Trichoderma* spp. (*T. virens, T. harzianum, T. viride, T. hamatum*) was tested to manage the disease. Antagonism was assessed in vitro on different medium (Corn meal agar, Potato dextrose agar, V-8 juice and 2 % Agar). *In vitro* antagonism showed that *P. parasitica* completely inhibited by *T .harzianum* and *T. virens* .The bioagents overgrown on test pathogen at 14 DAI. However, intensity of antagonism was different as per medium. In nursery, it was found that there is a continuous reduction in pathogen population from 41 to 8 propagules /g soil with reduction in root rot /collar rot in *Citurs jambhiri*. In absence of bioagent the reduction in dry weight of seedlings was 47.3 % suggesting that *T.* spp. are effective to reduce the disease in citrus nursery. An experiment was also carried out to assess the potential of bacterial antagonists *Pseudomonas fluorescens* to control *P. parasitica*. All Thirty seven native isolates were found positive for production of IAA, HCN and Siderophore. These isolates were screened initially on the basis of dual culture assay. Pf IV and Pf XXVI were found effective to manage the disease in addition to increased growth response under glass house condition. Among chemicals, seed treatment with Metalaxyl @2.5 g/ Kg seed f.b. spraying of metalaxyl at 45 and 90 days after emergence and Fosetyl- AL at 75 DAE was found effective to manage the disease at considerable level. However, a module was developed to manage the disease at maximum level. Removal of wounded bark + washing of wound with 1% Potassium permanganate f.b. Bordeaux Pasting 1:1:10. Removal of rotted roots + 25 kg FYM f.b. Soil application of 50 g *P. fluorescens* + CaSO4 1.5 kg + 500 gm Murate of Potash/tree + Neem cake 2 kg/tree. Removal of dead twigs + Spraying of Metalaxyl @ 0.2 per cent + $ZnSO_4$ 150 g/tree. Spraying of Fosetyl AL @ 0.2 per cent. Scraping of wound and washing with 1% Potassium permanganate + 50 g metalaxyl / liter of water / tree Spraying of Micronutrient @ 0.25%. This experiment was carried out for consecutive three years.

S-2 /NSIPS/O-3

Crops under Protected Cultivation: Scenario of Diseases and their Management

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A technique in which microclimate is controlled either partially or fully, to protect crops from undesirable climatic conditions and abiotic (soil nutritional imbalance) and biotic stresses (pest and diseases) is considered to be protected cultivation. A wide ranging literature is available for a sustainable production and protection in protected cultivations. In this abstract, we tried to update the most relevant information towards horticultural crops in protected cultivation, potential yield losses due to diseases and their management approaches. Also, assessments of protected cultivation in the west as compared with other countries in the world including India are discussed. However, this review was focused mainly on crops and diseases of vegetable, ornamental and some fruit crops and their management by using potential biocontrol agents (plants, bacteria and or fungi based agents or commercially available products).

The horticultural protected production in Europe has gradually moved from the northern countries towards the Mediterranean basin (Baeza, *et al*., 2013). Similarly, changing scenario of protected cultivation and protection in other continents is highlighted. Retail sales of organic products reached US $80 billion worldwide in 2014 and North America and Europe accounted for more than 90% of all organic product sales (Willer and Lernoud 2016). According to Tuzel and Oztekin (2008) area under protected cultivation varies from 10.2% (glasshouse) to 23.6% (greenhouse and high tunnel). Protected horticulture developed very rapidly in China after 1981 (Jiang et al 2010). Whereas, protected cultivation varied with geographic regions in India (Himalayas, Western Ghats, and mainland) and crops (vegetables, medicinal, ornamental and forest crops). Some of the major diseases reported are damping off, root rots, wilts, charcoal rots, stem rots (caused by soil borne pathogens), powdery and downy mildews, leaf spots, and blights (caused by foliar pathogens). Biocontrol agents have a greater potential in management of majority of these diseases as they are environmentally friendly than using synthetic chemicals as has been evident in several row crops published by us. The protected technology can be a key for sustainable production and productivity and to achieve food security in the regions facing the problems of food scarcity. In conclusion, a comprehensive review of low-cost technologies and economic analysis of some of the operations from different parts of the world along with their environmental impacts needs better understanding.

S-2 /NSIPS/O-4

Effect of Microbial Consortium of Phosphate Solubilizing Plant Growth Promoting Rhizobacteria on Onion

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The present investigation was conducted at the Department of Plant Pathology and Agricultural Microbiology, Post Graduate Institute, Mahatma Phule Agricultural University, Rahuri. Studies were carried out to know the effect of seed inoculation of liquid consortium of efficient Phosphate Solubilizing Plant Growth Promoting Rhizobacteria (PGPR) under graded levels of phosphatic fertilizers on growth, nutrient uptake and yield of onion.

The phosphate solubilizing PGPR isolates were obtained from the root rhizosphere soils of onion growing regions of western Maharashtra. Out of thirty two isolates, namely PGPR 21, PGPR 24 and PGPR 43 recorded maximum zone of solubilisation (24.94 mm, 23.20 mm and 21.61mm respectively) than the other isolates. On the basis of morphological, cultural and biochemical characters, the selected bacteria were identified at genus level *as Pseudomonas sp,*. *Bacillus sp.* and *Azotobacter sp.*

Three efficient P-solubilizing PGPR having the ability to highest phosphate solubilisation were selected to develop liquid consortium and evaluated for its potential in the field condition. In the field experiment, significant differences were observed between various treatments due to the application of consortium under graded levels of phosphorus on all growth attributing characters *viz.*, plant height, number of leaves, length of roots, fresh and dry weight of shoot and root, fresh weight of bulb, polar and equatorial diameter of bulb, bulb yield, population dynamics of PGPR in soil, available and total N,P,K uptake and storage quality parameters of onion crop as compared to un-inoculated control and the consortium alone. Highest yield of bulb was recorded by the treatment of inoculation of P- Solubilizing PGPR along with the application of P_2O_5 @ 100 per cent which was found at par with treatment of inoculation of P- Solubilizing PGPR along with the application of P_2O_5 @ 75 per cent indicating saving of P-fertilizer application by 25 per cent without any significant reduction in yield.

S-2 /NSIPS/O-5

Arbuscular Mycorrhiza, *Trichoderma* and PGPR Work in-Tandem Benefiting Litchi (*Litchi chinensis*) in Calciorthant Soils of Bihar, India

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In nature, plants recruit beneficial microbes to their root system which aids growth and boosts immune responses. Key beneficial microbes for litchi include arbuscular mycorrhizal fungi (AMF), biocontrol and biofertilizer fungi *Trichoderma* spp., free living nitrogen fixers *Azotobacter* spp., several plant growth promoting rhizobacteria (PGPRs), and fluorescent pseudomonads. Researchers are now emphasizing use of consortia mixtures of these microbes. Studies conducted during 2012-2017 examined

the microbial co-operation in the rhizosphere reflected as growth response of juvenile litchi (*Litchi chinensis* Sonn.) trees and effect on fruit quality in bearing trees. The microbial inoculants consisted of AMF, *Trichoderma viride* (TR), *Azotobacter chroococcum* (AZ) and *Bacillus megatarium* (BM) along with their combinations which were compared with application of recommended dose of fertilizers (RDF) and control (without any application). It was evident that application of AMF in combination with other microbes resulted in significantly higher increase in different growth parameters like tree height, girth, spread, shoot length, leaf area and leaf chlorophyll content. Growth response produced by combination of AMF+AZ+TR were the best or statistically at par with AZ+TR for most of the parameters. Significantly higher moisture content at different soil depths were observed with application of microbial inoculants. Application of these microbes positively influenced fruit size and fruit bioactive components like total phenolics, besides reducing incidence of disease like anthracnose and fruit blight. The studies not only confirmed the positive response of AMF and *A. chroococcum* reported in different crop species but also demonstrated synergistic response of AMF with *A. chroococcum* and *T. viride* in litchi under field conditions. The calciorthant soils of Bihar have high pH (8.0-9.5) where availability of phosphorus and other nutrients become limited. Such multiple microbial inoculation strategy will be a big step towards achieving healthier crops by native soil nutrient mobilization, higher yields and reduced costs leading to sustainability in litchi fruit production.

S-2 /NSIPS/P-1

Evaluation of Isolates of *Streptomyces* spp. from North Bengal Area as Potential Plant Growth Promoting Microorganism (PGPM) and Biocontrol Agent

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Three *Streptomycetes* were isolated from the root rhizospheric soil of *Solanum tuberosum*. These isolates were initially identified as being *Streptomyces* spp. depending on their morphological and biochemical properties. Further identification of the isolates by 16SrDNA technology confirmed them as *Streptomyces tricolor* (NCBI KX894280), *Streptomyces flavogriseus* (NCBI KX894281), and *Streptomyces griseus* (NCBI KX894282). Plant growth promoting activity of these isolates on *Phaseolus vulgaris* and biocontrol activity of these isolates against root rot pathogen *Fusarium solani* were confirmed by both in vitro and in vivo experiments. Among the three isolates *Streptomyces tricolor* was found to be more effective as a plant growth enhancer in terms of shoot length, root length, leaf number, leaf area and total biomass. *Streptomyces flavogriseus* was found to be most effective biocontrol agent among the three isolates against root rot of bean plant (*Phaseolus vulgaris*) caused by *Fusarium solani* followed by *Streptomyces tricolor* and *Streptomyces griseus*. Amount of key defense enzymes like Peroxidase, Phenylalanine ammonia lyase, Chitinase and â-1, 3 glucanase were increased in the *Streptomyces* spp. treated plants compared to that of untreated or fungal pathogen infected plants. The increased level of the plant defense enzymes chitinase and â-1, 3 glucanase in root and leaf tissue of *Phaseolus vulgaris* plants were also confirmed by indirect immune fluorescence technique. On the basis of the results obtained it can be concluded that *Streptomyces* spp. can be used as potential plant growth promoting microorganism(PGPM) as well as biocontrol against root rot pathogen *Fusarium solani*.

S-2 /NSIPS/P-2

In Vitro Efficacy of Native *Trichoderma* spp against *Sclerotium rolfsii* in Tomato

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Trichoderma has gained maximum attention as biocontrol agent due to the fact that it is effective against a large number of soil borne plant pathogenic fungi. Therefore present experiment was conducted to assess bioefficacy of native *Trichoderma* spp against *Sclerotium rolfsii* in tomato. An *in vitro* experiment was planned in CRD using 9 –local strains isolate of *Trichoderma* spp were evaluated by applying dual culture technique on Potato dextrose agar medium.

The result revealed that, all isolates of *Trichoderma* spp exhibited antifungal activity against *Sclerotium rolfsii* significantly inhibited its growth over untreated control. Among the isolates tested isolate Thm-L (T3) was found most effective and test pathogen was recorded least linear mycelia growth 40.79 mm with highest zone of inhibition 62.21 percent followed by Tv-H (T2) and Thr-O (T5) which were recorded mycelia growth of 38.72 and 38.78 mm of test pathogen, respectively and highest zone of inhibition 56.06 and 56.33 percent respectively.

S-2 /NSIPS/P-3

Isolation and Characterization of Local Species of *Trichoderma* from Rhizospheric Soils of Tomato Crop

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Trichoderma spp. are promising antagonistic organisms and are one of the best alternatives to manage soil borne pathogens. However, native / local strains of *Trichoderma* have been found effective. Therefore, in present study, from tomato plant 16 rhizosphere soil samples were collected from various locations in Marathwada region of the state of Maharashtra and subjected isolation on PDA, by serial dilution and plating technique.

The results revealed that, out of 16 samples, only 8 soil samples yielded growth of *Trichoderma* spp. Based on cultural, morphological and microscopic features, the most predominant species identified were *Trichoderma viride*, *Trichoderma harzianum* and *Trichoderma hamatum*. Among these, *T. viride* is predominant in Beed and Hingoli districts; *T. harzianum* predominant in Jalana, Parbhani, Osmanabad and Aurangabad and *T. hamatum* predominant in Latur and Nanded districts of Marathwada region of the state Maharashtra.

S-2 /NSIPS/P-4

Assessment of Antagonistic Activity of Selected Fungal Endophytes Isolated from *Nepenthes khasiana* Hook. F. against Phytopathogens

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The present study highlights on the antagonistic activity of fungal endophytes associated with the insectivorous plant, *Nepenthes khasiana* of West Jaintia Hills of Meghalaya, India. The fungal endophytes were isolated from roots, stem, leaves as well as pitcher cup. The isolates were investigated against two selected phytopathogens viz. *Rhizoctonia solani* (RS) and *Fusarium solani* (FS). Overall colonization frequency of fungal endophytes from surface sterilized tissues was 38.88 % in leaves, which is highest, whereas the least was 22.91% in the roots. Out of 39 fungal endophytes, 7 frequently occurring isolates viz. *Acremonium cerealis, Cladosporium cladosporioides, Colletotrichum gloeosporioides, Humicola grisea, Penicillium rubrum, Phoma eupyrena*, and MS (white) were selected for antagonistic activity. The result indicates that all the selected endophytic fungi showed inhibition, although *H. grisea* proved to be a good antagonist and showed maximum occurrence in suppressing the growth of both the phytopathogen by the percentage of *Fusarium solani* (69.23%), *Rizoctonia solani* (74.22%) followed by *Acremonium cerealis* at 67.85% and 78.74% for both *F. solani* and *R. solani* respectively. Dual culture studies revealed that *A. cerealis* and *H. grisea* are suitable candidates for extraction of biologically active compounds against phytopathogens. Pitcher plant harbors many endophytic organisms and some of them have antagonistic properties in contradiction of fungal pathogens.

S-2 /NSIPS/P-5

Understanding the Biocontrol Mechanism of *Talaromyces flavus* against Bakanae Disease of Rice

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Fusarium fujikuroi is an important pathogen associated with the bakanae disease of rice effecting crop production all over the world. The pathogen has been known to produce large amounts of gibberellins (GA3) which effects growth, elongation, seed germination and flowering of plants. *Talaromyces flavus* is an important biocontrol agent used to control the pathogenicity and toxicity of the Fusarium pathogen. Activity of pathogenesis related (PR) proteins (chitinase, â-1-3, glucanase, catalase and phenylalanine ammonia lyase) were increased in rice plants in the presence of *Talaromyces flavus.* Flourescein diacetate (FDA) dye used to detect the cell viability of the rice roots indicated more viable cells in *Talaromyces flavus* treated plants. Increased expression of cell cycle related genes (Cyc-A1-1, Cyc-B1-1, Cyc-D3-1, CDKA-1 and CDKB1-1) were observed in root tips of the rice plant inoculated with

Fusarium fujikuroi and *Talaromyces flavus. T. flavus* application reduced bakanae disease severity and incidence by 70-75%. It decreased gibberellic acid concentration of pathogen by 41-79% depending on the isolates. Further, it also increased aboveground biomass, grains/panicle and yield of rice. These results suggested that *T. flavus* might be useful in biological control of *F. fujikuroi* responsible for the emerging bakanae disease of rice.

S-2 /NSIPS/P-6

In Vitro Screening of Native *Trichoderma* spp. and Rhizospheric Phosphate Solubilizing Bacteria (PSB) against Rice Sheath Blight Pathogen of Manipur

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Sheath blight is a devastating disease caused by *Rhizoctonia solani* Kuhn in rice crop. Biocontrol agents have great demand now-a-days as they might replace chemical pesticides to a large extent and being cost effective and ecofriendly. Investigation on the occurrence of native *Trichoderma* spp. and phosphate solubilizing bacteria (PSB) from rhizospheric soil of rice from different regions of the valley districts of Manipur were carried out during the year 2015-2016. Evaluation of the potential of native *Trichoderma* spp. and PSB were done under in vitro condition. Fifteen soil samples each from the four districts were collected randomly to isolate native *Trichoderma* spp. and PSB by using agar plate method. Isolates of native *Trichoderma* spp. were screened by dual culture method and phosphate solubilizing microorganisms were screened by evaluating phosphate solubilization index using Edi Premono method in National Botanical Research Institute's phosphate growth medium (NBRIP). Six isolates, three isolates, two isolates and four isolates of *Trichoderma* spp. were isolated from different regions of Thoubal, Imphal east, Imphal west and Bishempur district respectively. Thirteen isolates, one isolate and another one isolate of PSB were isolated from Bishempur district, Imphal east and Thoubal district respectively. All the *Trichoderma* isolates tested showed considerable level of antagonistic activity against *Rhizoctonia solani*, causal pathogen of Sheath blight.

S-2 /NSIPS/P-7

Mass Multiplication of *Trichoderma harzianum* and Standardization of Effective Dose for Management of Soil Borne Diseases

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It is widely known that *Trichoderma harizanum* shows antagonistic behaviour towards soil borne diseases. This biological means to control the disease offers and eco- friendly way to increase the production of agricultural and horticultural crops. Hence, it becomes imperative to characterize the antagonist means of its usage for disease control. A study was taken up to standardize the effective dose

for management of soil borne diseases. Initially mother culture of the antagonist fungal biomass broth were mixed with talc powder at 1:2 ratio. The mixture was air dried later mixed with carboxy methylcellulose (CMC) @ 5g/kg of the product. Thus obtained mixed powder was then packed in polythene bags used in further studies. They were then incubated at 280 C. Samples of *T. harizanum* talc were drawn at 0, 15, 20, 30, 60, 90, 120, 150 days after inoculation the population was estimated by serial dilution method using TSM. The results of the study to assess longevity indicate that the population of *T. harzianum* decreased significantly (10 X 10^6 to 2 X 10^6 cfu/g) over the period of its storage (150 days). In a study to ascertain optimal application levels for disease control, the red gram seeds of variety ASHA (ICPL -87119) were treated with formulations of *T. harzianum* at the rate of 2, 4, 6, 8, 10 g/kg of seeds. They were then planted in pots containing the inoculum of *Fusarium* sps. @ 10 seeds per pot. *Fusarium* wilt incidence was showed decreasing trend with increased application of talc-based formulation of *T. harzianum*. It reduced from 30.60% (in control) to 4.8% (10g/kg seeds). Application of carbendazim was also found to be compatible with antagonist (*T. harzianum*).

S-2/NSIPS/P-8

Eco- Friendly Management of Sun Flower Powdery Mildew Disease in Haveri District Of North Karnataka

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Roving survey was undertaken in different talukas of Haveri district during october 2016-17 in different villages of Ranebennur, Hirekerur, Shiggaun, Haveri, Savanur, Byadgi and Hangal talukas. In all the places, the crop was in seed filling to physiological maturity stage were noticed. Powdery mildew severity was much higher in Hirekerur, Haveri, Byadgi talukas and low powdery mildew severity was recorded in Savanur, Shiggaun and Hangal talukas. Based on survey report Hirekerur, Haveri and Byadgi talukas are hot spots for powdery mildew incidence in sunflower.

Results of the experiment clearly indicated that, there was significant difference between the various treatments with respect to the PDI and seed yield. Significantly lower per cent disease index was recorded in the hexaconazole – quinolphos spray (16.53%) followed by hexaconazole – vermiwash (25.47%) which was on par with the spray of hexaconazole – soldier (27.07%) and hexaconazole – cow urine (26.50%). Highest per cent disease index of 41.93% was recorded in unsprayed control which was on par with soldier – soldier (37.12%) and cow urine – cow urine (36.74%).

Significantly higher seed yield was recorded in hexaconaxole – quinolphos spray (14.53 qt/ha) followed by hexaconazole – vermiwash spray (12.97 qt/ha), hexaconazole – soldier (12.77 qt/ha) and hexaconazole – nimbicidine spray (12.00 qt/ha.) lower seed yield was recorded in unsprayed control (9.7 qt/ha).

S-2/NSIPS/P-9

Isolation of *Pseudomonas fluorescens* on Growth and Yield Attributes of Brinjal

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India is a leading vegetable producing country in the world and ranks second next to china. Brinjal (*Solanum melongena* L.), belongs to the family solanaceae and grown in the subtropical and tropical regions of the world. Brinjal is locally known as "Bengun" and called as "Eggplant" in European countries. Seed treatment with biological control agents reduced the incidence of bacterial wilt by more than 65 per cent compared to chemical control. Further, an increase of yield (28 to 54 per cent) was observed in the biological control agent treated brinjal plants. *Pseudomonas fluorescens* enhances plant growth, induces systemic resistance and reduce severity of many disease and increase in yield. There is possibility of using an indigenous strain of *Pseudomonas fluorescens* which belongs to plant growth promoting rhizobacteria (PGPR), to manage *Ralstonia solanacearum* which is one of the most devasting disease of the economically important brinjal crop. block design with three replications and nine treatments. The results of field experiment showed that treatment (T6) seed+ root+ soil treatment with *P. fluorescens* significantly increased the yield (390.00 qha-^{1}). *Pseudomonas fluorescens* recorded significant increase in plant growth and yield parameters of brinjal crop.

S-2/NSIPS/P-10

Potassium Solubilizing Bacteria (KSB): Efficient microbe for Sustainable Agriculture

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Potassium is one of the essential macronutrient and the most abundantly absorbed cation in higher plants. It plays an important role in the growth and development of plants. In addition to plant metabolism it improves crop quality as it helps in grain filling and kernel weight, it strengthens straw and helps plant to withstand stress. In soil, Potassium found mostly in soil mineral form (90-98%), which is unavailable to crop. The potassium solubilizing bacteria can made it available by slow solubilization or weathering. The experiment was carried out with object to isolate potassium solubilizing bacteria (KSB) from rhizosphere of maize from Western Maharashtra. Out of 21 collected soil samples, two isolates of KSB were obtained; which were further studied for their morphological, physiological and biochemical characteristics. An efficient strain of KSB i.e. *Pseudomonas* sp. was identified on the basis of its ability to release K by solubilizing muscovite mica. The field experiment was conducted in a randomized block design with three replications and eleven treatments to study effect of KSB on maize. The results showed that yield obtained with T7 (100% RDK + efficient strain of KSB) was significantly superior over other treatments. Potassium solubilizing bacteria have effectively increased germination, plant height, stalk yield, dry matter produce, grain yield of maize crop along with microbial population count of KSB in rhizosphere and K uptake.

S-2/NSIPS/P-11

Saffron Production and Constraints in Jammu and Kashmir

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Saffron (*Crocus sativus*) is one of the most important foreign exchange earners among the spices of India, grown entirely in the state of Jammu and Kashmir; about 49 per cent of its total produce is exported outside the country. Saffron is world famous high value low volume cash crop of the Kashmir. But during recently the area under cultivation, production productivity is on decline with the result the saffron cultivation is under threat in the state due to presence of lot of problems in the sector. Saffron has shown its role in disease prevention and its treatment. Its stigma shows antioxidant activity and thus prevents the degeneration of cells by free radicals. The components of saffron, crocin and safranal showed role in the suppression of inflammatory pain responses and decreased the number of neutrophils and also possess strong activity against bacteria and fungi. It is an important commodity and is of great significance in the agricultural economy of Jammu and Kashmir. Saffron is well known spice it has many other uses in industries such as food, pharmaceutical, cosmetic and perfumery as well as in the textile dyes. The matter of concern is that the Saffron cultivation has declined by 25 percent from 4161 hectares in 1998 to 3110 hectares in 2008. However, Saffron production is currently suffering on several counts, especially those relating to productivity as well as post-harvest management. The decline in the sector is also due to lack of irrigation facilities, a major problem and lack of research and developmental activities in the related field related to cultivation, sowing of corms, seed protection. Also there is existence of the various intermediaries in the marketing of the saffron production of which leads to adulteration of Saffron to degrade the quality of the Saffron with the mixture of the Iran Saffron which is not in comparison to the Kashmir Saffron which leads to fetch the lower prices to domestic cultivation in the state. The need of the hour is to make the National Mission on Saffron cultivation in the state more improved and strengthen the implementation of the programme for the fruitful results in the long run to benefit the farmers in the economy.

S-2/NSIPS/P-12

Utilization of Detoxified Castor Oil Seed Cake as Potential Fertilizer in Organic Agriculture

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As a remedial, safe and cost effective approach, the plant protectionist around the globe switched on to safer tactics using organic amendments as evidenced by sporadic literature to search for a better option against chemical farming. In continuance with search of safe sustainable components against

chemical based farming concentrating on soil health enriched by organic amendments including non-edible oil seed cakes viz. neem, castor, sal and karanj are in the forefront. Castor, *Ricinus communis*, is highly important industrial and non-edible oil crop in tropical and sub-tropical parts of the world capable of growing under low rainfall and also low fertility conditions. It is most suitable for dryland farming, the oil content of the seeds varying from 50-55%. After extraction of oil, castor cake is valued as manure. It contains 6.4% N, 2.5% phosphoric acid and 1% K and some micronutrients. Castor is also valued for its anti-termite properties in addition to being nematicidal as well. The presence of ricin, and an allergen restrict its use as livestock feed. India is the principal global producer of castor followed by China and Brazil. Utilization of deoiled castor cake for crop production has been investigated in the present paper which is done by treating the same with calcium hydroxide between 100-120 degree C 45 minutes completely removal of the toxic protein i.e Ricin. The fertilizer thus obtained after extracting out the toxic compound ricin the same was used under pot trials for the investigation in comparison to Neem, Sal, Karanj oil seed cake keeping adequate control which clearly showed outstanding performance by castor in respect plant growth parameters of tomato, the test plant.

S-2/NSIPS/P-13

Characterisation of Native Endophytic and Rhizospheric Plant Growth Promoting Microorganisms from Chak-Hao (*Oryzae sativa* L.) and High Yielding Rice Variety of Manipur, India

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Chak-hao (*Oryzae sativa* L) is aromatic black glutinous rice in Manipur, India which has aesthetic and nutraceutical properties. No systematic work on the improvement of Chak-hao has so far been taken up. However, germplasm collection, characterization and evaluation of these rice cultivars have been made. In this study, rice roots and rhizosphere soils from Chak-hao (Ch) and high yielding (Hy) rice variety across three districts of Manipur were analyzed for diversity of rhizobacteria by culture based classical and molecular technique. Endophytic and rhizosphere origin of bacterial and fungal isolates were assayed qualitative for four plant growth promoting (PGP) attributes such as nitrogen fixation, production of indole acetic acid (IAA) like substances, solubilisation of phosphate and ability to antagonise pathogenic fungi. A total of 170 bacteria and 55 fungi isolates were obtained from Chak-hao and high yielding rice roots and rhizosphere soils. 51.94 % of the bacterial isolates and 30.2 % of fungal isolates were phosphate solubilisers, 9.2 % of were Nitrogen fixer and 41.26 % of the bacterial isolates were IAA producers. Out of 55 bacterial isolates, 16.36% and 58.10% showed antagonism against *Fusarium oxysporium* and *Rhizoctonia solani* respectively. Fungal antagonism were observed based on Bell's scale and based on this scale 10 fungus (3 HY and 7 Chak-hao isolates) showed the scale of d" 2.5. The current findings have led to the selection of 11 bacterial strains with multiple Plant Growth Promoting attributes and 7 fungi possessing phosphate solubilization and antagonistic potentials. Comparison with Genbank databases revealed that bacterial 16s rDNA sequences are at least 98 – 99 % similar to those of known species of *Enterobacter, Bacillus* and *Pseudomonas* and fungal ITS sequences to those of

Penicillium, Trichoderma and *Aspergilus*. The Genbank analysis revealed the dominance of strains belonging to *Bacillus* sp. and *Penicillium* sp.

S-2/NSIPS/P-14

Morphology and *In Vitro* study of Bio agents, Plant Extracts and Chemicals against *Pestalotiopsis mangiferae* in Bishnupur District of Manipur

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A study was conducted *in vitro* condition to analyse the morphology and efficacy of bio agent, plant extract and some chemical against *P. mangiferae* which was collected from Bishnupur district of Manipur. The morphological characters under study consists of colony and conidial characteristics such as colour, shape, size and appendages. The cultural growth colour of *P. mangiferae* on PDA varied from concolour to versicolour fuliginous. The conidial shape varied from oval and spherical to elliptical with prominent appendages. The conidial lengthand width were 22.4 and 5.7 µm respectively. The diseased sample which was collected from Bishnupur district of Manipur consists of three septation and the number of conidial appendages was found three numbers. Among seven antagonists namely *Penicillium citrinum, Trichoderma atroviride, T. ovalisporum, Hypocrea lixii, T. harzianum* (69 & 131) and *T. asperellum evaluated in vitro, T. asperellum* showed the best in inhibiting the growth of the fungus (85.8%). Among three plant extracts viz. garlic, neem and sweet flag evaluated *in vitro*, garlic extract (3.0%) showed the best result (100.0%). Among the seven chemicals viz. carbendazim, thiophenate methyl, mancozeb, imidacloprid, fipronil, profenophos and thiomethoxam evaluated *in vitro*, thiophenate methyl (0.05%) and carbendazim (0.05%) showed the best result with 100.0 per cent inhibition in fungal growth.

S-2/NSIPS/P-15

Cow Urine Applications for the Management of Sheath Rot of Rice

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Studies were conducted to determine cow urine to management of sheath rot of rice. Cow urine completely inhibits the growth of *S. oryzae* under *in vitro*. Rice seeds treated with cow urine leads to stronger root growth, which helped in better establishment of the plant. Glasshouse and field studies were conducted to study the effect of cow urine applications for the management of sheath rot of rice. The results revealed the effectiveness of cow urine at 100 lit/ha in reducing the sheath rot disease incidence and severity, which resulted in significantly increase in yield under compared with untreated controls. Cow urine applied on rice plants has not caused either macroscopic or microscopic cell death. Management of sheath rot of rice with cow urine by foliar application was not statistically different from

that obtained with foliar application with carbendazim. Sheath rot disease was developed during the booting stage causes yield losses, when cow urine was applied this stage can manage disease severity and improve rice yield. Our *in vitro* tests demonstrated that cow urine contains ammonia and nitrous acid are highly toxic to *S. oryzae* and therefore, at least partially responsible for pathogen inhibition in urine treated rice plants.

S-2/NSIPS/P-16

Efficacy of Chitosan and *Trichoderma harzianum* Rifai against *Sclerotinia sclerotiorum*

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An antagonistic cosmopolitan fungi (*Trichoderma harzianum*) is well known for its ability to produce some active compounds that play important role in suppressing the growth of phytopathogenic fungi e.g. *Sclerotinia sclerotiorum* which causes *Sclerotinia* rot of carrot. Chitosan (poly-â-(1, 4) N-acetyl- D- glucosamine) derived from the outer shell of crustaceans, has become a promising alternative treatment due to its natural character, antifungal activity, and elicitation of defense responses in plant tissue In the present study we hypothesized to increase the biocontrol potentiality of *T. harzianum* by amending with chitosan at different concentration viz., 0.025%, 0.25%, 0.5%, 1%, 2% and 4%. To fulfill this an *in vitro* assay was made to evaluate the efficacy of chitosan on the growth of *T. harzianum* and its effect on *S. sclerotiorum*. Highest mycelial growth reduction of *S. sclerotiorum* was recorded at chitosan 4% concentration. Radial growth of *T. harzianum* gradually increased with increase in chitosan concentration at 48 hours. There was no significant difference in growth of *T. harzianum* at 1%, 2% and 4% concentration of growth. Although maximum mycelial growth of *T. harzianum* was recorded at 1% concentration of chitosan. In this study, we found that chitosan along with *T. harzianum* enhances biocontrol ability against *S.sclerotiorum*, restricting and delaying the mycelial growth of *S. sclerotiorum*.

S-2/NSIPS/P-17

Mitigation of Blast Disease and Drought in Rice through Use of *Trichoderma* spp

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Blast, a devastating fungal disease of rice is cosmopolite in its presence. The disease is favored by warm temperature and high moisture. A drought like situation also occurs at a similar temperature and moisture levels and aggravates blast disease (Bonman, 1992). *Trichodema harzianum* used to mitigate the disease as well as the effect of drought revealed a substantial reduction in disease incidence

and leaf rolling due to drought. Among three strains of *T. harzianum* used, 94(A) strain gave maximum reduction in disease incidence (21%).The other two strains (T14,IRRI2) also yielded similar results with insignificant difference. All the three strains resulted in significant improvement over the control. Leaf rolling recorded after inducing drought condition was significantly less than the control treatment.

The results correlated with biochemical changes revealed increasing phenolic content, peroxidise activity and phenylalanine ammonia-lyase activity which are indicative of resistance factors against disease. Further proline, malondialdehyde (MDA) content was marginally lower in comparison with untreated plants. The low accumulation of MDA content revealed reduced accumulation of lipid peroxidase in drought stress. Estimation of superoxide dismutase (SOD) activity was much higher in *Trichoderma* treated plants than the untreated ones. The SOD activity is considered to be a major factor for assessing the drought in rice plants because of its ROS (reactive oxygen species) scavenging antioxidant activities (Gill and Tuteja, 2010). Due to drought a severe loss is found in membrane stability of untreated plants, however, significantly less fluctuation in membrane stability index value was observed in treated plants.

S-2/NSIPS/P-18

Foliar Spray with Sheep Urine for the Control of *Cercospora* Leaf Spot in Bhendi

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Studies were conducted to determine the sheep urine to control *Cercospora* leaf spot disease caused by *Cercospora abelmoschi* in bhendi (*Abelmoschus esculentus* (L.) Moench). Sheep urine at 10% concentration completely inhibit the mycelial growth of *C. abelmoschi* under in vitro. Bhendi seeds when treated with sheep urine at 10% show significant increase in root length, shoot length and seedling vigour. Foliar spray with sheep urine applied for thrice at 10 days interval from the initiation of the disease under pot and field conditions. Sheep urine was found significantly reduced the disease intensity and significantly increases the fruit yield. Sheep urine applied on bhendi plants has not caused either macroscopic or microscopic cell death. Our *in vitro* tests demonstrated that sheep urine contains ammonia and nitrous acid are highly toxic to *C. abelmoschi* and therefore, at least partially responsible for pathogen inhibition. Sheep urine was effective in controlling *Cercospora* leaf spot in bhendi and may be recommended as alternatives in agroecological systems.

S-2/NSIPS/P-19

Eco-Sustainable Management of *Alternaria* Leaf Blight of Groundnut Using its Phylloplane Microbiome

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Groundnut (*Arachis hypogea*) is an important source of edible oil and protein. It is widely cultivated in tropical and subtropical climatic regions of the world. Diseases caused by more than 55

pathogens are one of the major constraints in attaining high production of groundnut as they reduce the yield to the tune of 70%. Among them, leaf blight of groundnut caused by *Alternaria alternata* is a major disease causing 22% of pod reduction and 63% of fodder reduction depending upon the severity. Use of chemicals for plant disease management has caused severe environmental deterioration and many health hazards. Therefore, integrating natural beneficial micro-biome in plant disease management is one of the best strategies to feed a growing world population amidst changing global climate. In the present investigation phylloplane microflora of groundnut were isolated, characterized and tested for their antagonism against *Alternaria alternata*. Five bacteria and five fungi exhibiting constant association with the host phylloplane were identified to be *Enterobacter cloacae, Paenibacillus* sp., *Erwinia* sp., *Micrococcus luteus*, *Bacillus subtilis*, *Colletotrichum gloeosporioides*, *Fusarium solani*, *Fusarium pallidoroseum, Aspergillus fumigates* and *Aspergillus flavus*. *In-vitro* study using dual culture technique revealed *Aspergillus flavus* and *Fusarium solani* as the most potent antagonistic fungal microbes inhibiting 84.18% and 73.2% growth of the pathogen respectively. Similarly, among bacterial population *Bacillus subtilis* exhibited the maximum degree of antifungal activity followed by *Micrococcus luteus*, inhibiting 78.37% and 76.74% growth of the test fungus respectively. To the best of our knowledge this is the first such study where phylloplane microbiome has been shown to be effective for the management of leaf blight of groundnut. Further studies in this regard in laboratory and field conditions can lead to commercialization of these phylloplane microbes which will offer an eco-friendly and sustainable management of *Alternaria* leaf blight of groundnut.

S-2/NSIPS/P-20

Optimization of Enhancement of Chitinase Production Media for Bio-Control Fluorescent *Pseudomonads* from Cheap and Readily Available Nutrient Sources by CCD and RSM

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Out of 160 native putative fluorescent *Pseudomonads*, isolated from different agro-ecological regions of West Bengal, India, 25 were found to be positive for extracellular chitinase enzyme production as observed by semi-quantitative spot assay on chitinase detection medium. With a quantification of chitinase production by spectrophotometric assay, *Pseudomonas aeruginosa* FPK22 was selected for chitinase media optimization. Ten different rudimentary media were composed with several cheap and readily available nutrient and substrate sources. Out of them the media composed with vermi wash (V), molasses (M), Baker's yeast (Y), crab shell powder (C) exhibited the maximum population of *P. aeruginosa* FPK22 and highest extracellular chitinase production. The media (VMYC) was then optimized by a four factor (A, B, C, D) central composite design (CCD) and response surface methodology. A second order polynomial model with the media composition and the response (Y), chitinase activity, was obtained with coefficient of determination (R2) value of 0.9093 and model F- value 10.74. The optimum concentrations of vermi wash (aqueous extract of vermi compost) (250g/l), sugarcane molasses (20.7g/

l), Baker's yeast (15g/l), crab shell powder (5.2g/l) were recorded from desirability function with a predicted value of chitinase activity of 1.125 EU/ ml. Ten repetitive runs were tested under the optimized condition of the four variables and observed that they yielded a range of 92.9-98.7 % of the predicted chitinase activity. The cost of production of optimized VMYC media was more than 14 times lower than standard King's B media.

S-2/NSIPS/P-21

Bio-control Potential of Native *Trichoderma* Isolates against Some Soil Borne Plant Pathogens under Agro-ecological Conditions of Bihar

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Trichoderma are widely known for their ability to suppress phytopathogens through competition for nutrients, antibiosis, production of cell wall degrading enzymes, induction of systemic resistance and myco-parasitism. Production of vegetable such as brinjal, bhindi, pea etc is badly hampered due to soil borne pathogens such as *Fusarium, Rhizoctonia, Sclerotinia* etc causing wilt and root rot in these crops. In this present investigation, various isolates of *Trichoderma*, isolated from the rhizosphere of different vegetable crops growing at Pusa farm or nearby area, were evaluated for their bio-control potential against *Rhictonia solani*, *Fusarium solani* and *Sclerotinia* sp. causing root rot of Bhindi, root rot of Pea and collar rot of Brinjal respectively. Out of 8-isolates of *Trichoderma* tested against *Sclerotinia* sp.(causing collar rot of brinjal), *Trichoderma* isolate-4 *Trichoderma* isolate -7 showed very promising effect with 40.93 and 31.60 percent reduction in colony diameter of the target pathogen .When *Trichoderma* isolates were targeted against *Fusarium solani* f.sp. *pisi*, all the isolates showed more than 78 per cent reduction in colony diameter of the target pathogen ,isolates *Trichoderma* isolate -2, *Trichoderma* isolate -6 and *Trichoderma* isolate -7 resulted in more than 78 percent reduction in colony diameter. When evaluated against *Rhizoctonia* sp. (causing root rot of Bhindi), *Trichoderma* isolate -1 and *Trichoderma* isolate -5 resulted in more than 50 percent reduction in colony diameter of the target pathogen. The Potential native *Trichoderma* isolates, found effective under laboratory condition were also evaluated for their effectiveness under field condition using them as soil treatment @ 5.0g and 10.0g/kg FYM (FYM used as substrate @ 200kg/ha). It was found that the *Trichoderma* isolates were quite effective in checking the development of root rot of Pea, collar rot of brinjal and root rot of Bhindi under sick soil condition in the year,2015-16 and 16-17. It was also clear that *Trichoderma* isolate-7 and *Trichoderma* isolate-2 were highly effective against root rot of Pea, *Trichoderma* isolate-7 showed most promising effect against collar rot of Brinjal and *Trichoderma* isolate-5 was most inhibitory to the development of root rot of Bhindi. The effectiveness of all the *Trichoderma* isolates was found to be greater at higher inoculums level (10.0 g/kg FYM) than at lower level (5.0g/kg FYM).

S-2/NSIPS/P-22

Induction of Resistance in Tomato Seedlings against *Alternaria* Blight through SA, ABA and *Pseudomonas fluorescens* Strain PBAT-2

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Alternaria blight is devastating disease of tomato. As the disease severity is more during fruiting stage, the toxic effects of fungicides also restrict the applicability of these chemicals. Induced resistance can be an alternative to chemical fungicide for the control of early blight of disease tomato. In present investigation, three resistance inducing agents namely Salicylic acid (SA), Abscisssic acid (ABA) and Plant growth promoting rhizobacteria (PGPR) *Pseudomonas fluorescens* strain PBAT-2 (Psf) were treated to tomato seedlings under glass house condition and their impact on reduction in disease severity, activity of defense related compounds namely Peroxidase (POD), Polyphenol oxidase (PPO), Phenyl ammonialyase (PAL) and total phenolic content and expression of defense gene viz Pathogenesis related gene PR-1 and â-1,3-glucanse (GLU) was studied. SA, ABA and Psf exhibited significant reduction in disease severity compared to control under glasshouse condition. Significant increase in activity of POD, PPO, PAL and total phenol content had been recorded in all the three treatments while minimal activity was recorded in control. POD, PPO and PAL level remain significantly higher at 24h and 48h post *Alternaria solani* inoculation followed by start declining. However, total phenolic content increased upto 72h. SA and ABA treated leaves, the expression of PR-1and GLU gene rapidly upregulated at 24 h after inoculation of *A. solani*. As PR-1 gene is an indicator gene of systemic acquired resistance. It implies that both in SA and ABA treatment systemic acquired resistance confers resistance in tomato plants against *A. solani*. There was no expression of PR-1 and GLU transcript in Psf treated plant as PGPR has no role in induction of PR protein in Induced systemic defense response (ISR). On the basis of findings of glasshouse, biochemical and gene expression analysis, it may be concluded that SA, ABA and Psf could induce resistance in tomato plants against *A. solani*.

S-2/NSIPS/P-23

Studies on Effectiveness of Antibiotics against *Xanthomonas axonopodis* pv. *citri* Causing Canker Disease in Citrus

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The citrus canker is a serious disease in most citrus species and cultivars in many citrus producing tropical and subtropical countries around the world including India. In our state Odisha it is a common and most devastating disease. It is very essential to manage the disease successfully in field condition.

Hence, the studies were conducted in the Dept. of Plant Pathology, College of Agriculture, Orissa University of Agriculture & Technology, Bhubaneswar – 751003,Odisha in the year 2017 on bio-efficacy of different antibiotics in vitro against *Xanthomonas axonopodis* pv. *citri* causing canker disease in citrus. The bacterial smear of 24 old culture was done on nutrient agar plate. For each antibiotic four sets of discs were used in one nutrient agar plate .Hence, fifteen no. of nutrient agar plates were used for fifteen different antibiotics like Levofloxacin ,Chloramphenicol, Streptomycin, Ampicillin,Ceftriaxone,Cefoperazone,Ceffixime,Cephotaxime,Tetracycline,Amikacin,Cefuroxime,Erythromycin,Rifampicin,Ciprofloxacin,Cefpodoxime were procured from HIMEDIA, Mumbai. All the antibiotics used in the experiment were in minimum inhibitory concentration. The selected antibiotic discs were placed aseptically on nutrient agar plates and incubated at 30+20C for 24 hours in a BOD incubator. The zone of inhibition was measured with the help of a inhibition zone scale. Then they were categorized into resistant and sensitive. It was revealed that all the antibiotics used have inhibiting property against *Xanthomonas axonopodis* pv. *citri*. The inhibition zone range varied from 10mm to 38mm (moderately sensitive to sensitive).The inhibition zone was maximum in Cephotaxime (38mm) followed by Levofloxacin (36mm). The lowest zone was found in Cetriaxone(10mm).The antibiotics Levofloxacin, Chloramphenicol, Streptomycin, Ampicillin, Cefoperazone, Ceffixime, Cephotaxi-me, Tetracycline, Amikacin, Erythromycin, Ciprofloxacin, Cefpodoxime were sensitive while Ceftriaxone, ,Cefuroxime, Rifampicin were less sensitive. These antibiotics may need further testing of their effectiveness in field condition.

S-2/NSIPS/P-24

Biocontrol Ability of Different Isolates of *Pseudomonas* and *Bacillus* against Early Blight of Tomato *In Vitro*

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In the present study twenty *Pseudomonas* and twenty *Bacillus* isolates exhibiting inhibitory affects against early blight of tomato caused by *Alternaria solani* in preliminary tests, were screened for their activity towards *A. solani* by a dual-culture in vitro assay on malt dextrose agar medium (MDA). Out of 20 *Pseudomonas* isolates tested, isolate P28 exhibited maximum inhibition (74.19%) against *A. solani* followed by P35 (69.13%). Similarly twenty *Bacillus* isolates were tested, isolate B299 exhibited maximum inhibition (61.94%) followed by B33 (58.53%) based on the in vitro test results. The isolates varied in their antagonistic ability against *A. solani*. While, all remaining isolates exhibited>50% or <50% antagonism showing their potential as biocotnrol agents.

S-2/NSIPS/P-25

Comparative Study of Population Density of Two Native *Trichoderma* Species on Locally Available Substrates

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Trichoderma is one of the common fungal biocontrol agents being used worldwide for efficient management of various foliar and soil borne plant pathogens. Mycoparasitism, spatial and nutrient competition, secondary metabolites, antibiosis by enzymes and induction of plant defense system are typical biocontrol actions of these fungi. Unlike chemicals, the establishment of these biocontrol agents in the targeted niche requires support even after their application. This experiment evaluated the effect of various easily available substrates on population density of two *Trichoderma* species isolated from paddy straw mushroom beds and rhizosphere of groundnut. It deals with evaluation of nine substrates viz. spent maize cob, Maize grain, Wheat grain, Fingermillet grain, Wheat bran, Paddy husk, Cotton waste, Farm yard manure and vermicompost after 20 days of inoculation. Among different substrates tested, vermicompost recorded maximum growth of *T. harzianum* (60.20 x 10^8) cfu g^{-1} followed by rice bran (37.53 x 108) cfu g-1 and maximum biomass production of (25.16 x 10^8) cfu g^{-1} in *Trichoderma* sp as grown in paddy husk followed by rice bran (13.36 x 10^8) cfu $g^{-1}$and finger millet grain (13.36 x 10^8) cfu g^{-1}. However cotton waste and Farm yard manure did not perform well giving the least fungal growth.

S-2/NSIPS/P-26

In Vitro Efficacy of Local *Trichoderma* Isolates against *Rhizoctonia solani* and *Fusarium* sp.

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Trichoderma spp. have been widely used as antagonistic fungal agents against several pathogens as well as plant growth enhancers, especially for managing potential soil borne pathogens including *Rhizoctonia* and *Fusarium*. Though both of them are soil borne pathogens, chemical control is not an economical preposition. Continuous chemical use leaves residues which is harmful to human beings and can lead to resistance development in pathogens. In this study six *Trichoderma* isolates were collected from different crop ecosystems and their mycoparasitism inhibitory effects were tested against the growth of *Rhizoctonia solani* and *Fusarium* sp. by dual culture technique *in vitro*. Almost all the isolates of the biocontrol agent tested recorded considerable inhibition, but among them Isolate-1 (isolated from Ground nut) recorded maximum of 74.3% PIRG (percentage inhibition of radial growth) in *R. solani* and 70.5% PIRG in *Fusarium* sp. followed by Isolate-3 (isolated from Paddy) which recorded 69.5% PIRG in *R. solani* and 66.2% PIRG in *Fusarium* sp.

S-2/NSIPS/P-27

Management of Metal Pollution in Water by Phytoextracting with Biochar of *Centella asiatica*

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In this work, a locally available plant found in Assam, *Centella asiatica*, has been put to good use for management of metal pollution in water. Biochar of *Centella* having heavy metal removal potential was studied with the help of batch experiments. The heavy metal that was used for the study was lead. The result obtained from the study showed that biochar of this plant has the potential to remove heavy metal from aqueous solution containing metal salts. The effect on the adsorption of various parameters, such as contact time, adsorbent dose, initial metal ion concentration, pH and shaking speed were also studied. To know the effect over rate and extent of adsorption, different isotherms like Langmuir, Freundlich and Temkin isothermic models and kinetic models like Pseudo First Order, Pseudo Second Order and Elovich kinetic models were used. The adsorbate was analysed in ICP – OES and the functional group present in the adsorbent responsible for biosorption was studied by using FTIR and RAMAN Spectrometer. The surface microstructure was studied with the help of SEM. The carbon, hydrogen and nitrogen percentage of the sample was also determined using CHN analyser.

S-2/NSIPS/P-28

Bio-Intensive Management of Major Diseases in Tomato at Golapar Area of District Nainital in Uttarakhand

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Tomato is one of the major crop in the Golapar area of District Nainital in Uttarakhand, where farmers are facing problem of diseases in tomato cultivation. In the present investigation a survey of tomato fields in the Golapar area of Haldwani block was conducted. The survey revealed the occurrence of late blight, early blight, leaf curl, stem rot and wilt diseases causing average loss of 80% to tomato. Effect of *Trichoderma harzinium* (Th 43). *Pseudomonas fluorescens* (Pf 173), Jas mycorriza (AMF) and fungicide (mancozeb) in different combinations applying through soil application (SA), seedling treatment (ST) and foliar spray (FA) were evaluated for growth promotion and disease control in tomato. In experimental field maximum plant height (43.67 cm), highest number of branches (7.33) per plant, highest weight of fruit (47g), highest number of fruits (39) per plant, minimum plant mortality (4% at 30 DAT & 3.2% in 30-60 DAT), minimum plant disease index (6.85), maximum total yield (256.00q/ha) and marketable yield (246.67q/ha) were observed in Th + Pf + JM (SA) + Th + Pf (ST) + Mancozeb (FS). At farmer's field minimum plant mortality (7.31%) at 30 days after transplanting (DAT) (5.73%) in 30-

60 DAT, minimum plant disease index (11.47), maximum yield 249.91q/ha was observed in Th + Pf + JM (SA) + Th + Pf (ST) + Mancozeb (FS) combination. Among all the treatments, integrated treatment comprising of soil application of *T. harzianum, P. fluorescens*, Jas Mycorrhiza (AMF) + seedling treatment with *T. harzianum and P. fluorescens* + three foliar sprays of mancozeb was found very effective in reducing the plant mortality, promoting the plant growth and increasing the yield at experimental field as well as at farmers field.

S-2/NSIPS/P-29

Eco-friendly Management of Sheath Blight of Rice in Uttarakhand

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Rice is a staple food for majority of the world population. Globally, Asia is the hub of 90 percent of world aggregate rice production with India responsible for 21 percent. Sheath blight caused by *Rhizoctonia solani* is the most important and devastating disease in rice. This disease causes 10-30 percent yield loss worldwide and may reach up to 50 percent during prevalent years. Keeping in view of public health, environmental safety and the ill effects of chemical pesticides, other sustainable disease control strategies such as biological control by antagonistic microorganisms is gaining momentum. The present investigation was undertaken to study an effective management strategies for sheath blight by using potential biological control agents. In present investigation eight potential biocontrol agents were evaluated for the management of sheath blight. Four isolates of *Trichoderma* (TCMS 9, 36, 43, 14), two isolates of *Pseudomonas fluorescens* (Psf 173, 2), one isolate of Bacillus spp. (N18) and one consortia of *Trichoderma* and *Pseudomonas* named PBAT 3 (Th 14 + Psf 173) were used. One fungicide carbendazim was used as standard chemical check and untreated was used as control. The plan of work involved isolation, identification (Pathogenicity test) and morphological characterization of the pathogen; field experiment for the management of sheath blight by using these potential isolates in 10 different treatments (3 replications) in RBD with different mode of applications like; soil treatment, seed biopriming, root dip treatment followed by three sprays of biocontrol agents. Disease assessment was done on the basis of disease incidence and disease severity. Effect on crop health improvement was recorded through plant growth parameters and yield attribute. All biocontrol agents when applied as seed + soil + foliar spray found effective in reducing disease. Minimum sheath blight disease incidence and severity were recorded with carbendazim (8.70% and 9.98%), PBAT3 (10% and 12.59%), followed by Bacillus N 18 (11.20% and 14.73%). But maximum yield was observed in PBAT3 (56.33 q/ha) followed by *Bacillus* N 18 (54.66 q/ha).

S-2/NSIPS/P-30

Application of Endophytic Bacterial Isolates for *Ex Vitro* Rooting in Tissue Culture Plants of Papaya

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Endophytes are microorganisms residing inside the plants without any apparent adverse effect on the host. Endophytic bacteria are isolated by surface sterilization of the plant material followed by plating ground tissue extract or by direct culturing of plant tissues on suitable microbiological medium for bacteria, fungi or actinomycetes. Endophytic bacteria have been isolated from a large diversity of plants. *Bacillus, Enterobacter, Klebsiella*, *Pseudomonas* and *Methylobacterium* spp. The total population density of endophytic bacteria observed depends on plant species, plant genotypes, plant growth, and environmental conditions. General application of endophytes include Phytostimulation, Pigment production, Enzyme production, Antimicrobial activity, Biocontrol agent. Papaya cv. Arka Prabhat was used for this experiment. Only 50% of plants showed ex vitro rooting upon inoculation of the endophytic isolates EB01-EB10.

S-2/NSIPS/P-31

Bioremediation of Methane via Methanotrophy under Environment Friendly Rice Disease Management System

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Reducing or/and eliminating greenhouse gas (GHG) emissions where possible is need of the hour to improve resilience in agricultural system to climate change. Thus, an attempt was made to integrate methane bioremediation via methanotrophy with available biocontrol technologies in order to reduce major rice diseases along with supplementary reduction of atmospheric methane emission in Sali rice crop system. Altogether seven numbers of methanotrophic bacterial strains were isolated from flooded rice fields and manure pit located in Jorhat and Sivasagar districts of Assam. All seven strains exhibited considerable methane oxidizing ability within the range of 142.99 to 241.62 µl ml^{-1} in hermetically closed flasks culture analyzed by gas chromatographic method. In the *in vitro* assay, four methanotrophic strains were found to be compatible with saprophytic plant growth promoting microbes (PGPM) *Trichoderma viride* and *Pseudomonas fluorescens* without any antagonistic activity in co-culture. Using these compatible microbial strains a liquid based consortium bioformulation was formulated and tested *in planta*. In pot grown winter rice (cv. Ranjit) crop the consortia bioformulation efficiently lowered bacterial leaf blight and sheath blight disease intensity to a minimum of 18.4 and 28.5 percent respectively when applied as soil, seed, root and foliar treatment. Similarly, different treatment combinations with the methanotroph-PGPM consortia resulted in 2.26 to 19.76 percent reduction in seasonal methane flux over absolute control. Here, we demonstrate a novel cost effective method to arrest the methane production concomitantly with rice disease management in Sali rice crop cultivation system without altering the normal crop management practices.

S-2/NSIPS/P-32

Population Dynamics of Effective Bioagents in Commercial Biopesticides Available in Assam Agro-Market

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Organic bioinputs, particularly biopesticides and biofertilizers have emerged as inevitable component in the present day agriculture in the context of worldwide importance of organic farming. In this regard, microbe based biopesticides could play important role in ecofriendly management of major crop pests and diseases. However, limited availability of quality biopesticides in the market is a hurdle to the farmers for organic conversion of their crop as well as their land. In the present study we have made qualitative as well as quantitative evaluation of about twenty biopesticides that are available in the agro-market of Kamrup, Jorhat, Nowgong, Sunitpur and Golaghat districts of Assam. Most of the biopesticides, failed to show significant population count of the effective bioagents. Biopesticides developed by Tropical Agrosystem (India) Private Ltd. of Egmore, Chennai, Taglife-V contained *Trichoderma viride* (3×10^7 cfu/g), Taglife-H contained *T. harzianum* (2×10^5 cfu/g); Tag-veria contained *Beauveria bassiana* (5×10^4 cfu/g), Tag-Monas contained *Pseudomonas fluorescence* ($1x\ 10^4$ cfu/g) and 'Tag-Nema' contained *Paecilomyces lilacinus* (7×10^5 cfu/gm). The biopesticides developed by Green harvest, Guwahati, Assam, viz., Trichogreen and Escort contained bioagent population of *Trichoderma* sp. ($1x\ 10^7$ cfu/g) and *Streptomyces* sps. ($4x10^6$ cfu/g), respectively. While, biopesticides developed by S.S. Biotech, Guwahati, Assam, Bioderma contained population of *Trichoderma* sp. ($1x\ 10^3$ cfu/g). The biopesticides developed by Prabhat Fertilizer & Chemical works, Karnal, Haryana, Prabhaderma' and Prabhapseudo contained population of *T. viride* ($8x\ 10^3$ cfu/g) and *P. fluorescence* ($1x\ 10^7$ cfu/g). However, biopesticides developed by Green harvest 'Control-9' was found to be contaminated. Similarly, biopesticides developed by Liebigs Agro Chem Pvt. Ltd., Kolkata, West Bengal, were contaminated and their products, viz., Pnther-TV contained T. viride ($2x\ 10^2$ cfu/g), Panther-PF contained *P. fluorescence* ($1x\ 10^2$ cfu/g), Panther-PL contained *P. lilacinus* (4×10^7 cfu/gm), Panther- BT contained *Bacillus thuringiensis* (7×10^4 cfu/gm). The companies claimed that their biopesticide products are effective against most of the soil borne diseases like *Rhizoctonia solani, Fusarium* sps., *Pythium* sps., *Ralstonia solanacearum* as well as some insect pests of vegetable, field, horticultural and plantation crops, which need to be investigated.

S-2/NSIPS/P-33

Isolation and Screening of Phosphorus Solubilizing and Cellulose Degrading Actinobacteria from Deep Water Rice Ecosystem

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Eleven actinobacterial isolates exhibiting high phosphate solubilizing as well as cellulose degrading ability *in vitro* were isolated from rhizosphere soil of deep water rice. These isolates were isolated and

purified on glycerol asparagine salt agar medium. The phosphate solubilization efficiency of isolates was evaluated by calculating solubilization index (SI) on Pikovskaya's agar that ranged from 1.3 to 3.0. The isolate, 'Act102' recorded the maximum SI of 3.0. The cellulase and hydrolytic capacity (HC) was confirmed with clear zone around the colony on ISP-2 medium with Congo Red. The HC of the isolates ranged from 1.5 to 2.6. Gravimetric method was used for determining the concentration of cellulose degradation in mineral salt medium with filter paper as the sole source of carbon and energy. All the isolates recorded more than 50 percent enzymatic degradation of cellulose. The maximum cellulose degrading efficiency was recorded by 'Act116' (75.7%). Cultural and biochemical properties of the isolates were studied following standard methods. All isolates produced tough texture colony with powdery-cottony aerial mycelium in specific media. In micro-morphology studies, long spore chains with branched filaments were observed in all the isolates which are characteristics of actinobacteria species. The cultural, morphological and biochemical studies suggest the isolates belong to *Streptomyces* species. Hence, these *Streptomyces* strains can be exploited as biofertilizers in rice ecosystem as well as in composting and decomposing cellulosic wastes.

S-2/NSIPS/P-34

Arsenic Bioremediation using Arsenic Resistant Bacteria from Agricultural Soil of Assam

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Arsenic contamination in the rice growing areas of Assam poses a major human health problem. The potential of Arsenic resistant bacteria (ARB) for bioremediation of arsenic in rice fieldsof Assam was explored. Out of six *Bacilli* bacteria isolated from arsenic contaminated rice fields of Assam, two bacteria could tolerate 1000 ppm of arsenic with 98.30 and 97.68 per cent absorption ability, respectively. Morphological, cultural, biochemical and ribotyping (16s rRNA sequence) revealed their phylogenetic similarity with *Paenibacillus* sp. and *Bacillus cereus.* Enzymatic assay experiment conducted to assay the activity of glutaredoxin-dependent arsenate reductase (glutaredoxin 2 from *E. coli*), with NADPH/ arsenate being the electron donor/acceptor. Compared to the control without protein extracts or glutaredoxin, arsenate reduction by *E. coli*glutaredoxin 2 was observed, with absorption decreasing at a rate of 0.0012 ABS/min. Both the isolate could oxidize arsenite to less toxic arsenate. There is a potential for utilizing isolated ARBs for integration with plant growth promoting microbes for management of plant diseases *vis-a-vis* Arsenic bioremidiation.

S-2/NSIPS/P-35

Efficacy of Microbial Consortia against Bacterial Wilt caused by *Ralstonia solanacearum* in Hydroponically Grown Bhoot Jolokia Plant

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Effectiveness of bacterial wilt of Bhoot jolokia was evaluated under hydroponic culture tank system. Compatibility of four potential microbial bioagents, *viz. Trichoderma viride, Bacillus thuringiensis, Pseudomonas fluorescens* and *Metarhizium anisopliae* were tested *in vitro* and the three positively compatible bioagents were further assess for their antagonistic properties *Ralstonia solanacearum*. Bioagents applied alone or as consortia, significantly reduced bacterial wilt incidencepathogen *in vitro* producing varying sizes of inhibition zones in TTC medium. The inhibition produced by the combination of three antagonists *T. viride, B. thuringiensis* and *P. fluorescens* was significantly highest (70.27%) followed by combination of two bioagents *T. viride* and *Bacillus thuringiensis* (63.83%). This was followed by *T. viride* and *P. fluorescens* (59.84%).The combination of three antagonists *T. viride, B. thuringiensis* and *P. fluorescens* could also significantly reduce bacterial wilt incidence of Bhoot jolokia in hydroponic culture tank.

S-2/NSIPS/P-36

Evaluation of Potential Bacterial Endophytes against Major Vegetable Pathogens of Meghalaya *In Vitro*

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Utilisation of the endophytes against the plant pathogen is becoming a new trend for the disease management. Bacterial endophytes have beneficial effects on host plants in terms of growth promotion and in suppression of diseases. For the management of the diseases, different fungicides have been used that leads to the residue deposition and known to cause various environmental and health hazards. Native endophytes could be the alternative for chemicals as a component of Integrated Disease Management (IDM) in the North-Eastern Hill State, Meghalaya, India. Therefore, the present investigation has been formulated to evaluate the potential bacterial endophytic antagonists against major vegetable pathogens. Forty two (42) bacterial endophytic isolates have been evaluated against 4 major vegetable pathogens *viz; Colletotrichum lindemuthianum, Phomopsis vexans, Alternaria brassicola* and *C. capsici*. Dual culture assay was carried out where most of the bacterial endophytes showed inhibition against tested fungal pathogens. However, NGB 21-3 showed best inhibition against

*C. lindemuthianu*m (60.49 %) and *C. capsici* (55.92 %), isolate BE-1-3 against *P. vexans* (71.85 %) and SVC 11 -3 was recorded best inhibition against *Alternaria brassicola* (63.70 %). On the other hand, SAB1-3 and MB 3-4 were observed for lowest inhibition as compared to the other isolates. Best performed bacterial endophytes (NGB 21-3, BE-1-3 and SVC 11-3) should be evaluated further under field conditions to developed consortia against major vegetable pathogens of Meghalaya.

S-2/NSIPS/P-37

Endophyte Bacillus and Fluorescent Pseudomonads Associated with Cultivars of Mustard Crop as Antagonists of *Alternaria brassicae*

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Endophyte bacteria are increasingly recognized as promising source of novel organic natural metabolites for a variety of biological activities. *Alternaria* blight is one of the major constraints of higher productivity of mustard crop in rice-fallows of northeast India. Endophytes, *Bacillus* and fluorescent Pseudomonads of different cultivars of mustard crop from the northeast region of India are seldom reported for their use as potential biocontrol agents in rice-fallow rotation. This study isolated 33 bacterial endophyte from seed and root portions of 13 cultivars of mustard crop grown in uniform pot experiment. Out of 33 isolates, identity was confirmed for 12 isolates as *Bacillus* spp. and 10 isolates as fluorescent Pseudomonads and these isolates were tested for their biocontrol efficacy against *Alternaria brassicae* inciting blight disease in mustard. Tentative identification of *Bacillus* and fluorescent Pseuodomonads were confirmed based on their cultural, morphological, and biochemical properties. Out of 22 tentatively identified isolates, EB-JH2, EB-MN1 and EFP-MN4 recorded the minimum mycelial growth with maximum inhibition zone of pathogen over control. It was found that the *Bacillus* sp. (isolate EB-JH2) was more effective in terms disease suppression of *Alternaria* blight (60.98%). The isolate EB-JH2 seems to be a potential candidate for developing biocontrol formulation for use against *Alternaria* blight and plant growth promoting benefits to mustard crop.

S-2/NSIPS/P-38

Bio-priming treatment for management of damping-off of chilli

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Chilli is one of the important spice-cum-vegetable. Among fungal diseases, damping-off caused by *Pythium aphanidermatum*, in nurseries is a major constraint in chilli production causing 60 per cent plant death, either pre-emergence or post-emergence of seedlings. Present experiment was carried out *in vitro* and pot culture to observe the effect of bio-priming and dry seed treatment of bio-agents and

metalaxyl against *Pythium aphanidermatum*. Results revealed that bio-agents, *T. harzianum and T. viride* recorded maximum mycelial growth inhibition (63.35 and 54.97%, respectively) of the test pathogen and fungicide metalaxyl @ 0.1 and 0.2 per cent was found most effective in inhibition of mycelial growth (100%), of the test pathogen, over untreated control. In seed bio-priming test, significantly least pre-and post-emergence mortality was resulted with metalaxyl (7.40 and 22.22%, respectively), with 76.49 and 76.00 per cent reduction in damping-off incidence, over untreated control, followed by bio-priming with *T. harzianum* and *T. viride*.

S-2/NSIPS/P-39

Phytopathogenic Biocontrol Agents and Entomopathogens can Successfully Inhibit the Radial Growth of *Fusarium oxysporum* f. sp. *ciceri* causing Chickpea Wilt

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Chickpea is an important pulse crop of India but its productivity is quite low due to several biotic and abiotic stresses. Among the biotic stresses, diseases are the major constraints. Wilt caused by *Fusarium oxysporum* f. sp. *ciceri* has been considered as devastating disease causes yield loss upto 10% per annum. Present study was carried out to study the *in vitro* efficacy of one phytopathogenic biocontrol agent viz., *Trichoderma asperellum* and two entomopathogens viz., *Metarizium anisopliae* and *Beauveria bassiana* alone and in comination with other against *F. oxysporum* f. sp. *ciceri*. Comparison was made with chemical check (carbendazim @ 0.1%). Result showed that when three biocontrol agents were inoculated simultaneously the radial growth inhibition of the tested pathogen was found to be the highest 81% as compared to individual efficacy of the biocontrol agents. This was followed by combination of both *M. anisopliae* and *T. asperellum* with radial growth inhibition of 73.11%. Thus we can conclude that *T. asperellum*, *M. anisopliae* and *B. bassiana* are the potential biocontrol agents against the wilt pathogen of chickpea.

S-2/NSIPS/P-40

Bio-Priming of Soybean Seeds with *Trichoderma* Species to Combat Root Rot Pathogen *Rhizoctonia solani* Kuhn

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Soybean [*Glycine max* (L.) Merrill] is economically an important crop having worldwide adaptation. The present investigation was carried out to determine the effect of seed bio-priming with bio-agents, namely- *Trichoderma harzianum*, *T. viride* and *T. koningii* against root rot pathogen *Rhizoctonia solani* Kuhn, which causes the most destructive soil-borne disease of soybean. In the dual culture under *in vitro* condition, significant inhibition of *R. solani* was observed by *T. harzianum* and *T.*

viride and carbendazim @ 0.1% (as check) inhibited cent per cent growth of *R. solani*. Soybean seeds primed with *T. harzianum* resulted maximum root length elongation, followed by treatment with *T. viride*. In the *in vivo* experiment, seed primed with carbendazim showed minimum root rot disease incidence with maximum root length whereas highest plant height, number of leaves, fresh weight, dry weight with highest yield of seeds was obtained from the seeds primed with *T. harzianum* which was followed by *T. viride.*

S-2/NSIPS/P-41

In Vitro Evaluation of Commercially Available Plant Oils against Grey Blight Disease of Tea

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Grey blight of tea caused by *Pestalotiopsis theae* poses a great threat to the tea industry and has been reported to occur in almost all tea growing countries of the world leading to severe economic loss. Plant oils are now a days more preferred by the tea growers for controlling major insect pests *viz*., tea mosquito bug (*Helopeltis theivora*), red spider mite (*Oligonychus coffeae*), lopper caterpillar (*Biston suppressaria*) etc. So, the present study was made to evaluate the efficacy ofdifferent commercially available plant oils, *viz.*, neem (*Azadirachta indica*), karanj (*Millettia pinnata*), lemon grass (*Cymbopogon flexuosus*) and patchouli (*Pogostemon cablin*) against grey blight pathogen of tea, *P. theae in vitro.* The concentration of different oil used was @ 1.0 per cent. Copper oxychloride @ 0.20% was used as a positive control. Results revealed that neem oil could produce maximum suppression (90.41%) of mycelial growth over control which was followed bykaranj oil (85.34%), lemon grass oil (70.31%) and patchouli (63.43%). The positive control copper oxychloride showed 95.67% inhibition of *P. theae*. The findings show encouraging results that the plant oils which are generally used as insecticide suppressor could also serve as antifungal agent. The study also updated the usefulness of current strategies based on biological control for effective management of grey blight disease to achieve optimum effects in terms of lowering production cost, reducing environmental contamination, loss of biodiversity, delaying the development of resistant pest biotypes and above all minimizing the pesticide residues in tea to enhance potential of export business.

S-2/NSIPS/P-42

Studies on Antimicrobial Activities of Some of the Indigenous Herbs against *Aureimonas altamirensis,* an Opportunistic Human Pathogen Associated with Cotton Fabric

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The inherent properties of the textile fibers provide scope for growth of various forms of microorganisms. In some cases, these microorganisms lead to unpleasant odors, staining, fabric

deterioration, and even can cause physical irritation, such as skin allergies, skin infections and other medical issues. *Aureimonas altamirensis* is an aerobic Gram-negative bacillus and is a potential opportunistic pathogen of humans, causing inflammation of the lining of the inner wall of the abdomen (peritoneum). The bacterium was recently found to be associated with used cotton fabrics of hot and humid climatic conditions of Assam and was reported to be associated with cotton fabric deterioration. This raises potential scope for the microorganism to enter into the elementary canal of the user from cotton fabrics. Bioremediation is a natural and cost effective method to deal with microorganisms and can be perceived by public as an acceptable treatment process for different microbial agents. Therefore, we initiated this work to test antimicrobial susceptibilities of *Aureimonas altamirensis* against 22 local herbs with known ethno-medicinal values using the agar diffusion method. *Syzgium cumini* and *Phyllanthus fraternus* showed the best results against the pathogenic bacterium *A. altamirensis.* It was also found that the antimicrobial properties of the two plant extracts can remain till 11 washes and laundering procedures. These results will help to formulate herbal extract recipes to stop microbial contamination in cotton fabrics and will assist the community to get rid of humidity related health issues.

S-2/NSIPS/P-43

Evaluating the Antibacterial Efficacy of Crude Extracts and Essential Oils of Medicinal Plants against *Ralstonia solanacearum*

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Ralstonia solanacearum, a soil borne bacterial pathogen, is a major limitation in the production of a wide range of economically important crops. Bacterial wilt caused by the pathogen is one of the most important plant diseases in tropical agriculture. The present study was carried out to screen the antibacterial properties of some medicinal plants against *R. solanacearum*. Antibacterial activity was evaluated using crude plant extract from five medicinal plants *viz*. *Ocimum gratissimum* L., *Vitex negundo* L., *Alium sativum* L., , *Ferula assafoetida* L, *Cucuma longa* L. and essential oils from two medicinal plants *viz*. *Ocimum gratissimum* L., *Eucalyptus maculate* L. The *in vitro* assay elucidated the antibacterial efficacy of *O. gratissimum* L. essential oil and *A. sativum* L. crude extract against *R. solanacearum*. Of all the treatments, essential oil of *O. gratissimum* L. showed the highest inhibition zone (52 mm) followed by crude extract of *A. sativum* L. (30 mm), indicating high antibacterial efficiency against *R. solanacearum*. Though the antibacterial activity exhibited by essential oil of *O. gratissimum* L. was very high, surprisingly its raw crude extract showed no inhibitory action. This provides an indication that active principle for antibacterial activity of *O. gratissimum* L. lies in its essential oils and the extraction method used for preparation of crude extract was inefficient in release of sufficient quantity of oil due to high volatility of oil leading to escape or evaporation of oils during extraction, leading to the inefficacy of the crude extracts.

S-2/NSIPS/P-44

Assessment of Organic Amendments on Population Dynamics and Incidence of *Rhizoctonia* Rot of Gram

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Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops in India. The crop is grown in Western Maharashtra mainly in *Rabbi* season. The chickpea is severely attacked by *Rhizoctonia bataticola* (*R. bataticola*). Organic amendments, such as neem, soybean, castor, safflower, groundnut cakes and vermicompost, compost, FYM, gypsum, poultry manure were applied to chickpea, which was reduce the incidence and survival of *R. bataticola*. Many of these amendments reduced pathogen population. The lowest *R. bataticola*population was observed in neem cake treatment (4.5×10^{-3}/g) followed by castor cake (6×10^{-3}/g) and cotton cake (8×10^{-3}/g) as compared to control (30.5×10^{-3}/g). In case of organic amendment level assessment it observed that as level increases the population of microbe's decreases. Least incidence of *Rhizoctonia* root rot was observed in neem cake treatment (0-10%) followed by gypsum and poultry (5-10%) at different growth stages as compared to control (70%) Groundnut cake (15-40%) and safflower cake (25-35%) showed least adverse effect over incidence *Rhizoctonia* rot of chickpea.

S-2/NSIPS/P-45

Efficacy of Botanical Extracts against *Corynespora cassiicola* causing Leaf Spot of Cowpea (*Vigna unguiculata* (L.) Walp.)

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Cowpea is one of the important legume crops native to central Africa, belongs to family Fabaceae. Leaf spot of cowpea is one of the important diseases of cowpea in Assam. Studies were conducted on the efficacy of botanicals against *Corynespora cassiicola* under *in vitro* conditions. Five locally available botanicals namely *Allium sativum*, ***Capsicum chinense*** **JAQC**, *Peperomia pellucid, Phlogocanthus thyrsiflorus* and *Amaranthu stricolor* L. var. *Tristis* (Prain) Nayar, were screened against the pathogen in laboratory conditions. The extracts of different botanicals were tested at 5, 10 and 15 percent against *C. Cassiicola* following poisoned food technique. Among five botanicals tested against *C. cassicola*, garlic extract at 15 percent was found best. This was followed by ***C. chinense*** **JAQC**, *P. pellucid, A. tricolor*L. var. *Tristis* (Prain) Nayar and *P. thyrsiflorus*. Least growth inhibition of *C. cassiicola*was obtained in *P. thyrsifloru* extract.

S-2/NSIPS/P-46

Molecular Identification and *In-Vitro* Management of Mango Stem-End Rot Disease in Manipur

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Mango Stem end rot, a post-harvest disease has caused intense damage to mango production as well as in export. Present study was undertaken to identify and eco-friendly management of stem end rot of mango in Manipur. Molecular identification of the associated pathogen was done after Pathogenicity test by using ITS sequencing and found to be *Lasiodiplodia theobromae* (NCBI Accession no-MG273759). *In vitro* study on the effect of different Plant extracts (Garlic, Ginger and Neem of 1.25%, 2.5% and 5%) and *Trichoderma* isolates (eight) were taken for the present study. Results showed that among the botanical extracts of 1.25% 2.5% and 5%, Garlic was the most effective showing 100 per cent inhibition in all three concentrations. Among the *Trichoderma* isolates, for dual culture *T. harzianum* was the most effective showing 77 per cent inhibition, for non-volatile compounds, in 7.5% *T. koningiopsis* showed 100 per cent and in 15% *T. harzianum* was the best showing 100 per cent and for the volatile compounds, *T. asperellum* was the best showing 84 per cent respectively.

S-2/NSIPS/P-47

Effect of Different Organic Amendment on Population Dynamics and Incidence of *Fusarium* Wilt in Chick Pea

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Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops in India. The crop is grown in Western Maharashtra mainly in Rabbi season. The chickpea is severely attacked by *Fusaruim oxysporium* f. sp. *ciceri* (*F. oxysporum* f. sp. *ciceri*). Organic amendments such as neem, soybean, castor, safflower, groundnut cakes and vermicompost, compost, FYM, gypsum, poultry manure were applied to chickpea, which was reduce the survival and incidence of *F. oxysporum* f.sp. *ciceri*. Among above amendments reduced pathogen population. The population of *F. oxysporium* f. sp. *ciceri* was least in neem cake (4×10^{-3} /g) followed by cotton and castor cakes and the highest in control followed by groundnut (22×10^{-3} /g), safflower (21×10^{-3} /g) cakes. Chickpea wilt disease were the lowest observed in neem cake treatment (0-10%) and the highest in control (70%) followed by groundnut (25-35%) and soybean (25%) cakes.

S-2/NSIPS/P-48

Eco-friendly Management of Wilt of Pea with Botanicals and Bio-control Agents

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Pea (*Pisum sativum* L.) is a very common nutritious vegetable grown in the cool season throughout the country. It is an excellent food for human consumption containing protein (7.2%), carbohydrates (15.8%), vitamin 'A' and minerals. Pea grains are rich source of protein and also known as common man's meat. The potential yield of this important pulse crop is limited due to many biotic stresses and among them *Fusarium* wilt of pea is very serious and is responsible for widespread damage upto 50 to 60 per cent, affecting yield potential and quality. Antifungal potential of aqueous extracts of six botanicals at three different concentrations were evaluated in vitro for their efficacy against *Fusarium oxysporum* f. sp. *pisi* by "poisoned food technique". Results obtained on in vitro evaluation revealed that all the test plant extracts significantly inhibited growth of *Fusarium oxysporum* f. sp. *pisi* over untreated control. Highest inhibition on mycelial growth of the pathogen was recorded in *Allium sativum* showed 100%, 85.1% and 73.9% inhibitions at 4%, 2% and 1% concentrations followed by *Curcuma longa* 53.4%, *Azadirachta indica* 55.6%, *Zingiber officinales* 20.1%, *Aloe barbadensis* 19.2% and *Lantana camara* 18.1% inhibitions at 6% concentrations. Mancozeb at 0.05 showed 49%, 0.1 and 0.2% showed 57% and 69.8% inhibitions as a check fungicide. The effect of volatile compound produced by *Trichoderma* spp. against the pathogen showed inhibition ranged from 18.6 to 62.4 percent where the highest inhibition was recorded with isolate CAUNCIPM-69 (62.4%) and for non-volatile compound it was ranged from 7.02 to 14.5 percent at 7.5 % v/v concentrations and from 7.3 to 20.9 percent at 15 % v/v.

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In Vitro Study on Eco-friendly Management of Wilt of Pea with Botanicals and Bio-control Agents

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Pea (*Pisum sativum* L.) is a very common nutritious vegetable grown in the cool season throughout the country. Its grains are rich source of protein and also known as common man's meat. The potential yield of this important pulse crop is limited due several biotic or abiotic stresses and among them *Fusarium* wilt is very serious disease and is responsible for widespread damage upto 50-60 per cent. Antifungal potential of aqueous extracts of six botanicals (three different concentrations) were evaluated in vitro for their efficacy against *Fusarium oxysporum* f. sp. *pisi* by "poisoned food technique". Results obtained

on *in vitro* evaluation revealed that all the test plant extracts significantly inhibited growth of *Fusarium oxysporum* f. sp. *pisi*.. Highest inhibition on mycelial growth of the pathogen was recorded in *Allium sativum* of 100, 85.1 and 73.9 percent inhibitions at 4, 2 and 1% concentrations followed by *Curcuma longa, Azadirachta indici*a, *Zingiber officinales*, *Aloe barbadensis* and *Lantana camara*. Effect of volatile compound produced by *Trichoderma* spp. against the pathogen showed inhibition ranged from 18.6 - 62.4 percent and highest inhibition was recorded with isolate CAUNCIPM-69 (62.4%). Effects of non-volatile compound against the pathogen were ranged from 7.02 - 14.5 per cent at 7.5 % v/v concentration and from 7.3 - 20.9 per cent at 15 % v/v.

S-2/NSIPS/P-50

Combined Efficacy of Microbial Antagonists with Jatropha Oil for Suppression of Bacterial Wilt Pathogen *Ralstonia solanacearum*

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The oil extracted from seeds of the Jatropha tree (*Jatropha curcas*) has been found to possess molluscicidal, insecticidal, antibacterial, fungicidal and rodenticidal properties. Bacterial wilt caused by *Ralstonia solanacearum* is one of the most destructive diseases of solanaceaous crops like tomato, brinjal, chilli, etc., in Assam and other North-Eastern states causing significant yield loss. The present study was made to evaluate the enhanced efficacy of microbial bioagents by Jatropha oil leading to better suppression of *R. solanacearum in vitro*. The studies revealed that Jatropha oil at 3 different concentrations, viz., 5000 ppm, 10000 ppm & 50000 ppm could suppress the pathogen upto an extent of 25.3 %, 64.0 % and 66.2 % respectively. A positive interaction among Jatropha oil with five potentially effective microbial antagonists, viz., *Pseudomonas fluorescens, Bacillus thuringiensis, Beauvaria bassiana, Metarhizium anisolpliae* and *Trichoderma viride* was recorded. Amongst these, *T. viride* showed highest compatible interaction followed by *P. fluorescens, B. thuringiensis, B. bassiana* and *M. anisopliae,* showing minimum growth reduction of 0%, 4.82 %, 7.55%, 10.50 % and 17.31 %, respectively. Thus, combining Jatropha oil with microbial antagonists seems to have good prospect of enhancing the efficacy of the combination for management of bacterial wilt caused by *R. solanacearum* in solanaceaous crops.

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Ecofriendly Management of *Fusarium* Wilt Disease in Tomato Caused by *Fusarium oxysporum f. sp. lycopersici*

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Tomato (*Lycopersicon esculentum* Mill.) of Solanaceae family is considered as one of the world's most popular vegetable (Pritesh *et al*., 2011). Tomato crop is challenged by various pests and

diseases among which the fungal disease, fusarial wilt caused by *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.) W.C. Snyder and H.N. Hans, is considered to be very important and the losses have been estimated at up to 90%.

Use of chemical fungicides, have adverse environmental effects causing health hazards to humans and other non-target organisms, including beneficial life forms (Schickler and Chet, 1997). So as an alternative to synthetic chemicals, ecofriendly natural products viz., plant products, animal excrements, seaweeds and bio agents were screened against *F. oxysporum* f.sp. *lycopersici*.

Among the various substrates viz., sorghum straw, sorghum glumes, grains, fiber, sand maize medium and sugarcane trash tested, highest colony forming units were formed in sorghum straw, highest microconidia and macroconidia production were recorded in sorghum fiber and sorghum glumes respectively.

Among six different plant products, natural products and sea weeds tested, *Allium sativum extract, Azadirachta indi*ca extract and *Lawsonia inermis* extract @ 20% concentration; cow urine, hen litter and buffalo urine@ 20% concentration; *T. conoides* (brown algae), *U. lactuca* (green algae) and *S. wightii* (brown algae) were found to successfully inhibit the mycelial growth of *Fusarium oxysporum* f. sp. *lycopersiciin* the decreasing order of merit. The population of *F. oxysporum* f.sp. *lycopersici* in the soil showed drastic reduction when treated with Carbendazim @0.1% followed by application of *Trichoderma viride and* cow urine which was on par with *A. sativum* extract.

S-2/NSIPS/P-52

In Vitro Evaluation and Characterization of Bacterial Antagonists against *Alternaria ricini* Infecting Castor in North-Eastern India

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Castor (*Ricinus communis* L) is an important non-edible, export oriented industrial oilseed crop in India and also the primary food plant of Eri silkworm (*Samia ricini*). The pathogen *Alternaria ricini* can able to attack all the aerial plant parts of castor. The disease has the potential to reduce leaf yield up to extent of 21%. The applications of chemical fungicides are not recommended in ericulture due to their serious hazardous effect on silkworm; hence biological control is an alternative approach as it is safe, effective and eco-friendly for disease management. In this view, the study was conducted to test the antifungal activity of bacterial antagonists against the leaf blight of castor. In the present study a total of 57 bacterial isolates were obtained from the castor rhizosphere and subjected to antifungal activity against *Alternaria ricini*. Among the bacterial isolates tested, 6 isolates were found to restrain the pathogen. The isolate LRP- 2 showed the maximum inhibition against test pathogen followed by HF-3, HF-1, KM-2, KB- 4 and UR- 6 over the control. Biochemical characterization of the bacterial antagonists revealed that LRP- 2 has the ability to utilize wide variety of carbon sources, and hence it could be suggested as a biocontrol agent against *A. ricini* in caster growing areas of North-eastern India.

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A Study on the Impact of *Trichoderma* Isolates on the Growth Promotion and Defense Strategies in Rice Cultivars against *Dreschlera oryzae*

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Three strains each of *Trichoderma harzianum* and of *Trichoderma asperellum* were selected for the study of growth promotion and induction of resistance in three cultivars of rice (*Oryzae sativa* L). Seed coating and foliar spray of all the six different strains of *Trichoderma* caused plant growth promotion but significant increase was obtained in case of *T. harzianum*. All these strains exhibited antagonistic activity against *Dreschlera oryzae in vitro.* Disease incidence was markedly reduced following application of *Trichoderma* with a sharp increase in polyphenolic accumulations and activities of four major defense enzymes (peroxidase, phenylalanine ammonia lyase, chitinase and glucanase). Biochemical parameters such as total soluble proteins and reducing sugar were also evaluated following treatment. HPLC analysis of treated inoculated plants showed the highest level of phytoalexin accumulation suggesting induction of resistance in rice plants against brown spot disease.

S-2/NSIPS/P-54

Determination of Antifungal Activity of Rahmnolipid Biosurfactant against *Rhizoctonia solani* f. sp. *sasakii* for Management of Banded Leaf and Sheath Blight of Maize

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Banded Leaf and Sheath Blight (BLSB) disease is most prevalent in south and south-east Asian countries, is caused by a soil born pathogen *Rhizoctonia solani* f. sp. *sasakii* (Kuhn) Exner. Crop damage is caused by loss of photosynthetic leaf area and stalk rot, leading to crop lodging. Maximum damage occurs when the fungus infects the ears/cobs.Management of BLSB through chemical is still the mainstay till date. Alternative management strategies are needed for management of BLSB for rising environmental, ecological and health concerns due to use of chemicals in plant disease management, for which employment of organic molecules can be a viable alternative. Biosurfactants are a structurally diverse group of surface active molecules produced on living surfaces mostly on microbial cell surfaces or excreted extracellularly and contain hydrophobic and hydrophilic molecules that confer the ability to accumulate between fluid phases, thus reducing surface and interfacial tension. In the present investigation fungistatic activity of rahmanolipids was evaluated upto 4 generations in biosurfactant amended media

(@ 50ppm) adopting food poison technique. The per cent inhibition in mycelial growth was increased from generation 0 to generation 3 and afterwards decreased. Maximum inhibition (73.33 %) in mycelial growth was observed in third generation followed by second generation (71.56 %) and first generation (70.22 %) while minimum inhibition in mycelial growth (69.11 %) was observed in fourth generation. Growth rate of recovered mycelium was less than the control mycelium in un-amended media. It indicated the effect of biosurfactant persists in subsequent sub-culturing (generation) of the pathogen. However, exact mechanism of action of the biosurfactant on *R. solani* f. sp. *sasakii* is needed. The study suggests further exploration of biosurfactant for management of *R. solani* f. sp. *sasakii* in maize and other crops.

S-2/NSIPS/P-55

Elicitation of Defense Response in Late Planted Wheat Plants against Spot Blotch with PGPR Priming

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Spot blotch in wheat caused by *Bipolaris sorokiniana*, which becomes most damaging under late sown condition. Late sown cultivars get exposed to warm and humid *weather* which is conducive for *spot blotch* disease development. In the present study it was observed that effect late planting considerably increased spot blotch incidence in wheat plants. Two selected PGPR were tested to determine their effect on disease development as well as inducing resistance in late planted wheat against spot blotch. PGPR reduced disease severity as well as induced antioxidative defense response in these wheat plants. Accumulation of phenolic compounds in treated and inoculated plants in comparison with untreated healthy plants was analysed by HPLC which revealed increase in phenol accumulation. Defense enzymes- chitinase, â 1-3 glucanase, peroxidase and phenylalanine ammonia lyase expression enhanced significantly in PGPR primed plants. Greater accumulation of chitinase and â 1-3 Glucanase in PGPR primed plants were further confirmed by indirect immunofluorescence and immunogold probing with chitinase and glucanase specific antibodies. Further, relative expression of defense genes- phenylalanine ammonia lyase, peroxidase, chitinase, chalcone synthase, glucanase was analysed by semi quantitative real-time PCR and these results confirmed those of biochemical tests. Results indicate that PGPR priming reduces disease severity through enhanced activity of defence enzymes.

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Biocontrol of Anthracnose Disease of French Bean (*Phaseolus vulgaris* L.) caused by *Colletotrichum lindemuthianum* (*Sacc*. and *Magn*.) *Briosi* and *Cav*.

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Antagonistic effect of *Aspergillus flavus, Cladosporium herbarum, Penicillium expansum* and *Trichoderma viride* against *Colletotrichum lindemuthianum* isolated from infected pods of eight

varieties of French bean (*Phaseolus vulgaris* L.) was studied in *in vitro* conditions. For the present study, colony interaction (Dual culture method by Skidmore and Dickinson, 1973) and effect of volatile metabolites produced by biocontrol agents (Inverted plate method by Dennis and Webster, 1971a) were conducted. In both the methods, *T. viride* and *A. flavus* revealed the strongest inhibitory effects on the growth of the pathogen, exhibiting 81% inhibition in dual culture whereas, in inverted plate method, *T. viride* and *A. flavus* showed 79% and 70% inhibition respectively. *P. expansum* showed a low inhibitory percentage of 62% in dual culture and 27% in inverted plate. The least effective antagonist was found to be *Cladosporium herbarum which* exhibited a percentage of inhibition in dual culture of only 38% and 20% in inverted plate. *T. viride* and *A. flavus* are among the effective biocontrol agents against anthracnose disease of French bean and can be further exploited for controlling the disease at commercial scale

S-2/NSIPS/P-57

Oligochitosan Based Ecofriendly Approach to Inhibit Growth of *Alternaria porri, causing Purple Blotch Disease of Onion*

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The onion (*Allium cepa*) also known as the bulb onion or common onion, often called as “queen of kitchen” is used as a vegetable. Purple blotch (*Alternaria porri* (Ellis) Cif.) is one of the severe onion diseases in Maharashtra causing yield losses to the tune of 5.0 - 96.5 per cent as compared to other onion diseases. Chemical fungicides are commonly applied against onion purple blotch disease which result in the development of fungicidal resistance in pathogens. Oligochitosan is obtained by gamma irradiation of chitosan. Present study on spore germination assay specified that as the concentration of chitosan increased from 0.2 to 2.4 %, the inhibition of spore germination was increased from 51.69 to 79.18 %. The poison food method evaluated that the fungicide mancozeb @ 0.2 % inhibited maximum mycelial growth and this was followed by treatment of chitosan @ 2.4 %. These studies showed that oligochitosan exhibits antifungal potential against *Alternaria porri*. This indicates that the oligochitosan might be applied as safe natural polymer to reduce the losses caused by fungal infection and it will be helpful in development of economical and ecofriendly farming.

S-2/NSIPS/P-58

Evaluation of Antifungal Activities of Certain Plant Extracts against *Fusarium udum* Butler causing Wilt in Pigeonpea

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Diseases are major biological constraints to production of pigeonpea. Of these wilt caused by *Fusarium udum* is widespread and causes heavy damage. The wilt incidence may range 69-99% and 31-63 percent in susceptible and moderately susceptible cultivars, respectively. As the management of this soil borne disease through conventional technology such as growing resistant varieties, fungicidal seed treatment, single treatment of fungicide or bio-agent cannot provide a remedy for disease management. Non judicious use of synthetic fungicides since last four decades led to several problems to human and animal health besides environmental problems. This scenario, therefore, calls for alternative approaches which are economically feasible and ecofriendly to increase yield of pigeonpea. In view of the hazardous effect of synthetic fungicides, that too for the soil borne ones the present investigation has been carried out for evaluating the phytotoxic activity of locally available plants *viz., Citrus limon, Azadirachta indica, Allium cepa, Allium sativum, Polyalthia longifolia, Ricinus communis and Parthenium hysterophorus* at 5, 10 and 15% concentration against *F. udum* by following the poisoned food technique under *in vitro* condition. That none of the plant extracts could completely inhibited the growth of *F. udum in vitro* after 168 hrs of incubation but Garlic clove extract was highly effective in inhibiting the growth of *F. udum* as it produced 51.6, 58.2 and 62.8 percent growth inhibition of *F. udum* at 5, 10 and 15 percent concentration followed by Neem leaf extract (34.40%). Least inhibition was recorded in castor leaf, citrus leaf and onion bulb extracts were not very promising as they produced only 17.3, 13.5 and 12.2 percent inhibition at 15 percent concentration.

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In Vitro Efficacy of Chemicals and Antibiotics against *Xanthomonas axonopodis* pv. *punicae* causing Bacterial Blight of Pomegranate

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Six antibiotics and four chemicals were tested for their efficacy against *Xanthomonas axonopodis* pv. *punicae*. The antibiotics were taken at concentration 100, 250 and 500 ppm where chemicals taken at 0.25% concentration by using inhibition zone technique. Among that antibiotic Streptocycline at 100 ppm concentration was found effective for controlling *X. axonopodis*pv. *punicae* by forming 14.14 per cent inhibition zone followed by Bacterinol 10.83 per cent inhibition zone. Similarly, Streptocycline at 250 ppm concentration was found effective for controlling *X. axonopodis* pv. *punicae* by forming 22.21 per cent inhibition zone followed by Bacterinol 17.40 per cent inhibition zone. However

it was significantly highest with streptocycline at 500 ppm concentration, which was found most effective for controlling *X. axonopodis*pv. *punicae* by forming 31.60 per cent inhibition zone followed by Bacterinol 27.15 per cent, inhibition zone, whereas iodine at 0.25 per cent concentration was found effective for controlling *X. axonopodis* pv. *punicae* by forming 6.3 per cent inhibition zone. However the Charcoal and Potassium permagnate was not effective for controlling *X. axonopodis* pv. *punicae.*

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Efficacy of Botanicals Against *Erysiphe cichoracearum* causing Powdery Mildew Disease of *Cucurbita maxima*

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Leaf extracts of seven botanicals *viz.,* Shatavari, Sadaphuli, Adulasa, Karanj, Ashwagandha, Behada and Ritha were evaluated *in vitro* at 10 and 20 per cent concentration against *E. cichoracearum* by using inhibition zone technique.

Sadaphuli leaf extract at 10 and 20 per cent was found most effective for controlling *E. cichoracearum* by forming 8.22 and 9.06 per cent inhibition, respectively. Ritha leaf extract was found second best effective plant extract which showed 6.50 and 8.22 per cent inhibition, respectively followed by Adulasa leaf extract (5.35 and 6.99 %), Shatavari leaf extract (4.52 and 6.58 %), Karanj leaf extract (4.11 and 5.75 %), Ashwagandha leaf extract (4.11and 5.35 %) and Behada leaf extract (3.28 and 5.36 %) inhibition at 10 and 20 per cent respectively.

S-2/NSIPS/P-61

Biological Management of Damping Off Disease of Tomato in Lakhipur District of Assam

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Damping-off is a serious disease of tomato nurseries which results in high mortality of tomato seedling. Bio-pesticide viz Bioveer, Biofor PF, Biozin PTB and Biofumigant (Mustard) were assessed for the management of damping-off of tomato in the nursery bed in the Lakhimpur district during 2013 and 2014. Among bio- pesticides, Biozin PTB (76.42%) was found most effective followed by Biofor PF (65.36%) and Bioveer (48.85%) over control in management of both pre-emergence and post- emergence damping-off and also simultaneously improved seedling emergence and seedling vigour. However, biofumigantion with mustard (56.24%) was found most promising over control for the management of pre-emergence damping-off disease of tomato in nursery bed when incorporated with the soil at flowering stage. The study shows that, biofumigantion with mustard can be effectively utilized as a feasible, cost effective and eco-friendly method for the management of damping-off disease of tomato in the Lakhimpur district of Assam.

S-2/NSIPS/P-62

Effect of Different Incubation Period and pH on Biomass Production of *Trichoderma harzianum* (Th 14)

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The application of biological controls using antagonistic microorganisms has proved to be successful for controlling various plant diseases. Among the biological control agents, *Trichoderma harzianum* has been widely studied, and is presently marketed as biopesticides, biofertilizers and soil amendments, due to their ability to protect plants, enhance vegetative growth and reduce pathogen populations under numerous agricultural conditions. The present study was conducted to obtain optimum incubation period and pH for the production of biomass and sporulation of *T. harzianum* Th 14. Biomass and sporulation was measured in (mg/100ml) and (spores/ ml) respectively. Maximum biomass and sporulation (958mg; $4.54x10^8$) was observed at 15 days after incubation (DAI) followed 12 DAI (922mg; $4.28x10^8$) and both were at par with each other while minimum at 5 DAI (703mg; $2.64x10^8$). The influence of pH on production of biomass and sporulation of *T. harzianum* was clearly observed, significantly maximum biomass and sporulation was observed at pH 6.0 (1102mg; 5.00 $x10^8$) followed by pH 5.0 (993mg; 3.75 $x10^8$) and pH 7.0 (966mg; $4.25x10^8$). Twelve days incubation period (12days) and pH (6.0) could be recommended for the mass multiplication *T. harzianum* 14.

S-2/NSIPS/P-63

Isolation and Identification of Multi-Trait Bio-control and Stress Tolerant *Trichoderma* from Pulse Rhizosphere of India

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Trichoderma is a very versatile bio-control fungi which alleviate biotic, abiotic stress and have abilities to control multiple abiotic stress such as osmotic, salt, suboptimal temperatures which suggests a common mechanism through which the plant–fungus association enhances tolerance to a wide range of abiotic stresses as well as biotic stress. Trichoderma spp. has been known as biocontrol agents for the control of plant pathogens for decades which are capable of parasitising several plant pathogenic fungi. Therefore it is important to investigate the diversity of Trichoderma in the soil since such information can lead to the isolation of Trichoderma species having higher antagonistic efficiency and development of better biological control methods to manage plant pathogenic infections caused by pathogenic fungi through different mechanisms like competition, antibiosis, mycoparasitism, hyphal interactions and enzyme

secretion especially extra cellular lytic enzymes such as chitinase and glucanases. Evaluation of bio-control potentials of native *Trichoderma* isolates from the rhizospheric soil of chickpea and pigeonpea were characterized through cultural, morphological and molecular methods. Antagonistic potentials of Trichoderma isolates from the pulse rhizospheric soils were evaluated against *Rhizoctonia bataticola*, responsible for dry root rot of chickpea. Result indicated that the *antagonistic* potential of 57 isolates of Trichoderma against *R. bataticola* were varied which *inhibited R. bataticola ranges* 31-88% *in vitro*. The salt tolerance was shown upto 10% by the isolates. Thus, the potential and well characterised saline tolerant strains of *Trichoderma*, could be used as potential bioagent in stressed soils.

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Isolation and *In-Vitro* Evaluation for Antagonistic Activity of *Trichoderma* Species from Rhizosphere of Hill Banana against *Fusarium oxysporum* f. sp. *cubense*

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Application of biological control agents (BCAs) in agriculture has gained popularity as a way to reduce or eliminate the use of synthetic pesticides. They act against plant pathogens in several ways, either by mycoparasitism, antibiotic-mediated suppression, lytic enzymes and other by-products production, competition for nutrient, or induction of host resistance.

Among the BCAs, *Trichoderma* species are the most intensively studied species. They are the most isolated soil-borne fungi commonly found in plant root ecosystem. Besides that, these opportunistic, avirulent plant symbionts are antagonistic towards many phytopathogenic fungi. Depending upon the strain, the application of *Trichoderma* is proven to improve root and plant growth, as well as to induce resistance in plants. In order to utilize the full potential of *Trichoderma* species in specific applications, precise identification and characterization of these fungi is vital. The present study was carried out to examine the antagonism of *Trichoderma* species isolated from hill banana agro-ecosystem. Eight isolates of *Trichoderma* spp. isolated from different locations of Nagaland districts were characterized for their morphological and antagonistic activity against *Fusarium oxysporum* f.sp. *cubense*. The isolates revealed differential reaction patterns against the test pathogen. However, the isolates S37-4, S41G, S39 were most effective in percentage inhibition of mycelial growth of the test pathogen.

S-2 /NSIPS/P-65

A Preliminary Study on Biocontrol of Five Invasive Weeds of Meghalaya

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The state of Meghalaya, is one of the botanically richest regions in the whole of the Indian subcontinent and is endowed with a heavy cover of natural forest, mainly falling under tropical and

temperate types. A vast majority of the forests in Meghalaya are owned by tribal populations who traditionally practise jhum, as part of their socio-religious customs. This has resulted in the dwindling of the original forest area leading to change in the floristic composition of various regions in Meghalaya State and this is conspicuous by the presence of invasive weeds such as: *Mikania micrantha*, *Chromolaena odorata, Ageratum conyzoides, Spilanthes paniculata* and *Spermacoce hispida*. A survey for natural fungal enemies against these target weeds were carried out in different districts of Meghalaya with the objective of identifying potential biocontrol agents. A total of six pathogenic fungi were isolated from infected leaves of five target weeds. Of which, two fungi were isolated from leaf necrosis and leaf spot disease of *Mikania micrantha,* one each from leaf blight of *Spilanthes paniculata* and *Chromolaena odorata* and one each from leaf necrosis of *Spermococe hispida* and *Ageratum conyzoides* respectively. Further, *Fusarium* sp. was isolated from *S. hispida* whereas *Curvularia* sp. was isolated from *M. micrantha*. Pathogenicity test carried out in target weeds and agricultural crops (Maize, Chilli, Tomato, Rice and Ginger) revealed that all the isolated fungi were found infecting all the weeds and the selected crops except Rice and Ginger.

S-2 /NSIPS/P-66

Enhancement of Germination and Growth Parameters in Tomato through Application of *Trichoderma viride* Based Bioformulation against Damping Off Disease

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The present study was undertaken to examine the effectiveness of *Trichoderma viride* based bioformulation Bioveer to enhance germination of tomato and management of damping off disease caused by *Pythium aphanidermatum* in nursery. An *in-vitro* assay was conducted to evaluate the efficacy of three different concentration of *T. viride* formulation *viz.*, 2%., 5% and 10% along with 2.5% Mancozeb in enhancing seed germination of tomato. The result showed that seed germination was highest in seed treatment with 5% *T. viride* (93%). Least percent germination was recorded in control (72%) followed by Mancozeb (81%). The bioformulation of *T. viride* was further evaluated in nursery bed as Seed treatment (ST) and soil application (SA) individually and in combination. The combination treatment showed maximum germination per cent (91%) and damping off reduction (84.6%) in nursery bed. However, disease reduction was statistically *at par* with treatment of spray application of Mancozeb. Minimum disease reduction was recorded in control (61%) followed by ST with bioformulation alone (71.2%).

Growth parameters of tomato seedlings recorded in nursery bed revealed highest shoot length (18.2 cm) and root length (7.6 cm) in ST and SA of *T. viride.* Treatment with spray application of Mncozeb and control showed poorest performance in enhancing growth parameters. The results showed that *T. viride* could enhance seed germination and seedling vigour and as such could advance the transplanting time of tomato.

S-2 /NSIPS/P-67

Qualitative Assessment of Endophytic Microbes of Rice Plant

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Bacterial blight (BB) caused by *Xanthomonas oryzae* pv. *oryzae* is one of the most important disease of rice causing yield losses up to 50 per cent. There are reports about *in planta* suppression of pathogenic population by endophytic microbes, thereby reducing the disease incidence. Endophytes have also come to the fore of intensive research as they are helpful in maintaining the biotic diversity.The present study was done to assess the endophytic population of tolerant rice cultivars (*viz.*, IR-36) and susceptible (*viz*., Gitesh, Ranjit, Inglongkiri) to BB of rice. About 30 fungal, bacterial as well as actino-bacterial endophytic microbes were isolated. Two bacterial populations showed resilient growth with a population count of 37×10^{10}cfu/ml and 59×10^{10}cfu/ml, respectively, in different media. The morphological, cultural and biochemical characterization of the microbes revealed that the endophytic bacteria comes under the genus *Erwinia* and *Pseudomonas*.

TECHNICAL SESSION - III

Climate Change, Epidemiology, Disease Forecasting

Lead Lecture – 01

S- 3/NSIPS/L-1

Impact of Abiotic Stresses on Growth, Metabolism and Disease Development of Cereal Crops and Their Alleviation by Beneficial Microbes

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With the changing climatic patterns globally, plants are constantly subjected to extremes of environmental factors such as low and high temperatures, drought and flooding, salinity, heavy metals and UV-rays which in turn pre dispose plants to attacks by pathogens and pests. Plants have evolved a wide range of mechanisms to cope with biotic and abiotic stresses but those plants which do not have well developed constitutive coping systems are the most affected. In India, cereals are the most widely cultivated crops since they form the staple food of Indians. Rice and wheat are greatly affected by these stresses and their productivity is greatly reduced. In the present study, beneficial microbes such as different species of *Bacillus* and *Ochrobactrum* which act as PGPR have been used as alleviators of stresses in rice and wheat. The mechanisms by which these microbes act against biotic stresses were determined to be due to direct antagonism in the soil, or indirect through production of volatiles, siderophores etc. They also induce systemic resistance in the host through activation of defense mechanisms in the crop such as enhancing activities of defense enzymes- phenyl alanine ammonia lyase, chitinase, β 1,3 glucanase , peroxidase etc. and increase accumulation of phenols and other such metabolites. In general, alleviation of abiotic stresses such as drought, salinity or temperature occur through mechanisms such as enhancing antioxidant activities, reducing membrane damage, accumulation of osmolytes such as proline, glycine betaine, mannitol etc These have been confirmed by biochemical and molecular analysis such as SDS-PAGE and PAGE , HPLC, Microarray, RT-PCR analysis and also TEM. Results thus reveal that multifaceted bacteria can be used effectively in agriculture for growth promotion as well as alleviation of abiotic stresses and disease management.

Lead Lecture – 02

S- 3/NSIPS/L-2

Wheat Disease Dynamics in South Asia under Changing Climate Scenario

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Terminal heat stress coupled with spot blotch disease caused by *Bipolaris sorokiniana* has become major production-constraint in intensive rice-wheat cropping systems of South Asia. The genetic analysis of spot blotch resistance has been pursued by considering the trait as a quantitative trait locus

and a recombinant inbred line (RIL) population were developed from the crosses a) cv. Sonalika (susceptible) x cv. BH1146 (resistant), b) HUW234x Yangmai#6 and c) Kanchan x Chirya3 at Indian Institute of Wheat and Barley Research, Karnal and exposed to spot blotch pathogen, where some RILs are observed resistant to pathogen. Total three linkage groups (2D, 7B, 7D) in population Sonalika/BH 1146 and four linkage groups (1B, 2B, 2D, 7D) were detected in population Kanchan/ Chirya 1. The toxins of the pathogens have isolated and tested for their virulence in resistant and susceptible genotype. 18 central components of salicylic acid (SA), jasmonic acid (JA), ethylene (ET), and enhanced disease susceptibility 1 (EDS1) signalling pathways as well as the genes of the phenylpropanoid pathway have been identified in wheat The genetic resistance and management of disease has been worked out. Beside spot blotch disease, wheat blast caused by *Magnaporthe oryzae*, pathotype *Triticum* has become a major threat in South Asia after its first recorded appearance in Bangladesh in 2016. To combat the disease, a coordinated program of research and development has been suggested. These two diseases are now threatening diseases in South Asia.

Lead Lecture-03

S- 3/NSIPS/L-3

Simulation of Plant Diseases in Future Climates

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Climate change associated with temperature rise is affecting global agriculture in a faster way than the forecast. Recent changes in disease scenario in Indian subcontinents indicate already there are changes in disease distribution in time and space. Changes in disease scenario are not uniform as there are instances of increased incidence as well as decline in incidence also exhibited. Predicting the impact of climate change on the timing, abundance, and seasonal patterns of diseases is of great interest for on-farm management and for assessment of agricultural policies and practices. Based on infection models future suitability for potential epidemic in rice (leaf blast) and wheat (spot blotch) under changing climates is assessed. Spot blotch is favourable in eastern part of Gangetic plains and due to temperature rise the disease is now in severe form in eastern part. Western part has come within the threshold level for the disease and has become prone to epidemic. Leaf blast in kharif season no change whereas in rabi rice is likely to increase. Climatic index, as the potential indicator of the disease in recent past (current) and future climates using mechanistic infection model could be used for future agricultural planning and investment to meet the future demands of food security.

Invited Lecture-01

S- 3/NSIPS/I-1

Internet of Things (IoT) for Precision Monitoring and Management of Plant Health

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Internet of Things (IoT) activities is gathering momentum around the world, with numerous initiatives underway across industry, academia and various levels of government, as key stakeholders seek to map a way forward for the coordinated realization of this technological evolution. The IoT

contributes significantly towards innovating farming methods. Farming challenges caused by population growth and climate change have made it one of the first industries to utilize the IoT. The integration of wireless sensors with agricultural mobile apps and cloud platforms helps in collecting vital information pertaining to the environmental conditions– temperature, rainfall, humidity, wind speed, pest infestation, soil humus content or nutrients, besides others – linked with a farmland, can be used to improve and automate farming techniques, take informed and precision decisions to improve quality and quantity, and minimize risks and wastes. The app-based field or crop monitoring also lowers the hassles of managing crops at multiple locations. In the Internet of Things (IoT) paradigm, many of the objects that surround us will be on the network in one form or another. Radio Frequency Identification (RFID) and sensor network technologies will rise to meet this new challenge, in which information and communication systems are invisibly embedded in the environment around us. Climate change and environmental monitoring and management have received much attention recently, and an integrated information system (IIS) is considered highly valuable and a novel IIS that combines Internet of Things (IoT), Cloud Computing, Geoinformatics [remote sensing (RS), geographical information system (GIS), and global positioning system (GPS)], and e-Science for environmental monitoring and management, with a case study on regional climate change and its ecological effects on crop health based on data generated out of both public networks and private networks used to access and transport mass data and other information in the network layer. The internet of things is regarded as a new strategic industry and new economic growth point, and has unprecedented application prospect in modern precision agriculture development

Invited Lecture-02

S- 3/NSIPS/I-2

Increasing Incidence of Phytopthora Blight (*Phytophthora drechsleri* f. sp. *cajani*) in Gulbarga in lieu of Climatic Changes

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Due late onset of monsoon the pigeonpea crop could only be sown in July to August in majority of taluks of Gulbarga. In comparison to previous year area coverage of 5.39 lakh ha only 4.16 lakh ha could be sown that too in the mid of July month. In the month of September delayed monsoon was received almost daily and resulted in outbreak of *Phytopthora* blight. Continuous rains and water logging in the seedling stage of the crop favour *Phytophthora* blight (PB) often resulting into epidemics with 100% crop loss in preceding years in certain low lying areas.Field survey was undertaken in representative farmers' fields of Sedam and Chitappurtaluk wherein the crop was sown using 2 local and one variety (Double mung, Katthi and TS3R). As per record the crop was sown "between 15th to 20th July" covering 38824 and 53476 ha respectively in Sedam and Chitappurtaluk. Observations were made on randomly selected ten plants per spot from each fields at weekly intervals right from seedling stage and continued till the harvest of the crop. The affected crop was in vegetative stage with young dead plants. Matured plants could survive mortality but clearly depicted breakage and knot formation in the collar region. The late sown crop (August) could escape disease in other taluks also. The disease incidence could be quantified as moderate to severe with average incidence varying between 10 to 40%. Local variety Double mung sown field was recorded 41.50 % where as TS3R var sown fields was 10.6 % incidence of *Phytopthora*.

S- 3/NSIPS/O-1

Development of Leaf Blight and Tomato Fruit Rot under Changing Weather Condition of Kymore Plateau Zone of Madhya Pradesh

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Most widely grown and popular vegetable crop, tomato (*Solanum lycopersicon* L) is a rich source of Vitamin A and C with antioxidants like lycopene and beta-carotene. Early blight has been a major limiting factor in profitable cultivation that commonly appears in early October and remains a problem till November under Jabalpur conditions. In recent years, the prevalence and appearance of disease has shifted around 30-40 days, towards end of the year. Prevalence of disease was determined in two season crop during October-November & January-February 2017 by random plot monitoring technique with a sample size of 100 randomly selected plants at commercial truck gardens at Jabalpur. *Alternaria* leaf blight appeared during 42 & 43 standard week (2.0 to 11.0%) and increase up to 28% in 47th standard week. During the period (47th week), average temperature was (18.9ÚC) and relative humidity (57.5%) with 2mm rainfall. Incidence of blight was in higher range 12.0 to 24.0% during II fortnight of January 2017 (7 & 8 week) with average temperature (18.5ÚC) and relative humidity (53%) due to changing weather condition, disease appearance was prolonged upto February.

S- 3/NSIPS/O-2

Emerging Problem of Plant Viral and Bacterial Diseases in North Eastern Hill (NEH) Region of India: An Overview

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The North Eastern hill (NEH) Region of India comprising of seven states *viz.*, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura has a total geographical area of 1,65,162 km^2. Almost all field crops and horticultural crops are widely grown in this region; however, plant diseases are often a limiting factor for increased production and productivity. Among horticultural crops, *Khasi* mandarin (*Citrus reticulate* Blanco) is an important fruit crop. Citrus decline has been recorded as a serious threat to the production, which is due to the several biotic and abiotic causes. Among biotic, virus and virus like pathogens *viz.,* Tristeza (*Citrus tristeza virus*, CTV) and Huanglongbing (*Candidatus liberibacter asiaticus*) has been recorded as emerging disease, which causes significant yield losses by reducing the fruit yield and lifespan of the infected trees and ultimately leading to the declining of citrus trees. Bacterial wilt (*Ralstonia solanacearum*) has also been recorded as emerging threats in solanaceous vegetable and ginger cultivation. Every year farmers are facing significant (20-50%) yield losses in tomato, king chilli, ginger & brinjal. Viral complex (*Cucumber mosaic virus*, CMV & *Chilli veinal mottle virus*, ChiVMV) has been reported as destructive and devastating threats to King chilli cultivation. Recently some new and emerging plant viral and bacterial diseases has also been reported from this

region *viz*., *Turnip mosaic virus* (TuMV) in cole crops, *Papaya ringspot virus* (PRSV), *Banana bunchy top virus* (BBTV), *Banana streak MY virus, Soybean mosaic virus, Mungbean yellow mosaic India virus, Passion fruit woodiness virus, Cowpea aphid-borne mosaic virus, Zucchini yellow mosaic virus* (ZYMV) in cucurbits and bacterial stalk rot of mustard. Changing plant viral and bacterial disease scenario in NEH region due to climate change has highlighted the need for future studies on such models which can predict the severity of important pathogens of major crops in real-field conditions. Simultaneously, disease management strategies should be reoriented in sync with the changing conditions by amalgamating new strategies for sustainable food production. The knowledge on genetic diversity and evolutionary trend of emerging plant viruses from this region can be implemented in site-specific pathogen derived resistance (PDR) programme.

S- 3/NSIPS/O-3

Varietal screening, epidemiology and management of important fungal diseases of gerbera in the gangetic plain of West Bengal

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Ten fungal diseases e.g. *Cercospora* leaf spot (*Cercospora gerberae*), crown rot (*Sclerotinia sclerotiorum*), white rot (*Sclerotium rolfsii*), *Alternaria* leaf spot (*Alternaria alternata*), powdery mildew (*Golovinomyces cichoracearum*), petal anthracnose (*Gloeosporium* sp.), leaf anthracnose (*Colletotrichum capsici*), Phoma leaf spot (*Phoma* sp.), neck rot (*Choanephora infundibulifera*) and disc floret rot (*Fusarium* sp.) were recorded from the gangetic plain of West Bengal and their pathogenicities were also established. Of these diseases, *Cercospora* leaf spot and Choanephora neck rot were important. Out of 13 germplasm tested, Ruby red and Purple prince were resistant to *Cercospora* leaf spot. Minimum temperature, minimum relative humidity, rainfall and number of rainy days were identified as critical weather parameters for *Cercospora* percent disease index (PDI) increment. But maximum relative humidity was the only weather parameter considered critical for its rate of spread. Out of four systemic and four non-systemic fungicides tested, Indofil M 45 (Mancozeb), Captan 50 WP (Captan), Score (Difenoconazole) and Tilt (Propiconazole) were found effective against the management of *Cercospora* leaf spot.

Out of 12 germplasm tested, the lowest incidence of neck rot was recorded in germplasm Walhalla followed by Jaffana and Brilliance. In *in vitro* and in vivo testing of five non-systemic and eight systemic fungicides, Captan 50 WP, Score, Tilt and Nativo (Tebuconazole + Trifloxystrobin) were found effective in in vitro mycelial growth inhibition of neck rot pathogen whereas Captan, Indofil M 45, Tilt and Score caused higher reduction of in vivo neck rot disease incidence. Five non-systemic and three systemic fungicides were tested against *S. rolfsii* but Kavach (Chlorothalonil), Indofil M 45 and Beam (Tricyclazole) caused the highest inhibition of mycelial growth whereas out of five non-systemic and five systemic fungicides tested against *S. sclerotiorum*, Captan, Kavach, Indofil M- 45, Tilt and Bavistin (Carbendazim) caused maximum mycelial growth inhibition.

S- 3/NSIPS/O-4

Study of Thermal Longevity of *Macrophomina phaseolina* and Phytotoxic Effects of its Culture Filtrate on *Zea mays*

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Charcoal rot of *Zea mays* caused by *Macrophomina phaseolina* is a major devastating and widespread diseases in maize. It is economically important in arid maize growing area where extensive losses as high as 70 to 100 % occur when crop is infected early. To evaluate the thermal longevity of *M. phaseolina* in soil and culture medium, fungal inoculum was incubated in soil, at temperature 35Ú-70ÚC for 12 h with a difference of 5ÚC, isolated on PDA plates, and inoculated to pot culture of maize seedlings. Broth culture of the fungus was also given a thermal stress as above and immediately inoculated mechanically to the stalk of maize seedlings in pot culture. Serial isolations from the incubated soil exhibited sharp decline in dilution end point with no fungal colony at 70ÚC. The study revealed that, fungal inoculum is pathogenic up to 65ÚC in soil however; sporulation is reduced, in synthetic medium. Severe wilting symptom was observed up to 35Ú-45ÚC only. However, mechanical inoculation of the heat stressed broth culture of the fungus, to the stalk of test plants, showed yellowing of leaves followed by tip burn and blotching of tissues 4-5 days after inoculation. With increasing temperature stress, the yellowing and necrosis in leaves increased. The bioassay of the culture filtrate of *M. phaseolina* against maize seedlings resulted in poor growth. A progressive decrease in growth was observed with increasing toxin concentration followed by yellowing of leaves and necrosis of tissues at higher toxin concentrations. This may be due toxic compounds in the culture filtrate which interfere with nutrient uptake which is expressed as abnormal physiology. Symptoms of wilting, yellowing and necrosis were not observed in untreated control.

S- 3/NSIPS/P-1

Influence of Weather Factors on the Incidence of Yellow Vein MosaicVirus of Okra

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Yellow vein mosaic virus (YVMV) disease is the major limitation in the production of okra (*Abelmoschus esculentus*) an important vegetable crop of India. This disease is caused by Begomo virus Bhendi yellow vein mosaic virus. As the rate of disease increase is dependent on weather factors, weather-based forewarning system enable to guide farmers to take protection measures timely. The correlation study revealed that okra YVMV disease incidence showed positive correlation with whitefly (0.194). Minimum temperature (0.558) and Evaporation (0.526) showed significantly positive correlation with disease whereas Evening relative humidity (-0.516) showed significantly negative correlation. Maximum temperature (0.621) showed highly significant correlation with YVMV. In linear stepwise

regression equation, incidence of YVMV increased with rise in Minimum temperature (2.614). Coefficient of determination R2 value (0.40) represent that 40 per cent influence on the incidence of YVMV by one independent variables i.e. Min temperature.

S- 3/NSIPS/P-2

Epidemiology of Rust in Grape var. Bangalore Blue during 'March – April' Pruning Cycle

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'Grape cultivation is one of the most remunerative farming enterprises in India. Among different grape varieties 'Bangalore Blue' is one of the most important variety grown under mild tropical region – An area covered by 10° and 15° N latitude. It is tolerant to downy mildew and anthracnose diseases and is comparatively easier to grow. The variety is mainly grown for juice purposes but off late its seeds were identified as a rich source of antioxidants. Some 20,000 tonnes of Bangalore Blue are crushed annually to make juice. 'Bangalore Blue' is mainly grown in Bangalore, Kolar and Chikkaballapur districts of Karnataka state. 'Rust' disease (*Phakospora euvitis* Y. Ono) has been a major impediment in the successful and remunerative cultivation of this variety if not managed properly. The infection results in severe defoliation and vines had only short shoots and nodes resulting in great loss in yield. Two crops of this variety are normally taken in an year, for which pruning is practiced in "March – April' and 'September – October' months. The influence of climatic variables on the development of rust disease in this variety was assessed during March – April' pruning cycle by regularly calculating the percent disease severity index (PDI) and recording data on corresponding meteorological factors. Epidemic was analyzed (27th SMW, 2017 to 38th SMW, 2017) in terms of Apparent Infection rate (r), Basic infection rate (R), Area under Disease Progress Curve (AUDPC) and Relative Area under Disease Progress Curve (RAUDPC). There was a constant enhancement in 'r' that was increased from 1.3143 in 27nd SMW (2017) to 4.6000 unit/day during 33th SMW (2017) then it started declining and during 34th SMW, 'r' (unit/day) was 3.7227 that declined to 0.8773 during 38th SMW., AUDPC recorded a constant enhancement that was 1.16 unit/day during 49th SMW (2016) ranged to 471.35 unit/day during 38th SMW (2017). 'R' and RAUDPC recorded fluctuations. As 'R' increased from 0.2268 unit/day during 27nd SMW (2017) to 6.4016 during 29th SMW; decrease to 5.0540 during 30th SMW but further increased to 7.8822 unit/day during 31at SMW (2017) and subsequently declined from 6.7467 unit /day in the 33th SMW (2017) to 0.2268 during 38th SMW. A constant increase was recorded in RAUDPC that was 0.0080 unit/day in 27nd SMW but ranged to 3.2732 during 38th SMW. The relationship between severity of rust disease and weather factors was established through correlation analysis indicated that The severity of the rust disease was positively correlated with relative humidity morning 7.00 h (r = 0.6728), evening 14.00 h (r = 0.1882), rainy days (r = 0.5583), rainfall (r = 0.4005) and wind speed (r = 0.0479) The disease severity recorded a negative correlation with maximum temp., minimum temp & PEV. The influence of weather factors on the progression of rust disease to develop the disease prediction model and its management strategy has been discussed in the paper.

S- 3/NSIPS/P-3

Influence of Weather Parameters on Bacterial Blight of Hirsutum Varieties of Cotton

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Among various diseases occurring on cotton, bacterial leaf blight caused by *Xanthomonas axonopodis* pv. *malvacearum* causing serious loss to cotton. Since many years, it has been occurring in an epiphytotic form on commercially grown cotton varieties, leading to severe defoliation and substantial yield losses. A field trial was conducted during Kharif, 2016 on the experimental field of Plant Pathology Section, College of Agriculture, Nagpur. Studies were conducted to assess progress of bacterial blight disease on 11 varieties of G. hirsutum groups, in relation to the environmental factors. Bacterial blight disease was recorded with its first appearance and subsequently at weekly interval till it prevailed on *G. hirsutum* cotton varieties and its incidence varied from 0.37 to 21.11 per cent. Disease was first appeared in 33th Met. Week (2nd week of August) on the test cotton varieties, of which intensity ranged from 0.37 to 1.85 per cent and further prevailed up to 1st Met. week (1st week of January). BLB initiation and development were influenced by weather parameters. Highest disease intensity (21.11%) was recorded during 43rd Met. week on AKH-10-10. The disease started declining after 48th Met. week i.e. during last week December, 2016.

The correlation studies revealed that during the year 2016-17 maximum temperature and bright sunshine hours of preceding week had positive and significant correlation with bacterial leaf blight disease intensity. While, total rainfall, total rainy days, relative humidity (evening and morning) mean relative humidity of preceding week showed negative and non-significant correlation with bacterial leaf blight disease intensity.

S- 3/NSIPS/P-4

Aerial Blight (*Rhizoctonia solani*) - An Emerging Problem in Profitable Soybean Cultivation under Climatic Conditions of Kaymore Plateau Zone, Madhya Pradesh

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Soybean [*Glycine max* (L.) Merrill] is the cheapest source of edible-vegetable oil. Seed are valued due to major nutrients and contains about 40% oil and 22% quality protein. As a legume crop, soybean fixes atmospheric biological nitrogen about 270 kg N/ha that helps in enrichment of soil fertility and maintaining soil health.

The disease was prominent at R1-R3 stage (one flower at any node R1, flower at node immediately below the uppermost node with completely unrolled leaf R2, pod 0.5 cm long at one of the four uppermost nodes R3). Initially water soaked grey-green lesions appeared later that turned tan-brown, on foliage, a web like, spreading growth of fungal mycelium, associated with sclerotial bodies was noticed under high humidity conditions. Reddish brown to brown lesions were recorded on stem and leaves.

Prevalence of aerial blight in the range of 6.0-37.0% was recorded at 8 different representative villages covering 24 locations at farmer's field under standard fixed plot monitoring technique. Observations were made on 100 randomly selected plants in each field at locations, during 2nd fortnight of August to 1st fortnight of September, 2015-17, with average temperature 27.70 C and relative humidity 76.5%. In seed production fields' disease incidence ranged from 3.0 to 20.0%. In variety JS 335, incidence ranged from 13.0 to 35.0%, JS 90-41 (6.0-25.5.0%), JS 93-05 (3.0-15.0%) and JS 95-60 (4.0-5.0%). Observations on incidence of aerial blight were recorded in 26 soybean varieties under natural field conditions and ranged from 3.0-35.0%. Yield reduction up to 15.6% was recorded in soybean JS 335 as compared to JS -05.

S- 3/NSIPS/P-5

Screening of Mustard Lines against *Alternaria* Blight and Optimization of Screening Time under Cool Humid Conditions of Bihar

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Considerable losses caused by *Alternaria* blight on the oilseed crop rapeseed-mustard annually caused by *Alternaria brassicae* and *Alternaria brassicicola*. The study was conducted with the aim to assess tolerant or resistant sources of mustard lines against dark spot and to ascertain the optimum time of screening against the disease in Bihar region. Since, use of resistant cultivar is suggested as one of the most important component of any disease management strategy. We screened 50 lines of mustard against *Alternaria* blight under natural incidence in the year 2015-16 and 2016-17 using Area Under Disease Progress Curve (AUDPC). Visual estimation of disease severity was taken into consideration which was rated as no spot (0 %) on the leaves to more than 50 % spots on the leaves and the same was corresponded with the scale given by AICRP, 2011 ranging from 0 to 9. Germplasms showed moderate tolerance to high susceptibility. Based upon average AUDPC values for two years, 4 genotypes namely IC-399840, IC-312496, IC-342778 and IC-399802 showed lowest AUDPC values between 300-500 showing tolerance to *Alternaria* blight. In order to find out optimum time of screening of mustard lines against *Alternaria* blight, disease response was recorded at three different time intervals. Results suggested that at around 76 DAS would be the optimum time for assessment of mustard lines against *Alternaria* blight. At this time period (76 DAS) the disease distribution among the germplasm lines screened were found to be normally distributed. The resistant sources will be useful for selecting elite genotypes for disease resistance where mustard cultivation is prevalent. In addition, these sources will serve as resistant source for the development of new cultivar of mustard against *Alternaria* blight.

S- 3/NSIPS/P-6

Epidemiology and Management of Foliar Diseases of Groundnut in Kharif Season

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The epidemiological studies on early, late leaf spots and rust diseases in relation to weather parameters revealed that during kharif, 2010 the development of early leaf spot was highly influenced by mean temperature and crop age and for late leaf spot development, maximum temperature and crop age were highly favourable. Moreover, evaporation rate and crop age played predominant role in rust development in groundnut under Dapoli conditions.

Management studies on early leaf spot, late leaf spot and rust, revealed that three sprays of Hexaconazole + zineb (0.1%) at an interval of 20 days was the most effective treatment in reducing ELS, LLS and rust of groundnut. It was followed by tebuconazole (0.3%), tebuconazole (0.15%), difenconazole (0.1%) and propiconazole (0.1%).

S- 3/NSIPS/P-7

Land Use Change from Forests to Shifting Cultivation and Its Implication in Soil Organic Carbon Budget of Nagaland

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The state of Nagaland is an important part of Eastern Himalayan Biodiversity hot spot region. Nagaland has been undergoing tremendous land use change for centuries. One of the major drivers of land use change from forest to non forest in the region is age old traditional practice of shifting cultivation locally known as Jhum. Land use change in such highly diverse region not only affects the overall biodiversity but also alter the carbon budget of the ecosystem. The changing zone cycle from 10-15 years to 3-5 years also found to worsen the situation in terms of productivity and ecological stability. Soil organic carbon (SOC) is an important pool in overall carbon budget in a system. An attempt has been made to estimate the change in carbon stock in two contrasting land uses viz. 'forest' and 'shifting cultivation' following standard methods. 156 soil samples from both the land uses were collected from 15, 30 and 45cm depth and SOC was estimated following Walkley and Black method. The carbon stock in the forest was found to be 61.66 tC ha^{-1} whereas in shifting cultivation it was estimated 51.94 t C ha^{-1}. As shifting cultivation in Nagaland found to have increased over the years, most of these are reportedly at the cost of forest cover, these land use dynamic has serious implication in the overall carbon budget in Nagaland need to be addressed to effectively mitigate climate change locally and globally.

S- 3/NSIPS/P-8

Changing Home Garden Scenario and Its Impact on Soil Carbon Stock in Upper Assam

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Home gardens are a dynamic agro forestry system commonly strewn across the tropics. These species rich, sustainable systems have a complex structure, which fulfill an array of social, economic and ecological functions. Besides, home gardens hold substantial carbon stock. Sequestration of Carbon as a mitigation measure to compensate Green House Gas (GHGs) emissions has come to the fore of the climate change scenario after the Kyoto Protocol (1997) and home gardens being a biomass rich agro forestry system provides for a potential Carbon storage apparatus. An attempt has been made to estimate and understand the soil organic carbon (SOC) regime of home gardens in Upper Assam following standard methods. 100 soil samples, each from the depths of 15, 30 and 45 cm along with 25 vegetation samples were collected from 7 districts of Upper Assam. The SOC was estimated to be 29.58 tC/ha. It was also found that people are not interested in maintaining large patches of home garden which was a reality in Upper Assam earlier and gradual shift towards more profitable cash crop cultivation (monoculture) like Tea, Agar, Areca nut is emerging. Thus, these biodiversity rich agroforestry systems are not only found to be shrinking but the soil quality also seems to be degrading as in commercial cultivation, various fertilizers are readily used, which is a matter of great concern.

S- 3/NSIPS/P-9

Screening Pigeonpea (*Cajanus cajan*) Germplasm for Stable Resistance against Sterility Mosaic Disease

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Seventy four germplasm of pigeonpea were screened in the sterility mosaic sick plot against the sterility mosaic under high disease pressure in field condition to find out levels of their resistance. Test germplasms were sown in single row plot with spacing 20cmx50cm. after every two germplasms one row of ICP8863 a highly susceptible variety was raised to serve as an infector row. All germplasms including those of ICP 8863 were artificially inoculated using infector row and leaf stapling technique to create the disease pressure. The observation was recorded on the basis of area under disease progress curve(AUDPC) and based on the AUDPC Values, the germplasms were classified as resistant(less than 350), Moderately resistant(351-650) and susceptible(more than650). Out of 74 germplasms of pigeonpea, four germplasms viz. BRG16-1, NTL 30, ML31 and BDAH2013-41 were found resistant while 12 germplasms *viz.*, BRG16-2, ICP7119, ICPL15084, ICPL15036, BDN711, PT711-1-1-2, CO-6, WRG255, VRG06-003, NTL873, ML47 and BSMR 736 were found to be moderately resistant of sterility mosaic disease. Germplasm having resistant to moderately resistant may either used as donor parents for transferring stable sterility mosaic disease resistance in varietal breeding programme.

S- 3/NSIPS/P-10

Sheath rot an emerging diseaseof rice under gangetic alluvial region of West Bengal

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Rice *(oryzasativa)* is one of world's most favoured staple food grain and about more than 90%of the world's rice is produced and consumed in Asian countries.Rice crop is affected by number of fungal, bacterial and viral diseases. Among the different fungal diseases Sheath rot is considered to be one of the emerging diseasesand yieldlosses can be as variable as in the range of 20–85% under changing climate condition. The major feature of rice sheath rot disease is rotting and discoloration of the sheath, leading to chaffiness and sterility of resulting grains. For many years, rice sheath rot was considered as a minor and geographically limited disease. It is only recently that it gained momentum and became widespread. Keeping the fact in mind, an experiment was conducted at RRSS, Chakdah, Bidhan Chandra KrishiViswaVidyalaya, in Kharif 2015 - 2016 to unravel the dynamics of sheath rot disease of rice. Two farmers' popular varieties of this region namely, Satabdi (IET 4786), Swarna (MTU-7029) and one aromatic variety viz. Pusa Basmati-1 were considered for the study. The Correlation coefficient showed significant positive correlation with maximum temperature whereas RH (morning and evening), minimum temperature and Rainfall were negatively correlated with sheath rot disease development. On the basis Stepwise Regression analysis the variability in Disease severity in all the three varieties can be explained between 81-84% using minimum temperature as determinator. On the basis of multiple regression analysis the variability in disease severity could be explained upto 89-94%.Thirty five (35) traditional varieties tested against sheath rot, only seven (7) lines showed resistant reaction, eighteen (18) lines showed moderately resistant reaction and ten (10) were moderately susceptible.

TECHNICAL SESSION - IV

Extension Pathology

Lead Lecture – 01

S- 4/NSIPS/L-1

New Extension Tools to Effectively Manage Important Plant Diseases

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Agricultural Extension Education is an applied behavioural science, the knowledge of which is applied to bring about desirable changes in the behavioural complex of human beings usually through various strategies & programmes of change & by applying the latest scientific & technological innovations. It is a full-fledged discipline, having its own philosophy, objectives, principles, methods & techniques which must be understood by every extension worker & others connected with the rural development. Agricultural extension in our country is primarily concerned with the dissemination of useful & practical information relating to agriculture, including improved seeds, fertilisers, implements, pesticides, improved cultural practices, dairying, poultry, nutrition, etc.; the practical application of useful knowledge to farm & home; and thereby ultimately to improve all aspects of the life of the rural people within the framework of the national, economic & social policies involving the population as a whole. Agricultural extension services need to assume new challenges and reform itself in terms of content, approach, structure and processes. Extension in this context includes all those agencies in the public, private and civil society that provide a range of agricultural advisory services and facilitate application of new knowledge. A strong, vibrant and responsive extension with an expanded mandate is a pre-requisite for achieving a faster, sustainable and more inclusive growth through agriculture.

The challenges that most agricultural extension services face are mostly of a technical and logistic nature such as insect pest invasions, outbreaks of serious diseases, locust attacks, severe climatic effects, natural disasters, or intensive campaigns for an increase in agricultural production. Farmers currently need a wider range of support, including organisational, marketing, technological, financial and entrepreneurial. To be successful, farmers require a wide range of knowledge from different sources and support to integrate these different bits of knowledge in their production context. These challenges for effective management may be achieved through 1. input agencies (dealing with seeds, fertilisers, pesticides, equipments), 2. large agri-business firms (involved in manufacture and sale of inputs and purchase of farm produce), 3. farmer organisations and producer co-operatives, 4. non-governmental organisations (NGOs), 5. media (print, radio and television) and web based knowledge providers , 6. financial agencies involved in rural credit delivery, and 7. consultancy services.

The new extension tools which are now widely adapted by the extension personnel (field functionaries, rural youth and farmers) in rural areas are the use of plateforms like Facebook, WhatsApp, You tube, Instagram, Twitter etc., Agriculture Mass Awareness Program (A-MAP) though mass media, low cost videos by Digital Green for Agril. Extension, web portals (m Kisan portal, KrishiGyanPotal, KVK portal), Mobile Apps (e-Crop Doctor), AgriDaksh (Expert System for different Crops viz., rice, wheat, maize, jute, mushroom, seed spices), Mushroom AGRI Daksh, GraminKrishiMausamSewa project (GKMS), SkymetWeather app, AgroStar Farmer App (A “direct-to-farmer” technology platform), Network of smart phones, Community radio services at KVKs and Colleges etc.

The solutions for effective crop protection management (ECPM) may be as under :-

€ ECPM is a decision-based process involving coordinated use of multiple tactics for optimizing the control of pathogen in an ecologically and economically.

€ There is a very strong need of a National Plant Protection Policy.

€ Like human health and animal health being taken care of by the State Deptt. of Health, and Veterinary respectively, the Plant Health must be taken care of either by the State Deptt. of Agriculture being the Agriculture as a State Matter or by an Independent Agency.
€ There should be Plant Protection Centres at the village and Panchayat levels who should be made responsible for crop protection and be linked with SAUs, ICAR institutes for technological backstopping.
€ There should be trained Agril. Officers for identification and diagnosis of insect pests and diseases and who should visit the field twice in a week.
€ If they fail to go to the field, they should inform the framers in writing.
€ Plant protection should be the responsibility of PPO rather than the farmers who are illiterate and have no idea of pesticides, sprayers etc. Farmers should be charged less.
€ All the plant protection measures should be regularly and timely followed based on the appearance of the insect pests and diseases.
€ These centres should work like Deptt. of Electricity, Water Resources, Telecom who provide regular services to their clients.

Lead Lecture – 02

S- 4/NSIPS/L-2

Extension Plant Pathology: Strengthening Resources to Serve Farming Community

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Agricultural technology is constantly subjected to metamorphosis over years. Farmers are swamped with many new cultivars, pesticides, farm machines, farming techniques, new methods of disease and pest management. The plant disease epidemics cause major loss in food production worldwide. Totally 14.1 per cent of crops are lost due to plant disease alone and these losses are in part responsible for the suffering of 800 million people who lack adequate food. At this juncture, role of extension pathologist in disseminating the agriculture information through Information and Communication Technology (ICT) in the era of globalization, poses the best alternative means for a change in agriculture. Earlier extension work in plant pathology was undertaken in the context of fairs, farmer's institutes, short courses and so on. But in present era ICT is playing a major role in the progress of agriculture sector. "ICTs can be exploited to design cost effective systems to provide expert advice particularly to rural communities, helping to increase productivity and livelihoods." Types of ICT tools include Radio, Telivision, CD, Mobile, Internet data base, Agri-portals, Decision support system and Expert system. The agriculture programmes on TV and radio could hardly meet the information required by the farmers, affected with the compounding problems. With the use of cell phone the farmers who receive information through SMS are spreading the information to their fellow farmers and their foot falls along with other farmers to KVK have been significantly increased day by day for obtaining more information against a specific problem. The e-SAP model is an application of IT tool has helped for generating GIS maps ultimately to know the pest prone areas. It helps in disseminating the appropriate management practices to the farmers on real time basis and enables fast and deeper penetration of the information to the farmers. Even many agricultural apps are available for quick communication of agricultural technologies through mobile phones. As the new technologies are invented it has to be disseminated timely to the farmers. So there is an ample scope in strengthening of lab to land transfer. Research and extension must go hand by hand so that the end users are most benefited.

TECHNICAL SESSION -V

Biosafety, Biosecurity, Bioterrorism

Lead Lecture-01

S- 5/NSIPS/L-1

Ensuring Biosecurity through Efficient Plant Quarantine

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Biosecurity in agriculture refers to the preventive and mitigative measures to reduce the risk of transboundary and in-country movement of pests in crops and livestock. In India, crop production is at risk from exotic pest attack mainly due to free trade of agricultural commodities under WTO. In addition, development of GMOs, unrestricted movement of people and commodities within and across borders lead to introduction and spread of new pests in India. Agricultural biosecurity has emerged as a solution requiring both policies and technological capabilities to prevent, detect, and respond to such threats. Plant quarantine is a government endeavor to prevent the entry and establishment of exotic pests into the country which if introduced could cause severe economic and environmental losses. Being a signatory to both International Plant Protection Convention and WTO, India needs to comply with their requirements. The Plant Quarantine (Regulation of Import into India) Order, 2003 has been legislated and came into force from April 1, 2004, under which import of commodities, additional declarations for freedom from quarantine pests is based on a standardised pest risk analysis (PRA). Additional declarations have been specified for import of >100 agricultural commodities with specific lists of >600 quarantine pests and 31 weed species. Several amendments of the PQ Order 2003 have been notifies to the WTO revising quarantine pest lists; recognition of irradiation and cold treatments; pest free areas; revising the lists of crops under Schedule VI and VII to include 820 and 248 crops/ commodities, respectively. ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR) is authorized to issue import permit and undertake quarantine of plant germplasm including transgenic and for issue of Phytosanitary Certificate for material under export. Adopting a systematic workable strategy, using a combination of conventional and modern techniques, over the past forty years, a total of 64 exotic pests including fungi (5), viruses (17), insects/ mites (24) and weeds (16) of great quarantine significance to the country have been intercepted. All efforts are made to salvage the infested/ infected materials; however, if the material is unsalvageable, it was incinerated. The interceptions made signify the potential dangers in import of planting material if proper quarantine measures had not been followed. This task is being taken up by ICAR-NBPGR, but more concerted efforts are needed to develop and customize the modern detection and eco-friendly salvaging techniques to minimize the risk of escape in quarantine processing. Scientifically sound and transparent PRA prior to import is an important tool, so that, our agricultural production is not jeopardized. Also, the Agricultural Biosecurity Bill 2013 being drafted by the Ministry is an attempt at a holistic approach towards biosecurity in India.

Invited Lecture-01

S- 5/NSIPS/I-1

Impact of Diagnostics and Quarantine Regulations in Crop Biosecurity from Exotic Viruses

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The movement of agricultural produce across international borders has the potential to introduce new pests including viruses which may pose potential risk to the agriculture of the importing country. The National Plant Protection Organizations are responsible for preventing the entry of exotic viruses with the goal to protect domestic agriculture. The strategies for biosecurity from trans boundary plant viruses include stringent quarantine measures for the imported material. As per the Plant Quarantine (Regulation of Import into India) Order, 2003 (hereafter referred as PQ Order), the quarantine processing of bulk consignments of grain/ pulses etc. for for commercial purpose are undertaken by the Directorate of Plant Protection, Quarantine and Storage, Government of India through its 53 Plant Quarantine Stations located across the country. The imported germplasm including transgenics meant for research purposes are subjected to quarantine processing at the ICAR-National Bureau of Plant Genetic Resources, New Delhi. As per the PQ Order, 264 viruses are regulated pests which are of quarantine significance for India. Adopting a strategy of post-entry quarantine growing/inspection followed by use of combination of detection techniques viz., electron microscopy, ELISA and RT-PCR, several viruses of great economic and quarantine importance were intercepted in imported germplasm including transgenics in the last two decades. The interceptions include viruses not yet reported from India and not known to occur on particular host(s) in India. Also intercepted many viruses in germplasm imported from CGIAR centres. Some of the intercepted viruses are not known to occur in India, but their vectors exist and also congenial conditions to multiply, and spread them. *Bean pod mottle virus* (BPMV), a seed-transmitted virus, not reported from India, was intercepted in exotic soybean germplasm from USA. It causes yield-reductions ranging from 3 to 52.4% and seed coat mottling and dark pigments have often been problematic for soybean farmers and industry in USA as it reduces consumer acceptance. *Barley stripe mosaic virus* (BSMV), a seed-transmitted virus, not reported from India, was detected and intercepted in exotic germplasm of wheat from USA. *Maize chlorotic mottle virus* (MCMV), a seed-transmitted virus, not reported from India, was intercepted in exotic maize germplasm including transgenics from Puerto Rico, Thailand and USA. If not intercepted, these viruses could have been introduced into the country and established as favourable environmental conditions are available in India.. If introduced, BPMV, BSMV and MCMV would have caused an annual yield loss of Rs.2632.5 million, Rs.12111.85 million and Rs.3166.3million, respectively, with the incidence of 1%. India also need to establish a network of interconnected diagnostic laboratories and strong surveillance programme to identify new viruses that could facilitate trade and germplasm exchange with reduced risk of virus movement.

Invited Lecture-02

S- 5/NSIPS/I-2

Role of Plant Quarantine in Plant Disease Management in the Changed Global Scenario

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The exchange of plant and plant products between the countries are very essential for better quality and quantity of the food to be produced for the ever growing population of the world. Plant diseases have always moves to new regions along with their host material in the past and the diseases of minor importance have caused disasters in the new environment. Recently, wheat blast caused by *Magnaporthe oryzae triticum*, guava root knot nematode *Meloidogyne enterolobii*, has got introduced to India. Because of these type of incidents, worldwide every year nearly $ 1.4 trillion dollar and in India alone 91.0 billion dollar worth loss is occurring due to introduced pests. So to prevent such entries, establishment and spread of exotic diseases in to other countries an International treaty International Plant Protection Convention (IPPC) was came in to force in 1951 by member countries of FAO. The Convention provides a framework and a forum for international cooperation, harmonization and technical exchange between contracting parties by setting up the International Standards for Phytosanitary Measures (ISPM's). Its implementation involves collaboration by National Plant Protection Organizations (NPPOs), the official services established by governments to discharge the functions specified by the IPPC and Regional Plant Protection Organizations (RPPOs). Plant quarantine activities in India are carried out under the laws like Destructive Insects and Pests Act (DIP Act) of 1914 and Plant Quarantine (Regulation of Import into India) Order, 2003 regulates import and prohibition of import of plants and plant products into India. Directorate of Plant Protection Quarantine & Storage (DPPQ&S) was established in the year 1946 serves as NPPO, an apex organization for advising the Government of India and state governments on all the matter related to Plant Protection. It is an attached Office of Ministry of Agriculture and Farmers Welfare. It has various Sub-Offices throughout India involving in on all the matter related to Plant Protection like there are 35 Central Integrated Pest Management Centers (CIPMC's), 6 Regional Plant Quarantine Stations (RPQS's), 57 Plant Quarantine Stations (PQS's), 10 Locust Control Organizations (LCO's), one Field Station for Investigations on Locust (FSIL), 1 Central Insecticide Board & Registration Committee. The exchange of plant and plant products between the countries are very essential for better quality and to increase the food production for the growing population in the present scenario of the world. Plant diseases have always moves to new region along with their hosts, in the past, diseases of unknown or minor importance have caused disastrous in the new environment. Worldwide every year nearly $ 1.4 trillion dollar and in India 91.0 billion dollar worth loss occurring due to introduced pests. Recently wheat blast caused by *Magnaporthe.oryzae triticum*, guava root knot nematode *Meloidogyne enterolobii*, introduced to India. So to prevent the entry, establishment and spread of exotic diseases in to other countries an International treaty International Plant Protection Convention (IPPC) was came in to force in 1951 by member countries of FAO. The Convention provides a framework and a forum for international cooperation, harmonization and technical exchange between contracting parties by setting up the International Standards for Phytosanitory Measures (ISPM's). Its implementation involves collaboration by National Plant Protection

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S- 5/NSIPS/O-1

Role of e-Pest Surveillance in Plant Biosecurity and Food Security Issues in Northern Parts of Karnataka

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Biosecurity is a strategic and integrated approach that encompasses the policy and regulatory frame work to analyse and manage risks in the sectors of food safety, animal life and health and plant life and health including associated environmental risks. Aspects which are included in the biosecurity and food security are standard setting agencies, systems for improving international biosecurity networks, biosecurity linkages and involvement of stakeholders.WTO is an international agency which encourages trade between member nations, administers global trade. Its principles are transparency, safety values, binding and enforceable commitments. Sanitary and phytosanitary (SPS) measures are designed to protect human or animal life from risks arising from additives, contaminants, toxins or disease causing organisms in their food. Specialized tests used for detection of different groups of pests viz., Insects and pathogens help for biosecurity and food security mites. Pest surveillance is one of the primary aspects in biosecurity. Earlier surveillance was done manually by involving field crew which used to take more time and involved more human resources.

During 2011-12, e-pest project was initiated further, between 2011 and 2016 fivefood crops viz., chickpea, soybean, maize, sugarcane and sunflower were covered from 658 no of villages. Totally 21 no of insects and 25 no of diseases occurred regularly. In Gadag and Vijayapura districts, Gram caterpillar and chickpea wilt were predominant. In Belagavi and Bagalakote districts wooly aphid and ring spot were predominant on sugarcane. In Dharwad district Spodoptera and rust were major pest and disease in soybean. In Vijayapura district leaf hopper and necrosis were predominant in sunflower. In Haveri district maize stem borer and turcicum blight were in high proportion. The management of these pests and diseases would help farmers to reduce the losses caused by them and increasing yield thus, realizing food security in the country.

TECHNICAL SESSION - VI

Nano and Biotechnology Approaches for Plant Disease Management

Lead Lecture-01

S- 6/NSIPS/L-1

Genetic Engineering of Crop Plants for Resistance to Diseases and Insect Pest

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Growing population in the world demands more food as well as nutritious food. Productivity of most of the major agricultural crops remains stagnant as they encounter serious attack by biotic stresses such diseases and insect pests and abiotic stresses such as drought, salinity, flood etc. Conventional breeding techniques and management practices cannot overcome several agriculturally important biotic and abiotic stresses due to lack of resistant sources within the gene pool. Genetic engineering is one of the most modern approaches to encounter such problems through the development of resistant varieties and that will eventually lead to increase productivity of crop plants and provide food security.

GE crops have been now well commercialized especially for the traits with herbicide tolerance, insect resistance or combination of both traits. There is now 110 fold increase in the area of GE crops from 1996 – 2016. Currently global area under GE crops is 2.1 billion hectare.

In India, about 250 institutions are now engaged in GE research. However, only one GE crop that is cotton with Bt-Cry gene(s) has been commercialized in India. At present almost 99% of cotton area in India is covered by Bt – cotton that confers resistance against cotton bollworms. Use of Bt – cotton, introduced commercially in the year 2002 has doubled the production of cotton in our country and insecticide use has been reduced to more than half since its inception.

GE research for the development of disease resistant crop plants that has led to commercial application has been reported only against viral diseases. Two commercial GE crops for virus resistance are papaya for ring spot virus and squash for three major viruses. The GE lines for fungal resistance in different crops are in various stages of development.

Research in the area of Gene technology for the improvement grain legumes such as chickpea (*Cicer arietinum* L), is being carried out at Assam Agricultural University, Jorhat in order to obtain insect resistant transgenic lines. Two very serious insect pests of chickpeas are weevils (*Callosobruchus sp*) and pod borers (*Helicoverpa armigera*). We, in collaboration with CSIRO Plant Industry, Australia, have transformed chickpeas using a bean á-amylase inhibitor (á-*ai*) gene to confer resistance against the stored grain pests in the *Callosobruchus* group. Transgenic lines were found to protect the seeds from attack of the pest when compared to control seeds. We have also transformed chickpeas using two different Bt genes (*Cry1Ac* and *Cry2Aa*) and developed transgenic lines with complete protection against pod borers (*Helicoverpa armigera*). Such lines are in the process of deregulation in India.

Lead Lecture-02

S- 6/NSIPS/L-2

Nanotechnological Approach in Plant Disease Management

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Plant pathogens are posing threat to sustainable crop production and food security. Growing resistant plant variety and use of inorganic chemical pesticides and biocontrol agents have provided some relief from the menace of selective plant pathogens only. The extent of nanoscience and nanotechnological research has grown so wide that now we can consider its use in the area of plant health management. Several metal nanoparticles (like silver and copper) and their oxides have shown promise of managing fungal and bacterial plant pathogens. Metal nanoparticles did show synergistic effect when mixed with fungicide formulation against plant pathogens. Commercially available fungicide compounds when ground to nanosize showed higher fungitoxicity. Many fungi and bacteria including the biocontrol agent *Trichoderma* have been used to synthesize nanoparticles as well. This process of microbial synthesis of nanoparticle is environmentally safe and cost effective compared to physical and chemical methods. Nanofertilizer on the other hand show the promise of improving nutrient use efficiency and provide plant nutrition adequately thus maintaining vigour and vitality of crop plant. However, the phytotoxicity of nanoparticles to be as/in fungicides needs thorough investigation. The toxicity level of nanoparticles, if released, towards the soil and water microbes and their final impact on ecology and human health needs to be researched thoroughly over longer period of time. Besides these, detection of plant pathogens using nanotechnological approach will immensely aid in making the appropriate management decisions.

Lead Lecture-03

S- 6/NSIPS/L-3

Rapid Detection of Plant Viruses in Limited Resource/Laboratory Settings

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Plant viruses are of major concern to several field and horticultural crops as they cause huge economic losses through reduction in growth and yield. Conventional methods of virus detection were based mainly on biological techniques (symptomatology) which are too slow and notamendable to large-scale application. Two major breakthroughs in virus diagnostics came with the development of serological assay in the form of enzyme-linked immunosorbent assay (ELISA) and nucleo-based assay based on *in vitro* amplification of DNA commonly called as polymerase chain reaction (PCR). Over the years, various variants of ELISA and PCR were developed and successfully used for reliable detection of plant viruses. Most of these techniques, however involve complex procedures, are time consuming and

require well equipped laboratories as well as technical expertise. Recently, rapid and simple technologies that make possible analysis without special skill and equipment even under field conditions have been used for detection of plant viruses. A significant development has been made in serological techniques in the form of lateral flow immunoassay, a rapid user friendly dip stick/strip method that has been successfully applied for on-site detection of viruses infecting vegetable and ornamental plants. Rapid detection of plant viruses have also been made possible through various isothermal amplification techniques like loop-mediated isothermal amplification method (LAMP) and recombinase polymerase amplification (RPA). LAMP employs a set of four to six specially designed primers, which together recognize six distinct sites flanking the target DNA sequence. Amplification in LAMP proceeds without thermal cycling, utilising the strand displacement activity of DNA polymerase to remove newly amplified strands. The whole process can be carried in one hour at around 60-65°C in a water bath or a simple heating block. Recombinase polymerase assay (RPA) is another novel and simple method used for speedy amplification of nucleic acids in limited resource/laboratory settings. It employs a single primer pair and can be performed at a constant low temperature (37°C-42°C) dispensing the use of expensive thermal cycler. RPA constitutes a significant advancement in the development of portable nucleic acid tests using probe-based detection approach. Till date, very few plant RNA/DNA viruses have been detected using RPA. We have successfully demonstrated detection of banana bunchy top virus and cucumber mosaic virus using RPA. It holds great promise for application in indexing programme of plant viruses in the country under limited resource settings.

Lead Lecture-04

S- 6/NSIPS/L-4

Citrus Tristeza Virus a Major Biological Stress for Citrus Decline in Northeast India: Its Conventional and Biotechnological Management Approaches

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Citrus tristeza virus (CTV), a phloem limited Closterovirus, predominantly transmitted by brown citrus aphid (*Toxoptera citricidus*), is a destructive plant virus that kills millions citrus trees worldwide. The virus contains flexuous filamentous particles, 2000 X 11 nm in size, consisting positive sense ss RNA of 19.3kb with 12 ORFs encoding 19 proteins. CTV infects most of the cultivated citrus species inducing different kinds of symptoms; decline, yellowing, growth cessation/stunting and stem pitting with poor fruit yield and quality. Citrus, the important fruit crop, is cultivated in all the geographical zones of India, Northeast, Northwest, Central and South India. India is positioned in 6th in the world in terms of area (9.23 Lh) with production (11.1Mt) of citrus, where 15% of the area and 7.9% of production in Northeast India. CTV is a century old problem killing more than one millions tree in India till today. CTV occurs in all the citrus growing geographical zones and infects all the commercial citrus and its relatives.

The overall disease incidence 26.3- 60% in India has been estimated; where 47-56% in Northeast, 36.3% in Central, 36-50% in South and 16-60% in North-Northwest India.

A total of 114 CTV isolates (19 of from central, 56 from Northeast, 21 from South and 18 from North India) were characterized based on 5'ORF1a and coat protein (CP) gene. Indian isolates are extensive diverse showing 78-99% nt identity and fell into 7-10 different CTV genogroups. A decline inducing CTV strain, known as Kpg3 in the mandarin orchards of the Darjeeling hills of NE India was identified and its complete genome,19253nt (HM573451) was sequenced for the first time in India. The Kpg3 is a recombinant and genetically related to Israel severe CTV isolate VT. Based on the 32 half genome (8.4 kb, ORFs 2-11), another four CTV isolates from India; B5 (Bangalore: HQ912023), D1 (Delhi: HQ912022), G28 (Assam: KJ914661) and Kat1 (Vidarbha: KJ914662) were characterized. They had 89-99% nt identities among them. Genomes of Indian, Asian and International isolates were also analysed and compared. The Asian isolates fell into six, whereas the Indian isolates into four genogroups. Indian isolates D1, Kat 1 and Kpg3 grouped together (Kpg3Gr). The B5 isolate is a new and the G28 is distinct isolates/strains. The recombination phenomenon is the major factor for evolution of diversified CTV in India. Codon usage biasness (CUB), negative selection and gene flow also play major role for evolution of CTV variants.

Bud wood and shoot tip grafting for developing disease free citrus planting materials are very much important. CTV-free mandarin plantlets was developed and supplied to the farmers of in many areas of India. For development of transgenic resistant citrus, several antisence (RNAi) and hairpin (ihpRNAi) gene constructs targeting CP (p25) and suppressor (p23) gene of CTV were made in pBinAR and pRNAi-GG. Agrobacterium-mediated transformation protocol was developed using epicotyl explants of citrus seedlings. Regeneration efficiency of transformed plant was 1.38% at 2.0 mg/l BAP in MS medium. Mild cross protecting strains (MCPS) were identified through in silico CUB analysis using the CP and p23 gene sequences of CTV available in our laboratory and MCPS is being evaluated by challenging with severe CTV isolates through biological indexing.

Lead Lecture-05

S- 6/NSIPS/L-5

The Continuous Challenges of Citrus Greening Disease (Huanglongbin / HLB): Present Status and Future Strategies of its Management

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Citrus greening disease (HLB) caused by '*Candidatus Liberibacter asiaticus'*, a Gram negative alpha Proteobacterium is considered as the most important disease and principal cause of citrus decline in India. Extensive surveys revealed its presence in major citrus growing states like Maharashtra, Punjab, Andhra Pradesh, North-Eastern states etc. Among commercially important citrus cultivars, incidence of greening was more on sweet orange and mandarin varieties compared to other cultivars like acid lime and lemon. The disease was diagnosed through symptom expression, biological indexing and PCR based molecular diagnostic tools. Different sets of greening bacterium-specific primers were designed and synthesized for amplification of 16S rDNA, 16S/23S intergenic regions, ribosomal protein genes and omp genes. All the infected samples yielded specific amplification products, sizes of which were found similar to that amplified from 'Ca. *Liberibacter asiaticus*' as was confirmed by sequencing of the amplified DNA fragments and phylogenetic analyses. Again, duplex-PCR, real time PCR and LAMP

based diagnostic tools has been standardized to detect the pathogen in both plant and citrus psyllid collected from infected plants. Variability studies based on the tandem repeats at hyper variable genomic locus CLIBASIA_ 01645 reveals that the Indian populations of '*Ca. L. asiaticus*' is more diverse than other reported populations. Production of disease-free nursery plants and other novel approaches of disease management will be discussed.

S-6 /NSIPS/L-8

Harnessing Molecular Approaches for Diagnosis and Management of Plant Diseases

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Today we stand at the convergence of an incredible range of new sciences and technologies including recombinant DNA technology, information technology, and nanotechnology, to facilitate our understanding of the structure and function of the genome and to harness this information for holistic improvement of host plants. Most biotic systems have the innate ability to cope with pathogen attack through complex adaptive responses. Though some of the responses may be constitutive, most of the responses are induced after recognition of some feature of the pathogen and. subsequently may succumb to the pathogen (compatible interaction), or prevent the pathogen from colonizing it (incompatible interaction). Many biotechnological tools and techniques have been developed by using different plant pathogens as experimental materials for deeper understanding of host-pathogen interactions at molecular level, but somehow these have not been appropriately harnessed in India.

When an R gene product recognizes a corresponding avr gene product of the pathogen, signal transduction events are triggered that lead to the expression of both basal and specific defense responses. The majority of the identified R genes encode for intracellular proteins containing a predicted nucleotide-binding site followed by a series of leucine-rich repeats at their C-terminus. Transcriptional activation of genes coding for pathogenesis-related (PR) proteins, which play an important role in the expression of resistance, is a useful parameter to assess downstream signaling events. Defense pathways which are triggered by signaling molecules are not always independent. Crosstalk between different pathways is normally mediated through several means. The induction of specific pathways is also seen to be pathogen-dependent. Plants can therefore employ the right combination of defense pathways when encountered by a specific pathogen. In recent years, microarray analyses have been used to study the network of pathway interactions during expression of plant defense responses. Genetic engineering for improved disease tolerance has primarily targeted genes involved in the recognition of the pathogen (R genes), or in the overexpression of defense molecules (phytoalexins, PR proteins). An interesting alternate approach would be to target key molecules that act at points of convergence of different signaling pathways. Engineering plants with such genes, using techniques of precision now available, would enable expression of different downstream genes simultaneously, leading to activation of multiple defense pathways.

Though genetic variability in plant pathogens has been characterized by using DNA markers, the relationships between RAPD/AFLP groups of a pathogen and its pathotypes have not been established. It is very critical for practical applications of DNA markers. If there is a direct relationship between DNA fingerprinting groups and pathotypes/ races of a pathogen, it can be used as a diagnostic tool for race or pathotype identification. Ultimately, this will have important bearing in disease resistance breeding programmes. Products emanating from modern biotechnology offer abundant opportunities to achieve sustainable productivity gains in agriculture.

Invited Lecture-01

S- 6/NSIPS/I-1

New Direction and Dimensions of Crop Disease Management Approaches

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Hosts and pathogen/parasite/stress co-exist in the nature. Under this natural rule, crop plants are not exception. They usually encounter diseases caused by biotic factors like fungi, bacteria, viruses etc. and also disorders for some abiotic factors. Especially the diseases subvert host plants, thereby causing severe losses to humans in several ways. Successful and sustainable management of the plant diseases is still a challenge in the crop culture. Traditionally various disease management practices like cultural, physical, genetical (resistant varieties), biocontrol and chemical have long been adopted. It is also emphasized to achieve eco-friendly management of crop diseases up to the desired level and various IDM modules specific to crops and different agro-climatic situations have been developed. However, technological advancement in the recent times blending with the conventional practices aggravates hope of plant disease management in more effective way. Novel technologies such as improvement of biocontrol potentiality, use of biosurfactants, phytochemicals, disease resistant transgenic plants, induced resistance, nanoparticle based chemical and gene delivery systems, RNA interference, CRISPR technology (Genome editing) etc. are the recent interests of the plant pathologists in the field of crop disease management. We highlight here present and future trend of effective cum promising technologies of plant disease management considering the dynamic nature of the plant pathogens under ever changing climatic and environmental conditions.

Invited Lecture-02

S- 6/NSIPS/I-2

Chickpea Responses to *Fusarium oxysporum* f. sp. *ciceris* via Mediation of *Trichoderma asperellum* T42: A Proteomic View

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Proteome studies provide a true insight of the host's physiological responses to a given situation. In the current study, we examined chickpea responses to *Fusarium oxysporum* f. sp. *ciceris* (Foc) in presence of *Trichoderma asperellum* T42 through proteome analyses. Chickpea proteome was analyzed after 48 h of pathogen challenge and compared the results of each treatment (only T42, only Foc and T42 + Foc) with control (C). Analysis of proteomics results showed that 317 proteins were common in all treatments. In only T42 treatment without Foc challenge, expression of defensin, PR-5, NADPH oxidase, glucanase, peroxidase, calmodulin, NBS-LRR, NAC transcription family, WRKY transcription family, PAL, Rubisco and Thaumatin were more than doubled compared to control. Similarly, in only Foc

treatment expression of the proteins such as Thaumatin, glucanase, peroxidase, NBS-LRR, NADPH quinine oxidoreductase, NAC family transcription factors, superoxide dismutase, MAP Kinase, chitinase, autophagy, lipoxygenase, multidrug resistance protein, and WRKY were more than doubled. Further, in the T42 + Foc treated plants it was observed that in addition to some of the already mentioned genes there was increase in expression levels of NBS-LRR, glycolate oxidase, ascorbate peroxidase, peroxidase, and NADPH oxidase. Expression of NADPH quinine oxidoreductase was highest in T42 + Foc followed by T42 and C, which is known for production of ROS (Reactive oxygen species). Calmodulin protein related to calcium ion signaling showed highest 2.9 fold increase in T42 followed by 1.87 in Foc and 0.49 in T42 + Foc compared to C. Peroxidase showed highest 3.0 folds increase in expression level in T42 followed by 2.0 in Foc. Highest fold change 2.27 in cysteine protease was observed in Foc followed by 1.3 fold in T42 compared to C. From the results, it can be concluded that *Trichoderma* increases activities of antioxidant enzymes, calcium signaling, defense protein synthesis and structural integrity through lignifications. However, Foc enhances the activities of cysteine protease, autophagy, antioxidant enzymes and multidrug resistance proteins. Interestingly, in the co-inoculated treatment (T42 + Foc) there was enhanced expression of NBS-LRR proteins, glycolate oxidase, ascorbate peroxidase, peroxidase, and NADPH oxidase.

Invited Lecture-03

S- 6/NSIPS/I-3

Nanotechnological Approaches for the Management of Fungal Diseases of Vegetable Crops

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Nanotechnology is the emerging multidisciplinary science of physics, chemistry, biology, mathematics etc which has utilized in various sector from cosmatics to food industry to electronics. The application of nanotechnology in agriculture is though new but it can be better use in efficient use of fertilizers, pesticides, diagnostics, delivery of genetic materials and many more by maninpulating the size, shape, structure, etc. In plant protection, the emerging science can be used for detection and management of plant diseases. Nanoparticles are considered as the basic building block elements of nanotechnology. Nanoparticles from organic and inorganic sources like Ag, Au, Cu, ZnO, TiO2 can be utilized for the management of plant diseases caused either by fungi or bacteria. We at Assam Agricultural University, synthesized Ag, Cu, Au and ZnO by biological and chemical approaches and characterized with UV VIS, TEM, SEM, DLS, Zeta sizer etc to determine the shape, size, crystalinity of zete potential. *In vitro* efficacy test of Ag and ZnO at different doses was done against the fungal pathogens like *Sclerotinia sclerotiorum, Sclerotium rolfsii, Rhizoctonia solnai, Sarocladium oryzae, Fusarium oxysporum, Colletotrichum capsici* causing serious diseases of many agricultural crops. During the light and electron microscopy study, dissolution mycelial cell wall, formation of pit on hyphae, lysis, formation of lump etc were found as the mode of action of the tested nanoparticles on fungal pathogens. Further, electron microscopy and confocal microscopy study on effect of morphophysiology and karyogamy showed upto a concentration of 100 ppm nanoparticles like Ag and ZnO don't have adverse effect on the host cell. Similarly NMR result and study on biochemical activity showed positive effect on metabolom with increased concentration of primary and secondary metabolite.

S- 6/NSIPS/I-4

Whole Genome Sequencing and Functional Genomics to Understand Pathogen Diversity and Host Pathogen Interaction

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Plant diseases have been a great concern to Indian agriculture, as they are important biotic constraints, which cause significant crop losses. Fungal pathogens are emerging / remerging in climate change scenario. In the era of molecular biology, there is a need to understand pathogen evolution, biology, lifestyle, novel disease management strategies using molecular techniques. The genomes of 1090 fungal species are available in the public domain although a total of 2584 WGS projects on fungi are in progress. 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 India, only few fungal plant pathogens have been sequenced and to name a few *Puccinia* spp., *Tilletia indica*, *Magnaporthe oryzae*, *Colletotrichum* sp., *Ascochyta rebei* etc. The genomes of pathogenic fungi are slightly bigger than other sequenced fungi and they contain less coding sequences in relation to their genome size. Sequenced genomes provide insight for identification of potential virulence factors/genes which can be further manipulated for disease management. Genome sequences have also been used to evaluate adaptability of pathogens under different climatic conditions. The functional genomics attempts to illustrate the functions and interactions of genes and proteins by comparative genome-wide approaches. It is now well established that during pathogenesis, the host organism triggers the defense system by recog-nizing and responding to microbial factors popularly called Pathogen Associated Molecular Patterns (PAMPs). Specialized pathogen specific molecules like effectors and the genes coding them can be another potential targets for developing new disease management strategies. In order to gain insight into these finer aspects of pathogenesis, the genomic tools and their data become inevitable and essential. Basic information and identification of genome targets generated from these pathogens during their interaction on the host would be fundamental to better understanding of the diseases and the eventual disease management strategies in future. Some of the current advances made in WGS of emerging pathogens and their utility to understand diversity and functions of pathogenicity genes is being highlighted. Full Genome of *Tilletia indica* RAKB_UP_1, Karnal bunt pathogen has been sequenced and has been deposited at DDBJ/ENA/*GenBank* under the accession numbers MBSW00000000. The data generated has been analysed and helped in genetic diversity studies, identification and characterization of virulence related genes in *T. indica*. An Intergeneric comparative analysis of the predicted secretomes of *Bipolaris sorokiniana* and *Bipolaris oryzae* has led to identification of small secreted proteins specific and common to each pathogen. Expression analysis of six selected unique and common SSPs to *Bipolaris* spp. showed that only 2 SSPs (BS _SSP2 and BOBS_SSP2) expressed as a typical fungal candidate effector after inoculation (*in planta*). Further functional analysis of a scytalone dehydratase gene (*SCD1*) involved in melanin biosynthesis of *Bipolaris sorokiniana* has shown its role in melanin production and pathogenicity through gene-knock out strategy.

S- 6/NSIPS/O-1

Comparative Proteomic and Metabolic Analyses Identified Significant Secretomes Associated With *Verticillium dahliae*-Tomato Interactions

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Verticillium dahliae, a soilborne xylem-limited fungal pathogen, causes vascular tissue discoloration, wilting, and death of susceptible hosts. In this study, proteins and metabolites in xylem sap of race 1 -incompatible (Beefsteak) and -compatible (Early Pak) tomato cultivars were characterized with *V. dahliae* races 1 and 2. A total of 814 and 584 proteins in Beefsteak; and 456 and 637 in proteins in Early Pak were identified in xylem sap extracts of plants inoculated with races 1 and 2, respectively. A significant number of defense related proteins such as pathogenesis related protein Bet v I family, P69B protein (Zinc finger protein), Peptidase S8/Inhibitor I9 family protein, Peroxidase, PR-5x, PR10, purple acid phosphatase, glutamine synthetase, and S-phase kinase-associated protein 1 were abundantly expressed across all interactions. Only the Remorin 1, NAD-dependent epimerase/dehydratase, Polyphenol oxidase (POP), Phenylalanine ammonia-lyase (PAL), and SAM-dependent methyltransferase were differentially and uniquely expressed in the incompatible interaction, suggesting a possible role in race 1 resistance. Compared with uninoculated control, a significant overexpression of gene ontology terms associated with lignin biosynthesis, phenylpropanoid pathway and methylation were identified exclusively in the incompatible interaction. Seven weeks post-inoculation, phenolic compounds including two caffeic acid derivatives, four flavonoid glycosides, and three hydrolysable tannins (quinic acid derivatives), all of which are known to be involved in plant defense mechanisms, showed a significant upregulation in incompatible interaction. The differentially expressed xylem sap secretomes are likely involved in conferring *V. dahliae* race 1 resistance in tomato.

S- 6/NSIPS/O-2

Defense, Development and Gibberellic Acid Signaling Interplay During *Verticillium*-Host Interactions

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Various plant processes including plant development and defense responses are modulated by hormone signaling pathways. We analyzed Arabidopsis thaliana defensesignaling and hormonal signaling pathway mutants in response to the soil borne pathogen *Verticillium* spp., enabling the discovery of the interplay between defense and gibberellic acid signaling that regulates growth and flowering time. Infection by various *Verticillium* spp. enhanced the early flowering phenotype of the widely studied ndr1-1 mutant in *A. thaliana,* which lead to increased initial growth and significantly increased disease severity relative to the wild type. Our findings using the ndr1-1 mutant implicate NDR1 as a negative regulator of flowering, in a gibberellic acid dependent manner. It also provides evidence for a role of NDR1 in *Verticillium* mediated alteration in flowering time and growth response. This discovery highlights the importance of elucidating crosstalk between defense responses and hormonally regulated development prior to manipulating the pathways in crop plants.

S- 6/NSIPS/O-3

Emerging Viral Diseases of Crop Plants of North Easter Region of India

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Plant virus diseases appear to be proliferating at ever increasing rates. More than 1000 virus species have been described that infect cultivated plants worldwide. They have the capacity to cause major epidemics and total crop loss. The North Eastern region (NER) of India is the biodiversity hot spot. Plant viruses are occurring at ever increasing and alarming rates. Some of the DNA containing plant viruses are emerging as important plant pathogens in number of agriculturally important crops of the NER. They have been reported from several hosts. Tomato leaf curl virus (ToLCV) appears to be distinctive with upward and downward curling, puckering of leaves, thickening of veins, bushy appearance of the plant. Bhindi yellow mosaic virus (BYVMV) of okra shows typical yellowing of veins along with green inter-veinal areast. Chilli leaf curl virus (ChLCV) is characterized by upward and downward curling following by shortening of internodes and bushy appearance of the plants. Banana bunchy top virus (BBTV) appears with typical bunchy appearance at the top, narrow, upright and erect leaves along with presence of small dark green streaks and dot and dash like appearance on the petiole. Among the RNA containing plant viruses recorded so far from the NER were Citrus tristeza virus (CTV) which

produces various field symptoms ranging from vein clearing, stem pitting, yellowing, slow and quick decline. Potato virus Y (PVY) shows mosaic, crinkling, mottling, distortion and twisting of leaves along with reduction in leaf size. Potato leaf roll virus (PLRV) shows rolling of leave parallel to mid rib, chlorosis, necrosis and vein thickening. Papaya ringspot virus (PRSV) shows characteristic symptoms of mosaic, green islands, shoestring on leaf and blistering and ring spots on the fruit. Konjac mosaic virus (KoMV) from Elephant foot yam produces typical vein yellowing symptoms. Cucumber mosaic virus (CMV) in various ornamentals and medicinal plants show yellow and green areas on leaf lamina, thickening of veins and reduction of leaf size etc.

S- 6/NSIPS/P-1

Activation of Defense Response in Sorghum Plants against *Bipolaris sorokiniana* using Beneficial Microorganisms

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Sorghum [*Sorghum bicolor* (L) Moench] is the one of the most important cereal crops in the world. Within Asia, India is the largest producer of sorghum grain. Recently there have been severe signs of sorghum decline due to spot blotch disease resulting in decreased production of sorghum in villages of Kalimpong and Darjeeling. In the present study, initially, fungal pathogen causing spot blotch disease in *Sorghum bicolor* was isolated and identified as *Bipolaris sorokiniana*. Molecular characterization of the pathogen was done. Six potential PGPR and seven strains of *Triochoderma* showing in vitro antagonistic activity against *B. sorokiniana* were selected for their effects on growth of sorghum plants and induction of resistance against the pathogen. Root colonization with dominant abruscular mycorrhizal fungi followed by soil application with *T. asperellum* in combination with talc based formulation of *B. methylotropicus* reduced disease incidence markedly in sorghum plants which was evident by enhanced accumulation of phenolics as evident in HPLC and GCMS analyses. Pathogen infestation in leaf tissue was also evaluated by indirect immunofluorescence assay using polyclonal antibody raised against *B. sorokiniana*. Enhanced activities of defense enzymes (chitinase and glucanase) was found in plants treated with bioinoculants (AMF,PGPF or PGPR) in comparison with control set of plants which was confirmed by transmission electron microscopy using PAbs of chitinase and glucanase.

S- 6/NSIPS/P-2

Novel strategies for Management of Anthracnose of banana caused by *Colletotrichum musae*

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Anthracnose of banana caused by *Colletotrichum musae* is one of the most serious diseases of ripen banana. Symptoms of anthracnose include black and sunken lesions with spore masses or acervuli in the lesion. This has been a major constraint in the marketing of fruit intended for local as well as

distant markets. Control of postharvest diseases has been traditionally achieved by pre and postharvest applications of fungicides. However, at present situation producers have been compelled to seek alternative methods due to increased global demand for chemical-free fresh produce and due to issues like development of resistance in plant pathogens against currently used fungicides.

Plant-mediated biological synthesis of nanoparticles is gaining importance in recent years due to its simplicity and eco-friendliness. Present investigation was carried out on management of banana anthracnose by using green nanoparticles. Efficacy of green nanoparticles of copper, silver, nickel and magnesium has been studied in vitro at different concentrations against *C. musae*. Silver-Neemnano particles (Ag-Neem np) were tested for their bio-efficacy against anthracnose as postharvest spraying at 0.01, 0.02, 0.05, 0.1 and 0.2 per cent concentrations. Spraying of Ag-Neem np at 0.2 per cent concentration recorded lowest disease severity (6.67 PDI) which was on par with 0.1 and 0.05 per cent concentrations (8.89 PDI).

Among the botanicals evaluated in vivo, maximum disease reduction (92.11%) was recorded in neemgold, dischecк and nimbicidin at 2% concentration. Among the oils evaluated, lemongrass oil @1% reduced the disease incidence to the tune of 92%. Results indicated that post-harvest dipping of banana fruits with boric acid @% recorded minimum disease incidence which was on par with lemongrass oil@1% and significantly superior over all other treatments.

S- 6/NSIPS/P-3

In Vitro Antifungal Efficacy of Silver Nanoparticles against *Sclerotium rolfsii* in Tomato

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Trichoderma spp. is used as biological control agents against soil borne plant pathogenic fungi. The advantage of using *Trichoderma* in managing soil borne plant pathogens are ecofriendly, effective, ease of mass culturing with less cost of production and growth promoting effect. Silver in ionic or nanoparticles forms has a high antimicrobial activity and is there widely used for to control plant diseases. Myconanotechnology is the study of nanoparticles synthesis using fungi and their applications. In the present study was carried out on mycosynthesis of silver nanoparticles from *Trichoderma harzianum* and its antifungal activity against *Sclerotium rolfsii* in tomato was carried out. Silver nanoparticles were synthesized by using fungi *Trichoderma harzianum*. Characterizations of silver nanoparticles were carried out by UV-Vis spectroscopy and Transmission Electron Microscopy (TEM) which revealed that synthesized nanoparticles were having the UV absorption peak at 420 nm and size of nanoparticle was 50 nm. Silver nanoparticles demonstrated significant antifungal activity against *Sclerotium rolfsii* in tomato by using Agar well diffusion method and Poisoned food technique. In Agar well diffusion method, the zone of inhibition of silver nanoparticles at 100 ppm concentration was recorded 17.00 mm followed by 15.66 mm, 14.33 mm, 12.33 mm and 11.00 mm in 50 ppm, 30 ppm, 10 ppm conc. and *Trichoderma* culture filtrate, respectively. In poisoned food technique, the suspension of silver nanopartilces at 100 ppm concentration recorded highest per cent inhibition 68.53 per cent than other treatments.

S- 6/NSIPS/P-4

PCR Based Methods for Plant Pathogens Detection

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Globally nearly forty per cent crop and yield loss may happens due to crop infections incited from pathogens viz., bacteria, viruses and fungi and are persistent issues in agriculture for centuries. To ensure agricultural sustainability, to minimize the disease, an advanced disease detection and prevention in crops are imperative. In nature all organisms are having nucleic acid (DNA/RNA) as their genetic constitution. Based on the fidelity of DNA hybridization and replication, Polymerase Chain Reaction (PCR) is one such direct and advanced pathogen detection method. PCR results in the exponential amplification of a target DNA/RNA strand of pathogen. In comparison with traditional diagnostic methods, it offers several advantages which includes non-culturable pathogen detection. It is rapid and versatile possesses exquisite sensitivity, with the theoretical potential to detect a single target molecule in a complex mixture without using radioactive probes. Amplified products are separated by agarose gel electrophoresis and specific bands obtained are used to detect the pathogen and study the polymorphisms. Many derivative methods in PCR for pathogen detection such as real time PCR, multiplex PCR, RT-PCR, nested PCR etc., facilitates the detection of a single pathogen or many members of a group of related pathogens. However, specific primers are required to amplify DNA for detecting different pathogens. Because of its cost effective nature to analyze pathogens at a faster rate PCR based methods are getting popular in the recent scenario. Pathogens like *Ralstonia solanacearum*, *Alternaria tenuissima*, Citrus mosaic badnavirus, Cucumber mosaic virus, HLB, *Candidatus Phytoplasma oryzae*, Citrus Tristeza Virus and many more were recently detecting using PCR methods.

S- 6/NSIPS/P-5

Indexing of Citrus Nurseries against Mandarivirus and Greening Bacterium using Electron Microscopy, PCR and RT-PCR in Punjab

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Kinnow mandarin is one of the most important fruit crops in Punjab, Rajasthan, Haryana, Delhi, Himachal Pradesh, Jammu & Kashmir and parts of Uttar Pradesh. It is known for its production, productivity, juice content and fruit quality. Genus Mandarivirus which includes Indian citrus ringspot virus (ICRSV) and Citrus yellow vein clearing virus (CYVCV) and citrus greening bacterium (CGB) are very important graft transmissible pathogens causing reduced productivity in Kinnow mandarin. A survey was undertaken in 11 star rated kinnow mandarin nurseries in Ludhiana, Abohar, Fazilka and Hoshiyarpur. Samples collected from these nurseries were indexed by electron microscopy, immunosorbent electron microscopy (ISEM), PCR and RT-PCR. In RT-PCR test, out of 33 samples of kinnow mandarin mother plants, 3 samples were found positive for CYVCV and 6 samples for ICRSV. In two nurseries, both the viruses were detected in the same plant indicating mixed infection in the mother plants. In ISEM test, 4 samples out of 12 samples were positive for ICRSV and 2 samples were

positive for CYVCV. CGB was detected in two plants out of nine samples collected from four nurseries. As good quality antiserum of ICRSV and CYVCV is not available, the indexing of mother plants was performed by RT-PCR. In view of these studies it is evident that molecular diagnostics as indexing tool need to be applied for the production of clean planting material of kinnow mandarin in the state.

S- 6/NSIPS/P-6

RNA Interference: A Tool for Plant Disease Management

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Plant diseases are a threat to the agriculture. Significant yield loss will occur in both agricultural and horticultural crop due to development of new races of pathogens. Traditional plant breeding methods are used to develop cultivars resistant to various diseases. But it got less significant because of the limited availability of genetic resources and time consumption. Over the past decade the breeding possibility has been broadened by genetic engineering. In this RNA interference is an emerging technique used for the plant disease management. RNA i operate in both plant and animals, and uses double stranded RNA (ds RNA) as a trigger that target the homologous mRNA for degradation of its transcription or translational product, so the susceptible gene has been silenced. Silencing the specific gene by RNAi is the natural solution for the development of disease resistant transgenic plants. This RNA mediated gene control technology has provided new platform for the development of disease resistance in plants. So this technique has a significant role to control the diseases in economically important plants.

S- 6/NSIPS/P-7

Marker Assisted Pyramiding of Genes Governing Bacterial Blight (Xa13, Xa21) and Blast Resistance (Pi54, Pi1, Pita) Into A Popular Indica Rice Variety, "Samba Mahsuri"

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Samba Mahsuri (SM) is a popular medium slender grain rice variety widely cultivated across India and known for its unique fine grain and cooking quality. It is highly susceptible to bacterial blight

(BB) and blast diseases, which severely affects productivity and grain quality. As there are many R genes governing resistance to these diseases which have been mapped, utilizing them is an effective approach their management. The present study was carried out to pyramid two bacterial blight resistance genes namely xa13 and Xa21, and three blast resistance genes namely Pi54, Pi1, Pita into SM through marker assisted breeding. Foreground selection using gene based/ gene linked markers for target genes and phenotypic selection for grain and cooking quality was employed for recovery of SM genome and phenome. The pyramided genotypes were evaluated for its agronomic performance at New Delhi, Pusa (Bihar) and Aduthurai (Tamil Nadu) for two seasons during Kharif 2016 and 2017. Their reactions to BB were characterized through artificial inoculation and for blast disease in the uniform blast nursery at Palampur and Hazaribag. Three promising medium slender grain genotypes namely Pusa 1853-12-192, Pusa 1853-12-288 and Pusa1853-12-315 with significantly higher yield and better yield stability along with resistance to BB, blast diseases and desirable grain and cooking quality, and similarity with SM genome were identified. The promising genotypes will be nominated for testing in AICRIP trials for varietal release. They are also excellent source germplasm for developing with multiple stress tolerant medium slender rice genotypes.

S-6 /NSIPS/P-8

Biologically Mediated Nanoparticles have Antibacterial Activity

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The science nanotechnology is the emerging and fascinating field that deals with synthesis and application of the basic building block element i.e., nanoparticles. The science of nanotechnology consist of processing, separation, consolidation and deformation of materials either by single atom or molecule, where manipulation of matter is done at least one dimension sized from 1 to 100 nanometers. But its application in plant pathology is a new frontier and nanoscale materials have emerged as novel antimicrobial agents owing to their high surface area to volume ratio and the unique chemical and physical properties, which increases their contact with microbes and their ability to permeate cells. In the present study biologically synthesized Au and Ag nanoparticle was tested against *Xanthomonas oryzae* pv. *oryzae* causing bacterial blight of rice that causes yield loss of 12-75% by disc diffusion method. Both the nanoparticles were tested 1, 5, 10, 50, 100 and 200 ppm concentrations. We found that out the Au nanoparticles at 200 ppm concentration was highly effective against the pathogen. This was followed by 100, 50, 10 ppm. No growth inhibition of the pathogen was observed when the Au nanoparticle was tested at 1 and 5 ppm concentration. Ag nanoparticle at all the tested concentration could not inhibit the growth of the pathogen.

S- 6/NSIPS/P-9

Molecular Characterisation and *In Vitro* Eco-Friendly Management of *Sclerotium* spp. in Manipur

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Sclerotium spp. is a soil inhabitant, polyphagous, and a ubiquitous facultative parasite. It is widely distributed in tropics, subtropics and also in warmer part of temperate zone of the world, it has wide host range infecting more than 500 plant species. Present study was carried out to investigate the presence of *Sclerotium* spp in Manipur at molecular level and has it has been accomplished by PCR amplification of ITS (Internal Transcribed Spacer) regions followed by sequencing. *In vitro* management practices of *S. rolfsii* was done by using some botanicals and microbial agents Various species of *Trichoderma* like *T. asperellum, T. koningiopsis, T. hypocrea, T. harzianum, T. ovalisporum, T. atroviride* were considered for the present study, among them *T. asperellum* (KU933476) had shown best results with 63% inhibition and *T. atroviride* (KU933472) of 13% inhibition of pathogen growth. Among the Botanicals, *Ocimum* spp.(leaf), *Parthenium* spp (leaf) and onion (bulb) were used with three different concentrations, among them *Ocimum* at 5% had shown 100% inhibition and *Parthenium* at 2.5% had shown least inhibition(13%) on radial growth of *S. rolfsii*.

S- 6/NSIPS/P-10

RNAi Based Biotechnological Approach for Management of Cotton Leaf Curl Begomovirus Disease in Northwest India through *Agrobacterium*-Mediated *In Planta* Transformation

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Cotton leaf curl disease (CLCuD), caused by monopartite virus particles under the genus Begomovirus belonging to the family Geminiviridae in association with DNA satellite molecules, is one of the serious constrains in cultivation of cotton in Northwest (NW) India. This disease is transmitted by whitefly (*Bemisia tabaci*) in semi-persistent manner. Resistant or tolerant variety is regarded to be the best method for management of CLCuD. But recently none of the cotton varieties/hybrids/genotypes are resistant rather highly susceptible. No chemicals are available to control the insect vector, whitefly. Therefore, molecular-based management system targeting conserved virus sequence is necessary. The major constraint in cotton improvement has been the recalcitrance of cotton in tissue culture system. Effort was made in the present study to develop transgenic cotton plant resistance to CLCuD by a

tissue-culture independent *Agrobacterium*-mediated transformation procedure. Antisense gene constructs (RNAi) targeting complete âC1 gene of CLCuD- begomovirus associated betasatellite molecule was developed in pCAMBIA2301, called as pCAMBIA2301-As-âC1 construct. Complete âC1 gene (363 nt) was cloned into pHANNIBAL (CaMV 35S-âC1-OCS) in antisense orientation and the cassette, called "CaMV 35S-âC1-OCS" was sub-cloned pCAMBIA-2301 at Pst I/Sac I site. *Agrobacterium* strain EHA105 harboring the binary vector pCAMBIA2301-As-âC1 that carries the genes for â-glucuronidase (GUS) and neomycin phosphotransferase (npt II) was used for transformation.

Four cotton verities (RST-9, F846, HS 6 and PSS-2) were used for *in planta Agrobacterium*-mediated transformation with this gene construct made. Agroinfected seeds were sown in the soil rite (4 cocopit: 2 vermiculite: 2 perlite: 1 soil) in the growth chamber at 24-28ºC for 14h photoperiod. From the growth chamber, the plantlets were transferred in the pot filled with normal soil in the greenhouse. Total numbers of 278 agroinoculated cotton plants (To) were survived in greenhouse. The mature bolls of the To plant were collected and cotton seeds were screened using Kanamycin @ 300 ppm. The T1 transformants were identified by â-glucuronidase activity in GUS assay and subsequently confirmed by PCR analysis. About 65 number of T1 seedlings were found to be GUS and PCR positive. GUS expression and PCR analysis of the T1 generation suggested the feasibility of the *Agrobacterium*-mediated *in planta* transformation method to generate transgenic plants in cotton.

S- 6/NSIPS/P-11

Effect of Biosynthesized Silver Nanoparticles on Morphophysiology of Host

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Phytotoxicity is an important is important aspects of nanoparticles in relation to environment and plants. Here, we report on the effects of biologically synthesized silver nanoparticles (Ag NPs) from *Trichoderma asperellum* on the development of Mustard, Chilli, and French bean. Four toxicity indicators (seed germination, root and shoot length Chlorophyll content and Lipid peroxidation) were quantified following exposure to each nanoparticle at a concentrations of 1000ppm, 500ppm, 100ppm, 50ppm, 20ppm, 10ppm, 7ppm, 5ppm, 3ppm, 1ppm and carbendazim @0.3%. Results showed that silver nanoparticles at a concentration of 100 ppm and 50ppm effective in increasing all the growth parameters of the crops as compared to other concentration and carbendazim whereas it showed detrimental effect at a concentration of 1000ppm.

S- 6/NSIPS/P-12

Double-Stranded RNA-Mediated Interference with Cucumber Mosaic Virus Infection in *Capsicum chinense* Jacq.

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Cucumber mosaic virus (CMV) causes great losses in Bhut Jolokia pepper (*Capsicum chinense* Jacq.) plantations in Assam, India. We have successfully interfered with the infection of Bhut Jolokia plants by CMV, demonstrating the reliability of Double-Stranded RNA based management against this virus. This study constitutes a non transgenic approach of protection of Bhut Jolokia crop against CMV infection. To investigate possible means to induce plant resistance against this virus, the crude extract of bacterially-expressed double-stranded (ds) RNA, derived from CMV-2b gene (dsRNA_CMV-2b), was exogenously applied along with CMV onto Bhut Jolokia plants. In this 'RNA-vaccination' bioassay, disease incidence ranged from 0% to 29% in case of dsRNA-treated plants, and from 55% to 92% when only CMV was applied. CMV-infected pepper plants became severely stunted, having dull light green foliage with leathery appearance, whereas plants receiving dsRNA_CMV-2b exhibited milder symptoms or remained healthy. The results obtained suggest that this non-transgenic approach has a considerable effect in protecting pepper against CMV.

S- 6/NSIPS/P-13

Marker Assisted Selection for Plant Disease Resistance – A Review

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Marker assisted selection or marker aided (MAS) is an indirect selection process where a trait of interest is selected based on a marker (morphological, biochemical or DNA /RNA VARIATION) linked to a trait of interest (productivity, disease resistance, abiotic stress tolerance and quality), rather than the trait itself.DNA based polymorphism commonly known as DNA markers can be used for genetic improvement through selection for favourite trait such as disease resistance. Molecular markers have proven to be invaluable tools for assessing plants genetic resources by improving our understanding with regards to the distribution and extent of genetic variation within and among the species. It is expected to increase genetic response by affecting efficiency and accuracy of selection. By using molecular marker s, breeders can bypass traditional phenotypic based selection method, which involve growing plant to maturity and closely observing their physical characteristics in order to infer underlying genetic make-up. Maker assisted selection (MAS) provides opportunities for enhancing response from

selection because molecular marker can be applied at the seedling stage, with high precision and reduction in cost. MAS could be easily applied, but it is often not required because the resistance are selected phenotypically. In quantitative disease resistance s, MAS would be very useful , but the individual QTL often have small effects. Additionally only a few monogenic resistance are durable and only a few QTL with high effects have been successfully transferred into elite breeding material. Eventhough MAS plays an important role in the field of plant breeding examples of successful, practical outcomes are rare. The economic and biological constraints such as low return of investment in small grain breeding, lack of diagnostic markers, and the prevalence of QTL background effects hinder the broad implementation of MAS. Until complex trait can be fully dissected, the application of MAS will be limited to genes of moderate-to-large effect and the applications do not endanger the response to conventional selection. Till then, observable phenotype will remain an important component of genetic improvement programs, because it takes into account the collective effect of genes. In future, chip-based, high throughout genotyping platforms and the introduction of genomic selection will reduce the current problems of integrating MAS in practical breeding programs and open new avenues for a molecular – based resistance breeding.

S- 6/NSIPS/P-14

Efficacy of Silver Nanopaticles against *Colletotrichum musae* causing Anthracnose of Banana

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Anthracnose disease of banana caused by *Colletotrichum musae* (Berk. & M.A. Curtis) Arx is one of the most important post harvest disease of banana causing loss of 22 %. The disease is mainly managed by application of synthetic chemicals. But in the recent years, due to the discovery of the ill effects of these synthetic chemicals not only to the environment but also to the non targeted organism including human beings, scientists are searching for new particles so that reduced use can manage the targeted organism efficiently. Use of nanoparticles is one option whereby use of nanosized particle at reduced dose can effectively control the plant pathogen. In the present study we tested efficacy of biologically synthesized silver nanoparticles against *C. musae* causing anthracnose of banana. Efficacy of silver nanoparticles against pathogen was carried out by poison food technique *in vitro* at six different concentrations *viz*, 1000, 2000, 100, 10 and 1 ppm. A chemical check (Carbendazim at 1000 ppm) was maintained for comparison. Results revealed that effect of silver nanoparticles at 2000 ppm concentration showed maximum inhibition (95.55%) of mycelial growth of the pathogen and conidial germination as compared to the control. This was followed by mycelial growth inhibition by 1000 ppm which showed inhibition percentage of 82.22%.

S- 6/NSIPS/P-15

Effect of Zno Nanoaprticle on *Rhizoctonia solani* and Karyotype of Tea Seedling

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Application of nanoparticles in agriculture aims to reduce incidence of pests and diseases, minimization of nutrient losses and increase in yield. The present study was carried out to study the effect of Zinc oxide (ZnO) nanoparticles on collar rot causing pathogen i.e. *Rhizoctonia solani* of tea (*Camellia sinensis*) at 6 different doses. The result showed that with increasing concentration of the nanoparticle the efficacy was found to increase. The highest mycelia growth inhibition was found at 100 and 225 ppm concentration. Further, 4 different methods were tested to study the efficacy of the ZnO nanoparticle (at 100 ppm concentration) on karyotype of tea plant. Result showed that ZnO nanoparticles induce less asymmetrical karyotype than the control and hence the treated plants were primitive than the untreated plants. The result of present study paves the way for further use of ZnO nanoparticles for genetic improvement of plant.

S- 6/NSIPS/P-16

Marker Assisted Selection of Mapping Population against Chickpea Wilt

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The Chickpea wilt being the major constraint in the production, moreover the pathogen has high degree of genetic variability and it is soil borne. Now a days, application of chemical pesticides is limited because of their environmental pollutions and health risks. So, using genetic resistance and cultivating resistant genotypes is the most suitable and possible method for control of wilt of chickpea. Therefore, the present investigation was carried out to select the resistant of amongst the mapping population through marker assisted selection.

In the present study, the 30 chickpea genotypes were selected for screening from three mapping population of different crosses ICCV 08113 (resistant) X JG 62 (Susceptible), PG 04305 (resistant) X JG 62 and PG 07101 (resistant) X JG 62. 10 genotypes from each population by marker CS-27F/R linked to susceptibility and three microsatellite based markers TA-59 linked to resistance alleles were validated. The results indicates that amongst 30 genotypes 8 genotypes were resistant from cross I, 1 genotype from cross II and 7 genotypes from cross III shows amplification in CS27F/R 1200bp. Other than theses genotypes shows bands in STMS (TA59 258bp) primer which is linked to resistance to *Fusarium* wilt.

S- 6/NSIPS/P-17

Alteration of Metabolites and Isozyme Activity in Wilt Resistant and Susceptible Castor Genotypes during *Fusarium oxysporum* f. sp. *ricini* Infection

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Biochemical variations were studied in wilt (*Fusarium oxysporum* f. sp. *ricini*) resistant (SKI 215 and SKP 84) and susceptible (JI 35 and VP 1) genotypes of castor in inoculated and uninoculated conditions from leaf and root tissues. The experiments were carried out inside net house, and the castor seeds were sown in *F. oxysporum* f. sp. *ricini* inoculated pot. When symptoms started to appear, leaf and root samples were harvested for the biochemical analysis. The results showed that Total soluble sugar content was significantly increased both in root and leaf of susceptible and resistant genotypes when inoculated with *F. oxysporum* f. sp. *ricini* as compared to uninoculated. Maximum sugar content was noted in root of JI 35 (0.259%), whereas in leaf of SKI 215 (0.400 %). The phenol content was higher in susceptible castor genotypes compared to resistant castor genotypes and it was found more in leaf compared to root. In root, maximum phenol content was recorded in JI 35 (0.466 %) followed by VP 1 (0.397 %), SKI 215 (0.388 %) and SKP 84 (0.343 %). While in leaf, it was maximum in JI 35 (0.639 %) followed by SKI 215 (0.550 %). The protein and free amino acid content was significantly increased both in infected leaves and roots of susceptible genotypes compared to resistant. Maximum protein content in root (5.218 %) and leaf (7.904 %) recorded in SKP 84, however amino acid content was determined in root and leaf, SKI 215 (1.023 %) and JI 35 (2.354 %) respectively. The chlorophyll a, chlorophyll b and total chlorophyll content was significantly reduced when inoculated with *F. oxysporum* f. sp. *ricini*. Peroxidase and Polyphenol oxidase activity was significantly increased in wilt pathogen inoculated genotype as compared to uninoculated control. Peroxidase activity was increased in leaf of genotype VP 1 (0.290) followed by JI 35 (0.233), SKI 215 (0.103) and SKP 84 (0.091) at 460 nm/min./g fresh tissues, respectively. Polyphenol oxidase activity was increased in SKI 215 (0.0121 at 490 nm/min./g fresh tissue). These results reveal that higher biochemical content and isozyme activities after inoculation with pathogen may restrict the disease after infection.

S- 6/NSIPS/P-18

Evaluation of Local Cultivars of Rapeseed and Mustard against White Rust caused by *Albugo candida*

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Experiment was conducted during 2016-2017 on twenty cultivars/genotypes of rapeseed and mustard to understand the reaction against *Albugo candida.* Artificial inoculation was done by sporangial

suspension and the overall average disease incidence ranged from 4.16-23.42 per cent among the tested genotypes/cultivars. RAPD analysis on twenty cultivars/genotypes of rapeseed and mustard with OPB-01, OPB-08 and OPD-13 primers revealed that OPB-01 had the highest polymorphic information content. At a distance coefficient of 0.25, twenty cultivars/genotypes were cluster into 2 major clusters, the first major cluster consists of 19 cultivars/genotypes and second major cluster consist of only 1 cultivar/ genotype. Using 3 RAPD primers, all the 20 cultivars/genotypes were successfully classified except 4 cultivars/genotypes.

S- 6/NSIPS/P-19

Molecular Characterization of Mungbean Yellow Mosaic India Virus in Central India: Geographical Differentiation in Indian Subcontinent

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Mungbean yellow mosaic India virus (MYMIV) is widely prevalent in Central India and threatens many food legumes, including soybean, mungbean, and blackgram. Druing Kharif (monsoon) season, soybean is grown as the main legume in the state of Madhya Pradesh (MP) and is used as the oil seed crop. Three isolates of MYMIV were anlayzed in MP on the basis of their sequences; two genome components of the virus, DNA-A and DNA-B, eoncoded seven and two genes, respectively, and showed general features in the intergenic common region. Sequence identity scores and phylogenetic analyses showed that the three MP isolates were close to each other and were also related to some isolates previously collected in Central or North India. Comparison of two cladograms between DNA-A components and DNA-B components suggested gene recombination events in these three isolates, as has also been shown among other isolates. Analyses of the coat protein gene AV1 using some other isolates from Madhya Pradesh revealed sequence diversity and molecular variation among MYMIV isolates in this region. Phylogenetic analyses of a number of MYMIV isolates classified them into three general groups and virus map location illustrated that MYMIV has been differentiated on the basis of geographical distribution and relationship in the Indian subcontinent

S- 6/NSIPS/P-20

Compatibility of Green Synthesized Ag Nanoparticles with *Trichoderma harzianum*

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Green synthesized Ag nanoparticle was tested *in vitro* with *Trichoderma harzianum* by poison food technique. Four different doses of Ag nanoparticle @ 0.01%, 0.02%,0.03% and 0.04% were

considered for the study. Result showed that biosynthesized Ag nanoparticle was susceptible at all the doses without showing any radial growth inhibition of *T. harzianum.* Microscopic observation on mycelium and conidia showed no deformation. Hence the result of the present study may be used to study the combined effect of Ag nanoparticle *T. harzianum* on the management of plant pathogen.

S- 6/NSIPS/O-21

Antifungal Activity of Biosynthesized Gold Nanoparticles

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The use of cow urine in the biosynthesis of nanostructured materials considered as an eco-friendly, non-toxic and cost effective approach. In this study we tried to synthesized gold nanoparticles from cow urine with the help of a precursor Chloroauric acid. Synthesized gold nanoparticles were characterized by Fourier transform infrared spectroscopy (FT-IR), scanning electron microscopy (SEM), X-ray diffraction (XRD) and UV-vis spectroscopy. Further the gold nanoparticles were tested to study the efficacy against soil borne plant pathogens like *Rhizoctonia solani*, *Fusarium oxysporum*, *sclerotinia sclerotiorum, Sarocladium oryzae* and *Ustilaginoidea virens* at 100 percent concentration. The result showed that the gold nanoparticle can significantly inhibit the mycelial growth of all the tested pathogen. The per cent inhibition was found to be 44.11% in *S. sclerotiorum,* 43% in *F. oxysporum,* 43.1% in *U. virens,* 38.44% in *R. solani* and 54.22% in *S. oryzae*.

TECHNICAL SESSION - VII

Integrated Plant Disease Management

Lead Lecture-01

S- 7/NSIPS/L-1

Desert Speciality: Precious Desert Wild Edible and Medicinal Fleshy Mushrooms from Rajasthan and Production Status

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During rainy season of 2016 many forays were conducted and important mushrooms were collected. Many of them are popular among villagers and tribal's. These mushrooms are on the top rank in terms of liking and people eat them even in dried form. These are *Podaxis pistillaris, Phellorinia inquinans*. The marketing is being done by popular vendors and even export potential has been found because of their demand in Middle East countries. Some other important medicinal mushrooms can be domesticated and after making them acceptable can be marketed at large scale. Some of them are *Ganoderma lucidum, Auricularia auriculae judae, Schizophyllum communae Coriolus versicolor* and *Colotricia perrenis*. Apart from this edible species can be used to evolve potent strains through mycelial anastomosis and we have already initiated the work for this. Important among them are *Agaricus augustus, Agaricus bisporus , Agaricus trisulphuratus Clitocybe sp., Polypore sp, and. Pleurotus sp.* This innovative work will give new momentum to growers as well as farmers who are involved in local collection of precious edible desert mushrooms. We have initialed a dialogue with APEDA for possibilities of Export of these important mushrooms which are specialties of Rajasthan. In the state of Rajasthan Mushroom production is increasing very fast. Since last five years the production has gone up by four fold and right now 2000 MT of mushroom production has been recorded. Now button mushroom even being cultivated in desert districts. You will enjoy if you travel to Jaisalmer and if you are there in the month of December-January, see the button mushroom in Kaccha houses and dried *Podaxis* and *Phellorinia* dishes being served in hotels.

Lead Lecture-02

S- 7/NSIPS/L-2

Mushrooms and Bioremediation

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The contamination of soil, water and air by toxic chemicals as a result of industrial activities and extensive use of pesticides in agriculture is one of the major environmental problems facing the world today. Currently incineration is the most common practice to get rid of pollutants but is costly and not energy efficient. Utilization of micro-organisms to degrade toxic pollutants is an efficient and economical approach. Therefore, an ecologically safe method is "bioremediation" which is the process of using the biological properties of naturally occurring organisms, primarily microorganisms, fungi and plants, to degrade, immobilize or sequester environmental toxins. Mushrooms have been used as remediation tool for degradation of different types of pollutants because of their potential to produce a vast array of enzymes. Mushroom

forming fungi are most powerful decomposers in nature, which secrete strong extra cellular enzymes due to their aggressive growth and biomass production. These enzymes include lignin peroxidases, manganese peroxidise, lypase and laccase, etc. White rot fungi have been used for biotransformation of pesticides, degradation of petroleum hydrocarbons and lignocellulolytic wastes in the pulp and paper industry. *Phanerochaete chrysosporium, Agaricus bisporus, Trametes versicolor* and *Pleurotus ostreatus* are amongst many mushrooms that have been reported in the decontamination of polluted sites.

S- 7/NSIPS/O-1

Diversity, Characterization and Nutritional status of Wild Edible and Medicinal Mushrooms of Sikkim

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Wild medicinal mushrooms are specific strains of wild edible mushroom species that are used since ancient time for their unique and extraordinary health enhancing bioactive compounds. Now-a-days mushrooms are also a class of super foods created from the actual fruiting body as well as the mycelium biomass and spores or seeds of the mushroom. With the aim to study the diversity, nutritional content and identification of some wild edible mushrooms of Sikkim, the fungal cultures were isolated by the tissue taken from their basidiocarps, using moist chamber method. The cultures were purified by repeated sub culturing of the mycelium and the cultural characteristics of fungi were studied. On the basis of available literature the fungi were identified by matching their characteristics like external morphology and anatomical features etc. followed by molecular characterization using DNA markers with a standard protocol. Total ten different species of wild edible mushrooms were identified namely; *Laetiporus sulphurous* (Bull.) Murrill, *Polyporus tenuiculus* (P.Beauv) Fr., *Pseudohydnum gelatinosum* (Scop.) P. Karst, *Grifola frondosa* (Dicks.) Gray, *Pholiota nameko*, *Morchella esculenta* Fr., *Auricularia auricular judae* (Bull.)Quel. *Pleurotus ostreatus* (Jacq.) P. Kumm, *Lentinula edodes* (Berk.) Pegler, and *Schizophyllum* commune Fr. The nutritional contents of the mushrooms were also analysed in terms of moisture, protein, crude fat, carbohydrate (sugar) contents. The present study describes the existing situation of the wild mushrooms of Sikkim and putting emphasis on ecological effects of harvest. The results may be valuable for documentation and cultivation purposes of wild mushroom for nutritional and medicinal purpose.

S- 7/NSIPS/O-2

Comparative Study on Growth and Yield Performance of Pink Oyster Mushroom (*Pleurotus eous*) on Different Substrates

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The research experiment was carried out to investigate the cultivation of pink oyster mushroom (*Pleurotus eous*) on different substrate like paddy straw, ragi straw, sugarcane thrash, arecanut husk,

saw dust, coconut fibre, paper waste and combination of arecanut husk + paddy straw. Mushroom cultivation is a profitable agro-business, incorporation of non-conventional crops in existing agricultural system can improve the economic status of the farmer. Mushroom are the source of protein, vitamins and minerals, and are anticancerous, anticolesterol and antitumorous. Among the different substrate used, the maximum growth was found on ragi straw with mean weight of 483.4 g , paddy straw (413.4 g), saw dust (423.4 g) and combination of arecanut + paddy straw the mean weight was 396.7 g. the lowest yield was obtained on paper waste and sugarcane thrash with average weight of 280 g and 276.7 g respectively.

S- 7/NSIPS/O-3

Specis of *Agaricus from Ridge Forests of Delhi*

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During rainy season, (July-September 2015-16), a wild agaric was found growing in forest range of Delhi. The fungus was appearing in gregarious form on the soil surrounding the trees in Acacia forest. The fungus was brought in pure form by tissue culture and its morphological and anatomical features were studied. The basidiocarp of the fungus was beautiful in appearance, pileus appressed, convex, soon become flattened, reddish brown, with conspicuous scales on the dorsal side which is the characteristic feature of the fungus,ranges 4.2-8.5cm, fibrillose, gills yellow tinge, turns to deep pink to chocolate/dark colour on maturity. 5.0-8-5cm long, off white, solid, changes to pinkish when brushed, scaly downs, having a conspicuous annulus. Spores brown, turned pinkish on maturity, ovoid, smooth, 7.5-9.2x5.-5.5um, spore print chocolate/black coloured. The fruit-bodies did not remain closed for 3-4 days like in *Agaricus bisporus*, opened in early stage of their development. The spawn of the fungus was prepared on wheat grains by standard method and the cultivation studies were carried out on the compost prepared for A. *bisporus*. In an average 260 g fresh mushrooms were produced from 4 kg compost and weight of the single fruit body was recorded as 7.6-13.5 g. On basis of morphology, macro and microscopic characters and available literature, the fungus was identified as *Agaricus silvaticus*, falls in order Agaricales, family Agaricaceae The mushroom was found edible and reported a good species for intra for specific hybridization. The culture of the fungus has been deposited in Indian Type Culture Collection (ITCC No. 7902), Division of Plant pathology ICAR – Indian Agricultural Research Institute Pusa New Delhi.

S- 7/NSIPS/P-1

Comparative Study of Chemical Constituents and Antioxidant Potential of Three Edible Mushrooms Cultivated in North Bengal

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Three edible mushrooms *Agaricus bisporus* (button mushroom), *Calocybe indica* (milky mushroom) and *Pleurotus sajor-caju* (oyster mushroom) very common mushroom species in North Bengal were subjected to evaluate the antioxidant activity in terms of ferric reducing activity power (FRAP) and DPPH scavenging activity power. Phenolic, flavonoid and total free amino acid content responsible for antioxidative activity was also measured in methanolic extract. It was found that total phenolic and flavonoid content was maximum in *P. sajor-caju* followed by *A. bisporus* and *C. indica*. Maximum phenolic was measured in P. sajor-caju while minimum phenolic was found in *A. bisporus*. On the other hand maximum flavonoid was measured in *P. sajor-caju* while *A. bisporus* was recorded to have minimum flavonoid content. *A. bisporus* was considered to have maximum amino acid content while *C. indica* was recorded with minimum. The result revealed that *P. sajor-caju* had maximum ferric reducing power and DPPH scavenging activity whereas *C. indica* showed the minimum FRAP and DPPH scavenging activity. The GC-MS analysis revealed that the presence of phenolic derivatives, organic acids and essential fatty acids in these three mushrooms which are associated with some beneficial health activities like antioxidant. Fumaric acid, acetic acid and malic acid were detected as organic acid in the mushroom samples. Pyrazin a phenolic derivative responsible for antidiabetic activity detected in the mushroom samples.

S- 7/NSIPS/P-2

Influence of Environmental Variables and Host Characteristics on Occurrence of Wood-Rotting Fungi at Different Altitudes in Forests of Nagaland

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The present investigation was carried out in 3 selected reserve forest stands of Nagaland at different altitudes for two successive years (January 2015 to December 2016). A total of 57 wood-rotting fungi were identified. Forty four species belonged to the phylum Basidiomycota, 12 to Ascomycota and 01 to Myxomycota. Majority of the wood-rotting fungi were classified under the family Polyporaceae (16 species). The distribution of wood-rotting fungi depends on different altitudes and host characteristics. The highest number of occurrence of wood-rotting fungi was recorded at an altitude of 1469 meters

above sea level (msl) with 40 species. Logs, twigs and wood decay stage III provided essential habitat for the formation of sporocarps of majority of the species. The pH and percentage moisture content of the hosts ranged from 3.7 to 6.2 and 17 to 58 respectively. Majority of wood-rotting fungi (80%) were found growing exposed to light condition and only 20% under shaded condition. It was observed that species growing under shaded condition preferred later stages of wood decay (decay stages IV and V) and higher moisture content (above 34 %). Ordination of species and environmental variables with canonical correspondence analysis (CCA) indicated that the important factors responsible for determining the occurrence of wood-rotting fungi were (i) temperature in the tropical region, (ii) altitude in the sub-tropical region, (iii) high light intensity and relative humidity in the lower temperate region. All the variations where the species occurred are well predicted (93.37%) by the environmental variables.

S- 7/NSIPS/P-3

Evaluation of Different Grain Substrates against Contaminants of Spawn

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Eight substrates viz. wheat grains, bajra grains, oat grains, kodo grains(Sorghum grains), maize grains, jowar grains, maize cob powder plus wheat grains and barley grains were evaluated for their suitability to act as best substrate along with recording the data on per cent contamination in each case. Time taken for mycelial run, spawn run in spawn bags and incidence of contaminants were observed on daily basis till complete mycelium run was observed in spawn bottles. The spawn prepared on wheat grains and kodo grains had minimum contamination of 13.75% each followed by maize grains (15.25%); whereas maximum contamination (28.75%) was observed in maize cob powder with wheat grains (28.75%). Fungal contaminants were the major contaminants observed on these substrates followed by some bacterial contaminants. Kodo grains (Sorghum grains) with minimum contamination took minimum time for the complete growth of mycelium (18 days) followed by oat grains (20 days), wheat grains (21days) and maize grains (23days).

S- 7/NSIPS/P-4

Yield Performance and Nutritional Analysis of *Pleurotus* species on Different Agro Wastes and Vegetable Wastes

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Oyster mushroom was cultivated on rice straw, *brassica* straw, cauliflower leaves, pea pod shell, soybean husk and on various combinations of paddy straw and aforementioned

waste. *Pleurotus citrinopileatus* failed to grow on pea pod shell and cauliflower leaves when it was cultivate separately on these wastes. However, it grew very well on paddy straw in combination with other substrates. Yield and biological efficiency of *P. citrinopileatus* was seen better, when it grows on paddy straw mixed with other agro waste than paddy straw alone and also in case of nutrients. From different species of *Pleurotus, P. sajar-caju* have high biological efficiency than *P. florida when cultivated on soybean husk*.

Yield and biological efficiency of *Pleurotus citrinopileatus* on 70% paddy straw + 30% other agrowastes were significantly higher than 80% paddy straw + 20% agrowastes combination. Paddy straw and vegetable wastes combination gave better result in terms of total yield and biological efficiency than paddy straw alone. In respect of fruit flush, first flush gave much more yield than second and subsequent flushes. Moisture content of mushroom have been found to be 86.86% to 89%. The total yield of *Pleurotus sajar-caju* gives the highest yield in terms of fresh weight 303.56g and dry weight 46.17g as compared to *Pleurotus citrinopilatus*and *Pleurotus florida.*

S- 7/NSIPS/P-5

Effect of Different Supplement on the Yield and Dietary Values of Oyster Mushroom (*Pleurotus sapidius Kalchbr*)

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Oyster mushroom cultivation plays an important role in profitable agribusiness that can improve the socio-economic conditions of farmers in Assam as an alternative production technology. The aim of this study was to see the effect of the different supplement on the yield and dietary values of oyster mushroom (*Pleurotus sapidius)* in order to identify the best supplements. The experiment included 17 treatments with three replications. *P. sapidus* cultivated on the rice straw basal substrate using various supplements viz. rice polish, wheat bran, rice bran and sawdust with 10%, 20%, 30% and 40% combination ratios. The results revealed that rice straw + rice bran @ 40% contributed the highest yield along with dietary values viz. carbohydrate content, crude protein content and crude fibre content. An ideal lower fat content was also found in the mushrooms produced with the above same supplement.

S- 7/NSIPS/P-6

Evaluation of *Lentinula edodes* Growth on Different Media and Substrates

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Lentinula edodes is one of the most popular, widely cultivated and important edible mushroom in the world with medicinal and nutritional values. Cultivation is done on hardwood logs and also by using sawdust of broad leaved trees. In a preliminary study, four different strains of *L. edodes* were collected

namely LE -01, LE - 04, LE -05 and LE -06, out of which LE-06 showed the fastest growth on freshly prepared PDA medium. The fastest growing strain LE-06 was then evaluated on ten different media for the growth of *L. edodes* among which the maximum mycelial growth was observed on freshly prepared PDA. In the study, the spawn growth was tested on nine different sawdust spawn formulations and was compared with wheat grains spawn. The fastest spawn growth was observed on the wheat grains and among the sawdust formulations used tea leaves and rice straw both showed fastest growth.

S- 7/NSIPS/P-7

Farmer Friendly Innovations for Cultivation of Different Mushrooms and Spawn Production

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A pilot scale investigation was carried out to explore possibilities of solar panel enabled eco-friendly production units (10'x8'x8') with flexibility to handle various combinations of temperature and humidity control on an as-needed for cultivation of white button mushroom (spawn and case run 22-24^{0}C, pinhead initiation and button formation 15-17°C and humidity 85-90%) in Raipur, Chhattisgarh. Strain S-11 was selected as a potential strain from a repertoire of cultivated strains of *A. bisporus* and evaluated for yield and cultivation prospects round the year in these units. It was found that eight crops of S-11 strain of button mushroom can be taken if cultivated round the year with 15-20% biological efficiency (B.E.) on long method prepared paddystraw or wheatstraw compost. Production units (10'x8'x8') could accommodate 200 bags each containing 5kg of compost and with a cropping period of 45-50 days, production of 1.5 to 2.0 quintals of button mushroom was achieved. It was also recorded that though there was less no of button mushrooms per bag, the weight of individual unopened buttons were on a higher side with maximum being 230 gm of a single harvested button mushroom. This opens up novel avenues for cultivation of an otherwise temperate mushroom in tropical and subtropical areas successfully or as a profitable livelihood option without bearing the cost of huge electricity charges and danger of crop failure due to lack of power backing facilities. Similarly paddy straw mushroom (*Volvariella volvacea*) cultivation as a border crop in green houses under protected cultivation was also taken up by different farmers in Sirpur and was found to be an additional high value crop during the months from July to October. Another innovation was recorded during visits and training programmes conducted on oyster mushroom and spwan production technology at Sringarbhata, and Kokpur village, Kanker, Chhattisgarh, it was found that one of the lady mushroom grower named Rajabai Sahu and her son Ghanshyam Sahu had designed a highly innovative, easy to use and cost effective inoculation chamber for mushroom spawn production at home. The design of their inoculation chamber is such that it costs merely Rs. 800-1000/- . Basically it is a plastic container 75cm X 40cm X 40cm with a lid on its top. Towards one of it's face they had made two circular openings with provision to open and close them with the help of sliding flaps. The openings also had provision for attaching long gloves. Everyday before inoculating the substrate with pure culture they just wipe the container from inside and outside with alcohol. Thereafter they load the packets (10-15) to be inoculated from the top. A spirit lamp, inoculating needle and pure culture petridish is also kept before closing the lid. The packets filled with sterilized substrate are inoculated manually with discs of pure culture against the flame which was possible through the two circular openings on one of it's face. Three to four times a day inoculation was performed. As a result they inoculate about 40-50 packets of sterilized grains in one inoculation chamber for producing spawn everyday on a regular basis. They are now not handicapped in terms of lack of availability of good quality mushroom spawn and have taken up oyster mushroom production at commercial level producing about 20Kg of

fresh oyster mushroom daily. The unsold mushroom were sun dried or processed to prepare pickles which is also finding a lot of consumers. In fact they are also considering taking up mushroom spawn production on a large scale which still due to its lack of availability is hindering people from taking up mushroom cultivation as a rural enterprise. Furthermore a novel technique of taking spore prints on small plastics for long term preservation of fungal specimens was also developed at IGKV which can prove highly informative regarding mushroom diversity even at places with less or no infrastructure for fungal identification.

TECHNICAL SESSION - VIII

Etiology and Microbial Taxanomy

Lead Lecture -01

S-8 /NSIPS/L-1

Etiology and Microbial Taxonomy: Past, Present and Future

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World agriculture has shown phenomenal growth in recent past due to biotechnological applications, innovations in agriculture, development of disease resistant varieties, adoption of plant protection measures including integrated disease management and adaptation/development of crop varieties to suit climate changed. The growing population in Indian require around 30-50% more crop production to offer food and nutritional security. Approximately 25-35% of crop production is lost due to diseases caused by viruses, mycoplasma, fungi, nematodes and others. The late blight of potato in 1840 causes by *Phtophthora infestans* in Ireland, coffee rust in Ceylon and Great Bengal famine in 1943 by *Helminthosporium oryzae* in rice have emphasized the role fungi affecting crops.

Etiology deals with causal agent and causation of diseases by various agents. Disease production requires a susceptible host, virulent pathogen and congenial atmospheric conditions. The interaction among these results in disease syndrome and symptom production. The main emphasis has been the pathogenecity and its establishment as per Koch postulates (19.5). Therefore in etiology identification of disease causing agent, it's isolation, testing it disease reproducibility on healthy host and reisolation of it from the experimentally infected plant Diversified symptoms are produced on wide variety of hosts by various microbes, fungi and also by insects.

Etiology also includes plant pathogen detection. Farmer is interested in the early and rapid detection of pathogen and disease diagnosis. In the past diagnosis included symptom identification, pathogen identity and it's evaluation in reproduction symptoms on healthy host. In recent times DNA probes namely RAPD, RFLP, ISSR, URP, ELISA, PCR, Q-PCR, DNA array technology and others have been developed for the detection of pathogens in the field samples, serological techniques will add further strength, Epidemiology and forecasting of diseases, have their own importance id disease development and crop losses crop prediction models forewarn these menaces. The proteomics, genomics and metabolomics including transcriptions will help in deciphering plant, Pathogen interactions at molecular level.

Next generation sequencing will be playing an increasingly high profile role in transcriptomics, diagnostics and epidemiology. The incorporation of plant disease resistance genes in various crop plant and loss of resistance in hosts or logs of pathogenicity under certain environmental variables biogeographic regions are of utmost importance.

Cavalier-Smith (1998) included Six Kingdoms namely, bacteria, Protozoa, Chromista, Plantae, Fungi and Animalia. Earlier microbes particularly bacteria were classified based on shape and informal groups came into existence base on gram staining. The Bacteriological cod (1947) sorted out several problems classification systems include natural classification and two methods for construction. (Phenetic, Phylogenetic) classical characters included morphological, Physiological and metabolic, ecological and genetic analysis. Molecular characteristics include comparison of proteins, nucleic acid base composition, nucleic and hybridization, nucleic and sequencing and polyphasic taxonomy. Bergey's manual of systematic bacteriology which included morphology, phenotype 16 S phylogeny etc.

Stanier et al (1987) classified bacteria into archaebateria and eubasteria. In the beginning of 21st century viruses were classified into: plant viruses, invertebrate viruses, vertebrate viruses and Binary

viruses based on their hosts. An universal system of classification of virus as approved by the International committee on Taxonomy of Viruses (1999) which was based on 1. The nature of viral genome. 2. The strandedness of the viral genome. 3. The facility for reverse transcription. 4. The polarity of the viral genome.

Fungal Taxonomy has long history and nomenclatural type specimens constitute an integral part of fungal classification and nomenclature. The initial classifications of fungi proposed were mostly based on morphology and sexual stages. In modern times attempts were made to classify and establish the phylogenetic relationship on biochemical and molecular aspects. (Hibbet *et al* 2007). The importance of ICN (Melbourne code, 2011) will also discussed.

In conclusion reliable identification of the causal organisms of disease, disease diagnostic methods, aspects of microbial and fungal taxonomy will be discussed at length.

Lead Lecture -02

S-8 /NSIPS/L-2

Phytophthora diversity and its impact on horticultural crops in Indian subcontinent

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Stramenopile pathogens of the genus *Phytophthora* cause devastating diseases on a wide range of agricultural and horticultural crops, natural vegetation and forestry worldwide. There are over 120 species in the genus and many have wide host range. *Phytophthora infestans*, which caused the great Irish Potato Famine during late 1840s, still remains the most destructive pathogen of potatoes and tomatoes. The famine caused by *P. infestans* in 1845-57, changed the history of many countries. Other notable species that have emerged in more recent times are *P. ramorum* on oak, *P. alni* on alders, *P. kernoviae* on ornamentals, *P. cinnamomi* on forest crops, *P. agathis* on kauri, *P. cactorum* on hardwood trees, *P. capsici* on solanaceous and cucurbitaceous vegetables, *P. fragariae* on strawberries, P. *megakarya* on cocoa, *P. palmivora*on palms and *P. meadii* on arecanut, small cardamom and rubber from different parts of the world.

Diseases caused by *Phytophthora* spp are emerging as a major concern in India due to emergence/ migration of new clonal population with increased virulence and multiple fungicidal resistances. Although Phytophthora blight was a serious limiting factor in potato in India since 1952, these diseases never posed any threat to other vegetable crops. Since 2008, severe outbreaks of Phytophthora diseases such as late blight on tomato (*P.infestans*), fruit rot on brinjal,tomato and ridgegourd(*P. nicotianae*), foliar blights and wilts in chili and capsicum (*P.boehmeriae* and *P.capsici*) and blights in cucurbits were noticed.

It causes several types of diseases known as root rot, crown rot, collar rot, gummosis and brown rot in various economically important fruit crops such as citrus, guava (*P. nicotianae*), apple (*P. cactorum*), strawberry (*P. fragariae, P. cactorum, P. nicotianae*), papaya (*P.palmivora*), pear (*P. citricola, P. syringae*), pomegranate (*P. palmivora, P. nicotianae*), mango (*P. nicotianae*), pineapple (*P. nicotianae, P. cinnamomi*), avocado (*P. cinnamomi*), grapes (*P. nicotianae*) and jack fruit (*P.palmivora*).

Phytophthora causes several well-known diseases in plantation crops such as abnormal leaf fall in rubber (*P.meadii*), bud rot of coconut (*P.palmivora*), black pod and stem canker of cocoa (*P.palmivora*) and fruit rot of arecanut (*P.meadii*). Phytophthora species that are predominant among spice crops

include *P. capsici* which infects mostly black pepper, chillies and capsicum and *P. meadii* which infects mainly cardamom, vanilla and nutmeg. Leaf blight of taro caused by *P. colocasiae* and cassava tuber rot caused by *P. palmivora*are two serious diseases of tropical tuber crops.

Phytophthora species have emerged as bio- security threats due to increases in international plant trade. More than 90 members of the genus are considered as quarantine organisms. Accurate diagnosis and a proper risk assessment of *Phytophthora* species is required to implement control strategies. The emergence of new genotypes through sexual recombination and global migration, due to international agricultural trade, and concerns about bio-terrorism have necessitated use of sensitive and reliable diagnostic tools for rapid identification of the major *Phytophthora* species. Early detection, accurate identification and the ability to trace pathogens back to their source and eliminate them are the ultimate goals to reduce invasive species such as *Phytophthora.*

Global initiative on *Phytophthora* genome sequencing of tropical *Phytophthora* species, strengthening bio-security in agricultural trade; exploring the deployment of genetically modified crops wisely for disease management and use of new technologies such as CRISPR/Cas9 system gene editing; adequate human capacity building programmes to encourage young researchers; synergy between researchers and policy makers. There are a lot of good tools available (e.g. metabolomics, effector triggered immunity etc.) and these should be considered as part of the strategy. The "multi-pathed" approaches that include diagnostics capability to avoiding infection, improving soil health, use of disease-resistant crop plants, employing biological agents, fungicide resistance management strategies and utilization of new generation of molecules for combating Phytophthora diseases.

Lead Lecture -03

S-8 /NSIPS/L-3

Begomoviruses Diversity in India and Suspected Transboundary movement of Tomato leaf curl New Delhi virus

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The begomoviruses (genus *Begomovirus*, family *Geminiviridae*) constitute the largest group of plant virusus causing devastating crop diseases in India. About 16% geminiviruses recorded worldwide occur in India. . Currently, 322 begomovirus species have been officially recognised all over the world, of which 80 begomovirus species are known to occur in India. The Indian subcontinent represents one of the important centres for begomoviruses origin and diversity. Although as many as 80 begomviruses species have been indentified in India, the PAN-Indian distribution is recorded only for BYVMV, ChiLCV and ToLCNDV. The wide distribution of ToLCNDV in all the states in southern India is in contrast to earlier understanding that ToLCNDV, a bipartite begomovirus is present only in northern India. However, it is to be noted that even now ToLCNDV in southern India is recorded only in cucurbitaceous hosts. MYMV and MYMIV occur both in northern and southern India; again the distribution pattern conceived earlier has been negated. The most unexpected finding is that the leguminosae/fabaceae host plants are infected by highest number, 17 begomoviruses (Table 4; Fig. 6). Some of the viruses have been recorded only in the last five years. Whether, the viruses have moved to leguminous hosts in recent years or they have existed earlier but recorded now are not clear. The symptoms in these plants are not yellow mosaic but mosaic and leaf distortion. It is interesting to observe that, the maximum number of viruses are recorded in soybean, cluster bean, French bean and *Phaseolus aureus*. Surprisingly, the pulse crops,

blackgram and mungbean are so far affected only by MYMV and MYMIV. The vulnerability of leguminous plants especially soybean and French bean as revealed by infection by a large number of viruses is important in the context of possibility of recombination and emergence of new begomoviruses under the condition of mixed infection. Whether, these viruses will acquire ability to jump to blackgram, mungbean, pigeonpea and mothbean will have to be watched.

Solanaceous crops, tomato and chilli are infected by related viruses, those shares more than 75% nucleotide identity. They are also infected by distantly related begomoviruses, RaLCuV, PaLCuv and AEV, which share less than 70 % identity. In these group, the begomovirus, which infects a large number of hosts are PaLCuV (16 plant species), ToLCNDV (15 plant species) and AEV (14 plant species). Tobacco leaf curl is one of the earliest recorded diseases in India. The virus, tobacco leaf curl Pusa virus from Pusa, Bihar, may represent an isolate of the oldest virus reported. It is disheartening to see that though the disease is widespread in tobacco in different states, only one isolate has been characterized. Interestingly, tobacco curly shoot virus has been recorded from tomato, wild sunflower and French bean and not from tobacco. Some viruses like TbCSV, ToLCJV, ALYVV, ALCuV, HoLCV, MaYMV, SiLCuV, have been reported earlier in other countries like China, Thailand and Pakistan. These viruses would have existed here in India.or they gained entry needs to be investigated

ToLCNDV is the only begomovirus which has no trans-boundary limitations in movement across different countries in Asia and Europe. In Asian continent, ToLCNDV has been recorded in Bangladesh, Iran, Sri Lanka, Malaysia, Taiwan, Thailand and Indonesia. In Europe, its occurrence was first noticed in 2013 in Southern Spain. In Tunisia, ToLCNDV affect zucchini, cucumber and melon and in several vegetable crops in Scily and Southern Italy. At present, it appears that ToLCNDV is well spread in all these Asian, North African and Southern Europe countries. Typical symptoms of disease are curling, puckering of leaves, veinal yellowing, stunting, excessive branching, pale yellowing to deep yellowing of leaves. In severely stunted plants, flowers may drop off. In some genotypes, green vein banding, twisting, green enation are also seen on the under surface of the leaf.

The genome organization of ToLCNDV resembles organization of Old World begomoviruses, having two virion sense and four complementary sense ORFs. The sequence identity of ToLCNDV with the monopartite begomoviruses ranged from 69-73%. Interestingly with tomato leaf curl Rajasthan virus it was 86%.

ICTV in its Xth report differentiates only two strains among ToLCNDV, one strain comprising all the isolates of ToLCNDV and another comprising ToLCNDV isolates from Spain. It appears that more stringent analysis needs to be performed to group ToLCNDV isolates. An analysis performed including all the isolates (the present study) clearly showed that there is no association between host species and clustering of ToLCNDV isolates. The ToLCNDV isolates which showed less than 90% identity branched off independently akin to other monopartite viruses

Expansion in host range perhaps could be due to capturing of satellite DNAs and the ability of DNA B to complement different DNA A. Added to these features, in our recent studies we found seed borne nature of ToLCNDV in cucurbitaceous hosts like ashgourd and chayote. Importance of these observations in understanding emergence of ToLCNDV as invasive pathogen will be discussed.

Invited Lecture- 01

S-8 /NSIPS/I-1

Revisiting Indian Cercosporae in the Genomic Era

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The genus *Cercospora* was first described by Freseniusin1863. The generic description of this fungus was basedobclavate (Tail shaped) spores. Taxonomy in *Cercospora* sp. was based on conidial morphology (length, width, base, and tip) and conidiophores (length, diameter, geniculation, and fasciculation) (Chupp, 1954). Later on these features become less reliable since they are highly influenced by environmental conditions and therefore statistically not relevant. Deighton(1979), redesignated the various species of the genus *Cercsopora* and reclassified many *Cercospora* species into other genera, including *Cercosporella*, *Cercosporidium*, *Paracercospora*, *Pseudocercospora*, *Pseudocercosporella*, and *Pseudocercosporidium.* He focused his attention on the basal scars of the mitospores as criteria for generic separation. accepted 1,419 species and out of The 3,000 described of species of *Cercospora* in Genus *Cercospora* presently 659 are recognized (Crous and Braun, 2003).

Recent, generic analyses of fungi using DNA barcode (ITSs / LSU) and the 5.8S rRNA revealed that most species of *Cercospora*, particular the members of the *C. Apii* complex, are identical or very closely related (Goodwin *et al*.2001). Most of the *Cercospora* sp. described in the Indian *Cercosporae* by R. S. Vasudeva (1963) become misnomer after Deighton (1976). Type specimens of these species are not available in the form of culture for the re investigation. *Cercospora* sp. are important fungal pathogen of both plant and animal. Also significant for quarantine as well as sanitary and phytosanitory regulations. Many secondary metabolites of pharmaceutical importance are produced by this pathogen. The data available through specimens available in herbarium and culture based systematic study is not fully integrated with genomic and metabolomics profile of the fungus this limits in studying the taxonomic diversity. This underlines the importance that to study Cercospora genus using classical approach as well as sequence based classification and identification (SBCI).

A review of "Indian Cercosporae" revealed that out of 255species described only 108 are *Cercospora*, *Pseudocercospora* (83), *Passalora* (37), *Stenella* (4), *Asperisporium* (1), *Camptomeris*(1), *Colletogloeum* (1), *Cercosporella* (1), *Mycovellosiella* (1) *Scoleostigmina* (1), *Teratosphaeria* (1)and 16 different species are misnomer. Monoconidial culture of7species of *Cercsopora* when inoculated on a panel of hosts most of them were host specific. Their morphometric characters (conidia and conidiophore) could not be separated by statistical test. The phylogeny based on the ITS also could not separate them in different species. The draft and whole genome sequence of different *Cercospora* species may be helpful to distinguish them. Improved sequencing methods that includes long read and single cell technologies can resolve the ambiguities with ITS and look beyond in the background of new nomenclature and develop globally accepted database on fungal taxonomy.

S-8 /NSIPS/O-1

Progress of Phytoplasma Disease Research in India

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Phytoplasmas have been found associated with 129 plant species in India including vegetables, legumes, spices, medicinal plants and ornamental plants, cash and oil crops, palms, fruit trees and weeds, where ten 16Sr groups of phytoplasmas have been identified so far. Sesame phyllody, brinjal little leaf, sugarcane grassy shoot, sandal spike, coconut root wilt, areca nut yellow leaf and many diseases in ornamental plants are causing the most severe economic losses in the country. Identified phytoplasmas are related to '*Candidatus* Phytoplasma asteris', '*Ca*. P. pruni', '*Ca*. P. ziziphi', '*Ca*. P. trifolii', '*Ca*. P. solani', '*Ca*. P. cynodontis', '*Ca*. P. oryzae', '*Ca*. P. phoenicium', '*Ca*. P. australasia' and '*Ca*. P. pini'. Among them '*Ca*. P. asteris'-related strains (aster yellows, 16SrI group) are the prevalent phytoplasmas identified associated with 62 diseases followed by phytoplasmas classified in 16SrII, 16SrVI, 16SrXIV and 16SrXI groups. The majority of the reported phytoplasmas have been classified up to subgroup levels on the basis of RFLP analysis. Moreover, some phytoplasma diseases which were confirmed only by symptoms or transmission electron microscopy observation remains to be identified at molecular levels. Complete phytoplasma genome sequencing has not been done so far and thus would be a major thrust area of research in coming years. At least seven insect vectors, belonging to leafhoppers and planthoppers species, have been reported as putative or natural vectors for important phytoplasma diseases. The majority of phytoplasma disease reports are from north and south part of India. Little attempt has been made to genomics, epidemiology, host phytoplasma interaction and management aspects of these diseases. Moreover, for understanding host phytoplasma interactions, it is important to identify the function of membrane proteins or secreted proteins and effectors encoded in the phytoplasma genome. Presently the suggested effective management practices in India are growing resistant varieties, application of tetracycline, control of insect vectors, weed species as alternative hosts and use of healthy planting materials. The management approaches of widespread phytoplasma disease on major economic crops in India also need attention towards developing resistant genotypes, RNA interference and checking the natural spread of other alternative sources of weed hosts and potential insect vectors are also important information to be achieved. Numerous new phytoplasma strains have been identified in the last decades, and a preliminary classification of known and new phytoplasma strains has revealed that phytoplasmas are more diverse than the previously thought. Epidemiologic studies should also be carried out to prevent further epidemic spreading.

S-8 /NSIPS/O-2

Present Status of Sugarcane Diseases in Karnataka State

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Sugarcane is an important commercial crop of the country occupying around 5.06 million hectares of land with an annual cane production of around 338.96 million tonnes and average productivity of 67

tonnes per hectare. Where as in Karnataka 0.43 million hectare of land area with the production of 35.75 million tonnes and average productivity is about 83.09 tonnes per hectare. About 40 million farmers grow and depend on sugarcane for their livelihood. And an equal number of agricultural labourers earn their living by working in agricultural farms. The sugar industry is the second largest agro – based industry, next to textiles in the country. Sugarcane is the only raw material for all the major sweeteners produced in the country. More than 488 sugar mills crush about 50-60% of the canes produced to manufacture crystal sugar in the country. Many biotic and abiotic stresses affected the sugarcane production among the reported diseases of sugarcane are Red rot, Wilt, RSD, GSD, Smut, Sett rot, Rust, Leaf spot, Pokkahboeng and YLD are playing very important role due to economic threats in Karnataka state.

Recent survey showed increasing trend of disease incidence and most of the commercial cultivars affected by the disease ranged from 15-20%. Although Pokkahboeng, YLD and rusts are under minor concern but these days it is going to be major on the basis of their rapid epidemiology during last few years because the crop remains in the field for 2-3 years and propagated through cuttings. A large number of pathogens viz, fungi, bacteria, viruses, phytoplasma and nematodes attack this crop. Diseases are one of the major constraints in improvement of its productivity. In addition, leaf scald, mosaic, red stripe and eye spot have also been reported to cane losses in some parts of the country. Nowadays the incidence and severity of these diseases have been reported from major sugarcane growing states like Uttar Pradesh. Maharashtra, Karnataka, Punjab, Haryana, Assam, T.N, and Bihar in India and other sugarcane growing countries. Propagation of sugarcane though vegetative cuttings favours spread of different diseases through planting materials. Primary transmission of different diseases through seed canes poses serious threat to sugarcane growth and performance. Disease resistant varieties play a crucial role in managing many of the diseases in sugarcane and several varieties have been developed to manage the diseases in the past. In addition, different agronomical approaches and physical method like heat therapy are being effectively used to manage the diseases in sugarcane. Recently, multiplication of sugarcane through tissue culture is being advocated to produce virus and phytoplasma disease free planting materials. Use of disease resistant varieties along with healthy seed nursery programmes would form the basis to successfully manage the diseases in sugarcane. Keeping in view of seriousness of the problems, the present paper summarise the disease management practices through various approaches have been followed.

S-8 /NSIPS/O-3

Symptomatology and Etiology of *Alternaria* Leaf Spots and Blight of Oilseed Crops

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Eight oleiferous crops are grown in diverse agro-climatic conditions in India in all the seasons, Rabi, Kharif and Zaid. The oil extracted from their seeds are not only utilized for cooking purposes but some of them have medicinal values also (castor, linseed, sesame). Eleven species of *Alternaria* cause leaf spots and blight on eight oil yielding crops in India. Some of them are very specific to parasite only a particular oilseed plant like *A. helianthi* (sunflower), *A. brassicae* and *A. brassicicola* (rapeseed and mustard), *A. linicola* (linseed), *A. sesami* (sesame), *A. ricini* (castor) and *A. carthami* (safflower). *Alternaria alternata* is of wide spread occurrence causing leaf spots and blight of sunflower, mustard,

groundnut and soybean. *A. tenuissima* is next to *A. alternata* in causation of disease. The disease symptoms on all the oil yielding crops alongwith morphological characters of causative *Alternaria* spp. have been given in greater detail. On rapeseed/mustard and sunflower there is the involvement of four species of *Alternaria* on each crop so, a comparative study of symptomatology and etiology has been made and a very simple and feasible key has been framed for ready and correct identification of *Alternaria* spp. associated with them.

S-8 /NSIPS/O-4

Genome Characters Indicate Variability and Similarities among ssDNA Begomo Viruses Assemblages in West Bengal

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The explosion of the ssDNA begomo virus is now a big threat worldwide and is predominantly causing serious diseases in horticultural crops especially vegetable crops. The state West Bengal is the leading vegetable producing state in India but infection of begomoviruses result in reduced growth and significant reductions in yield and quality of several crops like tomato, chilli, pepper, okra, cucurbitaceous vegetables, papaya, sweet potato, mungbean, cowpea, soybean, all types of beans, cassava, including high value ornamentals. ssDNA begomo virus infection in plant and white fly *host* produce a dynamic population of closely-related sequences. Occurrence and the genome organization of begomo viruses infecting several plants species in West Bengal have been mapped and characterized. The presence of several begomo viruses in different plant species including ornamental plants were confirmed by nucleotide hybridization technique and PCR based methods. The full and partial genome of the respective viruses were cloned and sequenced which gave some distinctive isolates and diverse genome characters. Many of the isolates of begomo viruses infecting different crops were found distantly related with isolates of the respective viruses reported in the world. The obtained nucleotide sequences of several isolated were gene bank accessed and compared with the published data of sweet potato leaf curl virus, Bhendi yellow vein mosaic, Chilli leaf curl virus, Tomato leaf curl virus, Tomato leaf curl virus in cucurbits, cassava mosaic virus, Mungbean yellow India mosaic and ssDNA begomo viruses in ornamentals and several weed species. Multiple nucleotide sequence alignment of the isolates compared with other isolates for ancestor analysis. Characterizing these viruses can highlight important contribution that recombination makes to the evolution of their natural relatives. Moreover, these studies supply precise information about the frequency and distribution of distinct begomo virus isolates and its possible recombination breakpoints, which can shed light on the mechanistic processes underlying recombination.

S-8 /NSIPS/O-5

Incidence of Rice Tungro Disease in the North Eastern Region of India with Special Reference to Assam

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Rice tungro disease (RTD), caused by a complex of two different viruses and transmitted mainly by the green leafhopper *Nephotettix virescens* (Distant) in semi-persistent manner, is the most important viral disease of rice which is widespread in South and Southeast Asia. Of late, it is being considered as a high profile disease of uncertain appearance but its occasional outbreaks damage vast tracts of rice fields. With the spread of modern high yielding rice varieties, tungro became a potential menace to the rice production not only in Assam but in the whole of North Eastern region too. Out of 27 districts of Assam surveyed from 2012-13 to 2016-17 across the rice growing seasons, incidence of tungro was noticed in 20 districts, viz., Baksa, Barpeta, Bongaigaon, Cachar, Chirang, Darrang, Dhemaji, Dhubri, Golaghat, Hailakandi, Kamrup, Karimganj, Kokrajhar, Lakhimpur, Morigaon, Nagaon, Nalbari, Sonitpur, Sivasagar and Udalguri. RTD incidence was observed in number of open-pollinated cultivars, namely, Aathaisa, Ahujoha, Baismuthi, Bismuthi, Choyamora, Dichang, IR 64, Jaya, Luit, Lurki, Mahsuri (also known as Aaizong or Paizam), Naveen, Ranjit, Sahbhagidhan, Swarna, Swarna sub1 and hybrids, namely, Arize 6444, DRRH 2, JKRH 401, NPH 924-1, PAC 835, PAC 837, Sahyadri 4 etc. Barring a few instances, RTD incidence ranged from traces to less than 2%. Out of the four districts of Tripura state, viz., Sepahijala, Gomati, West and Khowai surveyed during amon season of 2015, RTD incidence was observed in three districts. In Sepahijala, disease incidence was not noticed. Altogether 16 rice cultivars were used as differentials against Gerua isolate and Nalbari1 isolate of RTD. Against the Gerua isolate, cultivars Balimah Putih, IR 20, Pankhari 203, PTB 8, PTB 18, PTB 21, Shuli 2, Utri Rajapan and Utri Merah showed resistant reaction. While the cultivars Habigunj DW 8 and Latisail showed moderate resistance. Kataribhog, Nidhi, TKM 6, T(N) 1 and Vikramarya showed tolerant to susceptible reactions. Nalbari1 isolate was found to be more severe in its reactions against the tungro differentials.

S-8 /NSIPS/O-6

Disease Occurrence and Seed Health Testing in Important Spice Crops Grown under Mid Hill Conditions of Himachal Pradesh

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Spice crops like coriander, fenugreek, garlic and ginger are grown under mid hill area of Himachal Pradesh including Solan and Sirmour districts. The farmers procure planting material of these crops

from government agencies, university seed farms or from private growers. The crops grown for seed or planting material production were periodically monitored for the occurrence of diseases for three years 2014-15, 2015-16 and 2016-17. As and when symptoms of any diseases appeared on the crops, proper control measures were followed immediately to check the diseases. However, some plots at seed research farm of the Department of Seed Science and Technology were left without fungicidal treatments and were monitored periodically for the occurrence or development of various diseases. The important diseases thus recorded on different spice crops were follows. On coriander seed crop important diseases were bacterial leaf blight (*Pseudomonas syringe* pv. *coriandiricola*) *and Powdery mildew (Erysiphe sp.).*Wilt (*Fusarium oxysporum*) and Powdery mildew (*Erysiphe* sp.) were recorded on fenugreek crop. Stemphylium blight (*Stemphylium vasicarium*), purple blotch (*Alternaria porri*) and mosaic virus were main diseases observed on garlic crop where as Rhizome rot (*Pythium spp.*, *Fusarium* spp.), Yellows (*Fusarium oxysporum* f.sp. z*ingiberi*) and Phyllosticta leaf spot (*Phyllosticta zingiberi*) were important diseases on ginger crop. Besides commonly occurring diseases on these spice crops, some diseases were recorded new in the region viz., white rot of garlic **(***Sclerotium cepivorum*), downy mildew of fenugreek (*Peronospora trigonellae***), s**tem gall of coriander (*Protomyces macrosporus).* The seed health testing of two spices viz., methi and coriander was done following two methods i.e. paper towel method and blotter method. Seed germination in fenugreek was 96.33 and 95.33 % where as in coriander 81.67 and 81.33 % as per the paper towel and blotter method, respectively.While observing the incidence of seed microflora associated with these crops under both the tests, the incidence was found highest under blotter method as compared to paper towel method. The incidence of seed microflora was observed 50% in coriander where as it was 10% in fenugreek following blotter method.The associated microflora with the seeds of these spice crops were identified as *Alternaria* sp. and *Fusarium* spp. (in fenugreek) and *Alternaria* sp., Bacteria and *Fusarium* sp. (in coriander).

S-8 /NSIPS/O-7

Pigeonpea Sterility Mosaic Emaravirus: a Journey from a Mysterious Disease to a Classic Emaravirus

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Sterility mosaic disease (SMD) of pigeonpea is a serious constraint for cultivation of pigeonpea in India and other South Asian countries. SMD of pigeonpea is associated with two distinct emaravirus species, Pigeonpea sterility mosaic emaravirus 1 (PPSMV-1) and Pigeonpea sterility mosaic emaravirus 2 (PPSMV-2), with genomes consisting of five and six negative-sense RNA segments, respectively. The recently published genome sequences of both PPSMV-1 and PPSMV-2 are from a single location, Patancheru from the state of Telangana in India. However, here we present the first report of sequence variability among 23 isolates of PPSMV-1 and PPSMV-2, collected from ten locations representing six states of India. Both PPSMV-1 and PPSMV-2 are shown to be present across India and to exhibit considerable sequence variability. Variability of RNA3 sequences was higher than the RNA4 sequences for both PPSMV-1 and PPSMV-2. Additionally, the sixth RNA segment (RNA6), previously reported to be associated with only PPSMV-2, is also associated with isolates of PPSMV-1. Multiplex reverse transcription PCR (RT-PCR) analyses show that PPSMV-1 and PPSMV-2 frequently occur as mixed infections. Further sequence analyses indicated the presence of recombination and reassortment of RNA4 between isolates of PPSMV-1 and PPSMV-2.

S-8 /NSIPS/O-8

Emergence of Virus and Virus-like Pathogens in Different Cropping Systems of North Eastern Hill Region of India: A Transboundary Concern

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Diseases caused by virus and virus-like pathogens are most tedious to detect and manage. The cropping systems in North Eastern Hill (NEH) region is largely characterized by its complex, diverse, risk prone and fragile nature. Large biodiversity coupled with high relative humidity and favourable environmental conditions disposes the crops to the emergence of virus and virus-like pathogens and their spread by insect vectors. Systematic surveys were carried out to record the prevalence of different virus and virus-like pathogens in different cropping systems of NEH region. Major cucurbits (bottle gourd, cucumber and pumpkin) were found infected with zucchini yellow mosaic virus (ZYMV) with an overall incidence of 42%. ZYMV isolates characterized for CP sequences showed more similarity to the isolates from Florida as compared to Indian isolates. Out of the out of 107 papaya samples tested, 80.13% were positive for papaya ringspot virus (PRSV) and two new genogroups of PRSV were found prevalent under NEH conditions. Pathogenically and genetically distinct isolates of chilli veinal mottle virus (ChiVMV) and turnip mosaic virus (TuMV) originating from king chilli and *Brassica* spp. respectively were characterized. The banana plantations in different groves of NEH region were found infected with banana streak viruses and banana bunchy top virus (BBTV). The RCA-RFLP showed genetically distinct BSV isolates infecting different banana mats. The BBTV isolates infecting banana were also genetically distinct as evident from the phylogenetic analysis. Prevalence of *Candidatus* liberibacter asiaticus (CLas) isolates sampled from citrus of different areas with tandem repeat number of 4-21 indicated existence of genetically divergent haplotypes in the region. A new genotype of potyvirus infecting passion fruit was also identified. Our studies highlighted the emerging problem of virus and virus-like pathogens infecting crops in different groves of NEH region. The pathogenic and genetic analysis indicated the possible transboundary spread of these pathogens.

S-8 /NSIPS/P-1

Studies on the Disease Incidence of Different Cultivars of Rice (MTU-7029, MTU1075, MTU-1064, Swarnasub-1, Pratiksha, BPT-5204 and Naveen) during Kharif under Old Alluvial Zone of West Bengal

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A field experiment under natural condition was laid out in Randomized Block Design (RBD) with seven treatments and three replications during Kharif 2015 and Kharif 2016 at Regional Research Station (OAZ), UBKV, Majhian to assess the varietal susceptibility against the diseases. The seven varieties namely MTU-7029, MTU-1075, MTU-1064, Swarna Sub-1, Pratiksha, BPT-5204 and Naveen were used in this experiment where the most susceptible variety MTU-7029 was used as check variety. The seeds of all varieties were sown in small beds for raising nursery and 25 days old seedlings were transplanted into the field with 20 cm inter and 15 cm intra row spacing in plots measuring 5.0 m x 5.0 m. All other cultural practices were followed as recommended in Agronomic package of practices. Per cent disease incidence and disease severity was recorded from the experimental plot based on different symptoms produced by different pathogens. It was found that sheath blight incidence was highest in MTU-7029 (52.60%) followed by MTU-1064 (50.04%), MTU-1075 (17.66%),Pratiksha (14.87%) and Swarna Sub-1(2.34%) and in the same way the disease severity was also found highest in MTU-7029 (24.19%) followed by MTU-1064 (22.48%), MTU-1075 (14.71%), Pratiksha (7.89%) and Swarna Sub-1(2.87%).The Blast incidence was highest in Swarna Sub-1 (80.32%) followed by MTU-7029 (71.17%), BPT-5204 (52.55%), MTU-1064(47.68%), Pratiksha (46.94%), MTU-1075(33.31%) and Naveen (1.14%) but the severity was highest in MTU-1079 (9.18%) followed by Swarna Sub-1(8.80%),BPT-5204(8.47%),Pratiksha(8.22%), MTU-1064(7.41%),MTU-1075(5.87%) and Naveen (0.15%). Swarna Sub-1 and Naveen showed no incidence to sheath blight and least incidence (5.90%) and severity (1.04%) of false smut was recorded in BPT-5204.

S-8 /NSIPS/P-2

Isolation and Characterization of Bacterial Pathogen Causing Soft Rot Disease of Potato Tubers

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Potato tubers showing soft rot symptoms were collected from experimental plots of Potato Research Project O.U.A.T. Tubers were washed with sterilized water, air dried and then surface sterilized with 70% ethyl alcohol. Each tuber was examined by cutting into two halves with the help of a flame sterilized knife. From the rotted tissues the bacteria was isolated aseptically and pathogenicity was proved in healthy tubers which developed symptoms similar to field infection.

Microscopic studies revealed that the isolate was gram negative rod, non-capsulated with peritrichous flagella. Colonies on Nutrient Sucrose Agar medium were raised, convex, shining, white

fluidal and slimy. Colonies onendo agar were found to be circular with initially pink coloured but later turning to deep red. The colonies on Tetrazolium Chloride Medium was cream coloured. On Crystal Violet Pectate medium the bacterial masses produced deep cup shaped cavities on the petriplates. Biochemically, the isolates showed negative response to ONPG, failed to decarboxylase orinthrine and lysine. The presence of urease was not observed. Deamination, nitrate reduction, H2Sproduction, citrate reduction could not be expressed. Methyl red test was found to be positive while indole, melonate and esculin tests as negative. The isolate could ferment carbohydrates such as adonitol, rhamanose, trehalose, glucose, lactose while xylose, cellobiose, meliobiose, saccarose, raffinose not fermented. Furthermore, the isolates could express the presence of oxidase, not hydrolysed gelatine and starch. From all these studies it was confirmed that the causal organism was *Pectobacterium carotovorum*.

S-8 /NSIPS/P-3

Next Generation Sequencing Reveals Huge Diversity in the Soil Managed under Organic System

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Next generation sequencing or deep sequencing or high throughput sequencing technology has revolutionized the genomics and the data generated by these kind of technologies is huge and runs in Gigabases. These methods are cultivation independent hence are less cumbersome but still provide huge amount of data. Samples were collected from organically managed plots and DNA was isolated using commercially available kits. Library preparation (Nextera XT index kit) and amplicon sequencing (Illumina Miseq) was done by a commercial company. Both bacterial (based on V3-V4) and fungal diversity (based on ITS region) was worked out and the results revealed high level of diversity present in the soils managed under organic system of cultivation.

S-8 /NSIPS/P-5

Seed-borne Nature of Mungbean Yellow Mosaic Begamovirus in Greengram

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Yellow mosaic disease caused by Mungbean yellow mosaic virus (MYMV) is one of the major destructive diseases on green gram. MYMV belongs to the family Geminiviridae and genus Begomovirus and is transmitted by vector whitefly, *Bemisia tabaci*. The Geminiviruses are confined to phloem parenchyma and cambium Due to this restricted distribution, it is believed that in general geminiviruses do not enter into seed parts as the vascular supply to the seed is partially up to the hilum region of the seed coat. However, there are some reports suggesting a seed-borne nature of the Curtovirus and Begomovirus of geminiviruses. In North Karnataka, heavy incidence of MYMV has been noticed on 10-15 old crop and quick spread in the field signifies that the source of inoculum may be very close to the

field. From these observations, it was hypothesized that the yellow mosaic virus may be transmitted by seeds. Whether the virus is seed borne or seed-borne inoculum has any role in the initial symptom emergence are the questions to be addressed for the present investigation. Greengram seeds were collected from the infected pods and were sown under controlled conditions. The seedlings were raised in insect proof cages. After 25-30 days of germination, typical yellow mosaic symptoms were noticed. For further confirmation, molecular detection (through PCR) was carried out by amplifying the coat protein (642 bp) gene from the cotyledon, cotyledonary leaves and epicotyls of the diseased seeds using MYMV specific primers. In the field symptom emergence in the very first trifoliate leaf of the plants and later yellow discoloration of pods and seeds from infected plants were observed. This suggested that the virus may be seed borne and it could be a source of primary inoculum.

S-8 /NSIPS/P-6

Overview of Stripe Rust of Wheat caused by *Puccinia striiformis* in Indian

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Stripe rust (yellow rust) in wheat caused by *Puccinia striiformis* has been an important disease of wheat in the Indian sub-continent. Currently, it prevails across all the wheat growing areas from north to south in the country. Due to the favourable weather conditions, the northern uplands have been historically hit by the severe disease epidemics. These epidemics cause significant losses to national wheat production. Acquisition of broader virulence pattern by the pathogen poses a serious threat to food security of the nation. Although the deployed wheat varieties have adequate resistance, but consequently evolving strains of the pathogen makes the work of plant breeders tougher to explore new source of resistance that are effective against this disease. Utilisation of race non-specific durable resistance and seedling resistance via gene pyramiding, based on the current virulence scenario of the pathogen, climatic variability and epidemiology of the pathogen should provide sustainable base for management of stripe rust of wheat. Stripe rust can, however, be successfully managed by the joint collaboration, sharing of information and capacity building

S-8 /NSIPS/P-7

A Decade Long Experiences in Development of Soybean Varieties with Resistance to Major Diseases in India

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Soybean diseases are major stumbling blocks in successful raising of crop and achieving the highest productivity. Among the various management options available, breeding for resistance a long term and sustainable approach. In this paper, we summarised here the efforts made in development of

resistant varieties of soybean against major diseases mainly rust, purple seed stain and pod blight complex. Rust in Karnataka was severe and caused losses up to 20-80 per cent in JS-335 depending on its severity, stage of occurrence and favourable climatic conditions in northern Karnataka. In recent years, soybean anthracnose has become one of the major production constraints in all soybean growing areas of India. The loss due to this disease in India has been reported to an extent of 16-25 per cent in seed yield apart from affecting seed quality. The research efforts on development and release of rust resistant varieties in India over a decade has lead to development and release of first ever rust resistant and high yielding variety DSb 21 for the state of Karnataka and also south India during 2013. Later, DSb 23 and DSb 28-3 highly rust resistant and high yielding varieties which have recommended for cultivation for Southern Zone (Karnataka, Maharastra, Tamil Nadu, Andhra Pradesh and Telagana States) during 2015and 2017.Out of 19 genotypes, the genotypes viz., DSb 12, DSb 20, DSb 23-5 and Kalitur were found highly resistant with a disease grade of one to pod blight complex.. The genotype JS 335 was highly susceptible to anthracnose with a maximum disease grade of nine. Among the markers used, Satt 275 showed polymorphism for both the parents (EC 241780 and JS 335) as well as other genotypes. The amplified PCR product of genotypes with polymorphic marker Satt 275 was sequenced and most of the sequences scored an E value of 0.031 and an identity of 90 per cent with the mRNA sequence of the Rpp5 gene. The classification results revealed that the sequence of the advanced line DSb 30-2 showed the highest degree of identity with the concerned Rpp5 like disease resistance mRNA sequence.

S-8 /NSIPS/P-8

In Vivo Screening Evaluation of Coriander (*Coriandrum sativum* L.) Germplasm for *Fusarium* Root Rot Resistance

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Coriander (*Coriandrum sativum* L.) is a spice herb widely used as an important ingredient in many parts of the world. Among the major diseases which reduces the productivity and yield, *Fusarium* root rot causes a major damage to this crop. One hundred twenty germplasm were grown in augmented block design in 2016-17 Rabi season to screen *Fusarium* root rot resistance. Three standard varieties Sudha, Sadhana and APHU Dhania-1 were used as checks in this experiment. Among the germplasm studied in this study from twenty to sixty days after sowing in sick plot, lowest disease incidence (%) was recorded in LCC-22 (2.73%), LCC-7 (4.90%), LCC-8 (5.32%), LCC-32 (10.20%) and LCC-71 (16.04%) and were shown resistant response to root rot. Moderate resistance response was elicited by accessions LCC-242 (49.64%), LCC-176 (48.53%), LCC-174 (47.37%), LCC-152(45.48%), LCC-120 (35.15%) and LCC-35 (24.71%). Accessions LCC-291 (73.74%), LCC-151 (73.09%), LCC-239 (50.60%) were recorded as susceptible germplasm. Whereas highly susceptible response with high disease incidence was shown by accessions LCC-73 and LCC-175 (100%); LCC-262 (99.58%), LCC-302 (99.56%). The checks Sudha (39.56%), Sadhana (43.06%) shown moderate resistance response and APHU Dhania-1 (80.80%) recorded as highly susceptible check to *Fusarium* root rot disease.

S-8 /NSIPS/P-9

Species Confirmation of Some Morphologically Diverse *Penicillium* Isolates through Multi Gene Analysis

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Penicillium is one of cosmopolitan fungus grow in the different habitats such as soil, plants, air, covered environments and several food items which have shown great impact in applied mycology including spoilage of food and feed through the production of mycotoxins enzymes and organic acids etc. Even though the *Penicillium* species are very common and the taxonomic structure of the genus is well defined, species identification is still problematic due to overlapping macro- and micro-morphological characters. Six *Penicillium* isolates (ITCC-1512, ITCC-2982, ITCC-3754, ITCC-3813, ITCC- 4080 & ITCC-6592) were collected from Indian Type Culture Collection (ITCC), Division of Plant Pathology, ICAR- Indian Agricultural Research Institute, New Delhi, which were deposited from different parts of India without species identification. These isolates showed diverse morphological characters. Therefore, a combined approach was attempted using morphology and multi gene analysis to identify theses isolates. These isolates were morphologically characterized based on colony diameter on different media viz., Czapek yeast extract agar (CYA), Oat meal agar (OM), Malt extract agar (MEA) and Yeast extract agar(YES); conidiophores branching pattern; phialide arrangement; conidial shape and size. Multigene analysis was done based on ITS region, ß-tubulin and Calmodulin genes. Based on phenotypic characters and sequence similarity through NCBI blast, ITCC-1512, 2982, 3754 and 3813 were identified as *Penicillium chrysogenum*, ITCC-2982 as *Penicillium flavigenum*, ITCC- 4080 as *Penicillium griseofulvum* and ITCC- 6592 as *Penicillium polonicum.*

S-8 /NSIPS/P-10

Specis of *Basidiobolus ranarum* a Zygomycetous Fungus from Rotted Fruit of Strawberry and Sapota

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Basidiobolus belong to order Entomophthorales and family Basidiobolace of phylum Zygomycota. Almost all members of the family are insect pathogens, but also reported to parasitize mites, nematodes and other invertibrates like fishes ,amphibians, reptiles, thallophytes of ferns and algae, some species are also reported as important facultive parasites of bats, kangaroos, wallabies, dogs, horses,human beings and other mammels especially in warmer climates. Saprobic species are also reported from soil, litter and dung. This suggest that the fungus is spreading by leaps and bounds. Strict host speciality and relatively rapid killing of hosts make *Entomophthorales* a focus on my many biological control studies. In present study the fungus was isolated from rotted sapota (chiku) fruit and identified as *Basidiobolus*

ranarum. Family Basidiobolaceae have septate mycelium, uninualeat cells with larger nuclei, some species have a tendency for the mycelium to fragments in to the structures called hyphal bodies,The mycelium on PDA have fast growth, dull white colour and covered the petriplate within 3-4 days of incubation at 25^0c. Primary conidia discharged forcibly by ejection of conidiophores contents after circumscissile ruptureof a conidiophores swelling. Secondary conidia that are forcibly ejectedare similar to primary conidia or may be passively discharged capilliconidia with prominent haptors. Distinctive, raired, beak like projections, remnants of the gamentangia, persist on the mature Zygosporangium. Resting spores (zygospores) are formedin the axis of the parental hyphae. It is reported that some strains of *Basidiobolus* produce benzene hexachloride like odors, charecteristics of prokaryotic actinomycetes. The culture of the fungus has been deposited in Indian Type Culture Collection, Division of Plant pathology, ICAR-Indian Agricultural Research Institute Pusa New Delhi.

S-8 /NSIPS/P-11

Reaction of Rapeseed-Mustard Genotypes to *Alternaria* Blight and *Sclerotinia* Stem Rot Diseases

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India ranks third in the world next to China and Canada in rapeseed (*Brassica campestris*) – mustard [*B .juncea* (L) Czern & Coss] production accounting for 11-12% of total production. *Alternaria* blight caused by *Alternaria brassicae* (Berk.) Sacc. And *Sclerotinia* stem rot caused by *Sclerotinia sclerotiarum* (Lib.) de Bary are the major diseases of rape and mustard in Assam. *Alternaria* blight appears first on leaves and becomes severe during siliquae formation stage causing 17-48% yield loss. *Sclerotinia* rot becomes severe from late flowering to maturity stages of crops accruing in to the extent of 80% yield reduction. *S. sclerotiarum* is a ubiquitous phytopathogenic fungus having the broadest host range of all known pathogens. With due consideration to the great extent of yield loss and adverse impact on oilseed economy because of these two menacing diseases, an experiment was carried out during Rabi 2016-17 at RARS, Shillongani, Nagaon, Assam to study the reaction of Indian mustard and rapeseed genotypes/lines against these diseases under field conditions. This was a strategic study to find out eco-friendly solution to these menaces for facilating *Alternaria* blight and *Sclerotinia* stem rot-free oilseed production system. Nine genotypes/lines were sown in 3m double row on 21 November and replicated thrice. The test plants were artificially inoculated at flower initiation and siliqua formation stages with conidial suspension (105cfu/ml) of pure culture of *Alternaria brassicae*. Artificial inculation was also done with 5mm discs of fungal mycelium of *Sclerotinia sclerotiarum* along with medium from 7 day old culture. Observation at 75 days after sowing (DAS) on leaf revealed that nine genotypes (DRMR-26, DRMR-2035, DRMR-32, DRMR-73, RMWR-09-5, DRMR-72, DRMR-7, DRMR-40 and NRCYS-5-2) were moderately resistant to Alternaria blight showing 17.87-21.53% disease severity. These genotypes also showed moderate resistance to *Alternaria* blight on pod (disease severity ranged from 19.30 to 23.00%). However, all were susceptible to this disease on leaf at 100 DAS. In all the test genotypes, *Sclerotinia* stem rot incidence was very high (93.3-100%) and lesion size ranged from 8.5 to 13.8 cm. The lowest sized lesions were observed in 'DRMR-2035' and 'DRMR-72'.

S-8 /NSIPS/P-12

DNA Barcoding of Phytoplasma Strains of 16SrV (Elm Yellows) Group and Their Putative Insect Vectors

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DNA barcoding of phytoplasma strains associated with tree species viz. *Ziziphus oenoplia*, *Tamarindus indica*, *Ficus amplissima*, *Vitex negundo*, *Vachellia nilotica* was employed for their deeper taxonomic characterization using 16S rRNA and three other genes viz. Protein translocase subunit (secA) gene, Elongation factor (tuf) gene, leucine-tRNA ligase (leuS) gene. The obtained 16S rRNA gene sequence of 16SrV showed 99.52 to 99.92 % sequence similarity with a reference strain 'BltWB' of *Ca. Phytoplasma balanitae* (AB689678) and 98.40 % with '*Ca. Phytoplasma ziziphi*' (AF305240) belonging to Elm Yellows (16SrV) group phytoplasma; when compared using the EzTaxon 16S rRNA database. However, the sequence analysis and phylogenetic of partial secA, tuf and luS gene sequences proved the association of different phytoplasma strains, that is strains different than those belonging to '*Ca. Phytoplasma balanitae*' or '*Ca. Phytoplasma ziziphi*'. Using the sequence data obtained using phytoplasma Multi-Locus Sequence Analysis (MLSA) approach we are proposing new phytoplasma taxon associated with these plants. Simultaneously, we collected and screened the putative insect vectors for the phytoplasma presence and found them positive for positive for 16S rRNA gene amplification. Further, sequence analysis confirmed these strains similar to group 16SrV strains found in symptomatic plants earlier. The Cytochrome c oxidase, subunit I (COI) gene sequences from the collected insects were obtained to identify them using 'Barcode of Life' (BOLD) database and found that all collected samples were belonging to family Cicadellidae. However due to poor database records of COI gene sequences, especially from India, we could not assign these insects to their lower taxonomic levels like genera and species which is vital factor in identifying the phytoplasma vectors.

S-8 /NSIPS/P-13

Variability in the Population of *Alternaria brassicicola* causing Dark Spot of Mustard

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Mustard is one of the important oilseed crop in the country. It contributes 26.5 % to the total domestic edible oil production. *Alternaria* blight is one of the major factor in the reduction of yield and quality which ranges from 15-71 % depending upon the severity of the disease (Awasthi & Kolte, 2001).

It is caused by *Alternaria brassicae* (Berk.) Sacc. and *A. brassicicola* (Schw.). The present study was undertaken to evaluate diversity among different isolates of *Alternaria brassicicola* collected from various regions of Bihar and adjoining parts. A total of sixteen isolates were collected from Saharsa, Supaul, Darbhanga, Khagaria, Samastipur, Bhagalpur, Gaya, Munger and Varanasi and its cultural, morphological, pathological, biochemical and genetic variability were studied. Isolates showed variability with respect to colony characters from olive gray to dark brown, radial growth rate ranged from 4.6 mm/day to 11 mm/day, and sporulation capacity showed variation from 33×104 spores/ml to 134×104 spores/ml. Substantial variation was found in spore morphology with respect to conidial length, width and number of septa. Incubation period of isolates varied from 48 hours to 96 hours. Relative melanisation of isolates were characterized which showed variations in the OD value from 0.316 to 0.984. There was significant positive correlation (r=0.64) between melanisation and sporulation and between growth rate and sporulation (r=0.74). Randomly Amplified Polymorphic DNA (RAPD) marker was used to identify the polymorphism among the isolates of *A. brassicicola* at molecular level indicated the existence of variability in the population of the pathogen under study. The results indicate presence of variation in the isolates of *A. brassicicola*, which were collected from only 8 districts of Bihar. There are chances of occurrence of clearer variation in the isolates when collected and analyzed from remaining districts representing different geographic locations. Presence of variability within the population

S-8 /NSIPS/P-14

Response of Wheat Varieties against Spot Blotch Disease of Wheat under Different Crop Establishment Technique

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Conservation agriculture (CA) is a new venture that have come into practice in different parts of world in recent years. Under CA, spot blotch caused by *Bipolaris sorokiniana* (Sacc.) Shoemaker has become a major biotic threat in the many wheat growing areas in eastern plain zone of India. A study was conducted in UBKV experimental farm to evaluate five different varieties of wheat against spot blotch disease under three different establishment technique, zero tillage (ZT), conventional tillage (CT) and bed planting (BP). A clear relationship was found showing ZT provides an environment which supports susceptibility towards spot blotch disease. ZT showed relatively highest disease with bigger lesion size and more number of spots on the leaves leading to more susceptibility whereas CT recorded least disease progress as well as smaller lesion size and less number of spots showing resistance. Irrespective of varieties ZT showed less days to heading (73.24) than CT and BP were statistically at par. Among varieties, highest disease progress were recorded in DBW39 (518.52) in ZT, followed by K0307 (515.64) with ZT technique while least disease was recorded by HD2967 in CT (181.48) and BP (207.40). Irrespective of establishment techniques, K0307 was found highly susceptible and HD2967 as moderately resistant variety. The disease data was found to be correlated with the canopy temperature and chlorophyll content (SPAD). Within the varieties lowest SPAD value was recorded in ZT plots. Thus, to get potential yield of any variety under ZT conditions, proper precautions has to be taken to keep the environmental effect low on the disease development.

S-8 /NSIPS/P-15

Diagnostic Technique for Seed Health Assessment in Pulses

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Seed health refers primarily to the presence or absence of the microorganisms of various kinds. Leguminous crops generally contains more protein commonly carry seed born mycoflora which is a major factor affecting seed health. Concentration of electrolytes leachates were increased in seed leachate may be due to altered permeability of cell membrane caused by seed borne mycoflora as the storage period increases. Neutral to slightly acidic nature of seed leachate were observed as the pH values shows decreasing trend over the storage period. These seed leachate when titrated with strong alkali solution (NaOH and KOH), the consumption of alkali solution shows increasing trend with the increase in storage period. Staining of seed leachate with basic stain Methylene blue, shows some promising results toward the development of colour chart of varying colour intensities for reference. Both titration method and staining could be further developed as diagnostic technique(s) for seed health assessment of seed lots before sowing.

S-8 /NSIPS/P-16

Screening Pigeonpea (*Cajanus cajan*) Germplasm for Stable Resistance against Sterility Mosaic Disease

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Seventy four germplasm of pigeonpea were screened in the sterility mosaic sick plot against the sterility mosaic under high disease pressure in field condition to find out levels of their resistance. Test germplasms were sown in single row plot with spacing 20cmx50cm. After every two germplasms one row of ICP8863 a highly susceptible variety was raised to serve as an infector row. All germplasms including those of ICP 8863 were artificially inoculated using infector row and leaf stapling technique to create the disease pressure. The observation was recorded on the basis of area under disease progress curve(AUDPC) and based on the AUDPC Values, the germplasms were classified as resistant(less than 350), Moderately resistant(351-650) and susceptible(more than650). Out of 74 germplasms of pigeonpea, four germplasms viz. BRG16-1, NTL 30, ML31 and BDAH2013-41 were found resistant while 12 germplasms viz., BRG16-2, ICP7119, ICPL15084, ICPL15036, BDN711, PT711-1-1-2, CO-6, WRG255, VRG06-003, NTL873, ML47 and BSMR 736 were found to be moderately resistant of sterility mosaic disease. Germplasm having resistant to moderately resistant may either used as donor parents for transferring stable sterility mosaic disease resistance in varietal breeding programme.

S-8 /NSIPS/P-17

Emerging diseases of tuberose and gerbera-new reports from Assam

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Leaf spot of tuberose caused by *Alternaria polyanthi* is of common occurrence in rainy season in Assam.But, during routine survey, severe incidence of a new leaf blight disease in tuberose (*Polianthes* tuberose cv. Prajwal, local single) was observed in experimental plots at HRS, Kahikuchi and also in farmers' field at Kulhati, Kamrup (Assam) during Sept-Oct, 2015. The disease affected 20 to 32 % of the plants in fields where its incidence occurred. Infection usually started during the period of profuse vegetative growth (June-July) which gradually increased till flowering stage and became very severe in later part (Sep-Feb) of the crop growth. The disease first appeared either at the leaf tip or at leaf margin and gradually spread towards mid-rib. The pathogen was isolated in pure culture and pathogenicity was proved. The causal organism was identified as *Phoma tuberosa*. Similarly, severe leaf blight symptoms on gerbera (*Gerbera jamsonii* cv. Red Gem, Red Monarch) were observed during Aug-Sept, 2015 at HRS, Kahikuchi and farmers' field in Hajo block of Kamrup district. Symptoms were observed in the form of large, round brown spots which appeared initially at leaf tips and margins. In later stages, the spots coalesced into irregular necrotic brown patches covering large portion of leaf lamina. Disease incidence was in the range of 22-35%. The causal agents were isolated in pure culture and pathogenicity of the causal agents were confirmed by using standard inoculation technique. The causal agents were found to be *Ascochyta gerberae* (in Red Monarch) and *Botryodiplodia theobromae* (in Red Gem) and *Phoma glomerata* (in Red Monarch). Occurrences of *Phoma tuberosa* in tuberose &*Ascochyta gerberae, Botryodiplodia theobromae*and *Phoma glomerata* in gerbera being reported herein are the first ever reports from Assam.

S-8 /NSIPS/P-18

Specific and Sensitive Detection of *Erwinia carotovora* subsp. *carotovora* from Infected Potato Tubers by Poymearse Chain Reaction

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Erwinia carotovora ssp. *carotovora* (Jones) Bergey *et al*. is major pathogen of potato causing soft rot diseases in field, transportation and storage. Sensitive and reliable early detection of these tuber borne bacterial incitants is key for the avoiding the occurrence of diseases in the field and rotting of tubers in storage. In present study, PCR protocol was developed for the detection of *E. carotovora* ssp. *carotovora* from potato tubers. A set of Oligos targeting the pectatelyase gene of *E. carotovora* ssp. *carotovora* amplified the 418 bp fragment. The sets were able to detect the *E. carotovora* ssp.

carotovora upto 1.0 ng of genomic DNA and assay on CFU detection, allowed detection up to 103 cfu/ml of *E. carotovora* ssp. *carotovora* by PCR. The study on artificial inoculation of *E. carotovora* ssp. *carotovora* at different population level and temperature reveal that 102 cfu/ml able to cause the rotting even at 21°C temperature. However maximum rotting i.e. 83.33 % was recorded at 108 cfu/ml at 35°C temperature. So, detection by PCR methods offers sensitive, specific, reliable and fast detection of soft rot bacterial pathogens from potato tubers. Thus offers a gain in time and materials thereby emphasizes its importance in large-scale detection processes such as pathogen-free seed certification.

S-8 /NSIPS/P-19

Development of Microsatellite Markers for Analyzing Genetic Diversity of *Puccinia triticina* Pathotypes Responsible for Leaf Rust of Wheat

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Leaf rust, caused by *Puccinia triticina* (PT), is the most prevalent and widespread disease of wheat in India. So far, limited information is available on genetic structure of Indian races of PT reported from 1931 -2014. Thirty six polymorphic microsatellite markers were developed for PT and used to analyze genetic variation of 50 races from three different geographical regions of India. These loci produced a total of 165 alleles with an average of 5.5 alleles per microsatellite marker. The polymorphic information content (PIC) values ranged from 0.044 to 0.857 with an average of 0.52. The average observed heterozygosity (He) across all loci varied from 0.045 to 0.85. Unweighted Neighbor-joining and race structure analysis grouped these 50 races into three major clades. The clades were not according to the geographic origin of the races. Analysis of molecular variance (AMOVA) showed 96% of the total variation within races and only 4% among geographical regions. There was low genetic differentiation in the total populations (FST = 0.042) as evidenced by high level of gene flow estimate (Nm = 5.648 per generation) among races. Information obtained from this study could be useful as a base to design strategies for better management of brown rust of wheat in India.

S-8 /NSIPS/P-20

Significant Top 10 Plant Viruses of India

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The knowledge of diseases on major agricultural crops as a result of their infections by viruses has resulted in enormous advances in our understanding of their implications. In this present climate

change scenario, India being a country known for her large agricultural cultivation potentials of many crops could set a pace to report the topmost economic important plant viruses based on their economic yield loss, if the crop is affected. Therefore, our top 10 list in rank order includes, Rice tungro virus (RTV, yield loss up to 100 %), Pigeonpea Sterility mosaic virus (PPSMV, yield loss up to 95-100 %), Tomato leaf curl virus (ToLCV, yield loss up to 90-100 %), Mungbean yellow mosaic virus (MYMV, yield loss up to 100 %), Chickpea chlorotic dwarf virus (CpCDV, yield loss up to 100 %), Urdbean leaf crinkle virus (ULCV, yield loss up to 100 %), Bhendi yellow vein mosaic virus (BYVMV, yield loss up to 96 %), Potato virus Y (PVY, yield loss up to 70-80 %), Potato leaf roll virus (PLRV, yield loss up to 70-80 %) and Cucumber mosaic virus (CMV, yield loss up to 75 %). This ranking suggests for opinions to which virus should be maintained in our present ranking and which should shift or totally be excluded from the list in years to come.

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Genetically Distinct Papaya Ringspot Virus Isolates Prevalent in North East India: Analysis Indicated Distinct Evolution

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Papaya ringspot virus (PRSV), an aphid-transmitted virus of the genus Potyvirus (family Potyviridae) is a cause of destructive disease and a major limiting factor in papaya and cucurbit cultivation worldwide. Present study reports on the widespread prevalence of PRSV from naturally grown papaya plantations in Manipur. A survey of papaya plantations in eight districts of Manipur and detection of associated virus through double antibody-sandwich-ELISA (DAS-ELISA) and reverse-transcription-PCR (RT-PCR) revealed that out of 107 samples tested, 80.13% were positive for Papaya ringspot virus (PRSV) infection. A biologically distinct PRSV isolate collected from Manipur was successfully transmitted to different cucurbitaceous host (ash gourd, bottle gourd, cucumber, pumpkin, water melon, squash, sponge gourd, ridge gourd, snake gourd, watermelon and bitter gourd) and different cultivars of papaya (TRCP-I, Red lady, PusaNanha and Local cultivar). Three genomic regions (HC-Pro, NIa-Pro and partial NIb-CP) of PRSV were amplified from the symptomatic papaya plants collected from different districts of Manipur. Partial NIb and full CP coding gene (1.2-1.3 kb) of eight PRSV isolates originating from different locations of Manipur were amplified, cloned and sequenced. For nucleotide sequences of CP, these eight PRSV isolates (PRSV-Mnp1 to 8) had heterogeneity up to 14.7%. For amino acid sequences of CP, PRSV isolates from Manipur had an identity of 88.8 to 99.6%. When compared to other PRSV isolates from India, Manipur isolates had an identity of 84 (Uttar Pradesh PRSV isolate) to 93.2 (Assam PRSV isolate) for nucleotide sequences of CP. Phylogenetic analysis with 75 PRSV isolates reported earlier from India, Asia, America and Australia revealed high genotypic diversity among PRSV populations. The phylogenetic grouping thus obtained did not correlate with geographical origin. PRSV isolates from Manipur characterized in the present study segregated in to two distinct groups (D and F). The Phylogenetic group F comprised of PRSV-Mnp3, 5 and 6, which was a new phylogroup to the world. Out of the six groups, Indian PRSV isolates were in five clusters, indicating high phylo- diversity of PRSV population in India. Role of recombination phenomenon in evolution of PRSV isolates was determined. PRSV isolates Mnp7 and Mnp8 were of recombination

origin with PRSV-Mnp2 and PRSV-Mnp6 was donors. Split decomposition analysis revealed reticulate type of evolutionary pattern and distinct evolution of PRSV isolates. Present study conclusively reported high pathogenic and genetic diversity of PRSV in North East region in general and Manipur in particular.

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The MLSA of Group 16SrII Phytoplasmas Associated with Phyllody Diseases of Pulse Crops, Weeds and Insects vectors in India

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The Multi-locus Sequence Analysis (MLSA) of phytoplasma strains associated with phyllody diseases of pulse crops (soybean, sesame, and cowpea) weeds (wild indigo, tickweed, parthenium, and cattle weed.) and insect vectors (*Cicadellidae*) were employed for their taxonomic characterization. In addition to 16S rRNA gene sequence, which is a preferred choice of microbial taxonomist to study bacterial taxa, to begin with; we analyzed multi-loci sequences obtained by amplifying partial genes viz. Protein translocase subunit (*secA*) gene, Elongation factor (*tuf*) gene, leucine-tRNA ligase (*leuS*) gene of 16SrII group phytoplasma strains. The obtained 16S rRNA gene sequence showed 98.31to 99.29 % sequence similarity with a reference strain WBDL of *Ca*. *Phytoplasma aurantifolia* (U15442) belonging to Peanut Witches' broom (16SrII) group phytoplasma; when compared using the EzTaxon 16S rRNA database. The virtual RFLP patterns derived from the 16S rRNA sequence of these samples divided them into two 16SrII subgroups 'C' and 'D' with a pattern similarity coefficient of 1. The 16S rRNA sequence analysis shows two different clades of different phytoplasma strains associated with diseases of studied plant samples. This phylogenetic pattern is further confirmed by the phylogenetic analysis of partial *secA, tuf* and *luS* gene sequences which also proves the association of different phytoplasma strains, that is strains other than those belonging to *Ca*. *Phytoplasma aurantifolia*; 16SrII-C. Based on the sequence data obtained using MLSA of 16SrII group phytoplasma strains it is worth investigating if these strains (16SrII- C and D) have evolved separately and whether they are taxonomically different species.

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Brown Spot Disease of Sugarcane: An Emerging Threat to Sugarcane Cultivation in Northern Part of Karnataka

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Sugarcane is an economically important cash crop in India. Many biotic and abiotic stresses affected sugarcane production from the era of 1900. Brown spot (*Cercospora longipes* Butler) of sugarcane was first reported by Butler and Singh in 1934. In 2014/2015 growing season, Brown spot

emerged as a devastating disease in sugarcane growing districts of Northern Karnataka *viz.*, Bagalkote, Belagavi, Dharwad, and Uttar Kannada. To this end, an urgent survey were conducted to determine the prevalence of the disease in the growing districts .The survey data collected revealed that, the disease severity varied from locality to locality in the districts surveyed. Highest severity of brown spot was observed in Dharwad district (60.75 %) followed by Belagavi district (31.66 %) and Uttar Kannada district (5.92 %) respectively, while the lowest severity was from Bagalkot district (0.92 %). In general, the highest PDI (85.18 %) was observed at Kagawad village of Athani taluk at 11th month cropping stage of ratoon crop and Mandhanakere village of Sirsi taluk at 10th and 11th month cropping stage of main crop, respectively. There was no disease in Konnur and Mole villages of Belagavi districts and all the surveyed villages of Bagalkote districts except Budhihal and Honnihal villages and the entire village of Uttar Kannada district except Madhanakere and Mareguddi villages.

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Characterization of ds RNA Bacteriophage Infecting the Olive Knot Disease causing *Pseudomonas savastanoi* pv. *savastanoi*

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Bacteriophages are viruses which parasitizes on bacteria. A vast majority (96.3%) of them are tailed having dsDNA whereas the rest (3.7%) are the polyhedral, filamentous and the pleomorphic (PFP) phages which include dsRNA phages. Only 12 numbers of dsRNA phages have been reported in the ICTV, amongst which sequences of only 6 of them were available in the NCBI. In the present study, a dsRNA containing lytic phage was isolated from an olive knot infected field of Agria, Volos, Greece. The olive knot disease, caused by *Pseudomonas savastanoi* pv. *savastanoi* is one of the most important bacterial disease of olive. In King's B media, the phage produced clear plaques surrounded by a small halo of 3.26±0.50 mm size. Morphological characterization by transmission electron microscopy (TEM) revealed that the phage particles were tailless and icosahedral having a diameter of 57.03±5.1 nm. Agarose gel electrophoresis of the extracted nucleic acid showed that the phage sample produced a tri-partite genome of around 7kb, 4kb and 3kb. Enzymatic digestion of the nucleic acid revealed that the sample was digested by RNase A and not by DNase I hence confirming that the nucleic acid of the sample phage genome is RNA. These results coincide with the phage family *Cystoviridae* having a tri-partite dsRNA genome. The findings of the present study indicated the presence of dsRNA containing lytic bacteriophages that can potentially kill the host bacterium and opens new possibilities to be used towards phage therapy in the near future.

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Isolation, Purification and Biochemical Characterization of Bacterial Pathogens Associated with Vegetables

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Vegetables are rich sources of proteins, vitamins, carbohydrates and minerals. Pathogenic bacterias cause many serious diseases of vegetables. Bacteria can survive in the soil, crop debris, seeds and other plant parts. Weeds can also act as reservoirs for bacterial diseases. In this investigation, infected vegetables were collected from the vegetable market of Jorhat District, Assam. Symptomatology of different diseases were studied. Seven bacterial pathogens were isolated from seven different vegetable *viz.*, tomato, brinjal, cabbage, squash, citrus, chilli and carrot. The pure culture of the dominant pathogens were isolated. Cultural as well as morphological characterization was done. Morphologically, the majority of the bacterias were rod shaped with polar flagella. Different biochemical tests of these bacterial isolates were also conducted. Gram staining test revealed that most of the bacterias are Gram negative

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Disease Complex of Patchouli (*Pogostemon cablin* (Blanco) Benth.)

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Patchouli (*Pogostemon cablin* (Blanco) Benth.), an important aromatic plant belonging to Lamiaceae family, is a native of Philippines. The crop is in demand for its essential oil namely "patchouli oil". Production of patchouli in India is limited (10 -15 tons/ annum) and India is annually importing over 200 tonnes of this oil from Indonesia, Malaysia and Singapore to meet its domestic demand. Various fungal and bacterial diseases and also nematode infestations are reported to cause huge losses to the crop. Different diseases associated with patchouli crop are Leaf and stem gall caused by *Synchytrium pogostemonis* f.sp. *patchouli*, root rot caused by *Fusarium solani*, bacterial wilt, leaf blight, *Rhizoctonia* and *Cercospora* infestation. Among these root rot disease caused by *Fusarium solani* is the major hurdle of cultivation of patchouli in Assam. Infected plant is characterized by gradual yellowing and drying of leaves followed by premature death. Discolouration of roots and collar region of fully grown plants is a typical symptom of the disease. Association of root knot nematode (*Meloidogyne incognita*) with *Fusarium* species develops a disease complex increasing the severity of the disease. Disease complex involving both fungal pathogen and the nematode causes huge losses than individual infestations. In management of the disease complex – application of mustard oil cake, carbendazim and biocontrol agents help greatly in reducing crop loss.

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Studies on Pathogenic, Cultural and Morphological Variability of *Pythium aphanidermatum* Isolates causing Ginger Rhizome Rot from Different Parts of Marathwada Region

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Pythium aphanidermatum is an important pathogen of ginger causing rhizome rot disease in ginger growing region of Marathwada**.** The diseased samples rhizome rot showing typical symptoms were collected from different parts were collected and subjected to isolations. The different isolates were evaluated for their pathogenicity by using sick soil method in pot culture (*in vitro*) on local ginger variety. All the isolates were pathogenic to ginger and caused rhizome rot disease and showed the typical symptoms of disease. The isolates from Aurangabad and Beed district were more aggressive and showed pre emergence rhizome rot and all isolates exhibited. The Aurangabad isolate showed post emergence mortality after 120 DAS while rest all isolates showed PEM after 150 DAS. Cultural and morphological variability was observed on PDA. All the five representative isolates exhibited a great variability in respect of colony diameter, colony elevation, Sporulation. The maximum growth of mycelia diameter of 90 mm was observed in Aurangabad isolate at 192 hrs of inoculation. Also the Aurangabad isolate showed ample sporulation, large size of zoospore (8.48- 15.89 µm) and maximum mycelia width (12.87 µm).

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Isolation of Fungal and Bacterial Pathogens Associated with Storage Rot of Ginger in Assam

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Ginger (*Zingiber officinale* Roscoe) is an important spice crop in India, which is one of the leading producer and exporter in the world. Ginger is one of the most promising spice crop grown in North Eastern State. Post-harvest losses in ginger is a serious concern as after putting hard labour for 7-8 months in production, the precious harvest is lost due to negligence in crop production and storage in underground pits and open heaps at various stages. During storage, the rhizomes was affected by fungal and bacterial infections. The objective of this study was to identify fungi and bacteria associated with the post-harvest rot of ginger rhizomes (*Zingiber officinale* Roscoe) in the Assam, India. Rhizomes with rotting symptoms were sampled in the storage-house, markets and households. The results demonstrated that one fungus and one bacteria were isolated from rotted samples.

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Molecular Characterisation of Sesamum Phyllody Disease in Assam

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Sesamum (*Sesamum indicum* L.) is one of the important oilseed crop grown in Assam. Major factors that limit its production are instability in yield, non mechanized harvesting, non synchronous maturity, and susceptibility to diseases and pathogens. Among various diseases attacking the crop, Sesamum phyllody is very serious and destructive disease causing economic loss to the growers. The pathogen is a phytoplasma which is an unculturable wall less bacterium under class: Mollicutes, present inside the phloem of host plants and in the haemolymph of insect vectors. Major symptoms of Sesamum phyllody disease were phyllody, witches broom, floral virescence and floral proliferation. The ovary of the flower was replaced by elongated structures, almost resembling a shoot. The calyx becomes polysepalar, and the sepals become leaf-like and remain smaller in size. Symptoms of fascination of shoot and seed capsule cracking were also observed in some Sesamum phyllody infected plants. Through PCR detection *Orosius albicinctus* and *Hisimonus phycitis* was confirmed as vector of the disease. Suspected Sesamum phyllody infected plants were collected to the laboratory and the infection was confirmed by PCR analysis using phytoplasma specific primer and electron microscopy. Partial sequencing of PCR product (1.25kb) was done. Phylogenetic analysis revealed that the phytoplasma is closely related to *Elaeagnus angustifolia* witches-broom phytoplasma strain 29.

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Effect of Sesame Phyllody Disease on Quantity and Quality of Sesame Oil

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Among the important oilseed crops widely grown in the world, sesame (*Sesamum indicum* L.) provides one of the highest and rich quality edible oils. India is the largest producer of sesame in the world producing 7 lakh MT seed in an area of 13.98 lakh hectares in the year 2017 Sesame phyllody disease caused by Sesame Phyllody phytoplasma is one of the most important diseases of sesame which is characterized by various symptoms like phyllody, floral virescens, witches' broom, flattening of stem

and splitting of the immature pods. Yield reduction of 57.20-100 % occurs due to sesame phyllody. Besides reducing the yield of sesame, the disease also deteriorates the quantity and quality of the oil to a great extent. In the present investigation both qualitative and quantitative analysis of sesame oil through various biochemical tests and oil extraction was being carried out for sesame seeds collected from healthy and diseased plants. Oil extraction using Soxhlet apparatus showed a higher reduction of oil contents on the infected plants. Biochemical analysis for the acid value, saponification value and iodine value showed significant changes for infected and healthy plants. The analysis carried out on the oil of healthy and infected sesame seeds have the following properties: acid value of 6.4 and 8.45mg KOH/g, saponification value of 187.93 and 140.25 mg KOH/g and iodine value of 101.52 and 126.90 gI_2/100g. Sesamum phyllody infection reduces the oil content upto 33.33 per cent and saponification value upto 32.03 per cent while the acid value and iodine value were found to be increased to an extent of 25.37 per cent and 25.00 per cent, respectively.

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Association of *Candidatus Phytoplasma asteris'* (16SrI Group) Phytoplasma with Flat Stem Disease of Flax (*Linum usitatissimum* L.) in Assam, India

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Flax (*Linum usitatissimum* L.) belongs to the family Linaceae is grown for food, fibre, medicine and also as ornamentals in homestead garden. Flat stem symptom of flax was observed in the experimental farm of Regional Agricultural Research Station, Shillongoni, Assam Agricultural University, Assam, India during February, 2016. The disease incidence varied from 2-3 per cent from plot to plot. Total DNA was extracted from the symptomatic and asymptomatic flax plants using universal phytoplasma specific primer pairs, P1/P7 followed by R16F2n/R16R2n which yielded approximately 1.2 kb amplicons in the symptomatic samples. Asymptomatic plants yielded negative result with the same assays. BLAST analysis of 16SrRNA partial gene sequence showed sequence similarity of 100 per cent with phytoplasma strain belongs to *'Candidatus Phytoplasma asteris'* (16SrI) group. This is the first identification and molecular detection of phytoplasma associated with stem flattening disease of flax in Assam.

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Diversity among *Albugo candida* Isolates Causing White Rust in *Brassica juncea* Based on Morphological and Molecular Approaches

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Brassica lines resistant to white rust disease caused by *Albugo candida* are reported, however, Indian mustard (*Brassica juncea*) cultivars with desirable level of resistance across locations have not been developed in India. It is due to lack of information on availability and distribution of *A. candida* pathotypes in the country and their degree of host specificity. So, an attempt was made to clarify and understand the diversity present within the *Albugo candida* species under a single host (*B. juncea).*Thirteen isolates of *A. candida* infecting mustard and one isolate of *Albugo bliti* infecting *Amarantus blitum* were collected from different parts of India. These isolates were characterized and grouped, based on morphological (sporangial shape and size), pathological (shape, size and colour of pustule) and molecular (internal transcribed spacer (ITS) region of rDNA and the cytochrome *c* oxidase subunit II (COX2) region of mtDNA) data. Based on morphological data, sporangia were mostly globose, whereas, some were spherical or ellipsoidal as well. Variation in sporangial size (sporangial area) was observed in different isolates. AbP1 pathotype produced the smallest (199.01ìm²), whereas, AcP3 pathotype produced the largest (357.23ìm²) sporangia. All the *A. candida* pathotypes have white to creamy colour pustule with a diameter (dia.) ranged from 0.5-3.0mm. Bigger pustules size was produced in AcP7 pathotype (2.7mm in dia.) and the smaller pustules were developed by AcP4 pathotype (0.9mm in dia.). COX2 gene was found to be more efficient marker for analysis of genetic diversity among *A. candida* species complex compared to ITS marker. Fourteen pathotypes were grouped into 7 clades using COX2 marker, while 11 pathotypes were classified into 4 groups with ITS marker. High degree of diversity is observed among *A. candida* isolates against a single host species of *B. juncea*.

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Identification and Molecular Characterization of Sesamum Phyllody Disease in the North East Region of India

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Sesame phyllody (SP) disease caused by phytoplasma is becoming serious problem to many sesame growing countries in the world including India. Sesame is one of the important cash crops of the North East region of India. In the present study an extensive survey was conducted in seven North

Eastern States covering 52 districts to record the incidence of SP disease and its molecular characterization during 2015 to 2017. Different kinds of symptoms like floral virescence, phyllody, floral proliferation, flattened stem, splitting of capsules and witches broom was observed on the infected plants during the survey. The disease incidence varied from 2 to 27 per cent in different locations of the North East region of India. Highest disease incidence was observed in the Sonitpur district of Assam in the variety ST-1863.Total 40 symptomatic samples were collected and analyzed by DNA isolation and polymerase chain reaction with phytoplasma specific primers, amplifying *16S rRNA* and *sec A* genes. PCR analysis using phytoplasma specific primer confirmed the association of aster yellows (16SrI) phytoplasma groups. Pairwise sequence comparison and phylogenetic analyses of 21 isolates of *16S rRNA* and 9 isolates of *secA* gene sequences further classified them with aster yellows (16SrI) phytoplasma groups. Further virtual RFLP analysis of 16SrDNA sequences allowed finer classification of the sesame phytoplasma strains into 16SrI-B, subgroups. In India, sesame is cultivated in the same season with many other crops. The scenario of natural phytoplasma spread from sesame to other plant species and vice-versa through an efficient vector species is very plausible. Hence, it would be important to evaluate the role of different epidemiological factors involved in the natural spread of phytoplasmas associated with sesame phyllody disease in India.

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Morphological, Pathogenic and Molecular Variability in *Fusarium oxysporum ciceri* causing Wilt of Chickpea

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Fusarium oxysporum ciceri causing wilt of chickpea is an important soilborne pathogen. Out of 32 isolates collected, the maximum colony diameter 90 mm was observed in isolates of FOC3, FOC10, FOC16, FOC18, FOC24, FOC25, FOC29 and FOC32 which were significantly superior to all other isolates. The minimum growth was observed in isolates FOC2, FOC4, FOC5, FOC6, FOC9, FOC13, FOC15, FOC21, FOC26 and FOC30 (55-70 mm).

Bigger size of macroconidia and microconidia (34.24-43.18×4.74-6.28 µm) (9.12 14.43×2.85-4.54 µm) was observed in isolate FOC24, with maximum 3 septa in macroconidia. FOC18 recorded smaller sized microconidia (2.10-2.32×1.05-1.50 µm) and macroconidia (8.78 16.01×4.00-3.52 µm) with 1-2 septa. Maximum dry mycelial weight was recorded in FOC16 (362.5 mg) and least dry mycelial weight was recorded in FOC9 (220.0 mg).

Maximum virulence was recorded in FOC16 (4.16) which took less number of days (24) to complete wilting of plant followed by FOC32 (3.65) required 24 days for wilting. FOC9 and FOC15 were less virulent with minimum virulence index of 1.67 and 1.85 required longer period 27 days and 36 days for wilting of plants. Isolates with higher virulence index required less period for wilting of plants. Grouping of the isolates of *Fusarium oxysporum ciceri* was done based on radial growth, dry mycelial weight, virulence index and no. of days taken for wilting. First group with ten isolates of highly virulent isolates, second group with twelve isolates of moderately virulent and third group with ten isolates exhibiting less virulence.

The race identification of *F. oxysporum ciceri* by using set of differentials indicated that all isolates belong to race 1a. Based on sequence comparison in NCBI (National Centre for Bioinformatics) all the ITS rDNA sequences of isolates were confirmed as *Fusarium oxysporum ciceri*.

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Comparison of Artificial Screening Methods for Evaluation of Resistance to *Fusarium* Wilt Disease of Castor

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This study was carried out to compare two artificial screening methods viz. Soil Infestation method (SIM) and root dip inoculation technique (RDIT), under glasshouse conditions at Castor and Mustard Research Station, S.D. Agricultural University, Sardarkrushinagar. Under Soil Infestation method (SIM), pathogen was mass-multiplied on sand (90%) and maize meal (10 %) medium. Both ingredients (1000 g) and 150 ml water were mixed thoroughly and filled in conical flasks which were sterilized by autoclaving followed by inoculation and incubation. After 20 to 25 days of incubation, colonised sand maize meal medium was dried under shed. Fifty gram of this inoculum was mixed with 1000 gram of sterilized soil thoroughly and filled in pots. Test genotypes were sown in these pots. Under root dip inoculation technique (RDIT) pathogen was mass-multiplied on sorghum grain. Sorghum grain was soaked overnight in 2% sucrose solution and boiled till become soft and filled in conical flask followed by sterilization through autoclaving and incubation. After incubation for 12 to 15 days, conidia was harvested in sterilised distilled water, quantified using haemetocytometer conidia and adjusted at 106 conidia/ml suspension by diluting with sterilised distilled water. Castor seedling of test genotypes were raised separately on coco pith and coarse sand (1:1 v/v) and 12-15 days old seedling were uprooted, their root were clipped from distal 1/3rd end. Clipped roots were dipped in conidia suspension for 60 seconds and transplanted in pots filled with sterilized soil. Wilt incidence was recorded after 30 days of transplanting in RDIT and 30 days of sowing in SIM. Ten seedling were maintained in each pot and two replication of each treatment was maintained. Tap water was used for irrigating all the pots as and when needed.

After the analysis of data obtained, it was revealed that both the artificial screening methods; SIM and RDIT were statistically similar. However, mean wilt incidence obtained through SIM (53.9%) was higher as compared to RDIT (44.8%). Interaction of screening methods and genotypes was also non-significant. However, all the genotypes exhibited comparatively higher wilt incidence when screened through SIM as compared to RDIT. Genotype DCS-9 exhibited resistant reaction (15.8 %) when screened through RDIT but was moderately resistant (32.5 %) when screened through SIM. Similarly, Genotype DCS-107 exhibited moderately resistant (23.5 %) reaction when screened through RDIT, but was moderately susceptible (41.7 %) when screened through SIM. Genotype Kranti exhibited moderately resistant (39.5 %) reaction when screened through RDIT but was moderately susceptible (42.5 %) when screened through SIM. It was observed that lower level of resistance could be efficiently evaluated through RDIT.

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Cultural, Morphological and Pathogenic Variability in the *Fusarium spp.* causing Post Flowering Stalk Rot in Maize

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Post flowering stalk rot of maize caused by *Fusarium verticillioides* symptoms were recognized by premature drying, discoloration of nodal tissues with shredding of pith and the affected internodes become pinkish/ straw colored with disintegrated pith and tilted cobs. The disease was found in moderate to severe form distributed in all the surveyed 48 villages of 4 districts during *Kharif* 2011 and 42 villages in 7 districts during *Kharif* 2012.Ten isolates of *Fusarium* spp. were recovered and their identification shows that three species *viz. F. verticillioides, F. proliferatum* and *F. Pallidoroseum* are associated with the disease. On the basis of cultural, morphological characteristics and response of various isolates on different germplasm including, local susceptible check, inbreds and different maturity groups, *F. verticillioides*, was highly virulent in terms of maximum disease rating. Two years trial on evaluation of 15 different germplasm emphasized thatgenotypes HM-5 and Surya were found to be highly susceptible against all the *Fusarium spp.* tested (disease rating > 6.0) whereas, Bio-9637 and HQPM-5were least susceptible (disease rating of 2.5 and 2.8, respectively). Hence, genotypes HM-5 and Surya could be used as susceptible checks and Bio-9637 and HQPM-5 could be used as resistant checks for comparing of test materials in screening programme for PFSR.

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Identification of Potential Fluorescent Pseudomonas Isolates Inducing Drought Tolerance in Rice and Wheat

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Roots are the important part of a plant which were unnoticed in the circle of crop production of cereals. Roots which grow into the complex soil system have to face a lot of obstacles, both abiotic and biotic. Microbes which are present in soil shows different activities in relation with crops. Land plants interact with microbes primarily at the roots, the result of which,could lead to crop failure or success. Fluorescent pseudomonas, which colonises in rhizoplane /endo-rhizosphere can help the plants to alleviate water stress through various known and unknown mechanisms. Various crop improvement programmes like, genetic engineering and conventional breeding are essential but are really cumbersome and time

consuming whereas, microbial inoculation is very simple and cost effective method that can be adapted quickly in an eco-friendly way. The present study was conducted with the aim of identifying potential florescent pseudomonas isolates which can help plants to overcome water stress conditions. The treatments were able to sustain water stress for 9 days at 0% moisture level as compared to un-treated control plants. Rice plants derived from treatments P1, P2, P5, P7, P8, P10, P11, P17, P19, P23 and P141 were able to survive under water stress. In wheat crop the results were appealing and all the 31 treatments were superior over control plants. The treatmentsP1, P2, P5, P7, P8, P10, P12, P13, P19 and P66 were found to be more persistent under water stress.

S-8 /NSIPS/P-38

Study the Growth Character of *Alternaria porri* (Ellis) Cif. on Different Media in Purple Blotch of Onion

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The test pathogen was successfully isolated on Potato dextrose agar, and proved its pathogenicity on onion Cv. N-53 under screen house conditions. Of the 7 culture media tested, Potato Dextrose Agar Onion encouraged significantly highest mean radial mycelial growth (90mm), followed by the second and third best culture media found were Conn's agar (63.66mm) and Czapeksdox agar (45.65mm), Corn meal agar (45.01mm),Potato malt agar (44.01mm), V¬8 juice agar(34.01mm) , Oat meal agar were found least suitable and recorded radial mycelial growth of (13.00mm).

S-8 /NSIPS/P-39

First Report of *Rhizoctonia solani* causing Sudden Wilting and Mortality of Agar (*Aquilaria malaccensis* Lamk.) Seedlings in Assam

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Aquilaria malaccensis Lamk. is one of the most economically important, medicinal and aromatic tree species of North-East India. It is naturally grown and commercially cultivated in different districts of Assam. Locally known as *Xashi* or *Agar*, the Upper Assam region is known for the natural belt of agarwood formation. The principal use of agarwood is in perfume industries. Besides, the essential oil from agarwood is valued for preparation of several pharmaceutical and cosmetic products and its cost is extremely high depending on the oleoresin content of the wood. Due to high demand for agarwood, people are getting engaged in large scale cultivation of this species in this region. But, due to unscientific cultivation practices, new diseases are emerging in the nursery. Unknown fungal infection of *A. malaccensis* with grey to brown spots on leaves leading to sudden wilting and mortality was observed in seedlings raised in polybags at Rain Forest Research Institute (RFRI) in 2017. The fungal infection causes 80% damage to the seedlings. The pathogen was primarily identified as *Rhizoctonia solani* ITCC No. 10.693.17 on the basis of morphology. Aqueous suspension of whitish brown growth of the

fungus sprayed on leaves produced typical symptoms in about 15 days followed by wilting and death of *Aquilaria* seedlings. The fungus was highly pathogenic on artificial inoculation. This is the first report of *R. solani* in affecting seedlings of *Aquilaria malaccensis*. Soil drenching and foliar spray of 0.1% Bavistin was found effective in checking further spread of the disease.

S-8 /NSIPS/P-40

Incidence and Symptomatology of Wilt Disease of Sugarcane in Assam

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Sugarcane is the first field crop as well as second most important commercial cash crops in the country after cotton. Wilt disease caused by *Fusarium sacchari* (Butler) W. Gams is an important stalk disease of sugarcane recorded nearly 100 years ago. A survey was conducted to study the symptomatology and to determine the incidence of this disease in four different locations in Golaghat district of Assam. Wilt is characterized by yellowing of the foliage followed by drying of canes in patches in the field. Internal pith tissues turned light pink to brown that pass from one internode to another and dried pith tissue takes boat shaped appearance that can be observed after splitting the diseased stalk. The cut ends of the affected canes display a hollow symptom with reduced cane weight at harvest. The average percent disease incidence was recorded upto 18.51 in late maturity stage of the crop.

S-8 /NSIPS/P-41

Differential Reaction of *Fusarium oxysporum* f. sp. *ricini* Isolates causing Castor Wilt

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Castor (*Ricinnus comunis* L.) is an important non-edible oilseed crop of arid and semi-arid regions of India. Castor *Fusarium* wilt is the major production constrain in the cultivation of castor growing areas. The resistant/tolerant varieties/hybrids developed against wilt disease do not perform uniformly in all areas. It might be due variability in the pathogen and pathogenic potential of the same pathogen. Variability in castor wilt pathogen is of great concern in breeding programs for the development of high yielding castor varieties/hybrids with durable and stable resistance. The pathogenic variability of eleven isolates of *F. oxysporum* f. sp. *ricini* representing various castor growing geographic regions of India was evaluated against ten castor genotypes by root dip inoculation technique (RDIT), under greenhouse conditions. The pathogenic reaction of all the eleven isolates of *F. oxysporum* f. sp. *ricini* was varied towards ten castor genotypes. The mean wilt incidence of castor genotypes against the isolates varied from 4.58 per cent (48-1) to 85.83 per cent (VP 1) and mean wilt incidence exhibited by the isolates of *Fusarium* wilt pathogen against the genotypes varied from 22.25 per cent (For 16-10) to 68.75 per cent (For 16-7).

Among the resistant genotypes, 48-1, SKI 215 and JI 258 showed resistant reaction (d”20 % wilt) to all the test isolates but DCS 9 showed susceptible reaction (>60 % wilt) against For 16-4, 6, 7 and 11 isolates, whereas PCS 124 showed susceptible reaction to For 16-3 and For 16-7 isolates.

Among susceptible genotypes VP 1, VI 9 and JI 35 showed susceptible reaction to all the test isolates but TMV 5 showed resistant reaction to For 16-5 and 16-10 isolates, whereas Kranti showed resistant reaction to For 16-5 and For 16-9 isolates.

S-8 /NSIPS/P-42

Study of Some Bacterial Pathogens Associated with Flowering Crops Grown in Assam

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Floriculture is regarded as a growing industry in India and commercial flowering crops have emerged out as a great contributor to the nation's economy. Although, the yield of the commercial flowering crops is largely affected by diseases and insect pests, study in regards to bacterial diseasesof these crops is stillin premature stage.In our study suspected diseased samples from popularly grown flowering crops,*viz*., Marigold (*Tagetes* sp), Anthurium (*Anthurium andraeanum*), Gerbera (*Gerbera jamesonii*), Tuberose (*Polianthes tuberosa*), Dendobrium (*Dendrobium* sp), Chrysenthemum (*Chrysanthemum indicum*), Rose (*Rosa* sp) and *Musseanda* (*Mussaenda erythrophylla*) were collected from Jorhat, Tinsukia and Kamrup districts of Assam. Initially symptomatological studies of the samples were conducted and eight bacterial agents were isolated and purified. The biochemical and cultural tests revealed that some of the pathogenic bacteria come under taxonomic group of the genus, *Xanthomonas* and *Pseudomonas*.

S-8 /NSIPS/P-43

Studies on Incidence of Fungal Wilt of *Kharif* Sesame under Different Cropping System in Karbi Anglong District of Assam

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Sesame wilt caused by *Fusarium oxysporum* f. sp. *sesami* is a major disease in sesame and its severity is increasing in recent years in Karbi Anglong district of Assam. A two years field study was carried out to evaluate the incidence of the disease under three different cropping systems namely, mixed cropping in new Jhum, old Jhum (3-4 years) and sole cropping during 2016 and 2017. The sesame crop grown as mixed crop in Jhum system of cropping showed less wilt disease incidence as compared to sole cropping. The lowest percentage of dead plants (4.50 %) & highest seed yield/plant (11.35 g) was recorded in new Jhum land. The sole crop recorded highest percentage of dead plants (19.83%) and lowest seed yield/plant (9.05g). This study demonstrates that mixed cropping can be employed as an efficient management to prevent fungal wilt of sesame.

S-8 /NSIPS/P-44

Infectivity Analysis of *Cucumber Green Mottle Mosaic Virus* (CGMMV) in Different Cucurbitaceous Hosts under Controlled and Field Conditions

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Cucurbitaceae, comprising of economically important crops such as cucumber, water melon, bottle gourd, musk melon, bottle gourd, ridge gourd, snake gourd etc., accounts to 50.0 % of world's total vegetable and 5.0 % of Indian vegetable production. *Cucumber green mottle mosaic virus* (CGMMV), a single stranded positive-sense RNA virus belonging to the genus *Tobamovirus* in the family *Virgaviridae* is an economically important seed transmitted viral pathogen affecting cucurbit crops. Infection of *Cucumber green mottle mosaic virus* (CGMMV) is restricted to cucurbitaceae, chenopodiaceae besides weeds belonging to *Amaranthus* spp., *Heliotropium* spp., *Portulaca* spp., etc., Infectivity studies of CGMMV were carried out in cucumber, muskmelon, bottle gourd, long melon crops under controlled and field conditions. Studies on systemic distribution of CGMMV in the edible portions of cucurbitaceous fruits were carried out to investigate the sites of localisation and accumulation of virions after successful infection. Electron microscopy studies revealed the presence of virions of CGMMV in the edible portions of cucumber fruit. i.e., epicarp, mesocarp and endocarp tissues. Accumulation of virions to significant levels in the endocarp tissues of cucumber fruit was observed at maturity. Similar pattern of higher virion accumulation of CGMMV was noticed in the endocarp tissues of long melon fruit. These results corroborate the previous study who reported the movement of virions of CGMMV through the phloem tissue according to the photo assimilate path. CGMMV was also reported to move from photo assimilate source to sink indicating phloem transport. The information generated out of the current study can be useful for successful production of vaccines/therapeutic proteins by engineered viral genomes carrying genes of vaccine epitopes/ heterologous proteins.

S-8 /NSIPS/P-45

New Bacterial Pathogen from Fruit Crops of Assam

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India is the second largest producer of fruits next to only China. Cultivation of fruit crops are important for improving the quality of life and have a great potential to earn foreign exchange. Different pest and diseases cause significant production loss of the fruit crops leading to decline in the farm income of the potential growers. Although bacterial diseases cause severe loss to different fruit crops in several districts of Assam, however, no systematic research has been conducted for identification, characterization and management of these diseases. So the present study was made to isolate, characterize and identify some of the bacterial pathogens associated with diseases of important fruit crops in Assam.

Suspected diseased samples from fruit crops *viz*., Banana (*Musa spp*.). Pomegranate (*Punica granatum*) and Mango (*Mangiferae indicae*) were collected from Jorhat and Sonitpur districts of Assam. Cultural, morphological, biochemical studies revealed their similarity with the genus *Ralstonia* (in Banana) and *Xanthomonas* (in Pomegranate and Mango).

S-8 /NSIPS/P-46

Screening for Resistance Sources of Different Mango Germplasms against *Xanthomonas campestris* pv. *Mangiferae-indicae* (MBCD) causing Mango Bacterial Canker Disease under West Bengal Condition

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Thirteen isolates ($HmHL_1$, $NsGF_2$, $NdGF_3$, $HmMoL_4$, $AmGF_5$, $HmGF_6$, $HmMuL_7$, Aa GF_8 , $BMoL_9$, BGF_{10} , $HmJL_{11}$, $RaGF_{12}$ and $HmKF_{13}$) of *Xanthomonas campestris* pv. *mangiferae-indicae* were obtained from the canker infected samples collected from different agro-ecological regions namely Nadia, Hooghly and Murshidabad and other orchards of West Bengal. All the thirteen isolates of *Xcmi* were found to be pathogenic on mango at varying degrees and based on virulence, the isolates were categorized into three groups, highly virulent, moderately virulent and low virulent. Approximately 69.2 % of the isolates of *Xcmi* of alluvial-agro-ecological region of West Bengal were found to be moderately virulent whereas 23.1% showed low virulence. Among thirteen isolates, one isolate, *Xcmi* BMoL9 was found to be highly virulent on mango. The hierarchical cluster analysis of the enzymatic activities studied for *Xcmi* isolates revealed that there is high similarity between enzymatic grouping of isolates and their virulence / pathogenicity.

Pathogenicity assay were made for screening of 39 different mango cultivars against most virulent isolate $BMoL_9$. Results obtained from the experiment indicated that seven cultivars (Himsagar, Bombai, Dashehari, Arka puneet , Mallika , Fernandin and Neelum) were found to be highly susceptible while seven were moderately susceptible, thirteen proved to be less susceptible, five showed moderately resistant and seven (Zardalu, Fazli, Sunder langra, Manjeera, Sorikhas, Suvarnrekha and Mankurad**)** were found resistant to the infection. The symptom initiation and expressions varied among the cultivars. It has been observed during the screening of cultivars that few of the cultivars which were earlier found to be resistant against the *Xcmi* infection now found to be moderately susceptible to susceptible. This may be due to the increasing aggressiveness of the pathogen with the course of time or might be due to the co-evolution of host-pathogen and or environmental factors contributing to the disease development.

S-8 /NSIPS/P-47

Cultural, Morphological and Molecular Characterization of *Fusarium oxysporum* f.sp. *cubense* Isolated from Mizoram and Assam

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A total of 35 *Foc* isolates were isolated from the Fusarium wilt infected vascular strands of six different cultivars of banana which belong to different genomic groups (AAB, AAA and ABB) grown in 19 different regions of Mizoram and Assam. The results of the cultural, morphological and molecular characteristics of the isolates indicate a great variability among them. The study on the cultural characters of *Foc* revealed variations among colony colours, shape, margin, texture and pigmentation among the isolates. The morphological characters revealed variability in sizes of microconidia, macroconidia and chlamydospores. The micro-conidia were more or less oval/ kidney shaped to cylindrical with 0-2 septations. The macro-conidia were typically sickle shaped curved with blunt or pointed ends, varied in size and number of septation (3-5). The chlamydospores were typically round to oval in shape. The genetic diversity was analyzed based on five different ISSR primers viz., $(GAC)_5$, $(GTG)_5$, $(ACC)_6$, $CCA(TG)_5TG$ and (AC)8YG for all the 35 *Foc* isolates. The ISSR amplification produced 04–12 bands out of which the numbers of polymorphic bands produced were 2–10. Genetic relatedness between the *Foc* isolates of banana were also assessed where the distance matrix was calculated based on the fingerprints obtained which ranged from 0.11 to 1.00. The dendrogram consisted of two major clusters A and B. The cluster ‘‘A’’ contains only six *Foc* isolates and where as the cluster ‘‘B’’ contains all the remaining 29 *Foc* isolates which were isolated from banana belong to different genomic groups AAB, AAA, ABB. The results of the study clearly indicates that there is an existence of wide genetic diversity among the *Foc* isolates obtained particularly from Mizoram thereby proving the polyphyletic nature of the *Foc* isolates

TECHNICAL SESSION - IX

Deficiency Disease and Angiospermic Parasites

S- 9/NSIPS/P-1

Present Status and Plant Health of Khasi Mandarin (*Citrus reticulata* Blanco) in West Garo Hills District of Meghalaya

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Khasi Mandarin (*Citrus reticulata* Blanco) is one of the most important horticultural fruit crop of West Garo Hills district of Meghalaya. It is grown in a total area of 1555 hectare with a production of 3375 metric ton and productivity of 2.17 ton/ha. Sadly, like most other agriculture crops, orange cultivation in the district is faced with various challenges like diseases, insects, parasitic plants, weeds, hazards of climate change, unscientific orchard management leading to low production and productivity despite having suitable agro climatic condition for its growth and production. Recent survey in 2016-17 of 8 villages in major orange growing areas under four blocks viz. Rongram, Gambegre, Dalu and Tikrikilla covering 40 orange growers in the district revealed that among major diseases 80.6 % of the orchards were affected by citrus decline followed by Citrus greening (60.63%),citrus scab (43.75), gummosis (40.62%),sooty mold (40.00%)and citrus canker (38.75%). Among various insect pests citrus trunk borer (80.63 %) was the major curse in the orchard followed by fruit sucking moth (58.12%). Other insects like leaf miner, fruit fly, mealy bug and citrus aphids also caused damage in the range of 9-23%. Among parasitic plants lichen caused considerable damage (93.75%) followed by *Loranthus* (69.36%). *Mikania micrantha* was the most obnoxious weed infesting upto 86.25% of the orchard. Despite facing all odds orange trees in the age group of 21-30 years were found to be outstanding in terms of yield followed by 10-20 years of age. The present study suggests that timely care of the orchards with various eco-friendly plant protection measures to manage various insect pests and diseases along with clean cultivation and nutrient management will enhance production of mandarin orange in the district.

S- 9/NSIPS/P-2

Deficiency Diseases of Cole Crops: A Review

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Nutritional deficiencies are basically physiological disorders in the plants that affect productivity as well as the quality of the produce. Physiological disorders of cole crops are abnormalities in leaf and stem morphology, colour or both which are not caused by infectious diseases or insects. The abnormalities occur as a result of environmental stress, nutritional deficiencies or excesses on the plant. When nutrient is not present in sufficient quantity, plant growth is affected. Plants may not show visual symptoms up to a certain level of nutrient content, but growth is affected. When a nutrient level still falls, plants show characteristic symptoms of deficiency. These symptoms are varying with crop and have a general pattern. In cole crops, the deficiency of B, Ca, Mg and Mo are common. Such as, hollow stem of

broccoli and cauliflower, buttoning of broccoli and cauliflower, browning of heads and curds of broccoli and cauliflower, leaf tip burn in cabbage and cauliflower, loose head of cabbage and chlorosis in cauliflower. Nutritional disorders have become widespread with diminishing use of organic manures, adoption of high density planting, disease and salt tolerance, unbalanced NPK fertilizer application. To get high quality produce and yields, micronutrient deficiencies have to be detected before visual symptoms are expressed. In this review article, an attempt has been made to correct visual and hidden micronutrient deficiencies, appropriate foliar and soil applications, soil analyses, and plant tissue analyses as diagnostic aids for confirming nutritional disorders are considered.

TECHNICAL SESSION - X

Nematode, Arthropod and Insect in Relation to Plant Pathology

Lead Lecture-01

S- 10/NSIPS/L-1

Nematode Diseases of Medicinal and Aromatic Crops: A Major Hurdle in the Advancement of Agrotechonology

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The trade and industrial advancement of a nation relies on development of profitable agrotechnologies, an enhancement in the export and limitation on avoidable imports. This is only possible when there is plentiful availability of highly productive and disease free planting materials of commercially important tropical medicinal and aromatic plants. The advancement of agrotechnologies, processing and trade through value addition of materials from MAPs are providing much needed avenues of self-employment in country like India. With increasing interest in natural products of plant origin for nutraceutical, health and cosmeceutical benefits, there is an added emphasis on the quality of the source raw materials of MAPs. In most cases the vegetative tissues and organs are the source of the required raw material. However, such tissues/organs may become infested / susceptible to many diseases causing deterioration of the quality of the desired economic product and loss of genetic resources. Considerable progress has been made with respect to the identification of disease causing organisms, and their pathogenic impact at organ, cellular and biochemical level. In this lecture focus will be made on nematode diseases threatening the yield, biomass, bioactive potential of medicinal and aromatic plants. Plant parasitic nematodes are considered a major constraint for the future prospects of tropical medicinal and aromatic plants. It constitutes one of the most important group of pathogenic organisms prevalent in and around the root system thus, playing a significant role in the plant growth and yield reduction. The damage caused by these phytonematodes to a particular plant depends on crop and cultivars, nematode species, level of inoculums in soil and the environment. Various plant parasitic nematodes have been found to limit the yield and productivity of numerous medicinal and aromatic plants. The most severe damage generally occurs in the field with high level of nematode inoculums are planted with susceptible host plants. Their deleterious effect on plant growth results in low crop / oil yield and poor quality. Primarily, three species of plant parasitic nematodes i.e. root-knot nematodes (*Meloidogyne incognita* & *M. javanica*), root lesion nematode (*Pratylenchus thornei*) and stunt nematode (*Tylenchorhynchus vulgaris*) affect medicinal and aromatic plants. The major crops which suffer root-knot nematode infestation are: Menthol mint (*Mentha arvensis*), Davana (*Artemisia pallens*), Geranium (*Pelargonium graveolens*), Patchouli (*Pogostemon patchouli* syn *P. cablin*) Henbanes (*Hyoscyamus* spp.), Basil (*Ocimum* spp.), Opium poppy (*Papaver somniferum*), Ashwagandha (*Withania somnifera*.), Serpagandha (*Rauvolfia serpentina*) Coleus (*Coleus forskohlii*), Qinghao (*Artemisia annua*), Brahmi (*Bacopa monnieri*) and safedmusli (*Chlorophytum borivillianum*), whereas the root lesion nematode is a major problem on Peppermint (*Mentha piperita*), Spearmint (*Mentha spicata*) and Citronella (*Cymbopogon winterianus*) and the stunt nematode mainly affects aromatic grasses i.e. Palmarosa (*Cymbopogon martinii*) and Lemon grass (*Cymbopogon flexuosus*).

Invited Lecture-01

S- 10/NSIPS/I-1

Nematode Infestation in Forest Flora: A Potential Threat to Indian Forests

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Nematodes are important group of pathogens, but their attack to forest trees remains unrecognized because, they cause non-discernible symptoms. High organic content, adequate moisture and moderate temperature of forest soils with diversified flora represent a conducive condition for nematode survival. The nematode infestation in forest flora has been highly neglected especially in India. Limited surveys and investigations so far conducted in Indian forests have shown the nematode infestation in the roots of important forest trees such as acacia, sal, teak, pine and sandal wood. The most common nematode genera encountered in the forest soils are *Helicotylenchus, Tylenchorhynchus, Hemicriconemoides, Macroposthonia, Pratylenchus, Meloidogyne, Xiphinema, Trichodoruss, Paratrichodorus* etc. Due to lack of adequate studies, information on nematode infestation and extent of damage to the Indian forestry is not known. However, the data available from foreign researches warrants immediate attention to monitor the nematodes infesting forest flora in India and to devise appropriate management strategies.

Normally nematode damage to forest trees appears as slow decline of growth, which gradually intensifies and results in tree death in a time span of 5-10 years. However, some nematodes, for example pine wilt nematode (*Bursaphelenchus xylophilus*) may cause death to a tree within a year. This nematode is a serious problem in coniferous trees in China, Korea, Taiwan, Japan etc. The environmental conditions prevailing in the Himalayan region under Indian territory are favourable for pine wilt nematode, although it is not reported there. Moreover, legal or illegal import of timber and wood material from risk prone countries such as China directly or via Myanmar, Nepal, Bhutan etc. has posed a serious quarantine risk of this nematode in India. With this paper, an effort is made to highlight the potential threat of nematode infestation in the Indian forests, and the risk of introduction and spread of pine wilt nematode in the country.

S- 10/NSIPS/O-1

Effects of Phenol Contents of Spine Gourd Varieties /Lines as Influenced by Root-Knot Nematode, *Meloidogyne incognita*

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The variation in total phenolic substances in six Spine gourd cultivars i.e sundargarh local-1 (Resistant), ankur, hybrid (ModeratelyResistant), nakhara (Susceptible), shankarpur local-1 (Susceptible),

dhenkanal local-1 (Highly susceptible) and banki local-1 (Highly susceptible) were studied 45 days after inoculation of *Meloidogyne incognita* . Phenol was quantified (from root) by Folin-Ciocalteu method.The total phenolic substances in the roots of both healthy and resistant cultivars was higher compared to the susceptible cultivars. The phenolic content of healthy plants of cucumber cultivars were 0.163, 0.158, 0.144, 0.153, 0.150 and 0.168 g/g in sundargarh local-1,ankur hybrid, nakhara, shankarpur local-1, dhenkanal local-1and banki local-1 respectively. But due to infection of root knot nematode the phenolic contents of these varieties increased by 74.23, 65.18, 56.94, 51.63, 41.33 and 31.54 per cent respectively. An increasing trend was also observed in the phenolic contents in the roots of inoculated susceptible and resistant cultivars. It was also observed that the phenol content ranged from 0.144 to 0.168 m g/g in healthy gladiolus varieties and 0.212 to 0.284 m g/g in infected cucumber varieties. A greater percentage in phenol content was observed as 74.23 % in the variety sundargarh local-1 and lowest 31.54% in the variety banki local-1 .The total phenol content in roots of healthy plants increased but in the infected plants phenols are reduced in shoots because the nematode infection interfere in the phenol metabolism and the basipetal translocation of free phenols contributed to the reduction of phenols in the shoots. The phenolic compounds are the best known factors responses and there is distinct correlation between the degree of plant resistance and the phenolic compounds in nematode inoculated samples possibly due to rapid liberation of conjugated phenols from the glycosidic compounds produced by the action of hydrolytic enzymes during feeding process. The increase in phenolic compounds during the infection period might be attributed to the rapid break down of bound phenols or switching over of phenols to different pathways leading to the formation of various compounds like lignin which plays significant role in resistant reaction.

S- 10/NSIPS/O-2

Attempts Towards Mass Culture of *Catenaria anguillulae*: A Facultative Endoparasite of Nematodes

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Among the endozoic fungal parasite of nematodes, *Catenaria anguillulae* Sorokin seems to be as one of the most important fungus that has numerous qualities of a good biological control agent. Since the fungus is a facultative endoparasite of nematodes that grows equally well as saprophyte on substrates of animal and plant origin and as a parasite on susceptible nematodes with varying degree of virulence, the initial attempts to grow this fungus were made on substrates of animal origin, viz., extract of small animal like concentrated fluke ova extract, liver extract, beef extract. Efforts were also made to know its nutritional requirements particularly preference for form of nutrition. Our work on development of synthetic medium based on chemical composition of oil cakes revealed that a combination of a three amino acids namely arginine, L-methionine and leucine supported the best growth of *C. anguillulae*. Further, dextrose supported the maximum growth at the 0.5%. The experiments on efficacy of oil cakes to support its growth showed that the linseed oilcake @ 0.5% yielded maximum growth even over the previously established good media viz., Emerson agar medium, YPSS Agar medium & Beef extract agar medium. The clarity in visibility of sporangia was also maximum in linseed oil-cake agar medium. On the fact that the fungus grows endobiotically inside nematode body and consumes fat globules present within, out of the six test oilseeds, groundnut was found to be best for growth of the fungus at 1.5 % concentration followed by sunflower. In other studies, calcium carbonate and sodium chloride at the rate of 0.5% were found to improve wall structure and size of sporangia, respectively. Out of the screening

of the sixteen locally available substrates @ 6%, wheat bran was found to be the best substrate supporting excellent growth of the fungus and the best mass culture of the fungus was found on a mixture of wheat bran and sand in ratio of 12:88 saturated with water containing 0.5% linseed oil cake in 21 days. It was also found that the fungus survives in the mass culture over a period of six month. However, still there is a need to find out efficacy of some easily available cheap substrates to support good growth of the fungus as well as to find out the best combination/ratio of the mixture of the substrate and the inert material to replace sand and develop formulations too.

S- 10/NSIPS/P-1

Myco-Control of Insect Pest using *Metarrhizium anisopliae*- A Review

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Myco-control of insects is based on the rational use of fungus to maintain environmentally balanced pest population levels and among the bio pesticides *Metarhizium anisopliae* has been the most studied and utilized fungal species. *M. anisopliae*, formerly known as *Entomophthora anisopliae*, is a fungus that grows naturally in soils and causes disease in various insects by acting as a parasitoid. It is a mitosporic fungus with asexual reproduction, which was formerly classified in the form class Hyphomycetes of the form phylum Deuteromycota (also often called Fungi Imperfecti), which is now classified under phylum Ascomycota and class Sordariomycetes.

Its action is epizootic in nature and does not hold any unwanted threat for humans or animals, as it a natural biocontrol agent and attacks only insects (White Grub, Termite, Locust, Aphid, Thrips etc).Since they are considered natural mortality agents and environmentally safe, there is worldwide interest in the use of entomopathogenic fungi for biological control of insects and other arthropod pests. Therefore, offers a striking substitute or addition to the application of insecticides in crop security. Taking in to consideration the effective utilization of entomopathogenic fungi in particular the *M. anisopliae* will be effective biocontrol agent in crop production with special emphasis to organic agriculture for sustainable and eco-friendly management of pests in North east regions.

S- 10/NSIPS/P-2

In Vitro Efficacy of Native Fungal Bioagents against *Meloidogyne incognita*

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Survey was conducted during 2014-15 for the isolation of native fungal biocontrol agents from eggmasses of *Meloidogyne incognita* infecting various crops in Assam. For isolation of fungi, egg masses from root-knot infected plants were inoculated on PDA and incubated at 25±2oC in BOD incubator for 4 days. The cultural and morphmetric characters were compared with the original description

given by Rifai, 1969; Booth, 1971; Samson, 1974: Gams, 1971; Link, 1809 and a total of 9 species viz., *Trichoderma harzianum, Paecilomyces niphetodes, Acremonium falciformi, Fusarium oxysporum, Fusarium solani, Aspergillus niger, Aspergillus flavus, Vermispora leguminacea, Penicillium* sp. were identified from five different locations (Charigaon, Alengmora, Danichopari, Namdeori and Barbheta) of Jorhat and Golaghat districts of Assam. An unidentified species was also recovered. These bioagents, including the unidentified species were evaluated for their efficacy on egg parasitism, egg hatch inhibition and juvenile mortality of *M. incognita* under *in-vitro* conditions at different concentration and time intervals by adopting standard methods. The data were subjected to statistical analysis by using SAS and IBM SPSS statistics 20.0 software and the mean differences among treatments were worked out at 5 percent level of probability. All the bioagnets were found to be effective in causing egg hatch inhibition and juvenile mortality with varying degrees. As far as egg parasitism is concerned, only five bioagents viz., *T. harzianum, P. niphetodes, A. falciformi, F. oxysporum* and *F. solani* showed egg parasitism with varying degrees. *T. harzianum* was found to be best in respect of egg parasitism, egg hatch inhibition and juvenile mortality with lowest LC50 value as recorded in the probit analysis.

S- 10/NSIPS/P-3

Biochemical Mechanism of Native Fungal Bioagents in the Management of *Meloidogyne incognita* on Tomato

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A pot experiment was conducted for studying the biochemical mechanism of native fungal bioagents in the management of *Meloidogyne incognita* on tomato in the Department of Nematology, AAU Jorhat during 2016-17 comprising of the treatments, *M. incognita + Trichoderma viride, M. incognita + Trichoderma harzianum, M. incognita + Pochonia chlamydosporia, M. incognita + Purpureocillium lilacinum, M. incognita* @ 1J2/cc soil and an uninoculated and untreated control. All the pots were transplanted with 25 days old tomato seedlings. The pots receiving the treatments with bioagents were inoculated with second stage juveniles of *M. incognita* @ 1J2/cc soil. Each bioagent was applied to the pot through vermicompost @ 2% (w/w) after enrichment. All the treatments were replicated five times and pots were arranged in completely randomized design. Data were subjected to statistical analysis and the mean differences among treatments were worked out at 5 percent level of probability. Defense related enzymatic activities viz., peroxidase, polyphenoloxidase, phenylalanine ammonia lyase and total phenol content in roots were recorded adopting standard methods. All the bioagents were found to be effective in increasing plant growth parameters (fresh shoot and root length, shoot and root weight) and decreasing galls, an eggmases in roots and nematode population in soil after 15, 30 and 45 days of inoculation. The enzymatic activities such as PO, PPO, PAL and total phenol were also found to be increased in bioagent treated roots. *T. harzianum* was found to be most effective in increasing plant growth parameters and reducing the nematode population in soil, galls and egg masses in roots with highest enzymatic activities.

S- 10/NSIPS/P-4

Comparative Efficacy of Bio Control Agents against Root Knot Nematode (*Meloidogyne incognita*) Infecting Brinjal

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A replicated pot culture experiment was conducted in the net house of Department of Nematology Assam Agriculture University, Assam during *Rabi* season with bio formulations like *Trichoderma viride*, *Pasteuria penetrans*, FYM and *Glomus fasciculatum* to compare their effectivity against root knot nematode (*Meloidogyne incognita*), along with chemical check (Carbofuran 3G), in a poly house against a susceptible local variety of brinjal (JC1). Data on plant growth parameters and nematode infestations were recorded 8 weeks after inoculation. Treatment of soil with Carbofuran 3G @ 9 g/m2 manifested best results of plant height (33.84cm), fresh weight of shoot (21.69 g), dry weight of shoot (5.22 g), fresh weight of root (12.84 g) and dry weight of root (1.32 g) and lowest infestation values of no. of galls (11.60), no. of eggmasses (17.20) and final nematode population (150.60/250cc soil) but soil treatment with *T. viride* conveyed significant results promoting plant growth and declining gall formation and nematode multiplication along with. The mechanism of mycoparasitism, antibiosis, and competition of *Trichoderma* has been widely studied. The chitinolytic enzyme system and cell wall degrading enzymes like gliotoxin, peptaibols plays a significant role in egg parasitism. Our result advocates wide scale application of selected metabolites like *Trichoderma sp* to induce host resistance and also represents a powerful tool for the implementation of IPM strategies to play a major role in crop protection and bio-fertilization.

S- 10/NSIPS/P-5

Performance of Pheromone Traps for Management of Rice Yellow Stem Borer in Darrang District of Assam

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Rice is the major staple food crop in India comprising a cultivated area of 44.11 million hectare with annual production of 105.48 million tons (2014-15). This crop is infested by many pests in the nursery bed as well as in the main field among which the Yellow Stem Borer (YSB), *Scripophaga incertulas* (Walker) is the most dominant and destructive pest that causes yield loss up to 38 to 80 per cent. In Darrang district of Assam, the farmers usually apply chemical pesticides for controlling yellow stem borer in rice. At present, Pheromone traps can be used as a most effective bio-control tool for the management of this pest. By keeping this in view, a study was undertaken for three consecutive years (2013-14 to 2015-16) on the adoption and performance of pheromone traps in managing rice yellow stem borer in Darrang district of Assam on the basis of on-farm trials. The study revealed that there was 48.57 per cent increased adoption of pheromone traps in farmers' field than the initial stage. The

performance of YSB lure at the farmer field revealed low incidence of dead heart in pheromone intercepted plot (4.70 and 2.90 per cent at 30 and 45 DAT) compared to the plot without any pest control (7.00 and 9.80 per cent at 30 and 45 DAT). White ear incidence of 4.90 per cent was observed in pheromone trap installed plot against 10.60 per cent in the control. The grain yield of 41.6 q ha^{-1} was recorded in the pheromone trap installed than control plot of 36 q ha^{-1}. We can conclude that the traps can be considered as a good and a cheap source of biological control agent as compared to chemical pesticide.

SPECIAL SESSION
On Wilt Disease of Crops

SS/NSIPS/O-1

Bacterial Wilt of Tomato caused by *Ralstonia solanacearum* and its Management

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Bacterial wilt of tomato incited by *Ralstonia solanacearum* (Smith) Yabuuchi is a very serious in solanaceous crops including tomato, potato, chilli and brinjal and occurs across the country mainly coastal areas, foot hills and lower altitude of hills. The damage caused by this disease to the crop was > 60% depends on environmental conditions and variety of crops. R. solanacearumis a major phytopathogen that attacks more than 450 host species, representing over 54 botanical families to cause wilt disease. The pathogen is a soil inhabitant bacterium and found in different agro-climatic regions of India. The disease is diagnosed based on the disease symptom, ooze test, morphological, biochemical, physiological, pathogenicity test, serological and PCR based advanced techniques. The most characteristics symptoms of tomato is very rapid wilting, especially where the plants are young and succulent. The flowering stage is the most critically stage where a plant shows sudden wilting. A common sign of bacterial wilt of tomato observed at the surface of freshly-cut sections from severely infected stems is sticky, milky-white exudates, which indicates the presence of dense masses of bacterial cells in infected vascular bundles. Molecular marker has been developed based on hrp gene and locus specific to *R. solanacearum* amplified at 323 bp and found sensitive to detect up to 100 cfu/ml. Besides this, LAMP, Bio-PCR and Real time –PCR techniques are very sensitive and reliable to detect bacteria every 1- 10 cells present in the samples. In BIO-PCR, combine the viable enrichment of mostly growth media with an enzymatic amplification. The target bacterium is enriched in liquid or solid media and detected at extremely low levels in seeds, soil and irrigation water and asymptomatic plants. The LAMP method proved to be the best approach for amplifying nucleic acid with high specificity, efficiency, and rapidity without the need for thermocycling. Species-specific primers were designed by targeting the *R. solanacearum* egl gene coding for flagellar proteins. Amplification performed for 30-60 min at 650C resulted in production of magnesium pyrophosphate, which increased the turbidity of the solution, permitting visual assessment. The LAMP product was detected only in samples containing *R. solanacearum* and not from other species. Genetic diversity of *R. solanacearum* has been studied by using different molecular methods such as RAPD, Rep-PCR and multilocus sequence typing (MLST) sequencing. Management of bacterial diseases of solanaceous crops must focus on prevention and must start before transplanting. Management of wilt disease is similar and requires cultural practices and preventive chemical applications, mainly copper compounds. Bleaching Powder (15 kg/ha) has been found effective against the disease. Root dip of tomato seedlings for 6 h in 200 ppm solution of streptomycin, chlorophenicol, oxytetracycline hydrochloride, norfloxacin, amoxicillin + cloxacillin, chloroquinone phosphate and 2000 ppm dichloroprophan before planting reduced the incidence of bacterial wilt of tomato. Biopesticide Biofor-Pf containing *P. fluorescens* strain PfD-1 in combination of vermicompost, carboxymethyl cellulose and mannitol applied at the time as seed treatment, root application soil application at the time of transplanting and soil application at 30 days after transplanting reduce wilt incidence and increases the yield in tomato. By Changing the planting dates of tomato crop generally designed only to avoid either periods of high

temperature or heavy rainfall or both to reduce wilt incidence. Follow crop rotations with crops like maize or ragi is included. Soil solarization has been exploited for the control of pathogen. Resistant varieties of tomato such as BT118-4-1-1, BT-116-8-1-1, Tomato-415, EC178823, EC179924, EC179926, EC179931, Sonali (Sel-2), DPT 38, VC 48, CRA 66(Sel-A), CRA 66(Sel-A), CRA 66(Sel-A), BWR 1(Asel. from VC 8-1-2-1), Hybrids ArkaAlok x SP-2-2 and Arka x L-101, Sonali x SP-2-2, BT 1(UtkalPallavi), BT 2(UtkalDeepti), BT12, BT 14, BT 18, Pusa Early Dwarf, Navodaya, Selection 7, BWR- 1(ArkaAbha), BWR— 5(ArkaAlok), SwarnaLalima, Swarna Naveen, , SwarnaSampada, Hawaii 7998, LA 2639A, LA 2691, 88 BWR, 83-211, 84 BWR, CR15955-223, D4 -22-0, LE 79(Shakti), BT- 10, CKVT-17 and Sikkim local are found effective to control wilt disease. Integration of soil solarization for 8 and 10 weeks during March to May along with incorporation of antagonistic rhizobacteria i.e. *Pseudomonas fluorescence* and *Bacillus cereus* in soil prior to solarization reduces the disease significantly. Application of actigaurd (Acibenzolar-s- methyl) in combination with *P. putida* 89B61 or Bioyield reduced bacterial wilt incidence. Integrated approach for management of bacterial wilt included bacterial antagonists and bleaching powder, minimum bacterial wilt incidence was found in bleaching powder (0.01%) + *Bacillus* treatment in both cultivars ArkaAbha (19%) and Pusa Ruby (29.6 %) under glasshouse conditions.

SS/NSIPS/O-2

Parawilt and Wilt of Cotton and Their Management

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The cotton crop is affected by wilt disease during the cropping season and it becomes difficult to speculate the cause of the disease because wilting may be due to a physiological disorder called “Parawilt or new wilt” or may be caused by fungus *Fusarium oxysporum* f.sp. *vasinfectum*. Symptoms of disease caused by fungus appear at any stage of crop but symptoms due to parawilt appear at peak flowering and boll formation stage of the crop. The fungus attacks vascular bundle of crop but in parawilt affected crop the vascular bundle remains healthy. The fungal wilt is common in Bt and non- Bt cotton crop but parawilt appears mostly in hybrid Bt cotton crop. There are repots that the Parawilt in Bt cotton is a physiological disorder govern by weather parameters including temperature, rainfall and sunshine hours. There were perceptions that Parawilt of cotton involves sudden drooping of leaves when irrigation/ rainfall are applied after long dryspell or environmental conditions like high temperature, bright sunlight followed by heavy rain was found to favour the parawilt occurrence. But it was also observed that the drought conditions or un-irrigated conditions also trigger parawilt. Moisture stress and water logging triggers parawilt incidence along with production of stress hormone ethylene. The study of influence of weather parameters on its incidence suggests that parawilt occurs when the soil is suddenly saturated by a heavy downpour of rain for a continuous period of time and the sun shines bright and hot for later days which they consider may be due to the imbalance of uptake and loss of water under flooding in cotton field. The data for the weather parameter causing parawilt were collected for two years and observed that rise in % parawilt incidence was coincided with subsequent rise in temperature and sunshine hours. Correlation study reveals that Maximum temperature and sunshine hours were found to be positively correlated in significant manner while rainfall was negatively correlated with parawilt incidence. This infers that increase in day temperature with bright sunshine soon after continuous overcast weather and heavy rainfall is responsible for parawilt incidence in Bt cotton. There are many fungicides and biological control measures are available for fungal wilt in cotton. Management

of parawilt is possible by following control measures like application of cobalt chloride (10 ppm) or application of urea near affected plant.

SS/NSIPS/O-3

Wilt of Chickpea: Host Plant Resistance and Variability of *Fusarium* Isolates of Central India

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Globally, Chickpea (*Cicer arietinum* L.) is the third most important legume after dry beans and pea cultivated on about 13.20 million ha area producing 11.62 million tons of seed with average productivity of 880 kg/ha. India accounts for approximately 64 percent of the world chickpea production. Large area exists under chickpea cultivation, but the total production and productivity is quite low and attributed to a wide gap between the potential and actual yield. The prime factor for low yields are biotic and abiotic stresses. Among soil borne diseases vascular wilt (*Fusarium oxysporum* f. sp *ciceri*), Dry root rot (*Rhizoctonia bataticola*), Collar rot (*Sclerotium rolfsii*), are most important causes yield losses annually. Management of diseases by using fungicides is not feasible, economical and ecofriendly. Hence, host plant resistance (HPR) offers most practical, cost effective, sustainable and durable disease management option to combat these diseases. Disease diagnostics and development of less time consuming, reliable and repeatable resistant screening techniques is the most important for exploitation of host plant resistance. Considerable efforts and excellent progress have been made in understanding the biology of the pathogens and managing the diseases through host plant resistance by using effective field and green house screening techniques. Besides this several broad based stable dual/multiple resistant genotypes have been identified through a multilocation test over years for *Fusarium* wilt and shared globally with chickpea scientists for developing resistant varieties in major chickpea growing areas. But, the performance of resistant varieties is not satisfactory in different locations because of the high variability in the pathogens that limits the effectiveness of resistance. Hence, to study the variability in FOC and race specific resistant genotypes , One hundred twenty isolates of *Fusarium oxysporum* f. sp. *ciceri* isolated from chickpea wilted plants collected from four different states viz. Madhya Pradesh, Maharashtra, Chhattisgarh and Gujarat and studied in respect to cultural, morphological and pathological variability and grouped. Out of Forty six grouped representative isolates, reaction of 14 chickpea differential genotypes recorded against 24 isolates of Foc. from Madhya Pradesh, 6 isolates from Chhattisgarh, 8 from Gujarat and 8 from Maharashtra states under artificial inoculation using soil inoculation method (2 % w/w).concluded that reaction of differential genotype against test isolates from each state was highly variable.

Based on the reaction of differential genotypes the isolates could be grouped into three pathogenic races along with 2 – 3 new variants of Foc in Central India. The race picture existing in state are- M. P. (Race -2, 4), Chhattisgarh (Race -2, 4, 5), Maharastra and Gujarat (Race -2). Existence of races in the chickpea wilts pathogen warrants for multi race or multi-variant resistance in chickpea. Evaluation of identified 26 donors against 8 races / variants selected from four states indicated that Foc. isolates not only differ in their virulence but also behaved differently in their reaction. JG 315 and Vishal were found resistant to the races / specific races (2, 4, 5 and 1new variants) indicating the broad based host resistance to *Fusarium oxysporum* f. sp. *ciceri*. However, BCP 91 was found resistant with all the isolates except I-77. The genotypes L550, PG 5, GG 2 ,DCP 92-3, CPS 1, Vijay, PBG 1, K 850 and H-82-2 susceptible to highly susceptible against these races. Virulence of the isolates do not have an important

role in identification of resistance against wilt in chickpea genotypes. In the present studies genotypes found having resistance against 8 isolates of *Fusarium oxysporum* f. sp. *ciceri* are of value and may be used as donors in breeding for wilt resistance. In respect to molecular characterization seven isolates from 4 states of central India could be grouped into three clusters by both RAPD and SSR Primers whereas it could be grouped into 2 main clusters by ITS-RFLP primers.

SS/NSIPS/O-4

Wilt Disease Complex Involving Plant Parasitic Nematodes and Pathogens

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The synergistic interactions of plant pathogenic nematodes with soilborne pathogens resulting in development of disease complexes have been demonstrated in many crops throughout the world. These synergistic interactions cause plant damage exceeding the sum of individual damage by either nematode or the pathogen alone. Plants in the soil ecosystem are always in contact with many different microorganisms comprising numbers of bacteria, fungi and other microorganisms. Consequently, nematodes rarely act alone to induce plant disease. They often initiate the pathological process in which bacteria and fungi follow, so that several kinds of organisms combine to induce the damage. Plant disease complexes involving nematodes and pathogen can be grouped obligatory and fortuitous relationship. In obligatory relationship, one member is completely dependent on another or influenced directly by it and expression of disease symptoms occurs only when both members are present at a time. Whereas, in a fortuitous relationship, there is no such interdependency found and each member acts independently. There is no direct influence of one on other member. Here, the presence of nematode is not required for the expression of disease symptoms but their presence enhances the incidence and severity of the disease. The life cycles of endoparasitic nematodes requires closer associations with their plant hosts. This usually subject to various nematode-induced modifications, which influence infections by soilborne pathogens. The endoparasites *Globodera*, *Heterodera*, *Meloidogyne*, *Rotylenchulus* and *Pratylenchus* are the genera most commonly reported to be involved in disease complexes with fungal pathogensl like *Verticillium*, *Fusarium*, etc. The Gram negative bacterium *Ralstonia solanacearum* (Smith) Yabuuchi, has been recognized globally as the causal agent of destructive wilt disease in many economically important crop species. The destructive soil borne vascular pathogen is responsible for serious economic losses in the tropical, subtropical and few temperate regions. Crop to crop this loss may range between 40-60 per cent and some instances may result into total crop failure. Situation become worse when nematode pathogen specifically root-knot nematode *Meloidogyne* species concomitantly infect crop plant along with the wilt bacteria. The participation of nematodes in bacterial invasion reportedly swells the wilt severity and may cause loss of genetic resistance to wilt pathogen. This review strived to discuss such nematode-wilt pathogen synergistic interaction, their underlying mechanisms, and approaches for management of the disease complex.

SS/NSIPS/O-5

Papaya Wilt -Root Rot Complex Incited by *Fusarium solani*: Etiology, Symptomatology and Management

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Papaya wilt -root rot complex was found to cause 60-95 per cent disease incidence resulting in failure of crop in the state. *Fusarium solani* was established as a causal organism of wilt -root rot complex of papaya in Bihar. Disease incidence was found to decrease with increasing plant spacing. June – July planted crop was found to favour the disease development while March-April planted crop recorded low disease incidence and higher fruit yield. Potato dextrose agar was found appropriate media for proper growth of pathogen whereas sporulation (macro conidia) was favoured in Carnation leaf media. Among native and commercial bioagent tested against the pathogen, *Trichoderma viride* (native) was found most effective in suppression of the pathogen. Among botanicals, *Adenocalymma alliaceum* (wild garlic) was found highly effective in checking the development of disease under sick pot condition. Among fungicides, carbendazim and thiophanate methyl showed good efficacy in checking the growth of pathogen in vitro. Again, among fungicides, thiophanate methyl showed best compatibility with *Trichoderma viride in vitro*. All the oil cake- mustard cake, neem cake, castor cake were found compatible with *Trichoderma viride*, but mustard cake was also found to be the efficient inhibitor of the pathogen. The most effective treatment for the management of disease was integration of disease free seedling + mustard cake (10%) + wild garlic (10%)+dipping of seedlings in thiophanate methyl (0.1%) for 30 min. + soil drenching with thiophanate methyl (0.1%) solution three times, 1st at time of transplanting, second at 3rd month after transplanting (MAT) and third at 5th MAT+ soil application of *Trichoderma viride* @50g/plant three times 1st at time of transplanting, second at 3rd MAT and third at 5th MAT+ soil application of *Pseudomonas florescence* @ 50g/plant three times 1st at time of transplanting ,second at 3rd MAT and third at 5th MAT.

SS/NSIPS/O-6

Wilt Diseases of Castor and Their Management

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Castor (*Ricinus communis* L.) belonging to family Euphorbiaceae is found across all tropical and sub-tropical regions of the world. It has the ability to grow under low rainfall and low fertility conditions and is most suitable for dry land farming. The importance of castor oil arises from it richness of ricinoleic acid which confers distinctive industrial properties. India is leading in terms of production, productivity and area under castor cultivation in the world. Gujarat is leading castor growing state of India, contributing around 82 % of total production in the country and has established a virtual monopolistic grip on international market. Castor crop is being attacked by several pathogens at all growth stages. Three types of wilt diseases are reported in castor crop namely, *Fusarium* wilt, bacterial wilt and *Verticillium* wilt. Among them, *Fusarium* wilt disease is most destructive, widely distributed and causes huge yield losses and

later two wilt diseases are considered of minor importance. *Fusarium* wilt is most important seed and soil-borne disease of castor which appears at all crop growth stages become more prominent during flowering and spike formation stage and it is considerably managed by cultivation of *Fusarium* wilt resistant castor hybrids, notable are GCH 7 and DCH 519. Thousands of castor genotypes has been screened for resistance to wilt disease and several of them are considered as source of wilt resistance but, resistant variety/hybrids for emerging isolates/races may not be available in time. Hence, integration of different disease management approaches is required for effective management especially under endemic conditions. Integration of wilt resistance varieties / hybrids, seed treatment with fungicides and/ or bio-pesticides and good cultural practices like crop rotation, deep summer ploughing, use of farm yard manure and/or green manuring, intercropping with non-host crops is needed for the management of *Fusarium* wilt disease.

SS/NSIPS/O-7

Fusariums Infecting Sugarcane

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Fusariums cause wilt and pokkahboeng diseases in sugarcane. Both the diseases were reported to impact sugarcane productivity for more than 100 years in India and other countries. Wilt caused by *Fusarium sacchari* was first recorded during 1913 in the country and thereafter we witnessed several epidemics of the disease. It severely affects cane production and productivity and in the past many elite commercial varieties were withdrawn from cultivation due to its severity to the disease. Recent studies revealed that wilt incidence in sugarcane varied with different agro climatic regions in the country. East coast regions, South Gujarat and subtropical plains were identified as the disease endemic regions in the country. The disease occurred either alone or in association with red rot in different states and such combined infection was more commonly found in Bihar and Gujarat. *F. sacchari* was identified as the causal organism based on morphological features and molecular profiling of the isolates. ISSR and IGS-RFLP were found to be the efficient molecular markers to establish variation in *F. sacchari* and also to distinguish this species with other *Fusarium* spp. *Gibberella sacchari* was established as teleomorph of *F. sacchari*. Biocontrol approach has been found as a viable strategy to manage the disease.
Pokkahboeng (PB), a foliar disease in sugarcane in which young leaves and growing point are affected. Although *F. verticilloides* is associated with PB other species such as *F. sacchari, F. proliferatum, F. andiyazi, F. subglutinans, F. semitectum* etc were also reported as the causal agent of the disease in different countries. In the recent years, we witnessed epidemic occurrences of PB in both the tropical and subtropical states. Earlier the disease was considered as a minor disease and its current severe scenario suggest possible climate change issues and this needs detailed investigation.

It was found that *F. sacchari* associated with PB also causes stalk infections and produces wilt in certain varieties. Further studies in this area would bring a new dimension on the *Fusaria* associated with PB and wilt and epidemiology of wilt in sugarcane, especially on survival of *F. sacchari* and its possible manifestation as foliar as well as stalk disease. Experiences in the past indicate that occurrence of wilt and PB in sugarcane is rapid and unpredictable due to changes in environmental conditions and this area needs special attention to identify specific edaphic and environmental factors influencing disease development. Sugarcane wilt fits to be an ideal candidate to study the impact of climate changes on disease buildup and development of epidemics in the future.

SS/NSIPS/O-8

Wilt Diseases of Ornamental Crops and Their Management

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In the present scenario, different species of *Fusarium* affects the various ornamental crops and cause the wilt diseases in Jasmine, Crosandra, Gladiolus, Carnation, Chrysanthemum and China aster; *Ralstonia solanaciarum* causes bacterial wilt in Geranium and anthurium and *Verticillum dohlia* causes wilt in China aster. Ornamental plant diseases can significantly affect the aesthetic quality of many plants in the landscape. Not only do some of these diseases impact appearance in this season, but they also impact overall plant health and survival during seasonal weather changes.

These pathogens are soil-borne and carried from season to season through planting materials. Sometimes the pathogens are carried in the vascular portion of the plant without showing any external symptoms. Conditions such as high temperature, high soil moisture and high levels of nitrogen in the soil are known to enhance the disease in the field. The wilt diseases are most severe in light sandy soils and in soils containing ammoniacal and organic sources of nitrogen. Anaerobic conditions and accumulation of carbon dioxide also favour the infection by the pathogens in soil. Managing ornamental diseases begins with the selection of resistant ornamental plants, maintaining adequate nutrition and irrigation, adopting appropriate cultural practices and providing the right environment for plants. To avoid a never-ending disease prone condition, it is critical to adopt a disease management program before getting to the point where fungicide/bacteriocides applications are necessary.

SS/NSIPS/O-9

Wilt Diseases of Medicinal and Aromatic Plants and Their Management

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Medicinal and aromatic plants (MAPs), an unexplored and fast growing crop industry in recent time and attracted the intention of researches. Commercial cultivation of this precious bio-wealth for sustainable utilization is essential to meet out the increasing demand of raw drugs in pharmaceuticals industries for curing the complex ailments of human health. Several biotic and abiotic factors affect the cultivation and production of MAPs. The study conducted at ICAR-DMAPR and Other centers in the country, where wilt diseases caused by different fungus species are highly destructive to these crops and imposed hindrance in production. The wilt and root rot diseases have been observed and reported in isabgol, senna, aloevera, asparagus, betelvine, coleus, safedmusli, opium, ocimum species and significantly affect the crops yield. The associated pathogenic organisms were identified as *Fusarium* spp., *Rhizoctonia solani, Sclerotium* spp. and *Macrophomina phaseolina* prevailing throughout the year on the MAPs. For management of these soil inhabitant pathogenic fungi, a preliminary study was carried out in vitro in order to select the most efficient and economically important methods to be used in field trials. In the in

vitro trial, the causal organisms survive up to 40ºC but unable to grow at 46ºC, therefore deep summer ploughing in western part of the country may provide a good opportunity and scopes. In the field trials soil amendments viz., Neem cake with the biocontrol agents (*Trichoderma* spp.) was used for effective management of soil borne pathogens and more than 50% incidence of the diseases was reduced. Under the severe condition soil drenching with carbendazim @ 0.2% control the wilt disease of senna. To minimize the spread of pathogens multiplication and supply of the disease free planting materials is essential for the economical and ecofriendly management of MAPs disease.

SS/NSIPS/O-10

Integrated Approaches for Mungbean and Urdbean Disease Management: Recent Trends and Opportunities

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Mungbean (*Vigna radiata* L. Wilczek) and Urdbean (*Vigna mungo* (L.) Hepper) are important kharif pulse crops of India, with wide adaptability, low input requirement and have the ability to improve soil fertility by fixing atmospheric nitrogen. They are valuable both economically as well as nutritionally and is widely used in different cropping systems. The major factor for low production of mungbean & urdbean in India are ecological factors, lack of appropriate pulse production and protection technologies, poor post harvest technologies, less thrust on basic research, inadequate supply of quality seed to farmers and socio economic constraints etc. Apart from these, the pest and disease problems are the major bottlenecks in realizing the higher yields. Though there are several diseases, which attacks crops the major ones are anthracnose cercospora leaf spot, powdery mildew, root rot and leaf blight rust, macrophomina blight, bacterial leaf blight yellow mosaic and leaf crinkle. In order to offset the losses caused by disease, farmers often resort to blanket use pesticides leading to disease resurgence, resistance, pesticides residues and associated environmental problems. This has dictated the need to look for other alternatives like use of botanicals pesticides, bioagents, manipulation of cultural practices and lastly the need based use of eco friendly pesticides. Integrated disease management(IDM) combines a wide array of all the above methods and practices for the control of diseases and at the same time protects the environment in the long run as natural enemies are conserved and pesticide use are minimized. The wisdom to adopt this technology is that no single method of disease control was useful in containing the losses. Various cultural practices like deep ploughing of fields during summer, after summer ploughing field is left for solarization. timely sowing , field sanitation, rogueing, destroy the alternate host plants, apply manures and fertilizers as per soil test recommendations, sowing the ecological engineering plants, rotating the crop with a non host cereal crop, cucurbit, or cruciferous vegetable, sow/plant sorghum/ maize/bajra in 4 rows all around blackgram and greengram crop as a guard/barier crop, apply well decomposed FYM @ 4 t/acre or vermicompost @ 2 t/acre treated with *Trichoderma* 2-3 weeks before sowing reduces diseases. Host plant resistance is the best option for management of mung and urdbean diseases. Pyramiding of genes (s) coferring resistance to different diseases is required to have multiple disease resistance varieties so that full potential of varieties can be realized at farmers's field. Varieties resistant to powdery mildew like Moongbean-TARM 1, Pusa 9072 &Urdbean LBG 17 and resistant to yellow mosaic virus disease like Moong bean- Pant Mung , Pant Mung, PDM 54 (Moti), PDM 84-139(Samrat),PDM 84-143, PDM – 11.ML – 337, Pant Moong MUM 2,MH-88-111 and MUM-2 Urd bean- Pant U 19, Pant U – 30,UG 218, PDU 1, PDU 88-31 are available. Seed treatment should

be done with *Trichoderma* spp. (8-10 g/Kg seed) and *Rhizobium* spp., AMF/PSB cultures each @ 30 g/Kg seed need to be promoted at large scale. Seed treatment with carbendazim + thiram (1:2) @ 2.5 g/kg of seed reduces the incidence of wilt and *Cercospora* leaf spot immensely. Early planting i.e. immediately after onset of monsoon, grow crop on bower system to avoid soil contact and maintain proper drainage in the field helps in reducing anthracnose, bacterial blight and cercosopora leaf spot. Foliar spray of Carbendazim @ 0.1% reduces the spread of powdery mildew, cercospora leaf spot and rust considerably. Foliar spraying of Thiomethoxam 25 WG @100g or Imdacloprid 17.8% @100 ml for control of vector of yellow mosaic disease is recommended.

Adoption of IDM in mungbean and urdbean is low to negligible. In fact IDM should by now the backbone of the entire disease management programme but still awaiting the due attention in field that it deserves. To increase the reach of IDM amongst the farmers it is also essential to invest in developing forewarning technologies for epidemiologically potential diseases. Similarly strengthening the surveillance mechanisms and educating the farmers through the transfer of technologies shall be of great help in adoption of IDM in future for mung and urdbean disease management.

SS/NSIPS/O-11

Fusarium Wilt of Crop Plants: Disease Development and Management

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Fusarium wilt of crop plants is highly destructive for causing economic losses apart from replacing adapted cultivars, shifting of production areas and manipulations of production practices. Interestingly, *Fusarium* wilt is mostly incited by the fungal species, *Fusarium oxysporum*, which is further recognized by an intraspecific taxon based on physiological or pathological adaptation. Majority of the known hosts of the pathogen species are herbaceous and woody angiosperms possessing characteristic xylem vessels, and comprises of field, vegetable, and fruit crops besides ornamental, shade trees and other horticultural crops. The fungus paves its way into the root vascular system of host plants mainly through wounds and by virtue of its ability to colonize the xylem vessels, causes wilting and ultimately plant death sets in. *F. oxysporum* produces asexual spores, macroconidia and microconidia as well as an asexual resting spore, chlamydospore. These life stages aid in pathogen perpetuation in soil. The chlamydospores formed by modification of conidial or hyphal cells, facilitate long term pathogen survival, which greatly retards successful management of the disease. Efficient and sustainable management practices are therefore needed to contain the vascular wilt pathogen for enhancing the yield and quality of marketable produces. The mechanisms involved in wilt development and prospects of exploring available management options to control *Fusarium* wilt of crop plants have briefly been reviewed.

SS/NSIPS/O-12

Fusarium Wilt of Tomato and its Management

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Fusarium wilt caused by *Fusarium oxysporum* f. sp. *lycopersici* (FOL) is an important disease of tomato (*Solanum lycopersicum* L.) crop worldwide especially under protected conditions. The disease causes heavy losses under favourable weather conditions. The pathogen is soil borne in nature and survives in the infected plant debris and in the soil as mycelium and chlamydospores. Being a soilborne disease it is very difficult to control through a single method. It can therefore, only be checked by adopting an integrated management approach. Various management practices include crop rotation, use of healthy seed, hot water as well as fungicide seed treatment, biological control, proper fertilizer application, application of soil amendments, bio-fumigation, resistance breeding and soil application of chemical. Combined application of inorganic fertilizers and organic manures is considered effective in reducing disease incidence to some extent. Bio-fumigation with residues of Brassica crops have been reported to reduce the number of chlamydospore of the pathogen in soil. Application of soil amendments like cakes of groundnut, mustard, sesamum and cotton also reduced the wilt disease index significantly. These oil cakes enhanced microbial activity in amended soil which resulted in reduction of wilt disease. Tomato varieties like Gambde, Globe, HS 101, HS 107, Improved Meerut, Marglobe and Pusa Early Dwarf have shown some resistance against FOL and therefore can be recommended for planting in affected areas. Soil application of biocontrol agents like *Trichoderma* spp., *Pseudomonas fluorescens, Streptomyces griseus* and *Bacillus subtilis* has also been found effective in reducing the wilt incidence. Tomato plants infected with FOL wilted less, if they had previously been inoculated with the endotrophic mycorrhizal fungus, Glomusmosseae. The fungus enhanced lignin deposition in the cell wall of the epidermis and stele, which is considered to increase resistance against wilt pathogen. Soil drenching with chemical fungicides viz., benomyl or thiophanate-methyl or carbendazim has also been recommended against tomato wilt and soil disinfestation with fumigants such as Basamid (dazomet) also ensured better plant growth in soils infested with FOL. Bio-fumigation of sick soil with taramira crop residues for 30 days, and application of formulation of *T. viride* along with FYM and inoculation of transplants with indigenous AM fungi resulted in to more than 80 per cent disease control under protected cultivation conditions.

SS/NSIPS/O-13

Pathogen Variability, Host -Plant resistance and Management of Wilt in Lentil

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The Preliminary screening of cultivars was carried out for identifying standard set of differential cultivars to determine races/ pathotypes under control net house conditions. From set of 120 resistant accessions, 16 accessions were identified as putative set. Out of 16 putative accessions, 7 accessions showed differential response against atleast one tested isolate which were further selected as a standard

differential set. Virulence pattern was proposed to understand distribution of isolates among of *F. oxysporum* races/pathotypes. Fourteen virulent isolates from 7 states were classified into five different races/pathotypes based on differential response on developed standard set of differential cultivars. To determine the genetic diversity, the UPGMA analysis was carried out and grouped the isolates into five major clusters from RAPD and SSR at 18% and 25% genetic similarities respectively. In root tissue, the highest â-1,3glucanase activity 16.64 ÄOD mg/protein was recorded in resistant cultivar L-4147 at 10th DAI. The highest chitinase activity 39.28 ÄOD mg/protein was recorded in resistant cultivar (L-4147) at 14th DAI. The highest catalase activity 879.29 ÄOD mg/protein was recorded in resistant cultivar (L-4147) at 10th DAI. Similarly, higher PAL activity was observed in resistant cultivar (L-4147) 186.93 ÄOD mg/protein at 10th DAI. At 10th days after inoculation highest protein intensity in SDS-PAGE was observed in susceptible cultivars as compared to resistant, whereas after 14th days of inoculation, the expression of the protein in resistant and susceptible cultivars started decreasing. This could be considered as a key point in protein pattern changes in resistant or susceptible cultivars. Twenty one isolates from different species of *Trichoderma* including Pusa 5 SD and Th-3 strains and 16 fungicides (4 combi-products) were evaluated under *in vitro* conditions, out of which 9 strains showed more than 70% inhibition (Pusa- 5SD, T-32, Th-3, ITCC 7856, T-15, T-16, T-19 ITCC 7838 and T-13) and Out of sixteen fungicides were tested only Captan 50% WP (captaf) and Carbendazin 50% WP (Bavistin) and combi products like Captan 70%+ Hexaconazole 5% -75% WP, Carboxin 37.5% + TMTD 37.5% WS (Vitavax powder) Trooper WS, Iprodine 25% + carbandazim 25%WP (Quintal) were found to be more effective under *in vitro* conditions.

SS/NSIPS/O-14

Wilt Diseases of Seed Spices and Their Management

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Seed spices are annual herbs and are susceptible to *Fusarium* wilt pathogen. Cumin, coriander, fennel, fenugreek are major seed spices crops affected by wilt disease and the causal organism mainly responsible to cause the disease is reported to be *Fusarium oxysporum* which is further divided into forma specialis based on host plant as *F. oxysporum* f.sp. *cumini* in cumin, *F. oxysporum* f.sp. *corianderii* in coriander, *Fusarium oxysporum* f.sp. *funiculi* in fennel. Cumin is most susceptible to wilt pathogen, and the disease is widely distributed in major growing districts of Rajasthan and Gujarat. Yield losses up to 25% and 60% have been reported from Gujarat and Rajasthan respectively. However, yield losses depends on the severity of the disease. The variability existed in the pathogen showed variation in cultural and morphological characters. The disease is difficult to manage as the pathogen is predominantly soil-borne in nature and survive for longer period in the soil. However, efforts have been made to manage the disease using cultural, chemical and biological means. Research efforts were also diverted to identify resistant sources and then to use them in resistance breeding programme. Crop rotation with non-host crops and deep summer ploughings decreased the wilt incidence significantly. Harnessing solar heat during summer months has also been found effective in minimizing wilt incidence in the field. Application of chemical fungicides has been reported to manage the cumin wilt pathogen. Carbendazim and thiram reported as the best seed dressers against *F. oxysporum* f. sp. *cumini*. Many number of antagonistic fungi were tested for their bioefficacy against cumin wilt pathogen under lab and field conditions. *Trichoderma asperllum*, *T. harzianum* and *A. versicolar* were found effective against the disease. Several organic amendments including oil cakes and mustard residue were also found effective in reducing population of *Fusarium* and wilt incidence in cumin.

SS/NSIPS/O-15

Diseases of Saffron (*Crocus sativus* L.) and Their Management

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The cultivation of Saffron (*Crocus sativus*) in the province of Kashmir at 2000-2300m above sea level dates back to AD 600 (Kalhana, 1200 AD) and the area remains lone quality saffron producing province of India. For the past three decades, the area as well as production of saffron in Kashmir has been steadily declined from 8Kg./ha-2Kg./ha. and the corm rot and parasitic weeds are being one of the important constraint. Preliminary survey were conducted saffron growing area in district Pulwama and Budgam of Kashmir, with the selection of 5 farmers field from each village at random based on the producing economic losses of crop during 2001-2005 & 2008-2017 to identify corm rot incitants and to estimate the crop losses due to corm rot. All the surveyed area were found infested with newly corm rot pathogens in Kashmir, India like *Rhizoctonia solani*, *Fusarium oxysporum* f. sp. *gladioli*, *Fusarium oxysporum*, *Fusarium solani, Phytophthora* sp., Basidiomycetes fungus, *Penicillium corymbiferum* and *Penicillium purpurogenum*, *Stemphyllium* sp., *Alternaria citri*, *Seclerotium rolfsii*, *Phoma multirostrata*, *Plasmodiophora* sp., *Bacillus* sp and *Cyprus rotundas* was also found (plant parasite) to be a major biotic constraint in yield loss, cumulative yield loss of saffron was cause up to 87 %. The symptoms were produced by these pathogens associated with corm wet & dry rot/wilt/blight were identified as above complex fungal pathogens. The incidence and intensity at various locations ranged from 11.41 to 72.46 per cent and 5.91 to 30.62 per cent, respectively. The pathogens were isolated and authentication was done by available literature and also taking the help of Indian Type Culture Collection Centre (ITCCC), IARI, New Delhi, India. In vitro evaluation of various bioagents and fungitoxicants indicated that all the fungitoxicants significantly inhibited the mycelial growth of the test pathogen, while the Sulphur improve the radial growth of Basidiomycetes fungus at all concentrations. For the management of leaf blight of saffron in field Captan 70% + Hexaconazole 5% has emerged the best in controlling the pathogen. Two to three years fellow land, seven to nine times summer ploughing at different intervals during applying well decomposed farm yard manure, selection of healthy seeds and proper draining, weeding after overwintering off leaves can avoid corm rot.

SS/NSIPS/O-16

Activation of Defense in Mandarin (*Citrus reticulata*) Plants against *Fusarium oxysporum* using Bioinoculants for Improvement of Their Health Status

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Citrus reticulata (Blanco) commonly known as mandarin is one of the ancient commercial crops that is cultivated in Darjeeling and Sikkim hills. The mandarin cultivation in Darjeeling has shown a massive decline due to various pathological, entomological and nutritional stresses. Fusraium root rot caused by *Fusarium oxysporum* is one of the destructive diseases of mandarin plants prevalent in almost all orchards of Darjeeling hills. Colonization of mandarin roots by three most abundant genera of AMF viz. *Glomus*, *Gigaspora* and *Acaulospora* have been extensively studied, and mass multiplication of two dominant AMF species *Glomus mosseae* and *Gigaspora gigantea* and their evaluation for improvement of plant health status against fungal pathogen (*F. oxysporum*) was made. Subsequently immunological formats have been developed by raising polyclonal antibody against these two dominant AMF species. On the other hand based on isolation, screening of PGPR from mandarin roots and their evaluation on the growth status of seedling of *Citrus reticulata*, a potential PGPR – *Pseudomonas poae* was selected for field trials. Foliar application with *P. poae* on mandarin plants, the roots prior colonized with *Gigaspora gigantea* when artificially inoculated with *F. oxysporum*, maximum suppression of disease was noticed due to joint inoculation with AMF and PGPR. Further, root rot incidence in mandarin plants was successfully reduced after application of *Trichoderma asperullum* in the rhizosphere along with AMF and PGPR prior to inoculation with fungal pathogen. Disease reduction was correlated with enhanced activities of key defense enzymes like chitinase, â-1,3 glucanase, phenylalanine ammonia lyase and peroxidase which increased significantly after pathogen challenge. Cellular localization of chitinase in mandarin root and leaf tissues was determined following indirect immune fluorescence test following treatment with PAb of chitinase and FITC labelling and further confirmed by immune gold localization of chitinase following treatment with bioinoculants and challenge inoculation with the fungal pathogen.

SS/NSIPS/O-17

Wilt Disease of Chickpea and its Management

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Wilt caused by *Fusarium oxysporum* f. sp. *ciceris* (*Foc*) is one of the major diseases of chickpea, distributed worldwide and causing approximately annual yield loss of 10-15%. The populations of the pathogen were highly variable in respect of their morphological features. Identifies a new set differential cultivars and the populations of *Foc* were characterized into eight races based on differential reactions. Genetic diversity analysis using various molecular markers indicated the existence of variability

among the populations predominated by a single race of the pathogen in an area. Gene specific markers such as TEF-1á, *â*-tubulin, and ITS were also used to determine the genetic diversity and high level of similarity among the populations in respect of these gene sequences was observed. The moleculat groups did not correspond to the state of origin and races of the pathogen. Highly sensitive and specific molecular markers were developed for detection of the pathogen using both convention and real-time PCR. Comparative transcriptome analysis of resistance (WR315) and susceptible (JG62) genotypes of chickpea infected with *Foc* race 4 was carried out to understand the basis of mechanism of resistance and susceptibility. *Trichoderma harzianum* and *T. viride* were found effective against *Foc*. Various seed dressing and soil application formulations were developed and were evaluated against the disease in different modes of application as seed treatment and soil application alone and in combination under pot and field conditions.A combination of PBP 10G (*T. harzianum*)/ PBP 4G (*T. viride*) for soil application and Pusa 5SD (*T. harzianum*) for seed treatment together with a fungicide, carboxin provided the highest seed germination, shoot and root lengths and grain yield with the lowest disease incidence in chickpea under field conditions. *T. harzianum* based formulations proved to be more effective as compared to others against wilt. The efficacy of Pusa 5SD as seed treatment has been validated at different locations in India. Further, a combination of seeds treated with Pusa 5SD developed from *T. harzianum* + *Pseudomonas fluorescens* 80 + *Mesorhizobium ciceri* + Vitavax power also provided the highest germination, grain yield and the lowest wilt incidence. The application of bio-formulation of *Trichoderma* enhanced the expression of several defense related enzymes and genes which provided protection to the plants at early stage of infections.

SS/NSIPS/O-18

Bacterial Wilt of Brinjal and its Management

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Brinjal cultivation India is severely affected by the incidence of bacterial wilt caused by *Ralstonia solanacearum*. Bacterial wilt management has been difficult due to the presence of diverse *R. solanacearum* strains, their ability to survive in adverse soil conditions, worldwide distribution, wide host range including asymptomatic hosts and efficient mechanism of invading the host. Multiplex PCR and the biochemical tests indicated that the isolates from brinjal and other solanaceous vegetable belong to phylotype I and biovar 3. Results of phylogenetic studies showed that Indian phylotpe I *R. solanacearum* strains are phenotypically diverse including the previously described sequevars 17, 44, 47, 48 and unknown/ newer sequevars. Draft genome sequence of two representative isolates from India infecting solanaceous vegetables was completed. Different PCR techniques viz. BIO-PCR, LAMP PCR were standardized for the detection of the pathogen from soil, plant and symptomless carrier plants. These techniques were highly sensitive and effective in detecting the bacterium from various sources. Various bacterial wilt management strategies, including development of resistant varieties, soil amendments, grafting on resistant root stocks, and use of plant products have been developed with varying levels of success. As biological control has been emerged as one of the important disease management strategies particularly for soil borne plant pathogens including bacterial wilt, different aspects of biological control from endophytic and rhizosphere bacteria has been studied and the promising antagonistic bacteria were evaluated for their biocontrol efficacy in the field. In this article, brief account of the bacterial wilt disease, the causal agent, disease cycle including symptoms, phylogenetic characterization of the bacteria, disease management aspects including the scope of biological control and possible mechanism of biological control agents are described.

SS/NSIPS/O-19

Current Status of Fusarium Wilt Disease of Banana in India

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Banana is one of the economically important crop which fetches more money in international trade and also consumed by most of the population around the world. Bananas are mainly consumed next to grains such as rice, wheat and maize. In India, banana is a food security crop and also an important source of income for farmers. India being the largest producer of banana in the world contributing 29.1% to the global production of banana with a total production of 29.75 million tons from an area of 0.80 million hectares. The total worth of banana production in India is approximately Rs 50,000/- crores annually.

Among the biotic constraints of banana production, Fusarium wilt caused by a fungal pathogen *Fusarium oxysporum* f. sp. *cubense* (*Foc*), is considered as one of the most devastating diseases of banana in India. At global level the disease is ranked as one of the top 6 important plant diseases and in terms of crop destruction, it ranked with the few most devastating diseases such as wheat rust and potato blight. The pathogen of Fusarium wilt disease persists in soil for decades and extremely difficult to manage.

In the past, among 3 types of races (race 1, race 2 and 4) affecting banana, only race 1 and 2 of Fusarium wilt pathogen were affecting most of the commercial cultivars except Cavendish group of cultivars. However, in 2016 a new race of Fusarium wilt called tropical race 4 affecting Cavendish group of banana such as Robusta and Grand Naine was identified in Katihar and Purnia districts of Bihar by ICAR-National Research Centre for Banana, Tiruchirapalli, Tamil Nadu. This strain is considered as more virulent as it survives for many decades in soil and capable of infecting most of the commercial cultivars grown in India without the presence of predisposing factors. As the strain TR4 can spread through planting materials, soils, irrigation water and bunch stalk, there is a chance for the further spread of this most devastating strain rapidly to other states like Maharashtra, West Bengal, Odhissa, Karnataka, Andhra Pradesh, Tamil Nadu and North Eastern Hilly states. In this case, there is a possibility of incurring a heavy loss to Indian banana industry as it mainly depends on Cavendish clones which occupy 52% of the total area under banana cultivation and contributing to 64% of the total banana production banana and hence would be more catastrophic. Therefore, prevention and management of Fusarium wilt disease is desperately required to save the money spinning banana industry in India and the same will be discussed in detail.

SS/NSIPS/O-20

Activation of Defense in Mandarin (*Citrus reticulata*) Plants against *Fusarium oxysporum* using Bioinoculants for Improvement of their Health Status

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Citrus reticulata (Blanco) commonly known as mandarin is one of the ancient commercial crops that is cultivated in Darjeeling and Sikkim hills. The mandarin cultivation in Darjeeling has shown a massive decline due to various pathological, entomological and nutritional stresses. Fusraium root rot caused by *Fusarium oxysporum* is one of the destructive diseases of mandarin plants prevalent in almost all orchards of Darjeeling hills. Colonization of mandarin roots by three most abundant genera of AMF viz. *Glomus*, *Gigaspora* and *Acaulospora* have been extensively studied, and mass multiplication of two dominant AMF species *Glomus mosseae* and *Gigaspora gigantea* and their evaluation for improvement of plant health status against fungal pathogen (*F. oxysporum*) was made. Subsequently immunological formats have been developed by raising polyclonal antibody against these two dominant AMF species. On the other hand based on isolation, screening of PGPR from mandarin roots and their evaluation on the growth status of seedling of *Citrus reticulata,* a potential PGPR – *Pseudomonas poae* was selected for field trials. Foliar application with *P. poae* on mandarin plants, the roots prior colonized with *Gigaspora gigantea* when artificially inoculated with *F. oxysporum,* maximum suppression of disease was noticed due to joint inoculation with AMF and PGPR. Further, root rot incidence in mandarin plants was successfully reduced after application of *Trichoderma asperullum* in the rhizosphere along with AMF and PGPR prior to inoculation with fungal pathogen. Disease reduction was correlated with enhanced activities of key defense enzymes like chitinase, â-1,3 glucanase, phenylalanine ammonia lyase and peroxidase which increased significantly after pathogen challenge. Cellular localization of chitinase in mandarin root and leaf tissues was determined following indirect immuno fluorescence test following treatment with PAb of chitinase and FITC labelling and further confirmed by immuno gold localization of chitinase following treatment with bioinoculants and challenge inoculation with the fungal pathogen.

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Races in *Fusarium udum* causing Wilt of Pigeonpea (*Cajanus cajan* L.) in India

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Pigeonpea (*Cajanus cajan* L. Millisp) is the second most important legume crop of India after chickpea. India is the largest producer and consumer of pigeonpea in the world. It is a multipurpose

crop, being grown not only for grain but also for fuel and fodder. Globally, India alone contributed over 77% of area and 81% production. The crop is affected by many biotic and abiotic stresses at various stages of its growth. Among the biotic stresses, wilt caused by *Fusarium udum* is one of the most important yield limiting factors and causes enormous economic loss every year.

For effective management of *Fusarium udum*, it is essential to distinguish variability among isolates occurring in the pigeonpea growing areas. 716 isolates of *Fusarium udum* were isolated from pigeonpea growing areas of the country and tested over the years for identification of *Fusarium udum* races. Based on the cultural and morphological characteristics and relative pathogenicity of the isolates, 31 distinct clusters were identified. On the basis of virulence and geographical locations, 50 isolates were selected for further grouping into races/variants using a set of 7 pigeonpea genotypes as differentials (BAHAR, C 11, ICP 8863, ICP 7035, BDN 1, KPL 44 and ICP 9174) under the ambit of the National Network Project on wilt of crops (ICAR-Phytofura). Based on reaction of differential genotypes, these 50 isolates were categorized in to 5 distinct races/variants. Most of the isolates (18) resembled race 2, followed by race 1 (14) and race 3 (8), respectively. Six isolates resembled race 4, whereas four isolate belonged to race 5. Prevalence of all these five variants/races has been indicated in some part of the country. Findings established a vast diversity among isolates of *F. udum* representing different parts of the country. It is concluded that the racial characterization in *F. udum* would be helpful not only for development of race specific cultivars/donors but also for the development of multiracial resistant pigeonpea genotypes.

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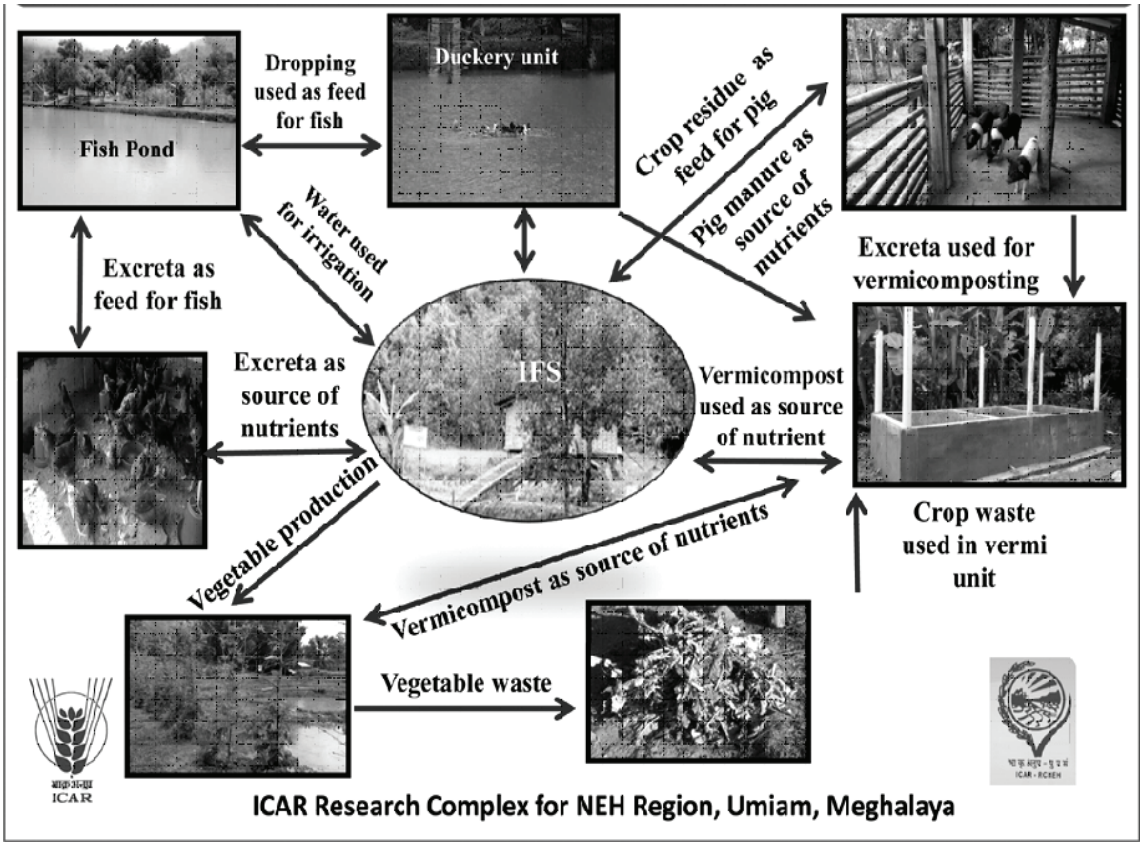
Diversification and integration in farming System : A way forward to Doubling Farmer's Income



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Fusarium wilt Tropical Race4 a potential threat to South Asia

Fusarium oxysporum f. sp. cubense tropical race 4 (Foc TR4), a highly pathogenic form of the banana Fusarium wilt fungus, was first discovered in Indonesiain 1990. The fungus has since spread to Malaysia, the Philippines, mainland China and Taiwan, where it has devastated Cavendish bananas and certain locally grown varieties for two decades. In 2013-2014, Foc TR4 incidence was officially recorded outside Southeast Asia for the first time when it was discovered in Oman, Mozambique, Jordan, Lebanon and Pakistan. In 2015, Foc TR4 was found in Queensland, Australia, and in 2016 in Vietnam, with unconfirmed reports from Laos, Myanmarand India. These reports highlight a major threat to bananas globally, as Foc TR4 has a wider host range than any other form of Foc, is highly virulent to Cavendish bananas which constitute 45% of bananas grown globallyand cannot be controlled.

The fungus enters the plant through the roots and colonizes the xylem vessels thereby blocking the flow of water and nutrients. Disease progression results in the collapse of leaves at the petiole, the splitting of the pseudostem base and eventually plant death. Once established in a field, the fungus persists in soil for an indefinite period and cannot be managed using chemical pesticides. The solution best adapted to the continued production of bananas in infested soils is replacing susceptible cultivars by resistant ones .

The pathogenic isolates are classified into races based on the cultivars on which they cause disease. For example, the isolates that affect cultivars in the Gros Michel, Silk and Pome subgroups, among others, are classified as race 1. When Cavendish cultivars exhibiting symptoms of Fusarium wilt were first observed, the isolates were classified as race 4. They were later subdivided into subtropical race 4 (STR4) and tropical race 4(TR4) to distinguish the strains that need predisposing factors to cause the disease from the ones that don't. The race concept has been criticized for being an imperfect measure of pathogenic diversity, but it is still considered useful to describe host reaction and new disease outbreaks .

In the past 25 years, Foc TR4 has caused damage of an unprecedented order in Asia, thereby decimating the livelihoods of small growers and income to producers selling their products on national and international markets. In China, Foc TR4 has affected significant acreages, and has resulted in the abandonment of small growers' fields in the Philippines and Indonesia. Foc TR4 in India, the largest producer of bananas worldwide, can significantly threaten people's livelihoods and food security.

Bioversity International continues to collaborate with key stakeholders and countries to address the serious concerns about the spread of Foc TR4 in Asia and Africa ,as well its impact on the region. It has also helped develop a contingency plan to manage TR4 in the event of incursion into Latin America. A stakeholder workshop of the Banana Asia Pacific Network (BAPNET) was held in Guangzhou, China from 23-26 August 2016 to focus on the theme: "Research and Programs on the Prevention of Spread and Management of Foc TR4 in Asia and the Pacific." Asian stakeholders must collaboratively address the threat of Foc TR4 to banana within highly specific and varying Asia-Pacific contexts.This will includedrafting action plans that integrate country and sub-regional recommendations on how to effectivelyi) prevent further spread of Foc TR4 into pathogen-free areas, and ii) manage Foc TR4 within already infected areas and mitigate the effects the diseaseincluding via raising capacities and awareness.

For More details refer

http://www.promusa.org/Fusarium+wilt
http://www.promusa.org/Fusarium+wilt#footnote1
http://banana-networks.org/barnesa/files/2015/01/BARNESA_appeal_final.pdf
https://www.oirsa.org/contenido/biblioteca/PlandecontingenciacontraFocR4TOIRSA.pdf
http://banana-networks.org/Bapnet/files/2017/12/Full-Proceedings-BAPNET-2016-as-of-Dec2017.pdf

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BIO FORE-PF : An Organic Bio Pesticide for management of Ginger rot and wilt diseases of Tomato, Brinjal, Potato & Chili and Soil conditioner
(A product of Orgaman R&D Division with technology Support of Assam Agricultural University)

INM MIXURE

BIO FERT : An intergrated Nutrient Management formulation
BIO-INO : An Intergrated Nutrient Management formulation

BIO-CONTROL AGENT (Research Product)

VIRICON (BIOGREEN) : *Trichoderma viride*-Liquid & Solid
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PSEUDOCON : *Pseudomonas fluorescens* - Liquid & Solid
HELOCON : *Beauveria bassiana* Liquid & Solid
ORGA VL. : *Verticillium lecani*
TREMICON : *Metarhizium anisopliae* - Liquid & Solid
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ORGA PLANT GROWTH PROMOTER : Crop Booster
SESA : Sticker, Emulsifer, Spreader and activator

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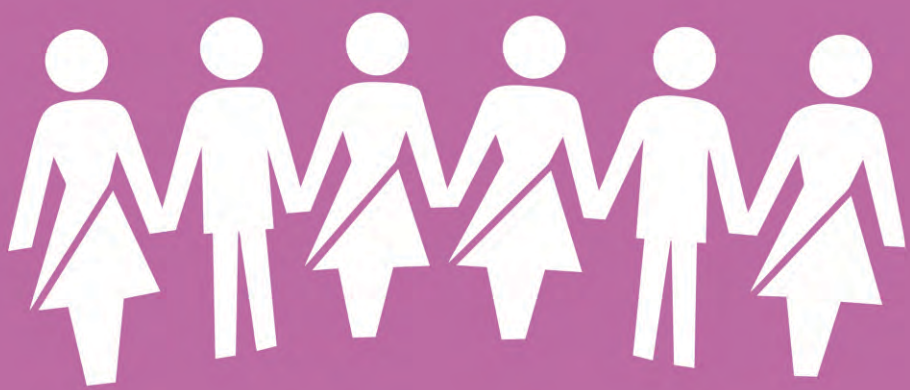

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