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AWARD LECTURES

Professor S. R. Bose Memorial Lecture

Botanicals in management of fungal and mycotoxin contamination of food commodities: retrospects and prospects

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Stored food items are highly prone to fungal infestation and contamination by mycotoxins secreted by toxigenic fungi. Use of synthetic chemicals for food preservation has been largely criticized due to serious implications over human health and environment. Volatile plant essential oils (EOs) are complex of low molecular weight secondary metabolites from aromatic plants. In last few decades, EOs have been extensively reported for remarkable antifungal and antimycotoxigenic efficacy in food system. Hydrophobic EOs target fungal cytoplasmic membrane by depleting ergosterol levels, thereby, enhancing efflux of vital cellular materials such as proteins, nucleic acids and ions as Mg^{2+}, K^{+} and Ca^{2+} from treated fungal cells. Inhibition of cellular methylglyoxal (AFB_1 inducer) biosynthesis by EOs confirms their antiaflatoxigenic activity, suggesting their future exploitation for development of aflatoxin resistant varieties through green transgenics. Biochemical investigations have revealed that EOs effectively inhibit the inducers of crucial regulatory genes in the mycotoxin biosynthesizing pathway, leading to suppression of mycotoxin producing potential of toxigenic fungi. In view of their ethnomedicinal history, several EOs have been categorized as 'GRAS' (Generally Recognized as Safe) substances by US EPA, supporting their safe and eco-chemical nature. Different EO based formulations *viz*. SporanTM, PromaxTM, 'DMC Base Natural', EcoPCOR, EcoTrol have been commercialized as food preservatives. Recently, EOs have been nanoencapsulated in diverse food grade polymer matrices to improve shelf life and preservative efficacies at low doses. The application of nanoencapsulated EOs has gained momentum of interest by the agri-food industries due to associated advantages of stability and controlled release of bioactives and minimized sensorial variations of stored food items leading to greater consumer acceptability. EO based nanoformulations showing excellent preservative potential and favorable safety profile, offer an eco-friendly, biorational approach for management of stored food biodeterioration by toxigenic fungi and associated mycotoxins.

Professor S. N. Banerjee Memorial Lecture

Harnessing fungal biocontrol agents for the management of plant diseases

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Biological control is becoming a workable alternative or supplement to chemical control in plant protection strategies, chiefly for the management of plant diseases caused by various bacterial, fungal and other phytopathogens. Several bacteria, antinobacteria and fungi have already been identified as potential biocontrol agents and are playing a vital role in biological control of various plant diseases. Importantly, antagonistic activity of different fungi *viz*., *Trichoderma*, *Gliocladium, Coniothyrium*, *Talaromyces, Trichothecium*, *Phlebiopsis*, *Tilletiopsis*, *Laetisaria*, *Penicillium*, *Ampelomyces*, *Aspergillus, Sporidesmium* and non-pathogenic *Fusarium* were well investigated and some of them were commercially exploited. The mechanisms of biocontrol activity exercised by biocontrol agents have been categorized under antibiosis, competition and parasitism, besides; they also induce systemic resistance in host plants. Among the fungal biocontrol agents, the members of the genus, *Trichoderma* gained enormous popularity due to their wide spectrum of activity, non-pathogenic and eco-friendly nature, amenability for large-scale multiplication and formulation and commercial viability. Although, several commercial formulations of *Trichoderma, Gliocladium, Coniothyrium,* etc. are being made available for farm use worldwide, acceptance by farmers is still in slow pace, which is probably due to short shelf life, no quick knockdown effect; inconsistent performance in the field attributed to many factors, lack of quality products in the market, etc. Considering the significance of prevailing scenario on plant disease management, our research efforts were focused towards biological control. In the past more than two decades, we have demonstrated the biocontrol potential of *Trichoderma* spp., *Fusarium chlamydosporum* and *Trichothecium roseum* against different fungal phytopathogens and determined the mechanisms of biological control. Moreover, liquid and powder formulations of *Trichoderma* spp. have been developed, evaluated in greenhouse and field conditions against different plant diseases caused by fungal phytopathogens. Results of the field experiments have revealed that application of liquid and powder formulations of *Trichoderma* was significantly reduced fungal diseases with commensurate increase in yield in different crop plants. Therefore, identification of promising biocontrol agents, development of efficient mass multiplication and formulation methods, use of proper delivery system at right time and dose, education of farmers for adoption will undoubtedly provide adequate control of plant diseases, which could significantly bring down the indiscriminate use of chemical pesticides.

Professor E. J. Butler Memorial Lecture

Phosphate (P) deficiency induced biofilm formation on insoluble P granules play a positive role in *Burkholderia* species for maximum release of soluble P

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Biofilm formation during phosphate (P) solubilization process by two potent phosphate solubilizing bacterial strain viz. *Burkholderiatropica* P4 and *B. unamae* P9 have been investigated. Scanning electron microscopic observations revealed prominent biofilm development on tricalcium phosphate as well as on four different rock phosphate granules by them. Variation in the biofilm developments were also observed depending on the total P content of insoluble P used. Biolfilm quantificationsuggested a strong correlation between the amount

of available P and degrees of biofilm formation. Lower concentrations of soluble P directed both the organisms towards compact biofilm development with maximum substratum coverage. Variation in the production of extracellular polymeric substances (EPS)in the similar pattern also suggested its close relationship with biofilm formation by the isolates. Presence of BraI/R quorum sensing (QS) system in both the organisms were detected by PCR amplification and sequencing of two QS associated genes viz. *braR* and *rsaL*, which probably responsible for biofilm formation during P solubilization process. Overall observations help to hypothesize for the first time that, biofilm on insoluble P granules creates a close environment for better functioning of organic acids secreted by *Burkholderia* strains for maximum P solubilization during P deficient conditions.

Professor S. B. Chattapadhayay Memorial Lecture

Yellow Mosaic of Major Pulses – Present Scenario and Way Forward

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In India, pulses are cultivated to an extent of 29.99 million hectares with an average production of 22.40 million tonnes with an average productivity 765 kg per hectare in India. Stagnant pulse production, low adoption rate and continuous increase in population, the per capita availability of pulses has decreased considerably. The per capita per day availability of pulses in 1951 was 60 g that has come down to a provisional level of 47.2 g in the year 2014. However, the increase trend has been seen both in per capita per day (52.9 g) and per capita per year (19.3 kg) consumptionsduring 2017.

One of the major constrains in pulse production are diseases caused by various pathogens.Viruses are among the most important groups of plant pathogens affecting pulse cultivation and production worldwide. Plant viral diseases cause serious economic losses in many major crops by reducing seed yield and quality.Most emerging infectious diseases of pulses are caused by viruses of which viruses inciting yellow mosaic in pulses are most common. The yellow mosaic disease (YMD) is known to affect a number of legume crops in the country. However, mungbean,urdbeanand to some extent soybean are the most important grain legume crops which are widely affected by this disease. Symptoms of the disease are broadly similar not only in mungbean and urdbean but also in other host plants and hence it is quite often taken as caused by the same virus.

Since the first description of YMD in mungbean and urdbean, the causal virus of the disease was always considered whitefly (*Bemisiatabaci)* transmitted.On the basis of electron microscopicobservations of purified virus preparations and leaf dip preparations showed that the MYMV had geminate particles.At present three distinct viruses viz., MungbeanYellowMosaic India Virus (MYMIV), MungbeanYellow Mosaic Virus (MYMV) and HorsegramYellow Mosaic Virus (HgYMV) are known to cause YMD in pulses where bipartite nature of the genome was reported. Yellow mosaic is prevalent on mungbean ,urdbean and soybean sown during March to May months. The increased disease incidence might be attributed to the higher temperatures prevalent during these months, which was favourable for the vector, *Bemisiatabaci* to develop and multiply. Simple correlation and regression analysis of whitefly population and yellow mosaic disease with weather factors has been established by several workers that help in predicting the occurrence of whitefly,YMD and yield loss as well.

Several management options like cultural practices, use of plant products and derivatives, chemicals, evaluation of germplasm are the present practices for combating YMD. As YMD is caused by number of viruses regular monitoring is required.There is need to explore differential hosts for identification of virus species and strains causing YMD. This will help in determining and developing new varieties, resistant to species/strain for a particular zone. Programme for exploring YMD resistant genes in the wild relatives of pulses needs to be strengthened further. Genetic engineering using viral genes of YMD producing viruses has potential to develop transgenic pulses with better resistance to YMD.

SESSION I : Microbial Diversity

LL1.1

Diversity of microorganisms in extreme environments and its utilization in agriculture

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Extreme environments represent a unique ecosystem which harbour novel microbial flora. India is one among 12 mega-biodiversity countries and 25 hotspots of the richest and highly endangered eco-regions of the world. Thermophiles from hot springs can be a source for enzymes that are active at high temperatures. They can also be used for decomposition process. Psychrophiles can be a source of anti freezing compounds. Halophiles and osmophiles can be a source of genes coding for osmolytes and can be used for the development of transgenic plants tolerant to salt and drought stress. Different surveys were carried out to collect soil, plant and water samples for analysis of microbial diversity from the cold desert of Leh and Rohtang, from mangroves of Sunderbans, West Bengal and Bhitarkanika, Orissa; thermal springs of Rajgir, Manikaran, Bakreshwar, Balrampur and Vashisht Sambhar salt lake, hypersaline soils of Rann of Kutch Pullicat lake (Tamil Nadu) and Chilka lake; acidic soils of Manipur, Kerala, Meghalaya and Mizoram for isolation of microbes growing under extreme conditions. During these surveys a total of 1540 bacteria, 157 archaea, 260 fungi and 200 actinomycetes were isolated. The archaeal and bacterial isolates were further screened for molecular and functional diversity. A huge database comprising microbes tolerant to high salinity, low and high temperature, drought and low pH was generated.

Microorganisms isolated from extreme environments can be developed as inoculants for crops grown in these stressed environments. Eubacteria and archaea isolated from saline habitats were used as inoculants to alleviate salt stress and to influence the growth and yield of crop plants. Bacterial isolates obtained from Sambhar salt lake and capable of exhibiting plant growth promoting traits at high salt concentration improved the growth of wheat in saline soils. Inoculation induced significantly higher proline and total soluble sugar accumulation in plants. In inoculated treatments, % Na in shoots was 22% less than control. Ratio of Na: K was 0.55 in treatment inoculated with *B. cereus* as compared to 0.91 in control. Grain yield and total biomass of wheat was significantly influenced by the inoculations, *B. pumilus* being the best, and gave a 43% increase in grain yield over control in saline soil. Likewise, a preliminary investigation suggests the role of archaea in supporting the growth of plants in saline soils. Acid tolerant bacteria isolated from soils of Kerala were used as inoculant to improve the growth of horticultural crops like coconut, areca nut, cocoa and vanilla. Psychrophilic bacteria isolated form Leh and Rohtang Pass significantly influence the growth of wheat on inoculation.

Low temperature tolerant microbial strains were screened for production of lignocellulolytic enzymes active at low temperature and a consortia consisting of two bacteria (*Bacillus atropheus* and *Bacillus* spp) and two fungi (*Eupenicillium crustaceumand Penicillium citrinum*) was developed for the preparation of compost at low temperature (4 to 10^{o}C).

The microbes obtained from extreme environments are a good source of enzymes to be used in agriculture and industry. Many of the isolates were found to produce proteases, cellulases, amylases and proteases. Candidate genes for abiotic stress tolerance were amplified from many extremophiles and can be used for the development of transgenic plants tolerant to salt, drought or temperature stress. The gene dnaK along with its flanking region was successfully amplified, cloned and sequenced from *Bacillus pumilus* strain B3 isolated from Bakreshwar hot springs. The gene was successfully expressed in *Escherichia coli* BL 21 (DE3) and allowed for the growth of *E. coli* up to 50 °C and survival up to 60 °C for 16 h, suggesting that dnak from *B. pumilus* imparts tolerance to host cells under high temperature. This novel gene can be an important component for possible utilization in abiotic stress management of plants.

The database of microbes from extreme environments also helped in identification of strains capable of solubilising potassium and zinc. Inoculation of these organisms enhanced the uptake of K in maize and Zn in wheat and soybean.

LL1.2

Translation of the pathogen diversity and population genetics knowledge into application: A case study-Late blight disease of potato.

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Plant pathogens causing an estimated worldwide annual loss of $ 60 billion are undoubtedly our enemies as they compete for the same food. *'Know thy enemy'* is an old adage, which aptly summarizes how our approach should be towards these enemies of humankind. However, knowing the enemy is constrained by the fact that the nature of the enemy which causes this loss is not genetically uniform and in certain cases like that of the late blight disease of potato and tomato, changes rapidly often causing epidemic outbreaks.An epidemic that causes significant crop loss involves thousands or millions of infection events involving an entire population of parasites and their hostplants. To control the disease, a plant pathologist must therefore develop methods to understand and control the entire pathogen population. Thus, it is important to understand the population biology and genetic diversity of plant pathogens in order to develop rational control strategies.

Plant pathogens co-evolve rapidly to overcome the disease control strategies that are deployed against them. Resistance genes often fail within a few years after deployment and fungicide resistance often emerges within a few years after the first spray. As the evolutionary potential of a pathogen population is reflected in its population genetic structure, the pathogen population needs characterisation and thereafter continuous monitoring through surveillance. By understanding these changes in pathogen populations due to pathogen micro-evolution,the ultimate aim to develop disease management strategies that will remain effective for a long time can be reached.
Phytophthora infestansfaQ casual organism of late blight (LB) of potato and tomato is a -240 Mb, 'two speed genome', with high evolutionary potential making it a formidable enemy. In some regions, *Phytophthora infestans* populations are dominated by specific clones, whilst in others, populations are genetically diverse. Effective late blight management requires an understanding of the contemporary pathogen population as aggressive and fungicide insensitive clones can quickly emerge in this polycyclic disease. Aggressive strains are exchanged across regions and even continents and this calls for global collaboration.Assessment of genotypic and phenotypic diversity coupled with detection of changes in LB populations worldwide through a set of standard phenotypic markers with 'field attributes' and neutral standardised 12 multiplexed SSR markers, has enabled characterisation and geospatial tracking of the populations of this pathogen. This information is linked to early warning and/or decision support systems and has enabled reduction of losses due to LB successfully in Europe. It is also useful for tracking of populations across regions and assessment of phytosanitary risks. Assessment of genetic diversity and population structure of plant pathogens is therefore not merely an academic

exercise, but a very important translational tool for management of diseases.

The knowledge has been translated to practice through formation of worldwide dedicated groups(which include all stake holders) for the integration of the population data and phenotypic field attributes for better management and reducing crop losses. EuroBlight (Europe)http://euroblight.net/, USABlight (USA)https://usablight.org/ , groups are working effectively, others include TizonLatino (Latin America) https.V/tizonlatino.wordpress.com/, etcand the newly formed AsiaBlight (Asia) https://www.asiablight.org/of which the author is a country co-ordinator (India) and the scientific committee member.The above developments, the methodologies adopted and the paradigm shift that it has brought about in management of LB will be discussed along with the progress of work done in this field till date in India,as a case study for utilising the genetic diversity data which has important translational benefits in reducing crop losses due to plant diseases.

OR 1.1

Fungal diversity of Sikkim: a potential bioresource for Biotechnology

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The region of Sikkim comes under the biodiversity hotspots, the unique geographical features and climatic conditions makes natural habitat for rich fungi diversity. The search for fungal biodiversity and construction of a living fungi data has potential in locating novel species, a part of agenda of National Biodiversity Documentation Program. In developing countries like India, rich fungal diversity combined with present technologies offer great potential for biotechnology based industries. Considering the importance of creating a databank on the naturally occurring organisms, including fungi, at the genomic, taxonomic and ecological levels, the work on diversity, taxonomy and ecology of the fungi will be the valuable contribution. It is in this context, an attempt has been made to isolate culturable fungi from various habitats viz. leaf litter, forest soil, healthy plants parts, diseased parts, soil nearby animals burrows/shed and mushrooms for their identification followed by molecular phylogenetic analyses to ascertain their evolutionary relationship with other members of the genera. A total of 300 plus fungal culture isolation has been done from various sources till date. The initial BLASTn results of ITS region of 27 fungal strains shows low similarity with the sequences of known species in the NCBI database suggesting they are probable novel fungi. The isolates will be further used for screening of various activities like enzymes, antibiotic, secondary metabolites and will be deposited at NCMR/NCCS, Pune for accession number. Future outcome indicates promising source of novel fungi with biotechnological potential for producing biologically active compounds from Sikkim.

OR 1.2

Taxonomy of Fusaria: An overview and current perspective

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Fusarium Link (Hypocreales, Nectriaceae) is a one of the economically destructive, ecologically diverse and large species-rich genus. It was first described in 1809 based on the production of distinctive fusiform multiseptate macroconidia. In the early development of *Fusarium* taxonomy, researchers mainly rely on morphological characteristics, especially the shape of macroconidia. In general, taxonomists were divided into two group's viz., the lumpers and the splitters. Wollenweber & Reinking (1935), Raillo (1950), Bilai (1955), Gerlach & Nirenberg (1982) and Joffe (1986) were the groups of 'splitters' and separated *Fusarium* into species, varieties and forms. By contrast, Snyder & Hansen (1940) (who reduced the number of the species into nine) and Messiaen & Cassini (1968) and Matuo (1972) were considered as the 'lumpers'.

Morphology based identification has gained several debates. The macroconidia character evolved convergently in different lineages of ascomycetes, and lost at least once within the *F. solani* species complex e.g., *F. neocosmosporiellum* and related self-fertile species (O'Donnell et al. 2013). Some members (eg., *F. nivale*) is now recognized as *Microdochium nivale* within the distantly related order Xylariales. Molecular phylogenic studies revealed monophyletic origin of the genus which is non-congruent with morphology-based taxonomy. Molecular systematics of the genus is based on multilocus sequence typing (MLST) schemes and Genealogical Concordance Phylogenetic Species Recognition (GCPSR) concept where two or more loci have been used as molecular marker. Commonly used markers include transcription elongation factor 1á (*TEF*-1á), DNA-directed RNA polymerase II largest (*RPB1*) and second largest (*RPB2*) subunits, calmodulin (*CAL*), â-tubulin (*TUB2*), nuclear ribosomal intergenic spacer region (*IGS rDNA*), internal transcribed spacer region (*ITS rDNA*), nuclear ribosomal RNA large subunit (28S or *LSU rDNA*) and mitochondrial small subunit (*mtSSU rDNA*). The GCPSR-based analysis reported by O'Donnell et al. (2015) indicated the genus *Fusarium* comprising of at least 300 phylogenetically distinct species, 20 clades referred to as species complexes and nine monotypic lineages based on phylogenetic analyses of representative fusaria in the ARS Culture Collection (NRRL), the CBS-KNAW Biodiversity Centre (CBS) and the Fusarium Research Center (FRC). FUSARIUM-ID and *Fusarium* MLST are two web-accessible databases containing multilocus data that have been recommended to use for proper identification of *Fusarium* isolates.

OR 1.3

Cultivable diversity of actinobacteria from Nongkhyllem Wildlife Sanctuary, Meghalaya, India, with preliminary assessment of antimicrobial and plant growth promoting potential

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This work reports on the cultivable diversity of actinobacteria from sub-surface pristine forest soil of Nongkhyllem Wildlife Sanctuary, Ri-Bhoi District, Meghalaya, India. This work also reports on the preliminary investigation of antimicrobial activity and plant growth promotion of the recovered isolates. Isolation was performed with different pre-treatment methods and selective media. The recovered isolates were characterized on the basis of micro-morphology, biochemical, chemotaxonomical, amplified ribosomal DNA restriction analyses (ARDRA) and 16S rDNA sequence analyses. Screening ofthe isolates for antimicrobial activity was done by agar-well diffusion assay against Gram-negative, Gram-positive and candidalstrains. The isolates were also screened for presence of biosynthetic gene clusters (BGCs) related to antibiotic synthesis viz. PKS-I, PKS-II and NRPS. The isolates were also screened for production of indole-3-acetic acid, phosphate solubilisation, siderophore production and

diazotrophy. Ninety-four isolates were recovered. Characterizationresults showed predominance of *Streptomyces* (77%). Other genera recovered were *Nonomuraea, Nocardia, Actinomadura, Streptosporangium, Kribbella*and *Amycolatopsis*. 11% of the isolates showed anti-Gram-positive activity and 4% showed anticandidal activity, and the potent strains were from the genus *Streptomyces*.61% of the isolates were detected with at least one BGC. However, 54% were detected with BGCs, but failed to show antimicrobial activity. 16% of theisolates could solubilize phosphate above 350µgml^{-1}, and showed siderophore activity above 25mm halo diameter and 63% showed diazotrophy. Most of the plant growth promoting isolates were*Streptomyces*. Therefore, the pristine forest soil of Nongkhyllem Wildlife Sanctuary in Meghalaya, India, is an actinobacteria-rich soil cultivably predominant with *Streptomyces,* with potential antimicrobial and plant growth promoting properties. The potential isolates could be further investigated for production of bioactive compounds and plant growth promoting bioformulations.

OR 1.4

Screening of Inorganic Phosphate Solubilizing Bacteria from Singalila Mountain Range of Himalaya

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Among a variety of soil productivity constrains, phosphorus availability plays a very crucial role in crop production as well as for natural vegetation. As the soil of Indian Himalayan region (IHR) is generally acidic in reaction, bioavailability of phosphorus becomes extremely low. High altitude phosphate solubilizing microorganisms (PSM) play a major ecological role from this view point. During this survey PSM have been isolated from eleven grass land soil samples collected from Singalila mountain range of Eastern Himalaya. Microbiological status showed total CFU count range between 7.1 X 10^7 to 43.6 X 10^7 per gram of soil and number of PSM appeared 1 6- 5.2% which decreased in number with higher altitude. Organisms with high phosphate solubilizing index were tentatively identified as the strains of *Bacillus, Micrococcus* and *Pseudomonas*. Application of such organisms as indigenous bioinoculants could be beneficial for high altitude agronomy.

OR 1.5

Documentation on Diversity of Vesicular Arbuscular Mycorrhiza Associated with some common Medicinal Plants of Ballabhpur Wild Life Sanctuary, West Bengal, India

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Plant health mainly depends on physic-chemical properties of soil as well as soil microbiota and environmental condition of growing areas. Amongst all soil microbiota, Arbuscular Mycorrhizal fungi play a crucial role for plant growth and development. Arbuscular mycorrhizae are obligate symbiotic fungi belongs to phylum Glomeromycota and well known for water management through enhancing root absorption areas as well as nutrient solubilisation & their immobilization. AM fungi occupied with most of the higher plants of the terrestrial ecosystem. Ballabhpur Wild Life Sanctuary (also known for Deer park) is a protected area dominated mainly by woody trees, located near Santiniketan, Bolpur of West Bengal, India covering about 200 hectares of area. The sanctuary is well protected by fencing and anthropogenic activity is strictly prohibited except some Deer park areas. Due to negligible anthropogenic activity several herbal medicinal plants are growing luxuriantK in this natural habitat.

Keeping the importance of medicinal plants for human welfare, altogether 13 medicinal plants belonging to 1 1 families have been selected for screening of mycorrhizal dependency and their documentation. Altogether 43 identified and 13 unidentified species of AM fungi belonging to 10 different genera have been isolated. Significant variation in terms of spore density, species richness and root colonization percentages of arbuscular mycorrhizal (AM) fungi was also noticed. Root colonization found to be varied in different medicinal plants studied. Spore population was also found to vary and is highest in the summer season whereas highest root colonization was noticed in rainy season. Outcome of the present study showed that Ballabhpur Wild Life Sanctuary does contain significant AM fungi diversity that needs be more explored for better scientific application of AM fungi in terms of sustainable agriculture.

OR 1.6

Emergence of *Labyrinthula* species from Marine to Terrestrial Ecosystem

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Labyrinthula terrestris causes rapid blight disease of cool-season turfgrasses that is generally prevalent where irrigation water and/ or soils have elevated salinity. Until L. terrestris was identified as a pathogen of turf grass, Labyrinthula species were only known to be associated with marine systems. L. terrestris might be well established as a terrestrial inhabitant but has been overlooked due to the requirement of a selective medium for isolating the organism. The disease was first observed on Poa annua in California in the year 1995. Prof. Robert L. Gilbertson recognized the similarity between the spindle-shaped cells in a rapid blight affected rough bluegrass and Labyrinthula zosterae that causes wasting disease of eelgrass in marine estuaries which is a marine slime mold in 2002. On the basis of shared morphological characteristics the rapid blight pathogen was proposed to be a member of genus Labyrinthula and named as Labyrinthula terrestris. Increased area under turfgrass cultivation and changes in cultural practices such as increased use of relatively high saline water or reclaimed water for irrigation might be the reason for its emergence as a terrestrial pathogen. As an important emerging pathogen of turfgrass, L. terrestris poses a potential problem in susceptible turfgrass varieties wherever soil salinity increases as a result of poor soil structure or suboptimal irrigation water. A successful integrated approach has been identified that relies on a combination of cultural practices and chemical control. The possibility of infections in agricultural crops will need to be further examined.

OR 1.7

Screening of indigenous bacteria isolated from oil contaminated soil ofAssamfor hydrocarbon degradation and biosurfactant production

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With the rapid increase in population and modernization of the society, the use of petroleum hydrocarbon and other allied products has increased which has resulted into the pollution of

the environment. Petroleum hydrocarbon contamination is a serious problem especially in the area near oil drilling sites which alters the sustainability of the ecosystem.Degradation of these pollutants by naturally occurring microorganisms might appear as green solution for removal of these pollutants from the environment. The present study was aimed to isolate indigenous bacteriafrom soil contaminated with petroleum hydrocarbon by using enrichment culture method and to screen them for potent hydrocarbon degradation and biosurfactant production.A total of 20 bacterial strains was isolated by enrichment culture technique using Bushnell Hass agar medium supplemented with 2% of crude oil as sole carbon source and maintained in pure culture for further analysis. Screening of the bacterial strains for hydrocarbon degradation was done by culturing the isolates in Mineral Salt Medium(MSM) using 2% crude oil as the sole carbon source. Three efficient hydrocarbon degrading bacteria were identified as *Pseudomonas sp, Dietziasp,* and*Bacillus sp*. based on biochemical and phylogenetic analysis results. Gravimetric estimation of hydrocarbon degradation showed a maximum of 80 % degradation by the isolates in culture period of four weeks. Production of biosurfactant is an important characteristic of hydrocarbon degraders which enhances the efficiency of degradation of hydrocarbon by making the hydrocarbon pollutants easily available for bioremediation. Strain *Pseudomonas aeruginosa,* isolated from the contaminated soil,appeared as a potential producer of biosurfactant, attaining 65% of emulsifying index and having the ability to reduce surface tension of the culture medium from 52 mNm^{-1} to 29 mNm^{-1}.LCMS and FTIR analysis revealed the biosurfactant to be comprised of both mono and di rhamnolipid congeners. Hydrocarbon degrading bacteria with biosurfactant production capabilities might be used as potential agents for enhancing bioremediation of environment contaminated with hydrocarbons.

OR 1.8

Morphological Variability, Management and development of PCR Based Molecular Marker of *Alternaria brassicae*

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Alternaria blight of mustard caused by *Alternaria brassicae* (Berk.) Sacc. isone of the major yield attributing factor in West Bengal causingconsiderable losses to the crop. In view of the potentiality of the disease and itsannual recurrent in unpredictable climatic condition facing off now in lateritic belt ofwest Bengal, attempts were made for studying the Alternaria blight of mustard witha view to get information on the existing isolates of the pathogen, their potential levelof natural incidence, disease – environmental relationship and to explore thepossibilities of controlling the disease with the help of SAR chemicals, bio-agentsand by selecting some resistant cultivars suitable for this location. Among thedifferent isolates collected, three isolates namely, MAbV-1, RAbA-1and RAbB9-3was reported to be highly pathogenic and produced spot diameter more than 1cm. The severity of Alternaria blight wasvaried with thelocation, variety and season. Maximum disease severity on leaves and pods in termsof PDI was observed in district Purulia followed by Birbhum, Paschim Medinipur andBurdwan while, minimum severity was observed in district Bankura. A range ofterminal PDI of the disease (50.45 % to 63.92%)on leaves; (50.07% to 55.67%)onpods was observed in different season.Salicylic acid was found the best treatmentfor reducing the PDI in field (21.61%) followed by Chitosan (26.82%). Of all the bio-control agents evaluatedagainst *Alternaria brassicae*, *T. viridae* inhibited maximum mycelium growth(80.68%)*in vitro* followed by *T. harzianum* and *T.virens*. *In vivo* evaluation showedthe supremacy of fungicide, Mancozeb among all the treatments which reduced thedisease severity (PDI, 9.62) in field. Among the bio-control agents, T. viridae provedto be the best treatment with reduced PDI value (29.44) followed by *T. harzianum*(31.54). Among thenine varieties of rapeseed and mustard tested, Varuna, Panchali, Agrani and B-9were found to be highly susceptible (HS) varieties with PDI >50%); Seeta andJhumka to be moderately susceptible (MS) with PDI >20-30%); Sarma to besusceptible (S) PDI >30-50%) and Bhagirathi and Kalyan to be moderately resistant(MR) with PDI >10-20%. None of the varieties were found to be highly resistant(HR) against Alternaria blight. Alternaria leaf blight of mustard was appeared in the field at about 35-39 days aftersowing i.e. 51ststandard week (3rd -4th week of December) of the year. The severity ofAlternaria leaf spot was increased at a faster rate during the initial period the disease,and reached its maximum level (11.42% (PIPDI and 26.8% CIPDI) during 3rdstandard week of successive year. Thereafter, rate of disease development was muchslower (0.65% PIPDI during 9th standard week) and finally disease progression ceasesat 10th standard week of the year. When maximum average temperature ranged from21.36 to 25.66 0C in field, minimum average temperature maintained between 9.62 ^{0}C to 13.31 ^{0} C, average relative humidity varied between 69.99 to 83.43 %, havingaverage rainfall between 0.1 to 8.9 mm during cropping period, an average sunshinepersists 4.39 to 7.12 hours per day in field and moderate wind speed from 2.07 to3.49 kmh-1 prevailed in mustard field maximum periodical increment in PDImight be expected. Value of standardizedpartial regression coefficients (P's) indicated the major contribution of maximum temperature (60.96%) and average wind speed /day(20.30%)in case of periodical increment ofdisease(PIPDI) in field. An attempt was also made for development of a probablepotent marker in relation to Alternaria blight resistance. RAPD profile analysis wascarried out using 17 RAPD primers and extent of polymorphism with each primer wasstudied. Using the RAPD derived finger print profiles using selected primers,amplicon size for susceptible, moderately susceptible, highly susceptible andmoderately resistant genotypes was also determined which formed the baseline fordevelopment of Alternaria blight resistant marker.

OR 1.9

Nuclear localization signals and 3-D structural prediction of coat proteins of sweetpotato feathery mottle virus reveal strain variation

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Sweet potato production is constrained globally by several RNA and DNA viruses especially Sweet Potato Feathery Mottle Virus (SPFMV) under potyviridae family is the most important and widespread sweet potato virus. SPFMV isolate from sweet potato in WB,India, was studied to examine the coat protein sequences among other SPFMV isolates from different countries. Symptoms of infected sweet potato were recorded at the experimental field of BCKV, WB, India. The present study highlights the enhanced molecular resolution and 3D state prediction of amino acid of coat protein of seven SPFMV strains. The polyprotein coding region of the coat protein (CP) were sequenced and recognized as phylogroup as Russet Crack (RC) isolate (GenBank Accession No.HM035545 and poly protein ID D6R1L4_9POTV) which was found diverged from the strains 4C, EC, S, O and K1 of SPFMV. Protein feature view of PDB entries mapped with watermelon mosaic virus (WMV) Polyprotein (PF00767) to a UniProtKB sequence S480335 and predicted structural similarities for the SPFMV strains in PDB ID 5ODV for WMV. Analysis of Nuclear Localization Signal (NLSs) and its prediction of CP sequences unveiled the key amino acids in the corresponding amino acid sequences of SPFMV strains required for systemic

infection, viral particle formation and insect transmission and showed typically rich in arginine and lysine residues. SPFMV, BCKV isolate revealed a significant correlation between clustering of the viruses and geographical origin and sequence variation in coat protein gene of SPFMV in different subcontinents of the world.The CP gene, SPFMV, BCKV isolate was compared with other elsewhere, phylogenetic analysis revealed major phylogroups which showed evolutionary compatibility with other viral taxa. A motif Asp-Ala-Gly (DAG) with the nucleotide sequence GATGCGGGA (nt 31-39) was found at the N-terminal region of coat protein (CP) gene of BCKV are same to other isolates and highly conserved domain which is required for aphid transmissibility. About 20 amino acids downstream from the DAG motif, there is a potential trypsin cleavage cited that is conserved in all potyviruses. The presence of the NLS and DAG motifs suggest that the virus is localized in cytoplasm and aphids could potentially be vector to SPFMV.

PP 1.1

Screening of Potential Phytopathogenic Strains of Foliicolous Fungi of Ethnobotanically Important Medicinal Mangrove Plants of Sundarbans (Eastern India): Biodiversity and Parasitism

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Mangroves have long been a source of astonishment for the laymen and of interest for scientists. Mangrove plants are specialised woody plants growing in the swamps of tidal-coastal areas and river delta of tropical and subtropical parts of the world. The Mangrove forest of Indian Sundarbans has a long and rich glory as eco-region and treasure house of genetic resources throughout the historic past. Mangroves provide innumerable direct and indirect benefits to human beings. The unique ecology, morphological characteristics, and traditional uses of mangrove plants have drawn the attention of researches over the years. Herbal drugs play an important role in health care programs especially in developing countries. Rural poor and marginalized people of mangrove forests of Sundarbans depend on mangrove plants for primary health problems. They harbour a wide array of novel phytoconstituents which are potential sources of future drugs against ancient and emergent diseases. This treasure house of mangroves is now the target of various fungal attacks which may create conservation problem in future and may affect the quality of drug. During the survey of faliicolous fungi of some ethnobotanically important medicinal mangrove plants of Indian Sundarbans a number of interesting potential fungi were isolated and recorded from infected leaves. The fungi belong to Coelomycetes, Hyphomycetes, Plectomycetes, Pyrenomycetes and Teliomycetes. A wide range of variation in conidial morphology of fungal species was also noted. Phytopathogenic fungi *Colletotrichum gloeosporioides* and *Pestalotiopsis agallochae* were found to grow abundantly in a wide range of mangrove hosts in different localities of Sundarbans. This has created an interest whether any strain variation exists in both the aforesaid fungal species. Results indicate the existence of distinct strains within the isolates of aforesaid species.

PP 1.2

Diversity and potential of Wild culturable macrofungi of Sikkim for domestication

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Fambong loh wildlife Sanctuary of Sikkim is an unexplored reserve forest with respect to the diversity study of macrofungi. Macrofungi are diverse in their uses as food and medicine and several species serve as decomposers. The subtropical and mixed temperate forests of the sanctuary have high diversity of fungi especially the macrofungi (mushrooms). Diversity survey was carried out throughout the year and with the background of ethnomycological knowledge, the samples were segregated into edible/medicinal and non-edible groups. A total of 100 plus mushrooms species has been collected from the study area till date which was morphologically identified by following standard keys. This data will help in understanding the portion of fungal diversity common to a forest type and act as a baseline for potential future studies at these sites to access forest health and environmental effects. There has been considerable research on the taxonomy and phylogeny of mushrooms, but domestication of novel species or strains form the wild for cultivation is rarely reported. In an attempt to contribute in the field, wild edible mushrooms growth on artificial media was established following tissue culture and spore culture methods. After establishing edibility and cultivability, identification through molecular level is under progress. And the best conditions for spawn production and fruiting body production testing will be carried out in different organic substrata.

PP 1.3

Acidobacteria and Burkholderia Community of Mixed-Crops at different *Jhum* cycles

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The abundance and composition of bacterial community vary according to micro-habitat depending on the niche types, for example, tightly adhered soil (rhizoplane) and loosely adhered soil within a plant rhizosphere. It is possible that the rhizosphere community may also vary in a disturbed environment such as *jhum* soils depending on the length of the fallow period. This study assessed whether the composition of Acidobacteria and Burkholderia in the rhizosphere of mixed-crops of *Jhum* (slash and burn) fields were influenced by the length of *Jhum* cycle. Rice (*Oryza sativa* cv. Manen), Maize (*Zea mays*), Perilla (*Perilla frutescens*), and Colocasia (*Colocasia esculanta*) were the selected crop-plants from 5, 10 and 20 years *Jhum* fields of Changki village, Mokokchung, Nagaland. Comparison of Acidobacterial and Burkholderia community structure in the tightly-adhered, loosely-adhered and bulk soils of these four crop-plants was determined by PCR-DGGE (denaturing gradient gel electrophoresis) fingerprinting using specific primer pairs. The DGGE fingerprinting gel image obtained by silver staining showed that diversity of Acidobacteria was more compared to Burkholderia community. Community shifts of both phylums were clearly seen within same crop-plant of different *Jhum* cycles. The community composition of Acidobacteria and Burkholderia varied among fallow periods in terms of presence and absence of bands in all fallow lengths and even within the same fallow. A few dominant bands along with fainter bands appeared in the tightly-adhered soils of Burkholderia community banding pattern. However, the Acidobacterial community showed fewer differences in the overall banding pattern although there are few differences with presence or absence of bands. Thus, these findings clearly indicated that the length of *Jhum* cycle exerts differential influence on shaping the rhizosphere Acidobacteria and Burkholderia community of the same crop-plant at different *jhum* cycles. Therefore, the selective pressure of a crop-plant in recruiting rhizosphere

community may be different at different stress levels i.e., 5, 10 and 20 years *Jhum* cycles.

PP 1.4
Diversity of Endophytic Fungi from different parts of the Medicinal Plant – *Kaempferia Galanga* L.

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Kaempferia galanga L. a medicinal plant, commonly known as *sying khmoh* in Meghalaya is reported to have various medicinal properties. Endophytes associated with medicinal plants were found to exhibit potent biological activity, with some even producing the same or similar important secondary metabolites or natural products as their host plant. Endophytic fungi exhibit a great variation with respect to host and even tissue of the same plant. In the present investigation, diversity of endophytic fungi of *Kaempferia galanga* was explored. The results showed that different plant parts, viz. roots, rhizome and leaf housed a variety of fungi and also some fungal species were found common in all the plant parts. However the colonization frequency and endophytic infection rate varied with different parts of the plant. The present study showed that *Fusarium* was the predominant genus isolated from all the plant parts of *K. galanga.* The endophytic fungal diversity appeared maximum in the root and rhizome of the plant. Since the rhizome part of the plant is used for medicinal purposes, therefore the tissue-specific endophytic fungi inhabiting the rhizome could be used for further study in medicinal or agricultural applications.

PP 1.5
Diversity of Wood-Rotting Fungi of Manipur

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The North-Eastern state of India, Manipur falls under Indo-Burma Global Biodiversity hotspot and is endowed with rich natural vegetation ranging from tropical to sub-tropical or evergreen to mixed deciduous forest. Despite the great biogeographic significance of the forest, there is no complete documentation of the wood-rotting fungi which play a vital role in recycling the forest ecosystem. The present study aims to document the diversity of wood-rotting fungi of the state and survey was carried out at 7 different forest stands located at different altitudes ranging from 150 – 1500 msl. A total of 91 species, 26 families and 48 genera were identified, 80 belonging to the phylum Basidiomycota and 11 belongs to Ascomycota. Polyporaceae is the dominant family and *Microporus xanthopous* is the most abundant species in all the study sites. It was also observed that production of fruiting bodies is related to the decay stage of the wood and the majority of the species prefer intermediate decay stage.

PP 1.6
Evaluation of Indigenous *Trichoderma* Isolates in different media and temperature

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The after effects of global warming, climate change and rampant use of agrochemicals are visible as significant reduction in soil microbial diversity. Use of biocontrol agents against soil borne pathogens is gaining importance in the present situation for eco-friendly management of soil borne diseases. Five native *Trichoderma* isolates were collected from soil rhizospheres of paddy, groundnut, brinjal and tomato grown in the research plot at Department of Agronomy and Central farm of OUAT, Bhubaneswar. Another two isolates were collected from banana fruit and IIHR Bangalore (*Trichoderma harzianum*). All the isolates were named as Isolate 1, Isolate 2, Isolate 3, Isolate 4, Isolate 5, Isolate 6 and Isolate 7 (IIHR). Potato sucrose agar supported best growth of all *Trichoderma* isolates with the maximum mean radial growth of 63.33mm, 65.90 mm, 58.80 mm, 53.10 mm, 72.30 mm and 57.27 mm for Isolate 1, 2, 3, 4, 5 and 6. Isolate 7 grew best in Corn meal agar (58.10 mm). Nutrient agar was found to be the least effective in supporting the growth of all the *Trichoderma* isolates followed by Potato dextrose rose bengal agar. From the observations it was revealed that by growing in different media Tr isolate 2 and Tr isolate 5 were the most virulent and taken for further studies. Both the Isolate 2 and 5 grew better in 25-30^{0}C with maximum mean radial growth in 30^{0}C (76.2 mm) in Isolate 2. No growth was recorded by both the isolates in 12^{0}C.

PP 1.7
Effects of nutrients and photoperiod on growth and sclerotia formation of three phytopathogenic fungi

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Rhizoctoniasolani Kühn, *Macrophominaphaseolina* (Tassi) Goidand *Colletotrichumcapsici*are ubiquitous fungal pathogens whichmainly propagate through formation of macrosclerotia, microsclerotia and conidiospores respectively. Hyphal growth of microfungi is affected by several abiotic factors especially nutrient sources and light conditions.To study their role in detail, specifically on mycelial growth, hyphal branching and sclerotia formation, *R. solani*, *M. phaseolina*and *C. capsici* were grown with different nutrient sources and photoperiods. Among various nutrients,oat mealfavored mycelial growth in *R.solani* whereas, vegetative growth of *M. phaseolina*was maximum in media containing peanut extract. Potato extract and dextrose supported growth and hyphal branching in *C.capsici*.But the same media composition favored macrosclerotia formation in *R.solani*. Alongside various nutrient sources, different photoperiods also affected vegetative growth in these three plant pathogenic fungi. Constant light condition showed enhanced mycelial growth in *M.phaseolina* and *C. capsici*. Interestingly, *M. phaseolina*growing on potato extract and dextrose in continuous dark condition showed melanization.On the other hand, alternating light and dark cycles promoted vegetative growth in *R.solani*. Hence, these fungi showed significant differences among themselves in growth under different conditions depicting preference for specific nutrients and photoperiods. Further study will reveal whether these factors have any influence on their pathogenicity.

PP 1.8
Rediscovery of *Pholiotamicrospora* after J.D. Hooker

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Darjeeling District, located within the Lesser and Sub-Himalayan belts of the north having a temperate climate creates better habitat for luxuriant growth of fungi. During field trip in the month of July,

2019, a unique agaricoid specimen locally called as chiplaychaw was collected from Lava, Kalimpong. The morphological and ecological features of this collected specimen were noted in the field. Through macro- and microscopic examination supported by ITS based phylogenetic analysis revealed this unique specimen to be *Pholiotamicrospora* (Berk.) Sacc. belonging to Strophariaceae family. Extensive literature survey revealed that this specimen was reported 169 years ago from Darjeeling, West Bengal, India ,by Berkley. Hence, the present finding reports the rediscovery of *P.microspora*after 169 years from Darjeeling, West Bengal.

SESSION II
Microbes and Soil Health

LL 2.1
Manipulation of soil microbiome for the management of soil borne disease

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Ecofriendly agricultural practices are important component in sustainable agriculture. The soil microbiome governs biogeochemical cycling of macronutrients, micronutrients and other elements vital for the growth of plants. Microbes in the rhizosphere are involved in many processes that determine agricultural soil productivity, including preservation of soil structure, nutrient recycling, disease control and degradation of pollutants. The soil microbiome includes bacteria, archaea, fungi, viruses, and other microbial eukaryotes plays an important role in shaping the rhizosphere of the plants. The rhizosphere microbes provides immense benefits to the plants against biotic and abiotic stresses and also helps in plant growth promotion. Soil microbes are capable of both directly and indirectly influencing the productivity, diversity, and composition of plant communities and also plant microbiome-manipulating strategies have emerged in recent years that manipulate the host for their own benefit, e.g., altering host metabolism. In addition, the abiotic environment (e.g., edaphic factors) influences both the plant and microbial communities, further enhancing the complexity of ecosystems. Soil borne pathogens are live within the soil which includes fungi, bacteria and nematodes that causes severe diseases in many crops. The rhizosphere, phyllosphere and endosphere as potential ecosystems for manipulation, in order to improve positive interactions with the plant. Introduction of external strains from bulk or rhizospheric soils may change the structure of the microbial community. In recent quantitative methods (qPCR and GFP (Green Fluorescent Protein)) and omics based technologiese.g. metagenomics, metatranscriptomics, and metaproteomics have expanded the understanding of the soil microbiome and their beneficial role rhizosphere.

LL 2.2

Three Dimensional Role of Rhizobacteria to Improve Soil and Plant Health

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Rhizobacteria are root-associated bacteria that form different type of relation to the plants either cause disease or to improve their health. Though parasitic varieties of rhizobacteria exist, the term usually refers to bacteria that form a relationship beneficial for both parties. It produces a wide spectrum of bioactive metabolites such as antibiotics, siderophores, volatile and growth promoting substances ranging between 0.4 to 2.0 mg/ml which help plants to cope up with environmental stresses. Rhizobacteria are often referred to as plant growth-promoting rhizobacteria (PGPRs) and they have different relationships with different species of host plants. These bacteria were isolated from rhizosphere of tomato and chilli plants from different climatic conditions of India. The total number of 48 rhizobacterial strains were assessed, 8 isolates were exhibited strong inhibition to *R. solanacearum*. The maximum antagonism was recorded by Kar-15 upto 77%. Growth promotion activities were assessed by screening siderophores, HCN, ammonia, IAA and P- solubilization. *Bacillus subtilis* DTBS-5 is massively used as biocontrol of plant diseases, and also for growth promotion. Various antagonistic rhizobacteria are applied in the field to control the different diseases of crops, among them *Bacillus* spp*.,* gram positive bacterium, which produces structurally diverse secondary metabolites with a wide spectrum of antibiotic activity has potential also to control many diseases. Out of 30 isolates of *B. amyloliquefaciens* isolated from rhizosphere of tomato, two isolates DSBA-12 and DSBA-11 were found *very good bio control efficiency against R. solanacearum in vitro* as compared to other species of *Bacillus*. *The minimum wilt disease incidence in tomato was recorded* in *B. amyloliquefaciens* strain DSBA-11(17.95%) followed by DSBA-12 (20.81%)and *B. subtilis* (21.38 %) under glass house conditions. Pesticides could be classified based on their toxicity, chemical group, environmental persistence, target organism etc. According to the Stockholm Convention on Persistent Organic Pollutants, 9 of the 12 persistent organic chemicals are pesticide including organochlorine, organophosphate, organometallic, pyrethroids and carbamates and many more. The ability of bacteria to bioremidate these pesticides mainly based on their biodegradation activity. The result indicates massive potential of *B. subtilis* DTBS-5 and *Pseudomonas fluorescens* DTPF-3 to degrade pesticides such as chlorpyrifos and glyphosate yielding diethylphosphoric acid (DETP). To get all the benefits from this strategy is necessary to carefully select the most potential bacteria to have it well-characterized. Regardless, further research on plant growth promoting, antagonistic and biodegradation activities through bacteria is imperative if these strategies are to be implemented or improved.

LL 2.3
Impact of conservation agriculture on soil health and diseases

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As a technique in search of sustainability in the agricultural sector, Zero-till (ZT) with crop rotation and residue retention is recognized worldwide as conservation agriculture (CA). It has demonstrated that conservation agriculture practices could have a major role in overcoming scarcity of farm labour and rising costs of production through mechanization. While conservation agriculture covers 161 million hectares globally it has mostly been a system adopted by large farmers with heavy machinery. Only a small percentage of conservation agriculture is practiced in Asia and Africa.West Bengal has been developing the elements of conservation agriculture for small farms for 15 years, but the adoption of full conservation agriculture on farms is just beginning to take off. In 2019, 8000 ha were planted using minimum soil disturbance and

crop residue retention. From pathological point of view, no or minimum tillage of soil and retaining residues in the field principally increases the soil borne pathogens, and poses challenges to pathologists to grow a crop in healthy state. An attempt was made to evaluate the disease dynamics under CA in different crops in northern districts of West Bengal. The treatments were ZT with residue and use of consortia of bioagents (*Azotobacter*/ *Azospirillum*, Phosphate Solubilizers and *Trichoderma*) and Conventional tillage without residue and consortia of bio-agents. Results indicate that spot blotch of wheat increases in no-tilled condition, but over the years gradually the disease decreases in the crop, whereas, sheath blight in rice was always found higher under zero tilled condition than under conventional tillage. Key soil parameters like organic matter, soil pH, and plant nutrients beside different soil enzymatic activities viz. acid phosphatase, dehydrogenase, microbial biomass carbon, active carbon and particulate carbon change positively correlated with plant performance in CA fields. The survival of the pathogen in CA was not significantly differed and population of beneficial microbes like Phosphate solubilizers, *Pseudomonas fluorescens, Trichoderma, Azotobacter*and*Azospirillum*were estimated in both CA and CT plots and their relationship with the disease incidence wassuggested.

OR 2.1
Evaluation of plant growth promoting and antimicrobial activity of rhizospheric bacteria isolated from Sundarban

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The Sundarbans, world's largest tidal halophytic mangrove ecosystem is recognized as a major UNESCO World Heritage site. Situated in the Marine-riverine delta of Ganges, Meghna, and Brahmaputra rivers, Sundarbans is one of the most productive coastal ecosystems which is characterized by daily inundation at high tide. It is the home for diverse flora, fauna and also harbours diverse group of microorganisms which can tolerate salinity.

In the present study soil samples were collected from rhizospheric soil of different mangrove plants in Sundarban including *Heritiera fomes*, *Ceriops decandra*, *Excoecaria agallocha*, *Sonneratia apetala*, *Bruguiera gymnorhiza, Aegialitis rotundifolia* and *Pheonix paludosa.* Physicochemical analysis of the soil samples were done and it revealed a moderate to high salinity ranging from 2.7 to 11 ppt. The pH range was found to vary from normal to slight alkaline (7.58-8.48) in nature, having a moderate level of organic carbon (0.030-0.456 %) and nitrogen (56.9-112.0 mg/kg).

Microbial density was moderate with a total count ranging between 0.52 ± 0.98 to 75. 6 ± 0.48 $\times 10^3$ cfu/g and had microbial activity which ranged from 2.0 to 13.96 µg fluorescein/g/h. A total of 58 phenotypically distinguishable bacterial isolates were obtained in pure forms and found to tolerate high concentration of salt. The isolates could also tolerate metals such as Ni, Cr, As, Fe, Mn, Mg and Pb. They were found to produce wide range of enzymes such as amylase, casienase, urease, pectinase and gelatinase. The isolates were also found to produce plant growth promoting traits such as production of indole acetic acid, ACC deaminase and siderophore which plays positive role in plant growth promotion. Apart from these plant growths promoting traits the potent isolates were also capable of producing antimicrobial substances against several Gram positive as well as Gram negative isolates and can be used as effectively for plant growth promotion.

OR 2.2
Enhancement of Efficacy of *Monarda citriodora (Cerv. Ex Lag)* essential oil after Encapsulation into Chitosan Nanomatrix against fungal and Aflatoxin contamination of stored functional food samples

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Monarda citriodora essential oilwas encapsulated into chitosan nanomatrix(MCEO-CsNe) to improve its efficacy as promising antimicrobial against deterioration of stored functionalfood samples causedby fungal infestation, aflatoxin B_1 (AFB_1) production and lipid peroxidation. The synthesized MCEO-CsNe was characterized through SEM, FTIR and XRD analysis. MCEO-CsNecompletely inhibited the growth of *Aspergillus flavus* (AF-LHP-SH1) and AFB_1 production at 0.6 and 0.5µL/ mL,respectively.The reduction in ergosterol biosynthesis, enhanced leakage of cellular ions and 260 and 280 nm absorbing materialsin AF-LHP-SH1 upon treatment withMCEO-CsNeconfirmed fungal plasma membrane as possibleantifungal site of action. The down regulation of methylglyoxal biosynthesis revealed anti-aflatoxigenic mode of action of MCEO-CsNe. In addition,MCEO-CsNe showed enhanced antioxidant activity in DPPH assay (IC_{50} value = 0.56 µL/mL) and exhibited reasonably remarkableefficacy against lipid peroxidation of stored *Salvia hispanica* (model food) seeds. Thenon phytotoxic nature along withfavorable safety profile with high LD_{50} value (26830.25 µL/kg) on male mice recommends its potentialutilizationas safeantimicrobial for protection of storedfunctional food samples from fungal andaflatoxin contamination.

OR 2.3
Biological Health of the agricultural soil – A case study in Northern Parts of West Bengal

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A long term experiment is continuing from 2006 in the farm of Uttar Banga Krishi Viswavidyalaya on conservation agriculture practices in rice-wheat cropping system with three interventions namely tillage (no tillage and conventional tillage), residue (residue removed and residue retained) and bio-inoculation (with and without bio-inoculation). The experiment follows 3 factor factorial design, giving 8 treatments with different combinations. An investigation was carried out for last two years (2017-2019) to analyse the microbial population dynamics in each of the treatments. Soil samples were collected at an interval of three months starting from June 2017 and population of total bacteria, Phosphate solubilising bacteria, Fluorescent pseudomonads, *Azotobacter* sp. and *Azospirillum* sp. were estimated using Most Probable Number method (MPN). Dehydrogenase and acid phosphatase assay was also done for the same period. Irrespective of other factors the microbial population was found higher in conservation agriculture (CA) plots than in conventional (CT) plots. Tenfold increase in Phosphate solubilizer, *Azotobacter* sp. and Total bacterial population was recorded whereas, hundred fold increase was observed in rhizosphere bacteria as

Azospirillum and Fluorescent pseudomonads. Dehydrogenase activity during the period was found higher in CA plots with no tillage and residue retained in the field, whereas acid phosphatase activity was numerically higher in CA plots than the CT plots but not significantly high. Carbon dioxide (CO_2) release by the surface soil to environment was assayed for all the plots and was found that tillage operation and residue retention increases the CO_2 release in atmosphere thus lowering the carbon sequestration in agricultural fields. Thus, conservation agricultural practices enhances the soil health in terms of its biological properties irrespective of its effect on yield of the crop.

OR 2.4
Effect of heavy metal on the growth of plant and soil mycobiota

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This study was conducted to evaluate the effect of metals on seed germination and plant growth of chickpea as well as effect on soil fungi.In this study 10 different fungal genera were isolated. *Aspergillus versicolor* and *Penicillium oxalicum* found to be most dominant isolate and used these fungi for indexing the tolerance. *Aspergillus versicolor* and *Penicillium oxalicum* were screened for their resistance to copper (Cu) in malt extract agar amended with various concentrations ranging from 100-500 mg/L. The isolates were resistant to Cu; *Aspergillus versicolor* was showed tolerant against the tested heavy metal at higher concentration, showed the tolerance index of 1.103, 1.05, 0.20, 0.07 and 0.00 and *Penicillium oxalicum* showed the tolerance index 0.84, 0.96, 0.66, 0.16 and 0.00. For evaluation of seed germination and early seedling growth of various concentrations (10, 50, 100, 250, 500, 750 and 1000 mg/L) of copper (Cu) were used. The inhibition caused by this metals was depending on the concentration used it reduced seed germination, root and shoot lengths, root and shoot dry weight on the treated plant compare to untreated plant.This metal affected significantly the seed germination, root and shoot lengths, root and shoot dry weight toxitcity starting from 100 mg Cu/l. This study concludes Copper has adverse effect on seed germination and plant growth. A*spergillus versicolor* and *Penicillium oxalicum* can be used as effective agents for bioremediative clean-up of heavy metal polluted environments.

OR 2.5
Influence of Soil Biotic/Abiotic factors on Soil Suppressiveness/ Conduciveness towards *Rhizoctonia solani*

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Rhizoctonia solani is the most important soil borne pathogen causing economically important diseases on numerous hosts and weeds of different families leading to considerable damage under congenial environmental conditions. Long term survival ability of the pathogen, wide host range and complex life cycle and pathosysytem of *R. solani* make the disease management strategies more complicated. Soil physico-chemical and biological parameters have an immense effect on survival and perpetuation of this pathogen. Therefore, attempts were made to reveal effect of different soil parameters (soil Physical, chemical and biological) on saprophytic survival ability of the pathogen. Results revealed that sandy clay loam and sandy loam soil promote highest saprophytic colonization of *R, solani* at combination of 30 °C temperature and 65% FC soil moisture followed by 30 °C temperatureand 75% FC soil moisture. Among all soil moisture, highest colonization was observed at 65% FC than other soil moisture levels. In both sandy soils (Red sand and white sand), increasing range of mycelia colonization was observed with corresponding increase of soil moisture. In red sandy soil, highest growth rate *of R. solani* was observed at 100% FC in combination with 30 °C temperature. While, saprophytic colonization were found more at 30 “C coupled with 85%FC and 30°C under l00%FC in white sandy soil.Among biotic factors, microbial activity (FDA hydrolysis), MBC, population of *Pseudomonadssp., Trichodermasp.* and actinomycetes were found as the most important predictor of soil suppressiveness against *R, solani.*

OR 2.6
Microbial diversity of Lateritic Soils of different regions of West Bengal

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Soil, the outermost covering of earth comprising of layers of organic and inorganic compounds is a complex microbial habitat with numerous microenvironments and niches. India being a huge country, it experiences a variety of climate and natural conditions leading to the formation of diverse soil types. Laterites (derived from Latin word “later” meaning brick) or lateritic soil, is mainly found in India and some tropical countries with intermittently moist climate.Well developed laterites are found on the summits of hills of the Deccan, Karnataka, Kerala, Madhya Pradesh, the Eastern Ghat regions of Orissa, Maharashtra, Malabar,Assam and West Bengal (Midnapur, Bankura, Burdwan and Birbhum).Lateritic soils are characterised by nutrient-poor acidic (pH 4.8–6.4) sandy loam, clay loam to sandy clay loam with different levels of sand (48.3–85%), silt (2–28.3%), clay (10.1–29.1%) and organic carbon (0.21–9.89%).Laterite soils are rich in bauxite or ferric oxides, they are very poor in lime, magnesia, potash and nitrogen.

Soilmicrobial diversity studies have showed that diversity varies with soil type and geographical location.*Bacillus megaterium* and some strains of *Bacillus coagulans*have been reported from laterites of Konkan-Goa coastal belts.Both these bacteria produce organic acids which speed up weathering of minerals. *Bacillus subtilis,Bacillus azotoformans,Bacillus farraginis and Bacillus amyloliquefaciens*isolated from lateritic soils of Orissa were reported to possess significant antimycotic activity. The present study aims to investigate the microbial diversity of the unexplored laterites of different regions of West Bengal.

Lateritic soil samples would be collected from six different districts of West Bengal (Birbhum, Bankura, Bardhaman, Murshidaabad, Medinipur and Purulia). Samples have been presently collected from parts of Birbhum, cultured on suitable medium and colonies were characterized. Colony morphology of the isolates were studied and documented. Chemical analysis of the soil sampleswere done on the following parameters – pH, organic carbon, organic matter, availableSulfur, Iron, available Phosphorus, Nitrogen, soil texture (involving parameters like quantity of sand, silt, clay and moisture content). pH of these soil samples ranged between 2.63 to 4.7, organic carbon 0.35-0.46%, organic matter 0.6 –0.79%, sulfur11.45-41.48 mg/kg, Phosphorus 18.24 –153.4 mg/kg, nitrogen 0.04 – 0.05%, iron 2.8 – 8.2%.

OR 2.7

Heavy metal tolerance of filamentous fungal strains isolated from Agricultural field near waste dump site of Dhapa, Kolkata

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Indigenous filamentous fungal strains from maize field near garbage dump site of Dhapa, Kolkata exhibited remarkable tolerance in heavy metal-rich media. In the present study about 11 fungal strains were isolated from the soil (15-30cm depth) of maize field, identified and assessed for their tolerance to heavy metal concentrations of cadmium (Cd), chromium (Cr) and lead (Pb). Out of the isolates, 2 fungal species *Aspergillus ochraceus* and *Chaetomium brasiliense* were selected for their higher potential for metal tolerance. The concentrations of heavy metals (Pb and Cd) in the soil were evaluated by Atomic absorption spectrophotometer. The Pb and Cd contents were found to be 218 and 2.15 mg/kg respectively which are significantly higher than the control non contaminated soil (27 mg /kg for lead and 0.4mg/kg for Cd as per Kabata-Pendias, 2011). The fungal strains were subjected to different concentrations of heavy metals and minimum inhibitory concentrations (MIC) were determined. The MIC of Pb was found to be highest (2000-2200 ppm) against the fungal strains. Both the fungal species showed moderate tolerance index against cadmium and chromium (<1). However the species were more adapted to lead and showed high tolerance index (=1 and >1). Out of the two fungal isolates *C. brasiliense* was found to be more tolerant to metals. The exceptional trait of heavy metal tolerance displayed by these fungal species indicate their potential as an effective agents for bioremediation. This eco friendly approach of using fungi can be emerged as a good alternative technique to existing conventional chemical methods for metal removal.

OR 2.8

Soil biological parameters associated with soil suppressiveness under different levels of tillage operation

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Soil-borne diseases are difficult to control, because of the hidden status of the causal agents. Among plant diseases, soil-borne diseases are the main factors responsible for lowering the production of many crops compared to seed-borne or air-borne diseases and account for 10-20% of yield losses annually. Management of soil-borne plant pathogens is difficult due to the low inherent level of resistance of crop cultivars against such diseases, existence of high level genetic variability and wide host range of the pathogens, their ability to survive in soil for a long time due to melanized sclerotia. Crop rhizosphere, soil physical environment and microbiota influence the suppressiveness and conduciveness of soil towards soil-borne plant pathogens. Successful parasitic relationship and rate of spread of soil-borne pathogen in soil-plant system depend on different types of crops in sequence, soil microbial diversities, soil physico-chemical and biological characteristics and abiotic stress factors. Manipulation of soil physical structure is one of the principal means by which microbial dynamics can be controlled. A diverse microbial habitat can be control through long term alternation in habitat space, water, substrate distribution and the spatial arrangement of pore pathways. Keeping these points in view, the present investigation was undertaken with the objectives of soil microbiological parameters influenced by different tillage management practices associated with *Sclerotium rolfsii* disease suppressiveness.Three types of tillage (conventional, minimal and zero tillage) were applied in paddy harvested fields where then*S. rolfsii* susceptible crop lentil was transplanted. Collar rot disease incidence, infection foci and sclerotial population was found to be least in zero tillage condition. Temporal changes in microbiological parameters viz., FDA and dehydrogenase activities were found to be higher in zero tillage condition and least activities was noticed under conventional tillage condition. Higher population of total bacteria, *Pseudomonas*and *Actinomyces*were observed under zero tillage condition, whereas, *Bacillus* and total fungi were found to be higher in conventional tillage but *Trichoderma* abundance are variable in different tillage system.The twelve isolates, isolated from experimental field, showed potential antagonistic activity in the range of 27.29 to 71.43% against the tested fungal pathogen, *Sclerotium rolfsii.* Most of the antagonistic bacteria were found to produce secondary metabolites but ZTS27, ZTS9 and MTS39 could be characterized as potential antagonistic isolates in terms of production of higher amount of secondary metabolites like HCN, NH_3, siderophore, SA, IAA, phosphate solubilization, protease, cellulose, amylase, pectinase and seedling vigor index by means of plant growth promotion.

OR 2.9

Isolation and characterization of Soil Yeasts for plant growth promotion

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Various groups of soil microbes have been studied and proven to play important roles in plant performance directly improving mineral nutrition. Additionally, these well characterized beneficial microbes(sometimes called plant growth promoting microorganisms (PGPMs))indirectly promote plant health by inhibiting phytopathogens and enhancing plant tolerance level to different kinds of stresses. Among these soil inhabitants, non-filamentous fungi, i.e., yeasts are among the least explored groups of organisms for their application in agricultural sustainability. Although, they are among the common inhabitants of diverse types of soil,their potential in plant growth promotion has been under exploited as suggested by recent studies. In the present study yeasts have been isolated from different soil samples. The isolates were screened for their plant growth promoting traits such as indole-3-acetic acid (IAA) production, phosphate solubilisation and ammonia production.They also exhibited antagonistic properties against phytopathogens in dual culture assays. Overall results suggested the prevalence of soil yeasts with potent plant beneficial characteristics and they could be formulated as PGPMs with further studies.

OR 2.10

Effect of temperature and humidity on the maximum concentration of fungal population in the potato plantation areas.

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Potato (*Solanum tubersum* L.) cultivar Kufri Jyoti was grown about one hectare in a local farmer's field in Imphal ($24^0 44^/$ N latitude and $93^0 38^/$E longitude) East areas. The Isolation of fungalspecies were carried out from the rhizosphere soil (healthy and diseased) and non-rhizosphere soil of potato plantation areas. The rhizosphere soil and non-rhizosphere soil mycoflora of potato plantation field in Imphal East areas were carried out by using dilution plate method for one crop season. Non-infected rhizosphere and rhizosphere soil mycroflora analysis revealed 10 fungal species. Out of which 2 belongs to Zygomycotina and 8 belongs toDeuteromycotina. The maximum number of fungal species were contributed by deuteromycotina. *Fusarium salani (23.30%)* showed highest population in non-rhizosphere soil whereas *Alternaria solani* dominated the fungal population in the rhizosphere soil (20.52%) and disease Rhizosphere soil (23.34%) respectively. The maximum concentration of fungal population was recorded in the month of February. The corresponding meteorological parameters recorded were temperature (24.7^0C, Min 6.7^0 C), relative humidity (85.6%), rainfall (0.6 mm) and wind speed (2.7 Km/hr).

OR 2.11

Selection and assessment of multi-trait rhizobacteria for bio-remediation of land previously loaded with biorefinery wastewater

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Effluent discharge from sugar industry in the fields is making farming difficult. The soil salinity level is becoming high with high toxic levels of Sodium, Calcium, Iron and other heavy metals. These affect the availability of several important nutrients to plants resulting in low yield. A total of 57 rhizobacterial isolates collected from saline fields of sugarcane were functionally characterized for salinity tolerance, indole acetic acid (IAA) production, phosphate solubilizing activities, siderophore production, and acid production. A pool of 12 rhizobacterial isolates was selected after functional characterization and was tested *in vivo* microcosm. A consortium of bacterial isolates (*Bacillus pumilus, B. licheniformis, B. marisflavi, B.amylosliquefaciens*) with potent arbuscular mycorrhizal fungal strains showed significant decrease of in total content of Na , Cu, Ca and Fe in soil compare to control and increase macronutrients and the growth parameters for plant. These consortia haveimmense potential for soil reclamation of distillery effluents as bio-remediator.

PP 2.1

Improving Seedling Development In Maize Through The Application Of Seed Endophytic Bacteria

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Endophytes are mutualistic microbes, such as bacteria and fungi, living inside the host tissues of plants without causing any symptoms of disease. Endophytic bacteria are now ubiquitous in almost all the plants and their parts, playing important roles in their growth and development. Seed endophytic bacteria are gaining considerable interest owing to their vertical transmission and close relationship with the developing embryo when compared to the bulk rhizospheric bacteria. Auxin production, phosphate solubilization, nitrogen fixation, etc. are some of the major functions performed by seed endophytic bacteria. The present study aims to explore the functional roles of the endophytic bacteria isolated from maize seeds in its seedling development. A total of 23 endophytic bacteria were isolated from different variety of maize seeds following surface disinfection. Molecular identification through 16S rRNA sequencing was done and the sequences were submitted to NCBI for obtainingaccession numbers. Bacterial isolates were further screened for their growth promoting traits viz. auxin production, phosphate solubilization, nitrogen fixation and extracellular enzyme production. Most of the isolates were found positive for auxin production, nitrogen fixation, phosphate solubilization while only few of the isolates showed extracellular enzymatic activity. Bacterial isolates were also screened for their antifungal activity through antagonism assays against different plant pathogenic fungi. The two isolates ZM1 (*Lysinibacillus* sp.) and ZM2 (*Paenibacillus* sp.) were further tested for their ability to improve seedling development in different varieties of maize (hybrid maize, baby corn and sweet corn) through re-inoculation experiments and the results showed an increase in root-shoot length, fresh weight and dry weight along with the chlorophyll pigments.

PP 2.2

Bacterial isolate *Bacillus pumilus* from sorghum seeds promote seedlings development and protect from fungal pathogens

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Seed endophytes reside inside the seed without showing any negative symptoms. They help plant and developing seedlings in various ways, and also directly protect them from fungal disease. Sorghum (*Sorghum bicolor* (L.) Moench) is an annual cereal crop belonging to poaceae family. The aim of the present study is to evaluate the role of bacterial isolate *Bacillus pumilus* on seedlings development and protection against fungal disease in sorghum. *Bacillus pumilus* was isolated from sorghum seeds and molecularly identified by 16S rDNA sequencing. *Bacillus pumilus* was evaluated for their plant growth promotion activities and antifungal activity against selected fungal phytopathogens including *Epicoccum sorghinum*, *Rhizoctonia solani, Alternaria* sp., *Fusarium* sp., *Curvularia* sp., *Colletotrichum* sp., *Exserohilum rostratum*. *Bacillus pumilus* showed auxin production in nutrient broth. *Bacillus pumilus* showed significant inhibitory effects against all the tested fungal phytopathogens. We have also extracted lipopetides from *Bacillus pumilus* which showed antifungal activity in disc diffusion assay against selected phytopathogens. Lipopeptides genes were also screened to confirm its gene in bacterium. By re-inoculation experiment, we found that re-inoculation of bacterial isolate *Bacillus pumilus* to the sorghum seeds play important role in seed germination, improving seedling development including increasing root and shoot length growth, fresh weights and root hair formation. Lipopeptides have very good antagonistic activity against fungal phytopathogens. By using fluorescence microscopy, we found that bacteria present on the root surfaces and in root parenchyma.

PP 2.3

Effect of *Trichoderma harzianum* IRRI-4 strain mutant on *Fusarium oxysporum*

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Trichoderma are good broad-spectrum bio-control agents which are mostly applied to the soil along with FYM. These have vigorous

growth, are cheap and are mostly green in colour. The *Trichoderma* taken here is *Trichoderma harzianum* (IRRI-4 strain).Mutation is a process of changing the genotype of a given organism by the use of chemical or physical mutagens. In *Trichoderma* mostly U.V radiation and Ethidium bromide is used. However, U.V mutation is cheap and is easy to be carried out. In this experiment *Trichoderma* was placed under the U.V lamp where the distance between U.V lamp and *Trichoderma* was kept constant(20 cm) while the time of exposure was made variable to 20 minutes,30 minutes,40 minutes and 50 minutes. A time gap of at least 5 minutes was kept between two adjacent mutation. By this process, 4 mutants were made from the pure culture of *T. harzianum*IRRI-4 strain. They were named as T1,T2,T3 & T4 according to the time exposure of 20 minutes,30 minutes,40 minutes & 50 minutes respectively.All these mutants along with the pure cultures were tested against *Fusarium* sp isolated from rice bean by dual culture technique. *Fusarium* which is an important soil borne fungus in Odisha condition causing mostly wilt diseases of crops.Control gave better result than T1 mutant. The mutant T4 gave best result when tested under dual culture method. This experiment can be well utilized to control the *Fusarium* pathogens.

PP 2.4
Physico- chemical properties of Rhizospheric Soil of wheat plant cultivated at Birbhum District of West Bengal and their correlation with fungal diversity

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Microbial diversity in rhizosphere is directly associated with various root exudations, nutrient content and also to environmental condition of the cultivated areas. In rhizosphere various types of fungal, bacterial and other microorganisms predominantly associated and interacting for increasing plant health and growth. The plant-soil interaction and other physical factors play selective pressures for the microbial communities in the rhizosphere. Type of cultivated crops is also found to have greater influence on the activity of soil micro-organisms. Fungi are an important component of soil microbiota, more in abundance than bacteria, and also depending on soil nutrient conditions and depth. Different soils have specific fungal flora, but the majority of species found in them are cosmopolitan. Fungi are fundamental for soil ecosystem functioning, especially in forest and agricultural soils where they play a key role in many essential processes such as organic matter decomposition and elemental release by mineralization and nutrient cycling. It was estimated 1.5million fungal species are present in natural ecosystems, but only 5-10% has been described formally.

Keeping the facts, the present investigation is to isolate mycoflora from different wheat fields cultivated at Birbhum district of West Bengal and their correlation with fungal diversity and their % contribution. All together 5 different wheat cultivated sites at different localities of Suri subdivision of Birbhum district was selected for present study. All together 24 fungal species of different taxonomic groups were isolated and identified of which genera of *Aspergillus*, *Penicillum*, *Curvularia*, *Alternaria*, *Verticillium*, *Rhizopus* and *Fusarium* are more common than other. The diversity of fungus was also found to vary from site-1 to site-5. Similarly the Organic carbon, Nitrogen, Phosphorus, Potassium, pH and Eelectrical conductivity were estimated in each sites and try to co-related the diversity of different fungi.

SESSION III : Microbes and Plant Health

LL 3.1
Arbuscular Mycorrhizal Fungi (AMF) for sustainable agriculture

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Arbuscular mycorrhizal (AM) fungi are most widespread symbionts colonizing more than 80% of the plant species. This symbiotic relationship promotes many aspects of plant life such as enhanced growth, stress tolerance, and disease resistance. AM fungi are utilized as biological substitute to chemical fertilizers and pesticides for maintaining quality and quantity in agro ecosystem and restoration. Use of AM fungal inocula offers cost-effective and non-destructive means to improve the soil health, crop productivity and yield quality.

As obligate biotrophs, they rely on soil based system either in field or pots which are often associated with other microbes. Rhizosphere soil of the host plant can be directly used as source of inoculum (colonized root fragments, AM spores and sporocarps) unless abundance, diversity and indigenous AMF are known. However, this might not be reliable source as spores may not be viable or may be parasitized. This can be overcome by setting up a 'trap culture' using a suitable host plant for multiplication of viable propagules and production of monospecific cultures. Monospecific cultures contain a known AM species and a suitable host grown together in a sterilized me-dium (soil/ sand).

Non-soil based system include *in vitro* systems involving the use of Ri T-DNA transformed plant root organs (genetically modified with *Agrobacterium rhizogens*) to grow on media under sterile conditions. This includes disinfection of AM propagules (spores and colonized root fragments) using appropriate disinfectant and plating them on Modified Strullu and Romand (MSR). Once the germination is achieved, these propagules are associated with actively growing Ri T-DNA transformed roots for establishment of AM symbiosis.

OR 3.1
Multifaceted Action of *Bacillus altitudinis* and *Bacilllus pumilus* on growth promotion and induction of resistance against phytopathogens in crop plants

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Bacillus altitudinis and *B. pumilus* isolated from natural undisturbed environment of Darjeeling Hills showed plant growth promoting activities *in vitro* which include phosphate solubiliztion, IAA, Siderophore, HCN production, ACC deaminase activity as well as inhibition of various fungal root pathogens. Versatality of both the PGPR were tested in different crops following at least two different modes of application *viz* seed bacterization of *Cicer arietinum* , *Glycine max*, *Vigna radiata* and *Triticum aestivum* followed by drench application in the rhizospheric soil. Treatment with both the PGPR showed significant increase in growth of all the test crops with concomitant increment in soil acidic and

alkaline phosphatases and enhanced mobilization of total soluble phosphate in the rhizospheric soil. These PGPR could also suppress seedling blight caused by *Thanatephorus cucumeris* and sclerotial blight caused by *Sclerotium rolfsii* of test crops under pot conditions. Production of important PR proteins like Chitinase, â-1, 3-glucanase and Peroxidase suggested that these PGPR were indirectly involved pathogen inhibition by inducing innate defense responses of the treated crop plants. On the other hand enhanced accumulation of enzymes like Phenylalanine Ammonia Lyase after PGPR treatment and pathogen challenge away from the site of treatment suggested that these PGPR could possibly be involved in phytoalexin production leading to systematic induction of resistance in treated crop plants. Increment in the concentration of PR proteins and PAL activities were significantly higher in crops where both *B. altitudinis* and *B. pumilus* were applied jointly. Direct effect of both the PGPR were also seen when pathogen population in the rhizosphere were significantly reduced. The current investigation suggests that both *B. altitudinis* and *B. pumilus* are versatile in function and exhibited multifaceted mode of action for plant growth promotion and disease suppression. PGPR isolates with versatile attributes are ideal microorganisms for developing effective and eco-friendly solutions for sustainable agriculture.

OR 3.2

Arbuscular Mycorrhizal Fungal Association In *Rhododendron Barbatum* Of Shirui Hills, Manipur

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The spore density, species diversity and colonization patterns of arbuscular mycorrhizal (AM) fungi was assessed in the rhizosphere and root samples of *Rhododendron barbatum* (family Ericaceae) collected from different altitudes of Shirui hill of Ukhrul District, Manipur. Maximum (32.9%) spore population of AM fungi was recorded in lower altitude of the hill soils, while the minimum (10.2%) was observed in higher altitudes. A total of 8 AM fungal morphotypes were isolated from rhizospheric soil samples, out of which 3 AMF species belonged to the genus *Acaulospora*, 2 from *Glomus*, 1 each from *Funneliformis*, *Rhizophagus* and *Septoglomus.* The root samples examined were colonized by different structures of AM fungi and revealed Intermediate- type of AM morphology. The percentages of total root length colonization by AM fungi varied between the samples collected from different altitudes. The AM fungal variables also varied significantly with the soil properties and were positively correlated with the AMF spore density.

OR 3.3

Effect of root endophytic fungal inoculation on growth and yield of Naga King Chilli (*Capsicum Chinense* Jacq.) Plants

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Phosphorus (P) is one of the major mineral elements that limit crop growth and yield productivity in most of the cultivable soils in North East (NE) India. However, the phosphates-solubilizing root endophytic fungi (RPSF) play a noteworthy role in increasing the availability of soil phosphorus and improving the crop yields. In view of this, the effectiveness of three phosphate solubilizing endophytic fungi such as *Talaromyces* sp. 1 (ST), *Aspergillus* sp. 2 (AP) and *Penicillium citrinum* (PC) were conducted individually to assess the seedling growth, fruit yield and tissue nutrient (N and P) contents of an indigenous cultivar i.e. Naga King Chilli (*Capsicum chinense* Jacq.) in sterilized field soils under nursery conditions of Manipur, NE India, along with four different treatments of bioinoculant (CN- Control, T1- ST, T2- AP, T3- PC) with five replicates each. No microbial inoculums were added in control treatments. Maximum shoot length, leaf number and shoot fresh and dry biomass were recorded in T1 (ST) treated pots, whereas that of root length, root fresh and dry mass were higher in T2 (AP) plants compared to other treatments and uninoculated control. Similarly, the fruit yield and early days of flowering were also observed in T1 (ST). The percentage of total root endophytic colonization (TEC) and microbial inoculation effect (MIE %) were highest in T1 (ST) treated pots and had significant differences among the studied treatments ($P > 0.05$). The tissue nitrogen (N) and phosphorus (P) concentration were highest in the chilli plant shoots and roots that were treated with ST and AP, respectively. Thus, our results revealed that the plant associated root endophytic fungi have the potential phosphate-solubilizing abilities, possess significant plant growth enhancement traits and can be used as microbial biofertilizers.

OR 3.4

Screening of wheat germplasm for resistance against spot blotch disease and analysis of defense mechanisms

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Spot blotch of wheat caused by *Bipolaris sorokiniana* is one of the most important diseases of wheat. Among the tested 115 wheat genotypes**,** CWL-6702 was found to be highly susceptible on the basis of serological assays and disease reactions. Highly susceptible genotype (CWL 6702) was further selected for induction of resistance using bioinoculants against *B. sorokiniana*. Talc based formulation of *Bacillus methylotrophicus* (NAIMCC-B 01492), a potent PGPR was applied both as seed treatment and foliar application, while wheat bran based formulation of *Trichoderma asperellum* (NAIMCC-F-01963) and mass multiplied *Glomus mosseae* were used as soil application. Combination of all three formulations were found to be most effective in disease reduction. Time course accumulation of chitinase (CHT), â-1,3 glucanase(GLU), peroxidase(POX) and phenyl alanine ammonia lyase(PAL) increased markedly in treated plants in comparison to healthy control following 12, 24,48, 72 and 96 h of challenge inoculation with *B. sorokiniana*. Accumulation of p-coumaroylagmatine (phytoalexin) in treated and inoculated plants were analysed by HPLC. Immunolocalization of chitinase in bioinoculant treated and pathogen inoculated leaf tissue was further confirmed by transmission electron microscopy using PAb of chitinase and gold labelled conjugates.

Microarray and bioinformatic analysis for comparing gene expression revealed a total number no of 461 and 1761 genes were differentially expressed in pathogen inoculated and bioinoculants +pathogen treated wheat genotype in comparison to control where 284 and 1541 genes were up regulated and 177 and 220 genes were down regulated. Among the up-regulated genes, most significant ones were those of pathogenesis related protein 10, Phenylalanine ammonia lyase, â-1,3 glucanase,

peroxidase, pathogenesis-related protein 4. Further, relative expressions of defense genes as well as genes involved in phytoalexin biosynthesis were analysed by real-time PCR with cDNA from leaf tissue. Expression of four defense genes encoding chitinase, â-1,3 glucanase, phenyl alanine ammonia lyase and peroxidase increased 2.42, 1.92, 2.19 and 1.75 fold respectively in *B. sorokiniana* inoculated plants whereas 2.98, 2.38, 2.70 and 2.25 fold in bioinoculant treated and pathogen inoculated plants within 48h than untreated healthy control. Expression of genes encoding chalcone synthase (CHS) and chalcone isomerase (CHI) involved in phytoalexin biosynthesis also increased 1.95 and 2.51 fold respectively in *B. sorokiniana* inoculated plants. However, bioinoculant treated and pathogen inoculated plants showed 2.74 and 3.13 fold increase in CHS and CHI respectively.

The present investigation may pave the way towards the possibility of exploring potential bioinoculants for their suitable bioformulations to develop disease management strategies.

OR 3.5
Arbuscular mycorrhizal fungal association in four medicinal ginger species of Manipur, North Eastern India

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The members of Zingiberaceae are well known for their medicinal and economical properties. We examined the occurrence and diversity of arbuscular mycorrhizal (AM) fungi in rhizosphere soils and the colonization patterns of AM fungal structures in the roots of four important medicinal gingers viz. *Alpinia allughas*, *Cucurma caesia*, *Cucurma longa* and *Hedychium coronarium* collected from Langol forest extension of Imphal West and Senapati District, Manipur, North Eastern (NE) India. A total of 23 AM fungal spore morphotypes belonging to seven different genera i.e. *Acaulospora, Claroideoglomus, Funneliformis, Glomus, Rhizophagus, Sclerocystis* and *Septoglomus* were isolated from the rhizosphere of studied ginger species. Maximum and minimum spore density of AM fungi was recorded in the 100 g root-zone soils of *C. caesia* (310 spores) and *A. allughas* (64 spores), respectively. The highest percentage of relative abundance (RA %) and isolation frequency (IF %) was recorded with the spores of *Funneliformis geosporus*. The distribution and species richness of AM fungal community was dominated by the members belonging to order Glomerales which was represented by 12 species. The examined root fragments of four ginger species had AM fungal colonization and intermediate- type of AM morphology. Total root length with AM colonization (%RLTC) was highest in *H. coronarium* (71.3%). Pearson's correlation analysis revealed the significant positive and negative interactions with some of the soil properties viz. pH with total AM colonization and %OC, N and K contents with AM spore density, respectively.

OR 3.6
Effect of arbuscular mycorrhizal fungi on nutrient uptake and growth of a medicinal plant *Coleus forskohlii*

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Coleus forskohlii Briq. (syn. *Coleus barbatus* Benth.) belonging to the family Lamiaceae is a well known plant throughout the country and known as 'Pashanbhedi' in Bengali, and 'Pathtchur' in Hindi is one of the most potential medicinal plants of the future, as its pharmacoproperties have been discovered only recently. Its tuberous roots are found to be rich source of forskolin which is being used as a remedy for hypertention, glaucoma, asthma, congestive heart failures and certain types of cancers and also being used as vegetables. In addition, forskolin is reported to have used in the preparation of medicines for controlling body weight, preventing hair greying and restoring normal colour of grey hairs. Its foliage is also employed in treating intestinal disorders and used as a condiment since a long time. Responses of an Arbuscular Mycorrhizal (AM) fungus, *Glomus fasciculatum* on phosphate uptake by the plant at different developmental phases have been studied. The result indicates that symbiotic association of mycorrhizal fungus amounts to greater uptake of phosphorus and increased chlorophyll content in AM treated plants than in non mycorrhizal plants which gradually happened to be maintained throughout their developmental stages. Different growth parameters like plant height, root length, no. of roots, no. of leaves, no. of branches, fresh weight of shoot, roots and tubers were significantly higher in AM treated plants than in respective controls. The better growth of mycorrhizal plants was attributed to improved nutrient uptake, especially phosphorous.

OR 3.7
Bioprospecting antimicrobial potential of endophytic bacteria from medicinal fern, *Ophioglossum reticulatum* L.

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Endophytic bacteria colonizing the internal tissues of plants are known to improve plant health by producing several metabolites. This study envisages bioprospecting of bacterial endophytes in perennial medicinal fern *Ophioglossum reticulatum* L. for their antimicrobial activity. A total of 20 phenotypically distinguishable bacterial endophytes were isolated from surface sterilized leaf lamina, petiole, rhizome and spike of *O. reticulatum* L collected from Darjeeling hills of West Bengal. The Shannon-Weaver diversity index showed that the rhizome (1.54) harbor more diverse types of endophytic bacteria than in its petiole, leaf lamina and spike. The endophytes were screened for the production of antimicrobial metabolites following cross-streak and agar-cup assay methods using a number of test organisms. The potent endophytic bacterial isolate OPL 19 was identified as *Bacillus safensis* (GenBank accession number KY029081) following morphological, physio-biochemical and 16S rDNA analysis. The antibacterial antibiotic produced by the isolate in tryptic soy broth was isolated from the fermented medium in ethyl acetate and partially purified by preparative TLC. The antibacterial compound produced by *Bacillus* OPL 19 was found to be relatively thermostable, non-polar and lipoidal in nature showing distinct absorption peaks at 220 and 235 nm. In addition it showed broad spectrum of activity inhibiting wide variety of Gram-positive and Gram-negative bacteria including *Acinetobacter baumannii, Bacillus subtilis, Cellulosimicrobium cellulans, Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus* etc. This study not only indicated the endomicrobiota as a potential resource for novel antimicrobials but also highlighted the fact that the therapeutic properties of *O. reticulatum* L. could be correlated with its inherent endophytic association.

OR 3.8
Isolation and bioactive potential of fungal endophytes associated with medicinal plant *Acmella paniculata* (Wall. Ex Dc.) R.K.Jansen

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Microorganisms play a very important role in the environment. Endophytes are the group of microorganisms that live inside the plant tissues without causing any harm to the host plant. Endophytes signify an eco-friendly option for serving as sustainable resources of novel bioactive natural products. *Acmella paniculata* (Wall. ex DC.) R.K.Jansen (Syn.- *Spilanthes paniculata*) belonging to Family Asteraceae is an important medicinal plant distributed in the tropical and subtropical regions all over the world with rich source of therapeutic and medicinal constituents. Popularly, the plant is known as "toothache plant" which reduces the toothache. The present investigation was focused on isolation and characterization fungal endophytes from *A. paniculata* and selected isolates were screened for their antimicrobial activity. A total of 171 isolates of endophytic fungi assigned to 10 representative morphotypes, including six genera i.e. *Aspergillus, Trichoderma, Curvularia, Diaporthe, Penicillium, and Fusarium* were found and three Mycelia Sterilia forms were also obtained from leaves, stems and roots of *A. paniculata.* Endophytic colonization frequency was found to be higher in leaves (97.14%) as compared to stem (87.14%) and root (60%) samples. Antibacterial activity was determined using the agar disk diffusion method against the gram-negative *E.coli* and *P. aeruginosa*; gram-positive *B. Subtilis* and *S. Aureus* bacteria with inhibition zone diameter ranging from 7.0-19.4 mm. Among the tested fungal strain, the endophytic fungi *Penicillium sp.* was isolated from the leaves of *A. paniculata* exhibited the strongest antimicrobial activity against *E.coli* with inhibition zone of 19.3±0.4 mm where as lowest inhibition is found also in *Penicillium sp. against P. Aeruginosa* with inhibition zone of 7.0±0.0 mm. The outcome of the study provides scientific evidences for endophytic fungal association with medicinal plant *A. paniculata.* Moreover, present data suggest that various endophytic fungi of *A. paniculata* could be exploited as sources of novel natural antimicrobial products.

OR 3.9
Isolation, identification and evaluation of antifungal and enzymetic activities of endophytic fungi isolated from *Anaphalis contorta* (D.Don) Hook. F., A medicinal plant from Manipur

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Endophytic fungi constitute an important part of microbial diversity and also the most unknown group. Endophytic fungi have unique genetic and biological systems to produce many bioactive compounds. In the present work,endophytic fungi were isolated from *Anaphaliscontorta* Hook, an important medicinal plant locally used by the people of Manipur. Major plant portions viz, leaf, stem, flower and root were used for isolation.In the present study a total of 28 fungal isolates were identifiedupto genus, which belongs to Dothideomycetes, Sordariomycetes, Eurotiomycetes, Zygomycetes and Euascomycetes using cultural and morphological features and 1 isolate was found to be sterile. All the isolated fungi were tested for antagonistic activity against a pathogenic strain of*Curvularialunata* and grouped under 5 antagonism classes. Five fungal isolates showed class 1, 3 isolates showed class 2, 11 isolates showed class 3, 10 isolates showed class 4 and none of the isolates showed class 5. All the isolates were also tested for the production of extracellular enzymes viz, protease, lipase, amylase, cellulase and laccase. Twenty six fungal isolates produce protease -enzyme, 26 isolates produce lipase, 28 isolates produce amylase, 28 isolates produce cellulase and 21isolatesproduce laccase. The present study reveals that endophytic fungi are abundantly harboured in all parts of the plant. The antagonistic activity suggests an important source of antimicrobial compounds as well as effective biocontrol agent. The production of extracellular enzymes shows a high potential for clinical microbiology and production industry.

OR 3.10
Evaluating the dependency of some chilli cultivars on microbial biofertilizers

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Chilli (*Capsicum annuum* L.) is one of the major vegetables cultivated throughout the world which is consumed for cooking and green salad. In India its cultivation is based on inorganic inputs however, their indiscriminate usage is creating negative effects on human health, environment and soil heath. Application of biofertilizers as gained tremendous importance during last few decades to achieve sustainable crop production. *Azotobacter*spp.as nitrogen fixers and phosphate solubilizers like *Acenetobacter* are most studied plant growth promoting microbes. In the present investigation, two chili cultivars, JK Divya as hybrid and Bhulaxmi as an open pollinated cultivar were used to evaluate their level of dependency on *Azotobacter* and PSB. The allocation of nutrients with incremental dose of inorganic fertilizers in bioinoculated and uninoculated plants were determined. Nitrogen dependency of JK- Divya and Bhulaxmi supplemented with *Azotobacter* revealed that physical attributes with 75% of recommended inorganic nitrogen was significantly at par with complete dependency on inorganic nitrogen fertilizer. Protein content indicated 25% replacement of inorganic nitrogen with *Azotobacter* application in JK- Divya and 50% in Bhulaxmi. The carbohydrate accumulation and chlorophyll content at 75% of recommended inorganic nitrogen with *Azotobacter* supplementation was significantly at par with full dose of recommended inorganic nitrogen fertilizer. The dependency of phosphorus fertilizer showed the fresh and dry biomass at 75% of recommended inorganic phosphorus with PSB was almost equal to full dose of recommended phosphorus except in case of leaf dry biomass of Bhulaxmi in which negative response was found. Flower initiation time was reduced with bioinoculation of PSB at 25% reduction of inorganic phosphorus fertilizer. Protein and carbohydrate content showed opportunity to save 25% of inorganic phosphorus with bioinoculation of PSB in JK- Divya and Bhulaxmi without affecting the yield.The phosphorus uptake by different parts of chilli revealed application of 75% inorganic phosphorus with PSB was significantly at par with complete dependency on Phosphorus.

OR 3.11
Efficiency of the microbial insecticides in comparison to the eco-friendly insecticides to debar *Epilachna* sp in Summer Brinjal

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Microbial insecticides are microbes derived unconventional *insecticides*,that could be applied in conventional ways to kill

insects. *Epilachna vigintioctopunctata* is a serious pest of summer brinjal which devours and skeletonizes the brinjal foliages leading to heavy loss in summer brinjal. Studies were conducted during March 2017-Aug 2017 and March 2018- August 2018 in summer brinjal with Strip plot design replicated twice with 18 treatments . The other treatments dealt with companion crops which is beyond the scope of discussion here. In order to discuss and evaluate the other pivotal treatments of this experiment i.e. efficiency of microbial insecticides and eco-friendly insecticides, microbial insecticides like *Bacillus thuringiensis kurstaki* (Btk) at 3gm/L for borer and *Beauveria bassiana* at 3gm/L for sucking pests are sprayed to the main crop brinjal with a knapsack sprayer when the pest population reaches ETL and observations of the pest populations of microbial pesticides treated plots are taken at the particular interval of time 0 days, 24 hours, 72 hours and 5 days after spraying of time both from the randomly selected 4 plants per plot of the main crop and thereby observations will be continued until the pest populations further reach the ETL level. . During March 2017- Aug 2017 , it was observed that *Epilachna* sp population crossed its ETL level on 10th May 2017 , the population being 1.428±0.011 per plant. Microbial insecticides was sprayed which showed sharp decrease in *Epilachna* sp population till 5 days after spraying . Both the microbial insecticides and the eco-friendly insecticides proved to be significant at 5% level during the 5th day after spraying. The population of the beetle population thereafter gradually rose when again on 3rd July 2017 the population (1.648± 0.008 per plant) crossed its ETL level . Microbial insecticides and eco-friendly insecticides were sprayed which showed alleviation of beetle population which also proved to be highly significant at 1% level after 48 hours of spraying. However, during the second year summer brinjal crop season , the *Epilachna* beetle population remained fairly uniformly low while, the population (1.521±0.003 per plant) crossed ETL on 7th June 2018 . Microbial insecticide sprayed proved to be more effective in comparison to the eco-friendly insecticides spraying. The population of the Epilachna sp after 24 hours, 48 hours and 5 days showed 1.499±0.010 , 1.524±0.005 and 1.469±0.003 per plants respectively in case of microbial insecticide spraying. Nevertheless ecofriendly insecticide spraying showed *Epilachna* sp population of 1.516±0.010, 1.537±0.005 and 1.445± 0.003 per plants respectively. While both microbial and eco-friendly insecticides proved to be non significant , yet on 10th July 2018, both the spraying proved to be significant at 1% level of significance.

OR 3.12

Efficacy of indigenous arbuscular mycorrhizae with plant growth promoting bacteria on yield of chilli grown in lateritic soil of Paschim Medinipur

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In modern agricultural system, organic farmingin term of mycorrhizalbiofertilization is now become an essential concept. Acidlateritic soil in south-west belt of Bengal is dry and infertile, deficient in available phosphorus, nitrogen and other essential macro and micro nutrients.Arbuscularmycorrhizal (AM) fungiare the symbiotic association between fungi belonging from the phylum Glomeromycota, receive photosynthates from host plant and provide them essential macro and micro nutrients, increase the growth and productivity.Plant growth promoting rhizo-bacteria (PGPB) include, nitrogen fixers (NFB) and phosphate solubilizers (PSB), act as mycorrhiza helper.In this experiment, chilli (*Capsicum frutescens*)was grown as test crop, inoculated with isolated indigenous AM speciesassociated with isolated NFB and PSB from lateritic soil.Experiment was conducted in both separated and combined treatments; compared for AM spore count, root colonization and growth and productivity of chilli. The productivity of chilli showed maximum in combined treatment of *Acaulosporadelicata* and PGPB. Also the AM spore count, root colonization found maximum in that treatment than others. Hence application of AM in low fertile lateriticsoil with PGPB may present better productivity in low cost organic agriculture.

OR 3.13

Phytochemical analysis and characterization of ethyl acetate extracted antimicrobial secondary metabolite produced by endophytic *Geosmithia pallida* (KU693285) inhabiting *Bruceamollis* Wall. ex Kurz.

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Endophytic*Geosmithia pallida* (KU693285)was isolated from*Bruceamollis* an endangered, traditional medicinal herb of North-east India. Endophytes are those microorganisms that inhabit healthy plant tissues asymptomatically without any immediatenegative effect on the host. They are of great importance for the plant as well as for human being. The present study was carried out to study the phytochemicals and the compounds present in the metabolite extracted from *G. pallida*. The ethyl acetate extracted secondary metabolite produced by endophytic*G. pallida* showed strong antimicrobial activity (zone of inhibition 23.93±0.12 mm) against *candida albicans*(MTCC 183). Flavonoids(7.89 g/100 g), terpenoids(3.69%), alkaloids (5.68 g/ 100g), saponin(4.19 g/100 g) were the phytochemicals present in the ethyl acetate extract of the secondary metabolite produced by *G. pallida*. The FT-IR spectrum of the bioactive metabolite showed bands at 3400 cm^{-1}, 2924.09 cm^{-1}, 2854.65 cm^{-1}, 1622.13 cm^{-1}, 1415.75 cm^{-1}, 1195.87 cm^{-1}, 1138.00 cm^{-1}, 1101.35 cm^{-1}, 651.94 cm^{-1}, 603.72 cm^{-1}. These bands correspond to the stretching vibration of alcohol,carboxylic acids, 1° amines, aromatics, alkyl halides, aliphatic amines, alkynes and alkyl halides.GC-MS analysis revealed the presence of 7 probable major volatile compounds in the bioactive secondary metabolite produced by *G. pallida*. The compounds were Phthalic acid, di(2-propylpentyl) ester; Nonadecane, 2,6,10,14,18-pentamethyl; Octadecanoic acid; Tetracosane; Acetic acid, 2-phenylethyl ester; Cyclooctasiloxanehexadecamethyl; Cyclononasiloxaneoctadecamethyl; with peak-area respectively 21488933, 6077466, 468476, 4299934, 4171805, 3515694 and 3116363.

OR 3.14

Mushroom Waste Amendment and *Trichoderma*–Primed Seed renders Efficient Prevention of Chickpea Charcoal Rot Disease

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Waste management is a global problem, particularly in the agricultural system. Used mushroom compost bags (mushroom waste–MW) are usually dumped after harvesting of mushroom and cause pollution in surroundings of the heap. To dispose–off agri–waste this study was designed to incorporate MW into a system for chickpea charcoal rot disease management.

Additionally, a beneficial microbe, *Trichoderma asperellum*, was delivered through seed priming. The 3–year field experiment conducted to determine the potentiality of MW on the survival of *Macrophomina phaseolina* (pathogen of charcoal rot) and to assess of the impact of MW on charcoal rot development in chickpea. Least population of *M. phaseolina* estimated in the rhizosphere of plants generated through *Trichoderma*–primed seeds (1.2–2.3 × 10^3 cfu). The charcoal rot epidemics started in late February and shoot-up in early March which was correlated with soil temperature kinetics. The larger difference in minimum soil temperature (4–4.5°C) and mean day temperature (5–6°C) helped in disease development. Charcoal rot in the *Trichoderma*–primed plots ranged between 1.1 and 3.9%. The plots applied with MW and sown with *Trichoderma*–primed seeds rendered 28.4– 36.3% greater yield compared to the control plots. Overall, the experiment indicates for suppression of chickpea charcoal rot with MW amendment. This is possibly due to enhancing the rhizospheric activity of beneficial microorganism. These findings enhance our understanding of charcoal rot epidemics and its effective management using MW coupled with a beneficial microbe, *Trichoderma*. The generated information could be used in uplifting the societal and economic status of farmers, and for optimising an integrated chickpea (or pulses)–charcoal rot–management program.

OR 3.15

Microbial consortiathe most powerful arsenal for plant disease Management in Pomegranate-special emphasis for wilt complex.

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Pomegranate (*Punicagranatum* L.), a high value crop is one of the important fruit crops in arid and semiarid regions known for its drought tolerance which thrives well in dry tropical conditions with marginal soils of low fertility. The fruit is symbolic for it cool, refreshing juice and valued for its medicinal properties. However the crop is under threat due to number of serious disease such as bacterial blight *X. axonopodis*pv. *punicae*), wilt due to *Ceratocystisfimbriata* anthracnose (*Colletotrichumgloeos-porioides* and leaf spot and severe fruit rotting due to *Alternariaalternata*, *Cercospora* sp. etc, *Pseudocercospora*sp. *Drechslera* sp. and *Spaceloma*sp. etc. Pomegranate wilt disease caused by different soil borne pathogens in pomegranate adversely affecting crop cultivation in all major growing regions of India. At present, the crop is severely affected by wilt pathogen and day by day, the wilting severity is increasing at faster rate even at initial stage. Soil borne diseases through chemical is not possible because chemical fungicides it will react up to 15 days to control the pathogens growth later same pathogens survive to other places for time bound and regain survive and attack on the root system in pomegranate. Biological control is a nature friendly approach that uses specific microorganisms, which interfere with plant pathogens to overcome the problems caused by chemical protection methods. Different bioagentsviz, fungal based bacterial based actinomycetes have the ability to control a range of pathogens under a variety of environmental conditions particularly in horticulture crops is being well worked. In search of novel strains of microbial consortia, containing Trichoderma strains bacterial strains and actinomycetes were isolated from rhizospheric soil of Pomegranate orchards in different pomegranate cultivation south-western region of Maharashtra and identified and developed microbial consortia. My talk deals with restructuring the crop rhizospheres for improving and sustaining the nutrient supply in the soils and enhancing the health and yield of crops through sustainable practices based on microbial technologies. By microbial technologies, we mean the principles of microbial ecology, which encompass inoculation of crops with beneficial microorganisms and the use of cultural practices that enrich indigenous beneficial microorganisms in individual agricultural fields.

There is an urgent need to promote integrated pest/disease management at a faster rate and it isdriven by emphasizing organically-produced food, conservation of biodiversity, unpolluted environment, and sustainable agriculture. Strengthening relationships among our societies through development,training, educationfor propagation of low-cost technologies would certainly help in the improvement of our farmers' economic situations and thereby eliminate the cycle of poverty.

PP 3.1

Isolation of lactic acid bacteria from Sauerkraut, A potent biocontrol agent

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Sauerkraut is a fermented product of cabbage caused by the action of Lactic Acid Bacteria (LAB) naturally present in air. Lactic acid fermentation increases shelf life of fruits and vegetables. It also enhances beneficial properties including nutritive value, flavor and reduces toxicity. Fully cured sauerkraut may be kept for several months in an airtight container at room temperature. Fermented fruits and vegetables can be used as a potential source of probiotics as they harbor several LAB such as *Lactobacillus plantarum*, *L. brevis, L. acidophilus, L. fermentum* etc. In the present study the main aim is to isolate LAB from sauerkraut produced in our laboratory which can be used as potent bio-control agent to control the fruit and vegetables spoiling pathogenic fungi.

The antibacterial activity of cabbage juice has been of interest to researchers with the activity been reported to be due to the glucosinolates degradation by-products found in the juice. Fermentation of the cabbage juice could enhance the bacteriostatic effect of the cabbage juice as acidified sodium chloride may be formed from the ferment. Such juice may have potential for extended use in the biopreservation of other foods. Production of sauerkraut is not an expensive method the perseverance of packaged foods using this isolated bacteria is a cheap, pocket friendly method. This is also eco-friendly as production of sauerkraut doesn't lead to any harmful wastes as cabbage is a bio-degradable object.

There is however limited information on the antimicrobial activity of fermented cabbage juice extracts to further gauge its possibility as a bio-preservative.(1)

In our study we have isolated one lactic acid producing bacteria from sauerkraut. The isolate is gram positive, rod shaped and grow optimally at pH 4.5 in MRS broth media. The bacterium was tested against the fungal pathogens isolated from rotten fruits of Apple and pear by cross streak assay method. It was observed that the growth of fungi was inhibited near the streak of bacteria and normal growth was observed in the opposite direction. A clear zone was observed when a filter disc dipped in cell free bacterial soup was placed in a fungal plate. This was due to the inhibitory effect of anti microbial compound produced by bacteri.

PP 3.2
Fungal endophytes in medicinal plants of Sikkim and screening for bioactive compounds

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Sikkim, a Himalayan state of India is rich in floral biodiversity and bestowed with abundant *medicinal plants*. Medicinal plants are also an integral part of ethnic communities in the state, who, from times immemorial has been using medicinal plants as a part of traditional medicines for the cure of various ailments. These plants are a valuable source for bioprospecting fungal endophytes. Over 50 medicinal plants which are endemic and non- endemic to the region with high medicinal properties used by local people have been selected in the present study to isolate fungal endophytes. Endophytes isolated from various medicinal plants are subjected to morphological characterization and molecular identification. A total of 120 fungal endophytes belonging to 15 genera were isolated from healthy leaf, stem, seed and root segments of 15 medicinal plants of the region. As Endophytic fungi are believed to be a treasure house of structurally and biologically unique natural products, the main focus of the present study is characterization of bioactive compounds and to generate metabolite profile of the endophytic fungi of medicinal plants of Sikkim.

PP 3.3
Plant growth promoting rhizobacteria of *Piper nigrum* L.

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The rhizosphere contains many useful microorganisms for plant growth. In both managed and natural ecosystems, beneficial plant-associated bacteria play a key role in supporting and increasing plant health and growth. Rhizospheric bacteria are involved in various biotic activities of soil ecosystem to make it dynamic for nutrient turnover and sustainable for crop production. The rhizosphere is a hot spot of microbial interactions as exudates released by plant roots are a main food source for microorganisms and a driving force of their population density and activities. In this study, PGPR from the rhizosphere of *P. nigrum* were isolated and screened for PGP traits such as siderophore, phosphate solubilisation, IAA and ammonia. Out of 34 bacterial isolates screened, 31 were positive for siderophore, 16 for phosphate solubilisation, 20 for IAA and 23 for Ammonia. Two isolates (N16 and N17) were found to exhibit antagonistic activity against *Colletotrichum gloeosporioides* that cause anthracnose disease in *P. nigrum*. These two isolates can be used as bioinoculants for better yield and production of *P. nigrum* and other crop plants.

PP 3.4
Heat stress responses in wheat and its alleviation by plant growth promoting rhizobacteria

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Climate change with rapid acceleration of temperature isimparting negative impact on global crop production and compromising food security worldwide. Plains of South Asia where the rise inminimum average temperature over most of the year already affecting wheat production.High temperature was responsible membrane injury and damaged chloroplast ultrastructure and alsoinduced the accumulation of ROS in plants.The present study was aimed to explore means of stress alleviation imposed by elevated temperature usingplantgrowth promoting rhizobacteria (PGPR).Seeds of two Wheat (*Triticum aestivum*) cultivars were primed with two potential PGPR *Bacillus safensis* and *Ochrobactrum psedogrignonense* and effect of PGPR priming onthemotolerance of primedplants was observed. As defence reaction plants in turn activated antioxidant signalling which increased redox enzyme activity and accumulated osmolytes.Seed priming with these two bacteria significantly modulate antioxidative signaling and induce tolerance in wheat plants at optimum as well as elevated temperature. Differential expressions of heat shock proteinswere also studied. PGPR mediated amelioration of heat stress seems to be associated with less ROS production, membrane damage, maintenance of chloroplast structure and photosynthetic efficiency, increased expression of array of redox enzymes and accumulation of osmolytes thus improved overall thermotolerance.

PP 3.5
Diversity and distribution of fungal endophytes in three medicinal plants growing in natural condition of Manipur

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Endophytes constitute an important component of microbial diversity. In the present study, endophytic fungi associated with healthy plant tissues of leaf, stem and flower of three potential medicinal plant species viz. *Ocimum basilicum*, *Elsoltzia ciliate* and *Leucus aspera* belonging to the family *Lamiaceae*, growing in natural habitats of Nambol, Bishnupur District, Manipur, North East India, during the month of June- November, 2018, were isolated. A total of 310 endophytic fungal isolates belonging to 11 genera (*Alternaria*, *Aspergillus*, *Cladosporium*, *Curvularia*, *Colletotrichum*, *Epicoccum*, *Gliocladium*, *Nigrospora*, *Penicillium*, and *Trichoderma*) and 25 species were recovered from 450 tissue fragments and were identified based on morphological characteristics. The isolation rate (IR%) of endophytic fungal communities were highest in stem (50%) fragments followed by flower (31%) and lowest in leaf (19%). Whereas, the colonization rates (CR %) was maximum in *O. basilicum* (71%). Among the plant species distribution of endophytic fungal genera were different. *Cladosporium* (7 species) was found to be dominant, followed by *Nigrospora* (4 species). The findings revealed the maximum relative abundance (% RA) with *Cladosporium* sp.3 (20.4%) and isolation frequency (% IF) with *Nigrospora oryzae* (32.5%). The richness of endophytic fungal species was also high in *O. basilicum* (17 species) as compared to other studied plants. Host specificity was observed for few fungal endophytes. The diversity indices of endophytic fungi identified from different medicinal plants and tissue segments varied significantly (P>0.05). The present finding is an important step in the study of diversity of endophytic fungi associated with medicinal plant species.

PP 3.6
Phosphate solubilizing bacteria and their Antagonistic activity against phytopathogens of *Curcuma longa* L.

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Phosphorus is an essential element for all forms of life, including plants. It is found in soils both in organic and inorganic forms (complexes with other elements) and its solubility is very low. Phosphate solubilizing bacteria are capable of converting insoluble phosphates into bioavailable forms through solubilization and mineralization processes. This ability is considered to be one of the most important traits of plant growth promoting rhizobacteria in regulating plant-phosphate nutrition. In the present study, attempts have been made to isolate and screen the potent phosphate solubilizing bacteria from the rhizosphere of *C. longa*. 33 isolates were purified, screened *in vitro* for their phosphate solubilizing efficacy and the amount of soluble phosphates was quantitatively estimated. *In vitro* antagonistic activities of selected PSB were also tested against *Colletotrichum gloeosporioides* and *Pythium* sp. Out of 33 isolates tested, 14 were positive for phosphate solubilizing activity. Isolate IJ2 was found to have the highest phosphate solubilizing ability (38.63 ppm) after an incubation of 5 days. It has also been found that 2 isolates (IJ2 and IJ10) exhibit antagonistic activity against the tested phytopathogens. Isolates IJ2 and IJ10, therefore, with both phosphate solubilizing ability and antagonistic activity may have probable use as bioinoculants for improved yield and health of *C. longa* plant, sustainably.

PP 3.7

Diversity of endophytic fungi associated with three medicinal plants of Zingiberaceae Family

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The present study was focus on the occurrence and distribution of diverse endophytic fungi from healthy plant parts of *Alpinia galangal, Zingiber officinale* and *Zingiber montanum* members of Zingiberaceae family which are traditionally used for their medicinal values. The sample plants were collected from Langol forest extension, Imphal West District, Manipur, North Eastern (NE) India. A total number of 254 fungal isolates (85 from *A. galangal*, 91 from *Z. officinale* and 88 from *Z. montanum*), belonging to twelve fungal genera could be isolated from six hundred seventy five segments of leaf, rhizome and stem part of these plants. The colonizing frequency (%CF) were 37.78%, 40.44% and 39.11% for *A. galangal*, *Z. officinale* and *Z.montanum,* respectively. Different fungal isolates belonging to *Alternaria, Aspergillus, Cladosporium, Colletotrichum, Curvularia, Fusarium, Gliocladium, Nigrospora, Pennicilium, Phomopsis, Phoma* and *Trichoderma* were isolated from different parts of the selected plants. Isolates of *Colletotrichu*m sp. and *Fusarium* sp. were found to be associated with all the three medicinal plants. The highest percentage of isolation frequency (IF%) were recorded for *Fusarium* sp. (42.22%) and *Colletotrichum coffeanum* (33.33%) in *A. galangal*, *Fusarium xylariodes* (28.89%), and *Alternaria* sp. (24.44%) in *Z. Officinale* and *Colletotrichum* sp.(35.56%), and *Fusarium* sp. (37.78%) in *Z. Montanum*.

PP 3.8

Antibacterial and antioxidant potential of endophytic fungi isolated from Tulsi (*Ocimum sanctum*): An Indian medicinal plant

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Endophytes are the microbes that reside inside healthy plant tissues without causing any negative impact on the host. These includes bacteria, fungi, actinomycetes, algae, etc. reported from all plants examined and provide an effective protection to the concerned hosts against array of biotic and abiotic stresses. Recent findings have shown that the fungal endophytes are highly promising and important source of bioactive metabolites. The present study involves the isolation of endophytic fungi from India's queen of herbs Tulsi (*Ocimum sanctum)* and to assess their antimicrobial potential against plant and human pathogens. Qualitative assays were also done for the extracellular production of enzymes by the isolated fungal endophytes. For the isolation of endophytic fungi, leaves of *Ocimum sanctum* were collected from the Botanical garden of Banaras Hindu University. Total four fungal isolates (SL1, SL2, SL3, SL4) were isolated from healthy leaves. Morphological identification of endophytic fungi were done by microscopic methods using morphological characteristics including colony growth, color, texture, conidia, conidiophores and spore. Molecular identification was done by ITS rDNA sequencing using ITS1 and ITS4 primers. Fungal isolate SL2 was grown in PDB and secondary metabolites were extracted using organic solvent. DPPH antioxidant activity of secondary metabolite extracted from SL2 (*Aspergillus allahabadii*) fungus was done which showed positive result. Antimicrobial activity of extracted metabolite was also tested against human pathogens. Crystal formation was observed in the secondary metabolite derived from SL2 isolate. Further study is focused to do X-ray crystallography and nuclear magnetic resonance (NMR) spectroscopy to reveal the structure of pure compound.

PP 3.9

***In Vitro* antibiosis and efficiency of plant growth promoting rhizobacteria (PGPR) for the enhancement of bush cowpea (*Vigna unguiculata*) growth**

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Using chemicals in disease management are creating extensive damage to our environment. Now the situation is alarming and we need an effective substitute to combat this hazardous situation. In this context, PGPR are subject to be a fascinating agent in reducing the dependence on chemicals. The current experiment was conducted to evaluate the potential of PGPR for disease management and overall growth of the plant. Three bacterial strains (NIIST-D31, NIIST-D54 and NIIST-D63), isolated from the Malampuzha forest area of Palakkad district in Kerala and were examined for antibiosis activity against ten plant pathogens. The study indicates a reduction of the colony growth of the pathogens with the application of PGPR strains. The maximum inhibition was observed in *Alternaria solani* (63.0 mm ±1.73) followed by *Botrytis cinerea* (50.0 mm ±8.66). Later on, PGPR strains were tested for growth enhancement in bush cowpea plants. For this, pot experiment was conducted with individual strain e.g. NIIST-D31, NIIST-D54 and NIIST-D63, and in combination of strains e.g. NIIST-D31+NIIST-D54, NIIST-D63+NIIST-D54, NIIST-D63+NIIST-D31 and NIIST-D63+NIIST-D31+NIIST-D54 along with a control on bush cow pea. The impact of seed bacterization results in overall growth of the plant with increase in seed germination, shoot height, root length, fresh and dry weight. For example, a combination of NIIST-D63+NIIST-D31 showed highest shoot height (44.0 cm ±2.00) and NIIST-

D63+ NIIST-D54 produced highest root length (49.3 cm ±1.12). Furthermore, those plant which are inoculated with these PGPR strains looks green and healthy with greater chlorophyll content. The outcome of this investigation promised PGPR to be an effective agent in disease management strategies and overall development of the plant. Hence, further exploitation of these PGPR strains can be a milestone for developing a precise disease management program.

PP 3.10

Effectiveness of *Pseudomonas fluorescens* in the management of Early Blight disease of tomato

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Early leaf blight of tomato caused by *Alternaria solani* is one of the most destructive diseases, which causes considerable loss in tomato production. In the absence of resistant cultivars, management of tomato early blight disease has relied principally on application of synthetic fungicides. The use of biological control agents has been recognized as a viable option to synthetic chemicals in the disease management. The present study evaluated the effects of *Pseudomonas fluorescens* on tomato early blight disease and investigated the efficacy on the yield components and yield of tomato plants. The field experiment was laid in a randomized block design with seven treatments and three replications in subtropical climatic condition of West Bengal at Regional Research Sub-Station (R &L Zone), Bidhan Chandra Krishi Viswavidyalaya, Sekhampur, Birbhum, West Bengal, India during *Rabi,* 2016-17 and *Rabi,* 2017-18.Application of powder formulation of *Pseudomonas fluorescens* (Bio Cure B) 1.75 % WPas seed treatment @ 5g /kg of seeds and three foliar spray @ 3 kg /ha from 50 days after transplanting at 15 days interval recorded the disease reduction (44.33 %) and yield increase (37.52 %). There foliar spray @ 3 kg /ha from 50 days after transplanting at 15 days intervalrecorded the disease reduction (36.32 %) and yield increase (33.68 %). In both treatments there were no negative impacts over the population of natural enemies and soil beneficial microorganisms in tomato field.Findings of the present study demonstrated a promising approach of biological control of early blight disease with *Pseudomonas fluorescens.* Results of this work could be used as effective and eco-friendly strategy for the management of early blight disease of tomato.

PP 3.11

Biological control of fusarium wilt of chilli using *Trichoderma viride*

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Fusarium wilt of chilli caused by *Fusarium oxysporum f.sp. capsici* is one of the most destructive disease, which causes considerable loss in chilli production. Wilt is a soil borne disease which cannot be managed effectively through chemicals. There are limited resistant sources available against wilt pathogen in the germplasm of chilli throughout the world. Wide host range of the pathogen also increased the survival potential of the pathogen. The use of biological agents has been recognized as a viable option to synthetic chemicals in the disease management. The present study evaluated the effects of *Trichoderma viride* on chilli wilt disease and investigated the efficacy on the yield components and yield of chilli plants. The field experiment was laid in a randomized block design with seven treatments and three replications in subtropical climatic condition of West Bengal at Regional Research Sub-Station (R &L Zone), Bidhan Chandra KrishiViswavidyalaya, Sekhampur, Birbhum, West Bengal, India during *Rabi,* 2016-17 and *Rabi,* 2017-18.Application of powder formulation of *Trichoderma viride(Eio* Cure F) 1.15 % WPas seed treatment @ 5g /kg of seeds andseedling dip@ 5 g/1 of water and soil application @ 3 kg / ha at the time of transplanting and at the time of flowering recorded the disease reduction (62.45%) and yield increase (54.78%). Soil application @ 3 kg / ha at the time of transplanting and at the time of floweringrecorded the disease reduction (48.36.32 %) and yield increase (38.28 %). In both treatments there were no negative impacts over the population of natural enemies and soil beneficial microorganisms in tomato field.Findings of the present study demonstrated a promising approach of biological control of wilt disease with *Trichoderma viride.* Results of this work could be used as effective and eco-friendly strategy for the management of Fusarium wiltof chilli.

Session IV :Microbes and Human Health

OR 4.1

***In-vitro* susceptibility of different MDR strain bacterial isolates with silver nanoparticles**

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Silver nanoparticles (AgNPs) are prepared by chemical reduction method from a silver salt ($AgNO_3$) with milli -equivalent reducing substance and a capping macro-molecule. Dextrose has been used as reducing substance and Carboxy-methyl cellulose (CMC) or Polyvenylpyrrolidine (PVP) or Sodium citrate as capping substance. Generated AgNPs acquire a different materialistic behavior with potent pan-microbicidal properties constituting a robust core of aggregated unstable reduced silver atoms (Ag^O), stabilized by the macromolecule. Their higher antimicrobial action than ionic silver (Ag^+) is termed as “Bonus Effect” which represents higher permeability due to membrane damage for altered surface volume ratio and zeta potential, along with initiation of programmed cell death by excessive production of ROS. This mechanism is resistant-proof, universally synergistic with conventional antimicrobials for their higher permeability across damaged cell wall.

We tested in-house prepared, physically characterized various AgNPs, challenging with different multi-drug resistant (MDR) clinical isolates (*Pseudomonas aeruginosa,Klebsiellapneumoniae, Staphylo- coccus aureus*…) by conventional serial micro-broth dilution method. Synergism study of AgNPs were performed in automated susceptibility testing device (VITEK-2 Compact) in terms of “Resistant” to “Sensitivity” conversion of resistant antibiotics in combination with $1/4^{th}$. MIC effective concentrations of AgNPs . Results support the possibility of using AgNPs either alone or in combination of so called resistant antibiotics, in safe mode of application for combating super-bug infections.

OR 4.2
Two types of eumycetomas in a patient: A rarer of the rarest possibility

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Mycetoma is a chronic, slowly progressing granulomatous disease of skin and subcutaneous tissue, clinically manifested as a triad of tumification, multiple discharging sinuses and presence of grains in the discharge. Mycetoma is classified as eumycetoma caused by fungi and actinomycetoma due to filamentous bacteria. India is one of the countries in which mycetoma is endemic. Here we report an unusal case, first time in India as per our knowledge where a 60years old male farmer presented with double eumycetoma in different sites of same limb, discharging black and white grains. The patient presents with swelling and multiple discharging sinuses on left foot for 9years, started with small nodule. Same type of lesion developed in left buttock after 6 years of first lesion. There were history of two different traumatic injuries over the lesions. KOH microscopy and culture on SDA at 22^0 C were donefrom serosanguinous discharges of both sites. From the left foot, around 0.5-1mm, round, firm to hard, black grains were demonstrated by direct microscopy in KOH preparation. From the buttock around 300-400micrometer, soft, white, vermiform grains were demonstrated. Culture on SDA showed fungal growth provisionally identified as *Madurellagrisea* from foot and *Acremoniumspp* from buttock. The patient is now on oral Itraconazole 200 mg twice daily.Simultaneous double mycetoma is a rare presentation. Worldwide only two cases are found in literature. This is an example that in high endemic area mycetoma can present with all types of manifestations.

OR 4:3
Bio-control of aflatoxigenic aspergillus flavus strain as well as aflatoxin production through various fungal isolates of wheat rhizosphere

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Due to various root exudations, rhizosphere creates specific root microbiome by favouring growth and survival of various types of fungal, bacterial and other microorganisms. Due to increased nutrient availability, rhizosphere zone may treat as hot-spots for microbial abundance, growth and diversity. Microbial diversity is also varied from plant to plant because of variant root exudates production either in terms of its quality or quantity. In rhizosphere, varieties of symbiotic and antagonistic interactions are also continuously operated and maintained microbiome equilibrium. Microbes present in soil and rhizosphere are interacting in various ways for increasing plant health and growth as well as sometime it may produces different types of toxic compounds as well as several types of mycotoxic substances, known for detrimental of plant and human health. Among all mycotoxins, aflatoxins are one of the most important groups of mycotoxin mainly produced by *Aspergillus flavus* and *A. parasiticus* as secondary metabolites on several feeds and foods commodities. Chemically it is a difuranocoumarine derivative compound, having potent carcinogenic as well as mutagenic and teratogenic properties. Amongst all 17 structurally related aflatoxins B_1 is the most potent aflatoxin in terms of their mutagenecity.

Aflatoxins contamination in wheat grain is not only the storage problems but also it is associated with standing crops too where the rhizospheric isolates of toxigenic *Aspergillus flavus* strain acts as primary inoculums of stored grain contamination. For the management of aflatoxin production in wheat grains and other crops, reduction of source-inoculam i.e., reduction of richness of toxigenic *Aspergillus flavus* strain in rhizosphere is prime importance. Scientist from different discipline may apply some physical and chemical methods for combating the inhibition of aflatoxin production but have several limitations however; in recent past biological control methods are proven as best and safest approaches. It also maintains the ecological balance of rhizosphere microbial biota for crop sustainability. In the present investigation, for the management of aflatoxin production in wheat grain, several fungal antagonists' collected from wheat rhizosphere were screened out as antagonists of aflatoxigenic *A. flavus* as well as aflatoxin production under dual culture experiment.

OR 4.4
***In-vitro* susceptibility of multi-drug resistant candida albicans with silver nanoparticles**

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Silver nano particles have weak antimicrobial activities. After nano-conversion into reduced stabilized state, many heavy metals show wide range of antimicrobial activities, several folds higher than that of respective ionic state. Higher antimicrobial actions of silver nano-particles (AgNPs) are indicated by " physical parameters" like smaller size, triangular shape and higher zeta potential. Similar input can be obtained from "biological parameters" like increased antimicrobial actions or "Bonus-effect" between ionic and nano-state of equivalent heavy metal concentrations.

Citrate, polyvinyl pyrrolidone and carboxy-methyl cellulose capped AgNPs were prepared using dextrose as reducing agent. Difference of MIC values of nano-silver preparations and equivalent concentration of ionic silver solutions against reference strains & multidrug resistant clinical isolates *of Candida sp.* were determined by micro broth dilution method. A proposed hundred point scoring for different range of "bonus effect" was compared with scores for physical parameters and found almost equal for any particular family of microbe, irrespective of antibiotic resistance differences. Synergism study of silver nanoparticles with anti - fungal agents are performed by checker board method analysis. Results indicated that silver nanoparticles can be considered as better alternatives for managing highly resistant microbial infections.

OR 4.5
Adrenal gland as an organ of localization for histoplasma capsulatum: A mystery

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Histoplasmacapsulatum is a dimorphic fungi endemic in the central and southeastern America. Although India being non-endemic area for histoplasmosis, sporadic cases have been reported mainly from the eastern India. It flourishes in soil fertilized

by bird droppings. The birds themselves are not infected because of their high body temperature. Such soil appears to be the source of this fungal infection in human. The infection takes place by inhalation of microconidia, which are the infective forms due to their smaller size. After inhalation, it is subsequently converted into yeasts in alveolar macrophages in lungs. This may also occur when old foci of infection gets reactivated following immunosuppression. If the disease gets disseminated, all cells of reticuloendothelial system are involved, including those in liver, spleen, lymph nodes and bone marrow. Adrenal involvement is a very rare form of disseminated histoplasmosis, usually seen in immunocompromised patient. About 5% adrenal histoplasmosis have been reported from India. Here we report a series of nine cases of adrenal histoplasmosis in apparently immunocompetent persons coming from all over West Bengal within a period of eight months.

A total twelve patients came to Endocrinology department from October 2018 to May 2019 with intermittent abdominal pain and weight loss. Four of them also presented with diabetes mellitus and hyperpigmentation due to adrenal insufficiency. On CT-scan bilateral or unilateral adrenal mass was found in all patients. CT-guided FNAC material from adrenal mass were sent for histopathological examination and to the Microbiology department for fungal-stain, fungal culture and ZN-stain, AFB-culture.

Out of twelve cases, in nine cases intracellular yeasts morphologically resembling histoplasmosis were found in PAS and GMS stain. Three were confirmed by culture. Remaining two cases were diagnosed as tuberculosis and one case was undiagnosed. All nine patients survived on i.v. Amphotericin B and oral Itraconazole.

Although adrenal is not a part of reticulo-endothelial system, its predilection for histoplasmosis is a mystery! Is there any new intermediate steroid-synthesis ingredients serving as nutrient forbetter survival of Histoplasma or a genetically modified form of the same? In-vitro trial in near future may resolve these queries.

OR 4.6

Preservative potential of *Bunium persicum* essential oil nanoemulsion against fungal and Aflatoxin B_1 contamination of stored masticatories

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Bunium persicum essential oil (BPEO) exhibited preservative potential against fungal and aflatoxin B_1 contamination of stored masticatories and its efficacy was enhanced when encapsulated in chitosan as nanoencapsulating matrix. GC-MS analysis revealed ã- terpenine and cuminaldehyde as major compound. The BPEO completely inhibited the growth of toxigenic strain of *Aspergillus flavus* (AF-LHP-PE-4) along with 15 common food borne moulds and aflatoxin B_1 secretion at 1.2 µL/mL. Probable antifungal and antiaflatoxigenic mode of action of BPEO was assessed. Further, DPPH assay showed strong antioxidant activity of BPEO (IC_{50} = 7.36 µL/mL). *In situ* investigation after one year of storage showed BPEO completely inhibiting aflatoxin B_1 production without altering the sensory properties of stored food and also exhibiting high LD_{50} value (14584.54µL/kg) tested on mice. The nanoencapsulation of BPEO into chitosanvia ionic-gelation techniqueshowed enhanced activity and completely inhibited the growth and aflatoxin B_1 production at 0.8 µL/mL.

OR 4.7

Bacterial coat on Indian Cat-Fish : A clue for biofilm intervention on medical devices

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To find a strong biofilm-colonizer from natural source in order to inhibit further biofilm colonization by pathogenic bacteria, an interaction study with *Aeromonas jandaei*(MTCC-12967), derived from surface colonizer of Indian Cat-fish *(Arius thalassinus*) was performed. The extent of biofilm growth was experimented by dye extraction method and microtitre plate assay. Over a preformed *Aeromonas jandaei* biofilm, further biofilm formation by another strong biofilm forming microorganism, *Staphylococcus aureus* was assessed. Conversely, the growth and extent of biofilm formation of *Aeromonas jandaei*over*Staphylococcus aureus* was also assessed. Results showed that *Aeromonas jandaei*inhibits the formation of *Staphylococcus aureus*but reverse is not true. Biofilms are highly competitive communities and show anti-biofilm capacities by virtue of altered surface topography and hydrophobicity. The deciphering and control of anti-biofilm properties represent future challenges in human infection control in many medical devices like Catheter, Heart valves, contact lens and can be exploited as a biofilm preventive natural strategy.

OR 4.8

Scopes and limitations of applying silver nanoparticles as infection controlling agents

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Silver is known as weak antimicrobial agent. Their energized tiny particles containing robust cores of plenty reduced silver atoms (Ag^o) in colloidal state stabilized by large surfactant molecule as outer coat, have much higher anti-microbial action than silver ions (Ag+). Due to nano size range (1-100 nm) they have to enter into cell by endocytosis with higher probability of surface-volume contact ratio. For their high positive zeta potentials, silver nanoparticles (AgNPs) target more to the negatively charged cell surface of microbes. For oxidative burst by reduced silver atoms, lipid membrane integrity of cell is disrupted and programmed cell death is initiated for production of excessive ROS. Thus AgNPs have proved to be very potent, resistant-proof, non-specific antimicrobial agents including bacteria, fungus, virus and parasites. Yet present formulations for nano-silver particles have only restricted use for coating medical devices or treating surface wounds for their risk of cytotoxic effects on host cells by same mechanisms. Their spillage in environment may also cause ecological disbalance.

For combating major drug resistant parasitic infections, there is little scope for topical application of AgNPs, even if microbicidal effects are in-vitro demonstrated using AgNPs prepared by green synthesis methods. Very little drug can permeate across skin and may quickly degrade, being photosensitive and oxygen labile. Oral application of AgNPs are of no value for quick decapping by acid and enzymatic exposure. By using system tolerable reducing and homologous serum as stabilizing agents for AgNPs preparation, a potent, safe systemic usable non-conventional antimicrobial drug can be obtained. Our preliminary study for

preparing newer nano-silver formulations using human plasma indicated development of effective AgNPs by in-vitro studies which may spare endocytosis into host cells for failure of receptor-ligand binding by homologous capping molecules. Such novel AgNPs may not be effective on intracellular parasites.

OR 4.9

Nanoencapsulated *Pimpinella anisum* essential oil as green biocontrol agent for preservation of stored food commodities against fungal infestation, aflatoxin contamination and oxidative deterioration

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The study investigates encapsulation of *Pimpinella anisum* essential oil (PAEO) in to chitosan nanobiopolymer and bioefficacy against toxigenic *Aspergillus flavus*, aflatoxin B_1 (AFB_1) secretion and lipid peroxidation. Chemical characterization of PAEO through GC-MS exhibited anethole and estragole as major components. Nanoencapsulation of PAEO was done through ionic gelation and characterized by SEM, FTIR and XRD techniques. Biphasic release profile of PAEO from chitosan nanoemulsion indicates controlled delivery system. Nanoencapsulated PAEO exhibited significant fungitoxicity against 15 food borne molds and aflatoxin secretion. Inhibition of ergosterol biosynthesis and enhanced leakage of cellular cations depicted plasma membrane as target site of action of nanoencapsulated PAEO. Inhibition of methylglyoxal (AFB_1 inducing substrate) biosynthesis by nanoencapsulated PAEO suggested novel antiaflatoxigenic mode of action. Superior efficacy through *in silico* molecular docking against aflatoxin biosynthesizing genes such as Ver1 and OmtAsuggested biochemical and molecular mode of inhibition of aflatoxin biosynthesis. In addition, favorable safety profile, non-phytotoxic effect, *in situ* antifungal andantiaflatoxigenic efficacy in stored rice samples (model food system) suggest the possible recommendation of nanoencapsulated PAEO as an effective green biocontrol agent alternative to environmentally hazardous synthetic pesticides for protection of food commodities during storage.

OR 4.10

Antimicrobial effect of some major mangrove plants of Sundarban, Patharpratima, West Bengal

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The main objective of this study is to analyze the antimicrobial effect of leaf extracts of ten different mangrove plants of Sundarban, West Bengal. The plants used for the study were *Herittierafomes, Aegialitisrotundifolia, Avicenniaalba, Avicennia marina, Avicenniaofficinales, Rhizophoramucronata, Ceriopsdecandra, Ceriopstagal, Bruguieragymnorrhiza and Aegicerascorniculatum*. The extracts were made in three different solvents viz water, 95% ethyl alcohol and 80% acetone and their effects were tested on two gram positive bacteria, *Bacillus subtilis* and *Staphylococcus aureus* and two gram negative bacteria, *Escherichia coli* and *Klebsiellapneumonia*. The antimicrobial effects of the plant extracts were measured by measuring the inhibition zones following agar cup plate method. The extracts of *Aegialitisrotundifolia* and *Rhizophoramucronata* in all the three solvents showed antibacterial activity against *B. subtilis.* Acetone extract of *Herittierafomes, Avicenniaalba, Avicenniaofficinales* and *Bruguieragymnorrhiza* showed antibacterial effect against *B. subtilis*. The water and acetone extract of *Aegicerascorniculatum* and water extract of *Ceriopsdecandra* were found to be antibacterial against *B. subtilis*. Both water and acetone extracts of *Aegialitisrotundifolia* showed antibacterial activity for *S. aureus* whereas acetone extracts of *Avicennia marina*, *Rhizophoramucronata* and *Aegicerascorniculatum* inhibited the growth of *S. aureus*. Water extracts of *Aegialitis, Rhizophora* and *Aegiceras* showed effective bactericidal activity against *E. coli.* Both alcohol and acetone extracts of two most plants, *Aegialitis* and *Rhizophora* showed inhibitory effects on the growth of *K. pneumoniae*. The growth of *K. pneumoniae* was also inhibited by alcohol extract of *Herittiera* and water extract of *Avicenniaalba.* Hence, eight out of ten mangrove plants used for the study was found to have antimicrobial activity though the responses varies considerably with change in solvents used for extraction. Proper and extensive studies on the antimicrobial components present in different extracts can lead us to the development of drugs with less harmful side effects.

OR 4.11

Effect of synergistic activity of green nano particles against methicillin-resistant (MRSA) strains by Time-Kill Kinetics

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Nanotechnology is an emerging technological advancement in the present years due to its applications in medical science fields. Among the different types of nanomaterials, silver nanoparticles have proved to be an excellent antimicrobial agent. Herbal products have great efficacy against microorganisms with minimum side-effects. Multidrug resistant (MDR) bacteria are one of the most important current threats to public health especially those which are associated with nosocomial infections and community-acquired infections like methicillin-resistant *S. aureus* (MRSA). Antimicrobial resistant of microorganisms has paved the way for the application of nanoparticles and their nanocomposites as an alternative therapy. The present work focuses on the synergistic activity of green nanoparticles in comparison to silver nanoparticles as antimicrobial agents against MRSA strains by time-kill kinetics. Green nanoparticles were synthesized from *Curcuma longa* and *Azadirachtaindica*plant extracts by using different concentrations of silver nitrate ($AgNO_3$). The Ultraviolet–visible(UV-Vis) absorption spectroscopy was used to monitor the formation of nanoparticles and morphology of synthesized nanoparticles were determined by scanning electron microscopy(SEM).The antimicrobial sensitivity pattern of the MRSA strains were tested against green nanoparticles with comparison to standard antibiotics as per CLSI guidelines. The synergistic activity of green nanoparticles (*C. longa* and *A. indica*) at a concentration of 1/2 MIC showed the best result against MRSA strains in comparison to chemically synthesized silver nanoparticles and antibiotics. This study is an attempt in using green synthesized silver nanoparticles as potential antibiotics.

OR 4.12

Study of selected medicinal plants on biofilm inhibition–Penetration ability study

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A biofilm can be defined as a surface-attached (sessile) community of microorganisms embedded and growing in a self-produced matrix of extracellular polymeric substances. In the present study 107 clinical isolates were screened for biofilm producers. Antibiotic sensitivity pattern of all the isolates were studied. Common Indian medical plants *Curcuma longa* (Haldi), *Azadirachtaindica*(Neem), *Ocimumtenuiflorum*(Tulsi)*, Aloe vera, Allium sativum (*Garlic) were tested against all the positive biofilm formers and metabolic activity of the organism were tested after treatment. Later, one of the strong *Staphylococcus aureus*biofilm former was used to study the penetration ability of the two most effective plant extracts treated at 128*MIC to 2048*MIC on biofilm formation on polycarbonate membrane filter compared with standard antibiotic Vancomycin. The growth pattern of biofilm was morphological studied by scanning electron microscopy (FESEM) and Atomic force microscopy (AFM) along with colony forming units.

A total of 107 isolated were collected from various clinical materials. Out of which 36.44% were *Staphylococcus aureus*, 34.57% were *Acinetobacter baumannii*, 20.56% were *Pseudomonas aeruginosa* and 8.4% were *Escherichia coli*. Strong biofilm formation was seen in 53 (49.53%) isolates. The maximum biofilm production was seen in *A. baumannii* (67.56%). The $\log_{10}$ CFU/ml in *S. aureus* biofilms after standard antibiotic challenge was 3.74± 0.161 for Vancomycin and 3.97± 0.23 for *C.longa* after 24hrs treated biofilm at 2048*MIC. The $\log_{10}$ CFU per membrane for no-inhibitor control was found to be 5.23± 0.0007. AFM images were analysed to quantify from their height distributions to correlate the effects of ageing and antibiotic/ fractions administration to the different orders of moments of the biofilm distributions.

PP 4.1
Antifungal activity of Essential oils on *Aspergillus flavus* isolated from stored maize

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Aspergillus species are the most common fungi contaminating stored food commodities such as maize, peanuts, rice, and spices. These fungi being the major causative agents grow on varieties of susceptible food and feed crops. The use of plant based essential oils with antimicrobial properties has been a considerable interest to control and inhibit the growth of fungal pathogens and toxin-producing moulds. Therefore, in the present investigation, essential oils from five medicinally important aromatic plants viz. *Gaultheria fragrantissima* Wall, *Artemisia nilagirica* Clarke, *Curcuma longa* Linn, *Zingiber officinale* Roscoe and *Litsea cubeba* (Lour.) Pers were evaluated for their efficacy as antifungal agents against the growth of toxigenic *A. flavus* isolated from stored maize of Meghalaya. Antifungal activity of different concentrations of essential oils was evaluated by Poisoned food technique to determine the minimal inhibition concentration (MIC) and minimal fungicidal concentration (MFC). Among the five essential oils tested, essential oil extracted from *Litsea cubeba* showed high antifungal activity with complete mycelial growth inhibition at a concentration of 0.8µL/mL. The essential oils also exhibited free radical scavenging activity through DPPH (2,2-diphenyl-1-picrylhydrazil) assay as IC_{50}value ranged between 0.5 and 14.44µl/ml and are non-phytotoxic in nature during seed germination and seedling growth experiments with maize seeds. Based on the antifungal, antioxidant and non-phytotoxic potential, the tested essential oils may be recommended as plant based food preservatives.

SESSION V : Microbial Technology

LL 5.1
Process development for production of microbial exopolysaccharide: Petri plate to Pilot plant

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Polysaccharides are natural and biodegradable polymers that envelop the surface of most cells and have variety of biological functions.Recently there has been an increasing interest in extracellular microbial polysaccharides for food, pharmaceutical, and medicinal use. Xanthan, gellan, curdlan and dextran are the majorcommercially availablebacterial polysaccharides. Few fungal exopolysaccharides are also well known for their unique physicochemical properties and industrial potential.

Pullulan is one such commercially important fungal exopolysaccharide. Due to its unique physicochemical properties, pullulan has found applications in diverse industrial sectors. Pullulancapsules may be usedfor pharmaceutical and nutraceutical products. Its non-animal origin and GRAS status ensures safety and acceptability across diverse consumer groups. Despite large number of valuable applications, major constraints associated with fermentative production of pullulan are formation of melanin pigment, low yield andhigh cost associated with pullulan production. Hence, it would be highly desirable to develop a cost effective technology for pullulan production.

In CSIR-IMTECH, we have developed a process for pullulan production using an osmotolerant strain of Aureobasidium pullulans. Initially, the process was optimized in 5L fermenter and later it has been scaled up to 500 L fermenter. It was possible to obtain more than 80g/L pullulan after process optimization and scale up. The yield and productivity of our process is higher as compared to published literature. Moreover, the process of CSIR-IMTECH has been developed using inexpensiveagri-industrial residues and would result in significant reduction in the cost of production. Hence, our process is actually about creating wealth from waste

LL 5.2
Bacterial consortium for the biological control of fungal diseases caused by *Pyricularia oryzae* and *Fusarium oxysporum*

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In the last few decades' significant efforts to increase agricultural productivity has led to increased use of chemical fertilizers and pesticides,resulting in environmental pollution and human health hazards. Plant rhizosphere associated bacterial communities offer alternate strategies to reducesynthetic fertilizers and pesticides inputs leading to costeffective ecological sustainable ecosystem services. Rhizomicrobiome play key roles in nutrient acquisition and assimilation, secretion of phytohormones for plant growth promotion and production of antibiotics, secondary metabolites, and various signal compoundsfor the management of insect pests and diseasesin agriculture crops. In this background, the present research focused to develop beneficial bacterial consortium for the management of fungal diseases.

Twenty strains of 2,4-DAPG producing pseudomonads viz., *Pseudomonas fluorescens*, *Pseudomonas brassicacearum*, *Pseudomonas putida*, *Pseudomonascorrugata* and phenazine producing *Pseudomonasaeruginosa*and *Pseudomona schlororaphis*, and *Bacillus* spp. isolated from agricultural soil that exhibited antagonistic activity against broad spectrum fungal pathogens namely *Pyriculariagrisea* TN508, *Gaeumannomy - cesgraminis* DSM1463, *Fusariumoxysporum* DSM62297, *Xanthomonascampestris*DSM3586 and *Erwiniapersicina* HMGU155, *Fusarium graminearum* MML4005, and *Fusarium solani* MML4002 were identified. The *Pseudomonas* spp. and *Bacillus* spp. exhibited plant growth promoting traits, production of siderophores, hydrolytic enzymes and Indole acetic acid (IAA) and solubilisation of phosphate.Expression of antibiotic coding genes involved in the synthesis of antibiotic 2,4-DAPG in *Pseudomonas* sp. MSSRFD41 and phenazine-1-carboxamide (PCN) in *P. chlororaphis*MSSRFC15 in the co-existence of *P. grisea*TN508 and *F. oxysporum*MML4002 determined by quantitative Real Time–PCR (qRT-PCR) revealed the down regulation of *phlD* and *phz* genes controlled by global regulator gene *gacA*, particularly by fusaric acid producing *F. oxysporum* DSM62297. Based on these results, liquid formulation of a consortium of compatible beneficial bacteria was developed and evaluated. The bacterial consortium tested under *invitro* and *invivo* conditionsshowed significant reduction incidence of blast disease in millets and wilt disease in tomato compared to individual treatments and chemical control.

LL 5.3

Application of microbial consortium for bioremediation of opencast coal mine spoils

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Open cast coal miningthat involves a surface mining technique of extracting coal from earth by removing the top soil covering the coal seamis practiced in all the coal mines of Assam.It causes destruction of landscape, topography and alteration of land use pattern due to dumping of spoil soils in unplanned manner.It also leads to acid mine drainage (AMD) and heavy metal contamination in the soil.The heavy metals do not get degraded rather persists and get accumulated in the food chain forming complex toxic compounds causing oxidative stresses and altering protein structures and severely influencing the biological functions. The remediation of such acidic heavy metal polluted soil is important as they occupy large areas and make the soil unsuitable for agricultural and other human uses.The physico-chemical remediation technologiesare considered temporary alternatives because the heavy metals are not removed from the soil.The rhizosphere inforcement strategy that involves manipulation of rhizosphere of hyperaccumulator by incorporating efficient strains of microorganisms (AMF, PGPR etc.) to enhance the rate of phytoremediation. This technique is also known as “Mycorrhizoremediation”.In the present investigation we have used indigenous PGPR and AMF isolates which were best adapted to the polluted soil to remediate coal mine spoils of Assam.We havethus developed a suitable combination of indigenous, stress tolerant AM Fungi and PGPR and hyperaccumulator to improve efficiency of phytoextraction of heavy metals from contaminated soils in order to remediate them for future use.

OR 5.1

Effect of substrates and their size on Lignocellulolytic enzyme production and substrate degradation by *Pleurotus* spp.

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Pleurotus spp., commonly known as Oyster mushrooms are well known White rot fungi. They are cultivated on a variety of grass based substrates. In the present study, three *Pleurotus* spp. namely *P. citrinopileatus*, *P. sajor-caju* and *P. sapidus* were grown for 15 days under Solid State Fermentation (SSF) on grounded substrates of two different size range prepared from two locally available wild grasses namely, *Saccharum spontaneum* (SS) and *Neyraudia reynaudiana* (NR) and production of lignocellulolytic enzymes (laccase, cellulase and xylanase) and resultant substrate degradation were compared. The substrate size used in the study was: large size (0.85 -1.0 cm diameter; denoted as ‘ls’) and small size (0.5 to 0.85 cm diameter; denoted as ‘ss’).

All *Pleurotus* spp. showed higher laccase activity throughout the sampling period on ‘ls’ of both NR and SS in comparison to ‘ss’($p<0.05$). The highest laccase activity was 1129 IU/g in *ls*-NR while in *ls*-SS it was 1050 IU/g. The endoglucanase production by all *Pleurotus* spp.was much lesser (1.0-4.0 IU/g) and did not show any effect due to substrate or its size except a few instances. Substrate size showed a significant effect on xylanase production ($p<0.05$). In comparison to endoglucanase, all *Pleurotus* spp. produced fairly high amount of xylanase throughout the sampling period and it was always higher on‘ls’ (115-144 IU/g) than ‘ss’ (71-92 IU/g) of both NR and SS ($p<0.05$). Percent degradation of all lignocellulosic components was more in SS than NR on 5th and 15th day and so on the ‘ls’ than ‘ss’. On 15th day, all lignocellulosic components were degraded almost equally in ‘ls’ of both SS and NR with slightly more degradation of hemicellulose. Same happened on *ss*-SS but here the lignin degradation was slightly more whereas in *ss*-NR, the degradation of hemicellulose and cellulose was equal and about 2.0-2.5% more than the lignin.

OR 5.2

Intergeneric hybrid production between *Agaricusbisporus* + *Pleurotus florida* and evaluation of molecular, biochemical and nutritional parameters of the hybrids.

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Polyethylene glycol-mediated inter-generic protoplast fusion experiments were done between edible mushroom strains *A. bisporus* + *P. florida* with the aim to develop somatic hybrids with simple cultivation technique like *Pleurotus* parent and having superior qualitative and quantitative features of both the parent strains. Six (*PfAb*) somatic hybrid lines were raised between *A. bisporus* + *P. florida* and were screened by double selection method. Basidiocarp could be generated from five *PfAb* hybrids. Hybrids *PfAb* 3, *PfAb* 5 (without casing) developed basidiocarp in the simple paddy straw bed whereas *PfAb* 1 (without casing) and *PfAb* 2 and *PfAb* 4 (with casing) developed fruit bodies in special modified paddy straw bed. Hybridity of the resulting *PfAb* hybrids were confirmed by morphological, biochemical, molecular and nutritional parameter study. Morphological study included colony morphology, mycelial growth, hyphal traits and fruit body morphology like pelius diameter, stipe length and yield. In the barrage reaction test a dark pigmentation zone and a gap zone

were formed between different mycelial cultures which indicated incompatibility of the strains and hence proved hybrid nature. Two Isozyme (Malate dehydrogenase and Superoxide Dismutase) activities were analysed in *PfAb* hybrid lines which depicted polymorphism among the hybrids and their parents. Five ISSR primers amplified a total of 75 DNA fragments which ranged from 100-2900 bp in size with overall 92 % polymorphism in *PfAb* hybrids. Jaccard's proximity matrix and dendrogram derived from ISSR data depicted the genetic distance between the hybrids and parent strains. PCR amplification of the rRNA-ITS region produced bands ranging between 650-710 bp in *PfAb* hybrids and parents. RFLP analysis usingrestriction endonuclease enzyme (*Alu*I, *Eco*RI and *Hae*III) revealed polymorphism in restriction digestion profile of *PfAb* hybrids and parentstrains. Hence these proved the hybrid nature of the *PfAb* and *AbCi* lines. HPLC based sugar content analysis of hybrids and parents showed increase concentration of mannitol and trehalose in some of the hybrids. GC-MS based fatty acid analysis indicated increased concentration of unsaturated fatty acids mainly oleic and linoleic acid in the hybrids. So from nutritional point of view these hybrids will serve as a better nutraceutical compared to their individual parent strains.

OR 5.3

Production of protease by *Bacillus aerius*UB02 endophytic to carnivorous plant *Utricularia stellaris* L.f.

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Bacteria endophytic to carnivorous plants have long been explored for production of novel bioactive metabolites including several extracellular enzymes. *Bacillus aerius*UB02 (GenBank Accession no. MK 696417, MCC Accession no. 4132), an extracellularprotease producing bladder endophyte of *Utricularia stellaris*L.f. isolated in this laboratory was used for the present study. The isolate produced maximum protease in synthetic medium supplemented with casein after 36 h of growth (38.29 U/mg of protein). Glucose (2.2%, w/v) and ammonium chloride (1.2 g/L) served as the most suitable carbon and nitrogen sources respectively for enzyme production. Production was further enhanced with an inoculum density of 1.5%, CVF 1:10, temperature of 37°C, substrate concentration of 2.5% and pH 7.4. The enzyme was partially purified by ammonium sulphate precipitation followed by dialysis and lyophilisation and the optimum conditions for protease activity were determined. Maximum activity was detected at 40°C, pH 7.8 and 2% casein. The enzyme appeared to be thermolabile with loss of around 65% of its activity at 70°C. Kinetic studies indicated the K_m and V_{max} values as 6.81 mg/ml and 62.5 U/mg of protein respectively. The enzyme was also sensitive to Pb and Cd ions and protease inhibitors 1,10-phenanthroline and â-mercapthoethanol. The molecular weight of the neutral protease as determined by SDS-PAGE was found to be around 35 kDa. This study could be of help in understanding the role of endophytic bacteria in the nutrition of the host plants as well as commercial production of enzyme.

OR 5.4

Enhanced Yield of Oyster Mushroom (*Pleurotussajor-caju*) (Fr.) Sing.Cultivated on*Senna hirsuta*L.) Irwin &Barnebyas Nitrogen Supplementing Material in Arunachal Pradesh

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Two legume-based nitrogen supplementing materials, *Senna hirsuta*(L.) H.S. Irwin &Barnebyand powdered soyabeanmeal, *Glycine max* (L.) Merill were evaluated for their suitability and effect on the biological efficiency of*Pleurotussajor-caju* (Fr.)Singin anoutdoor cultivation trial in Arunachal Pradesh.*S.hirsuta*commonly known as Hairy Sennagrowsabundantly on roadsides, wastelands and most of the forest types in Arunachal Pradesh. Itdoes not find any economic importance in the region. *S.hirsuta*(sundried and chopped) was combined with paddy straw in1:4ratio. Soyabean meal was added at 0.5% on dry weight basis. Urea was used as standard inorganic nitrogen supplementing materialand applied @0.5%(w/v) prior to mushroom primordial initiation.The prepared substrates were inoculated with freshly prepared, 3-4 weeks old grain spawn @5% on wet weight basis by layering method. The yield data was compared with paddy straw as control substrate. For each treatment, 5 replicates were kept. The experiment was carried out in a semi-technical, outdoor mushroom house constructed out of cheap, locally available plant-based materials at cropping room temperature between 21 to 26^{0}C and relative humidity between 72 to 91%.The highest mushroom yield was recorded on *S.hirsuta* supplemented paddy straw that gave a Biological efficiency of 117.8 % ($p<0.05$). Early pinhead appearance (time taken for mushroom primordial initiation) and the maximumnumber of flushes werealso recorded in this treatment.Rest of the treatments gavecomparatively less mushroom yield. Evident on its effects on high biological efficiency and early pinhead appearance, *S.hirsuta* can be employed as a cheap, suitable, wild organic nitrogen supplementing material forcost effectiveoyster mushroom cultivation.

OR 5.5

Comparative analysis on the effect of various substrates on the growth, productivity and biological efficiency of *Pleurotusflorida*

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Edible mushrooms cultivation on easily available and suitable substrate is one of the most financially viable techniques for agro-waste bioconversion to produce protein-rich food with different medicinal values. The specific aim of this investigation was to find out the most efficient and suitable substratum by using four different substrates (paddy straw, saw dust, bagasse and grass) for *Pleurotusflorida* cultivation, taking into consideration of growth, productivity and biological efficiency. Specific parameters like mycelium running rate, development of fruiting bodies, cropping phase, productivity and biological efficiency of this mushroom were evaluated. In grass substratum, the total running of mycelium (10 days), maximum primordial formation (45, 38 and 29 in three flushes) and total numbers of fruit bodies (37, 32 and 20 in three flushes) were commanding. In

the grass substratum, fruiting body size was also higher as well as higher productivity (22.67, 18.33 and 14.31 %) and biological efficiency (157.41, 127.31 and 99.35 %) were also observed in all three flushes. The current study indicated that the various types of substrates affected mushroom growth, productivity and biological efficiency.

OR 5.6
Evaluation of extracellular amylase enzyme activities produced fromwild edible mushroom *Lentinus sajorcaju*

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Amylase is an important enzyme that can be utilized for various applications in juice processing, starch processing, desizing of textiles, paper sizing, detergent additives, utilization of waste biomass for valuable products, treatment of waste water and other fermentation processes including malting barley and bakery industries. The present study was conducted for screening, production and enzymatic activities of extracellular amylase produced by wild edible mushroom *Lentinus sajor-caju* collected from Lake chowmuhani marketof Tripura, Northeast India.In the growth media containing soluble starch a halo zone was formed around mycelial plug that confirmed hydrolysis of starch indicating positive activity of extracellular amylase enzyme. Maximum amylase production was observed after 6 days of incubation period.Extracellular amylase produced from *L. sajor-caju* exhibited highest activity at 50^0C temperature, pH 5.0, 1.4% concentration of soluble starch and at 20 minutes of reaction time. The present study revealed that wild edible mushroom *L. sajor-caju* can be used as a source of amylase enzyme for commercial purposes.

OR 5.7
Evaluation of lignocellulose degrading ability of termite gut bacteria

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Lignocellulose is the major component of the plant wastes in the form of agricultural and forest residues. It constitutes the most abundant but underutilized source of renewable organic biomass that could be converted in to energy source and chemicals production. A major challenge in the process of valorization of plant biomass is the presence of lignin which is considered recalcitrant structural biopolymers and subsequently classified as persistent organic pollutants. Termites are considered promising reservoir of microbial symbionts and hydrolytic enzymes for the bioconversion of lignocellulose. The present study was, therefore, carried out to isolate and screen bacteria associated with termite gut and screen them for production of extracellular hydrolytic enzymes such as cellulase, amylase, protease and lipase. The ability of isolates to degrade lignin modifying enzymes was also studied. A total of 12 phenotypically distinct bacterial isolates were characterized, out of which two bacteria belonging to genus*Bacillus* (identified based on phenotypic and 16s RNA sequencing) were screened and evaluated for degradation of paddy straw, domestic vegetable waste and forest waste under solid state fermentation. Cellulose, hemicellulose, lignin content and physiochemical characteristics of the compost was monitored at regular intervals. Scanning electron microscopic (SEM) and FTIR based analysis revealed changes in physical and chemical properties respectively of bacteria assisted degradation of biomass. Consortium of the isolates was found to be more effective in degradation than individual bacteria.

OR 5.8
Production and optimiztion of pectinolytic enzyme of a *fusarium oxysporum* isolated from *lathyrus* sp.

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Pectinolytic enzymes are one of important virulence factor for degradation of plant tissue by the fungal pathogen. These enzymes share 25% in the global sales of food enzymes and are used in various applications such as clarification of fruit juices, pulp, paper and textile industry, waste water treatment, and so on. In the present study, a *Fusarium oxysporum* isolate identified by rDNA sequencing and isolated from wilted *Lathyrus* sp. was tested for pectinase production. On pectin agar plate the isolate showed solubilisation index 1.43 after 5 days of growth. In surface batch broth culture the isolate was subjected to varying parameters of incubation conditions as time, pH, temperature, pectin concentration, different culture media, carbohydrate and nitrogen sources for optimal enzyme production. Crude pectinase obtained by filtering the fungal biomass was used and activity was measured by estimating amount of reducing sugar monomer released using dinitrosalicylic acid reagent after incubating the reaction mixture for 30 min. The enzyme activity was expressed as International Unit (U) which is defined as an amount of enzyme releasing one ìmole of reducing sugar per min per mg of protein. An optimal production of pectinase was observed when the culture was incubated for 7 days at 30°C producing up to 100 U of the enzyme. At pH range 5.5-7.5 isolate showed highest activity and activity also increased with increase in initial substrate (pectin) concentration from 0-5%. Among 10 different culture media studied maximum activity was observed in Czapek's Dox medium. In the medium when sucrose was replaced with other carbohydrates, maximum activity was obtained in presence of lactose (97 U); whereas nitrate salts are the nitrogen sources that showed maximum activity. Crude pectinase was also obtained by growing the isolate in solid substrates such as wheat bran, orange peel and sugarcane bagasses for 10 days and extracting with water. Maximum activity was obtained in wheat bran as 81 U. Thus the fungal isolate could be treated as an effective producer of pectinase enzymes with various biotechnological applications.

PP 5.1
Evaluation of plant growth promoting properties of bacterial isolates from rat-hole coal mine soil samples of Meghalaya for phytoremediation potential

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Coal mining areas are highlycontaminated with heavy metals such Cr, Ni, Cu, Zn, Cd and Pbraising a concern due to their toxic and non-biodegradable nature.Phytoremediationhas emerged as one of the technique for uptake of heavy metals as

it is an environment friendly andcost effective approach.However, the efficiency of phytoremediation processunder the high metal concentration conditions is affected by plant growth hindrance, hence using plant growth promoting bacteria can facilitate plant growthand also transform heavy metals into soluble and bioavailable forms andpromote phytoremediation. The present studies investigate the plant growth promoting traits of threemetal tolerant isolates (KH-CC, KH-12A and KH-16F) from rat-hole coal mine soil samples. Plant growth promoting traits such as production ofindole compounds, siderophores, ammonia, phosphate solubilisation, HCNproduction and catalase activity were studied in the present investigation. Production of hydrolytic enzymes was also screened being the most common mechanism used by microbes to inhibit the growth of pathogenicmicroorganisms. 16S rDNA analysis revealed theisolates KH-CC, KH-12A and KH-16F to be *Serratiamarcescens*, *Bacillus siamensis* and *Bacillusaltitudinis*. These isolates were further used for seed germination assay in plates using rice seeds. The preliminary screening revealed the isolates possesspotent PGP with hydrolytic enzymes activities indicating them to be promising bacteria foruse in phytoremediation approaches.

PP 5.2

Evaluation and assessment of shelf life of liquid substrates and talc formulation for mass production of native *Trichoderma* spp.

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The efficient management of foliar as well as soil borne pathogens makes *Trichoderma* one of the most used biocontrol agents in the world. Development of formulations with enhanced shelf life and broad-spectrum activity could pave the way of rapid commercialization of these beneficial microorganisms. Two native isolates of *Trichoderma* species (Tr Isolate 2 and Tr Isolate 5) were collected from paddy and groundnut rhizospheres respectively. Their vigorous growth in different culture media and profound inhibitory effects on two potential soil borne pathogens namely *Rhizoctonia solani* and *Sclerotium rolfsii* as observed in dual culture experiment were the basis of selecting these two isolates among all the seven other isolates collected from different crop rhizospheres for mass production. Present study deals with evaluation of nine liquid substrates and one talc based formulation. Colony forming units were counted following the serial dilution technique and a gradual reduction was observed over a period of six months. Among various liquid substrates put into test, Coconut water was observed to be the best for both of the isolates (Tr Isolate 2 and Tr Isolate 5) recording the maximum cfu count 170.00 x 10^7 cfu/ml and 99.00 x 10^7 cfu/ml of substrate in the first month respectively. So far as talc based formulations are concerned, the maximum count 44.33 x 10^7cfu/g was recorded in the first month in Tr Isolate 2. Similarly in case of Tr Isolate 5 the highest cfu count 48.00 x 10^7cfu/g was recorded in first month after inoculation.

PP 5.3

Bioinfluenced green conversion of graphene oxide to graphene nanosheets by using a novel fungus, *Alternaria alternata*

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Graphene is a novel class of material of significant interest withone atom thickness; possess exceptional electrical, thermal andmechanical properties. These extraordinary features offer greatpotential applications in different fields such as nanoelectronics, composites, fuel cells, super capacitor, surfactant as well assensors and catalysis.To meet the increasing demands for commercial production of graphene nanosheets, new eco-friendly better alternative “green” biological methods of synthesis are being discovered. Due to slower kinetics, they offer better manipulation and control over monolayer growth and their stabilization.Due to the toxic and hazardous nature of some of several chemicals commercial chemical approaches are less promising route for biological applications of the synthesized graphene. Therefore, the demand for the new, eco-friendly and easily scalable biosynthetic approaches for the synthesis of graphene nanosheets is mounting up. To serve this purpose of green synthesis, our research unveils the potentiality of a novel fungus, *Alternaria alternata* (Fr.) Keissl. (strain number: MAMP/C/51)to reduce graphene oxide to graphene nanosheet due to its high production rate and easy to scale up properties. The cell free culture filtrate of *Alternaria alternata* is first time applied to perform this job. Proper characterizations have been executed by various sophisticated instrumental techniques. In application part we have investigated the degree of biosafety of the reduced graphene oxide.So, in this study, a green approach to the synthesis of graphene nanosheets is reported using exfoliated graphene oxide as the precursor and a cell free fungal culture filtrate as the reducer.The method should find practical applications in bulk-synthesis of graphene nanosheets. Also, from all the toxicity endpoints, this newly synthesized nanosheets could be considered biologically safe.

SESSION VI : Host Pathogen Interaction

LL 6.1

Development of disease forewarning model for prediction of target leaf spot disease of tomato

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The tomato (*Solanum lycopersicum*) is one of the most widely grown vegetable food cropin the world after potato.Target leaf spot disease of tomato is caused by *Corynespora cassiicola*, is a serious and emerging disease in West Bengal, India. The biology of the pathogen, *Corynespora cassiicola* is highly weather dependent with adaptability capacity in various weather situations. Management of any disease and more importantly polycyclic diseases is dependent on developing management strategies based on the epidemiological aspects of spatial and temporal spread of the pathogen.The management of target leaf spot disease of tomato depends mainly onprophylactic application of fungicides. Excessive use of fungicides not only cause environmental hazards but also triggers thedevelopment of resistance race of the pathogen. A reduction in the number offungicide applications could be achieved by applying fungicides only whenconditions are conducive for disease development.

Weather based disease forewarning system and need based application of selective fungicides at righttime is the only management strategy that can be adopted by the farmers foreffective management of the disease. Keeping in all the points in mind, the present research work was aimed to study the predisposing weather factors associated with the onset and spread of *Corynespora cassiicola* and also for the development of region specific disease forewarning model for prediction of target leaf spot disease of tomato. Infection occurs during Oct-Nov to Jan-Feb. The target spot has been shown to occur at temperatures as low as 20^{0}C, and even at 28 to 32^{0}C with RH > 85 %. Based on avg. temperature and avg. RH, the algorithm based disease forewarning model was developed with (0-4 disease severity values DSVs) and after accumulation of 18 DSV(from the emergence), the disease will be appeared within 7- 14 days. The application of this algorithm based model could able to forecast the occurrence of initiation of TS leaf spot with 66.7% of success during 2011-12, 2012-13, 2016-17 and 58.3% of success during 2015-16, and 75% success during 2017-18 and 83.33% success during 2018-19. Whereas, this model could not efficiently explain the occurrence of TS leaf spot during 2013-14 and 2014-15. The overall success of the model in six years is 69.46%. The multiple regression analysis, multinomial logistic analysis, support vector machine and 1D convolution neural network (1d CNN) forewarning model were also developed to predict disease. Among these various models, 1d CNN was found to be highly effective for prediction of target leaf spot disease of tomato at various weather conditions and the accuracy percentage of this model was above 96%. The real-time data basedprediction models developed and validated with independent data set, from 2011-12 to 2018-19 would render themsensibly more important for prediction and timely management of this dreaded disease.

OR 6.1

Compatibility of Fungicides and insecticides against *Pythium aphanidermatum*, *Phytophthora parasitica F. sp. Nicotianae* and *Cercospora nicotianae* on tobacco

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Studies were conducted to evaluate the efficacy and compatibility of certain new fungicides with insecticides alone and in combination against *Pythium aphanidermatum*, *Phytophthoraparasitica*f.sp. *nicotianae* and *Cercosporanicotianae* in Virginia tobacco nurseries and planted crop. Among the recommended fungicides, carbendazim showed high compatibility against *Cercosporanicotianae* as it recorded cent *per cent* mycelial inhibition. It was followed by pyraclostrobin + metiram (76.39%) alone and in combination with imidacloprid (74.17%) and flubendiamide (72.78%). Cent *per cent* mycelia inhibition was recorded in fenamidone + mancozeb alone and in combination with emamectin benzoate and imidacloprid showing very high compatibility followed by metalaxyl + mancozeb + imidacloprid (96%) against *Phytophthora parasitica f. sp. nicotianae*. In case of *Pythium aphanidermatum* 100% mycelia inhibition was recorded in combination treatments i.e. (fenamidone + mancozeb) + emamectin benzoate, azoxystrobin + emamectin benzoate and (metalaxyl + mancozeb) + imidacloprid followed by (metalaxyl- m + mancozeb) + emamectin benzoate (93.33%). Other fungicides and insecticides combination were also found inhibitory at their respective recommended doses. Jar test results also indicated that all the recommended fungicides against *Pythium aphanidermatum*, *Phytophthoraparasitica f. sp. nicotianae* and *Cercosporanicotianae* were physically compatible with recommended insecticides at their recommended doses. All insecticides and fungicides alone and their combinations showed no phytotoxicity in nursery and transplanted crops even after 14 days of spraying.

OR 6.2

***Phytophthora* diseases of Orchids - An overview with Indian perspective**

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Orchids are economically high valued ornamental flowering plants, belongs to one of the largest plant families, *Orchidaceae*. They are commercially traded globally for a variety of purposes, such as ornamental plants, cut flowers and potted plants; medicinal products and food. At present, 29 199 species have been accepted. More than one lakh hybrids are available world over. Every year, new hybrids are being added. They exhibit huge diversities in flower size, shape and colours, and are famous for their longevity and exquisite appearance. They are, therefore, economically popular ornamental cut-flowers and potted floricultural crops worldwide. Although, orchids are naturally hardy crops unlike cultivated field and horticultural crops, however, they are not exceptional. Orchids are also aggravated with several biotic and abiotic stresses including viruses and nematodes during different stages of their commercial production. There are numbers of microbialbiotic stresseswhich cause serious losses to orchids. Among the biotic stresses, a disease frequently named as black rot caused by species of *Phytophthora* (and in some country by species of *Pythium*) is considered as one of the most threatening diseases of orchidaceae.Orchids are globally attacked by 10 species of *Phytophthora*. Among then only five (*P. palmivora* Butler, *P. nicotianae* Breda de Haan, *P.cactorum* (Leb. and Cohn) Schröeter, *P. multivesiculata* Ilieva et al., *P. Meadii)* are considered major destructive pathogens and frequently occurred on members of orchidaceae including Vanillas and rest five are not much important.In India, attention on *Phytophthora* disease of orchids has never been paid till the establishment of NRC for Orchids at Pakyong, Sikkim. The disease has been found to cause severe damage to *Cymbidium* and other orchids, mainly in Sikkim and Darjeeling hills.Based on morphological features, *Phytophthora palmivora* and*P. nicotianae*are thought to be present in this hilly areas and appeared to be major pathogen of the disease. Distribution and host range of the disease in the hill has been documented.

OR 6.3

Detection of *Sclerotium rolfsii* in tea roots and its management

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Among 18 varieties of tea tested against *Sclerotium rolfsii*, UP-8, Teen Ali-17/1154 and B-157 were found most susceptible while K1/1 and HV-39 were resistant. Polyclonal antibody was raised against mycelial antigen of *S.rolfsii*. The immunoglobulin fraction of the antibody was purified by ammonium sulfate precipitation and Sephadex column chromatography. Effectiveness of raising antibody against the pathogen was confirmed by agar-gel double diffusion test and optimization of antigen and antibody concentration was done using PTA-ELISA format. The pathogen could be detected in root tissues after inoculation with *S.rolfsii* using PTA-ELISA. Cellular localization of the pathogen was evident as bright fluorescence mainly in the epidermis, cortical and endodermal layers using PAb of the *S.rolfsii* with FITC. Attempts were made for effective integrated

management practices for seedling blight disease of tea using plant extracts (*Azadirachtaindica* and *Catharanthus roseus*), bio-control agents (*Trichoderma harzanium* and *T.viride*), organic additives (cow dung, rabbit manure and chicken manure) along with selected fungicides (thiodan and calixin). *Invitro*tests were effective in inhibiting the radial growth of *S.rolfsii.*Under pot culture conditions *T. harzianum* alone and in combination with neem cake, oil cake and *Azadirachtaindica* provided best effective management practices of seedlings blight in all the three modes of application *viz*., simultaneous, repeated and pot infection.

OR 6.4

Biochemical responses of tea plants to brown blight infection before and after treatment with hydrogen peroxide

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Eighteen varieties of tea were screened against *Glomerella cingulata* (Stoneman) Spauld&Schrenk, causing brown blight disease. Three tea varieties, one resistant (TV-30) and two susceptible (TV-22 and T-17) were selected for induction of resistance following application of hydrogen peroxide. Total and ortho-dihydroxy phenol content, peroxidase (POX) activity and isozyme profile were assayed in healthy and inoculated tea plants of these varieties. Time course activity profile of defense enzymes involved in phenol metabolism, that is, phenylalanine ammonia-lyase (PAL) and polyphenol oxidase (PPO) were also monitored during the infection process. It was found that activity of these enzymes were significantly higher in the infected tissues of TV-30 than in the other two varieties. After bioassay of the inducer, hydrogen peroxide, and determination of induction period, time course accumulation of peroxidase (POX), catalase (CAT), ascorbate peroxidase (APX), chitinase (CHT) and b-1,3-glucanase (GLU) were evaluated in plants following treatment with hydrogen peroxide. Assay of these enzymes were also done after induction with hydrogen peroxide in *G. cingulata* – inoculated tea plants. CHT and GLU accumulated more than POX and APX in all the varieties. On the other hand,level of CAT did not change to any significant extent in susceptible treated varieties, but increased significantly only in resistant treated variety. Pre-treatment with hydrogen peroxide was found to protect the tea plants from brown blight disease. Inoculation further stimulated the activities of these enzymes, which was greater in the incompatible reactions.

OR 6.5

Integrated application of botanicals, fungicides and bio-agents against anthracnose (*Colletotrichum truncatum)* of greengram to improve benefit cost ratio

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Greengram anthracnose caused by *Colletotrichum truncatum* (Schw.) Andrus and Moore have become one of the major diseases which cause major production problem in many countries. An experiment was conducted for two consecutive years 2013 and 2014 to develop an integrated management of anthracnose of green gram by using botanical, fungicide and bio agents combinely under natural field conditions with ten treatments and three replications. Before selection for field trial the individual treatments were tested in bio-efficacy in *in vitro* condition. From the field trials it revealed that combinations of single spraying of Propiconazole 25% EC @ 0.1% along with one spraying of garlic oil @ 0.15% with one spraying of *T. harzianum* @ 4g gave minimum disease severity (8.20%) with highest grain yield (7.89 q/ha) and highest Cost benefit ratio (4.37).This was followed by One spraying of Propiconazole 25 EC @ 0.1% with two sprayings of garlic oil @ 0.15% which gave 10.05% minimum disease severity, grain yield 5.99 q/ha) and Cost benefit ratio (2.52). From this study it is clear that the spraying of Propiconazole along with Garlic extract and *T. harzianum*was effective against anthracnose (*C. truncatum)*and which is also in affordable limits of the farmers.

OR 6.6

Activation of defense strategies of rice plants against *Drechsleraoryzae* using bioinoculants

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Rice (*Oryza sativa*) is the major source of nutrition, specially in Asian countries. In global food production, rice is second highest consumed cereal after maize. Rice is attacked by different groups of soil/air/seed and water borne pathogens, among those fungal diseases, brown spot of rice caused by *Drechsleraoryzae*reduces its annual grain yield production. Production of rice has been increased and to some extent the diseases have been controlled by using excessive agrochemicals to meet the global rice demands. Plants have their own resistance mechanism which can be activated and used as a strategy for control of diseases, and this is known as induced resistance. During expression of immunity in plants, first of all, the microbial molecules are recognized by the plants, which are then transduced through different pathways leading to responses, which in turn results in activation of defence reactions whereby the microbes are inhibited. This immunity can be triggered in the plants by elicitors both chemical or biological which keeps the plant primed against future pathogen attack by pathogens and pests. The present study was designed with an aims to explore the possibility of using beneficial bioinoculant, *Trichoderma harzianum* (PGPF) and arbuscular mycorrhizal fungi (*Glomus mosseae*), and potential plant growth promoting rhizobacteria (*Bacillusaltitudinus*) isolated from rhizosphere of rice cultivars grown in West Bengal and Sikkim hills for management of brown spot disease caused by fungal pathogen (*D.oryzae*).Induction of immunity in rice plants by joint inoculation of bioinoculants (*T.harzianum*and *G.mosseae*) against brown spot disease has been demonstrated.Root colonization with *G. mosseae,*soil application of*T.hazianum* and foliar application of *B.altitudinus,* singly or jointly suppressed brown spot of rice disease. Multifold increase in activities of chitinase, b-1,3-glucanase, peroxidase and phenylalanine ammonia lyase in leaves of rice plants was observed after application of AMF and *Trichoderma* and PGPR followed by inoculation with *D. oryzae*.It has also been found that colonization of root by *T. harzianum* and foliar application of *B.altitudinus* has led to extensive changes in the plant genome and metabolism which is responsible for the accumulation of rice phytoalexin (Phytocassanes) in leaves following challenge inoculation with *D. oryzae.*Observed plant health improvement and disease suppression in rice plants may be due to a combination of at

least three mechanisms – direct inhibition of the pathogen in the soil, better nutrient availability and induction of resistance in the host.

OR 6.7

***Homalomena aromatica* Schott. essential oil as a novel botanical preservative against fungal and aflatoxin B_1 contamination of stored spices**

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Spices are extensively utilized in food and medicine preparations worldwide but are highly prone towards *Aspergillus flavus* and aflatoxin B_1 (AFB_1) contamination during post harvest storage. The present study explores the efficacy of *Homalomena aromatica* Schott. essential oil (HAEO) as novel, plant based approach against fungal and AFB_1 contamination of stored spices. GC-MS analysis revealed Linalool (68.51%) as the major compound of HAEO. Antifungal and anti aflatoxigenic potential of HAEO was assessed in terms of minimum inhibitory concentration (MIC) and minimum aflatoxin inhibitory concentration (MAIC) which were found to be 1.75 µL/mL and 1.25 µL/mL respectively. Dose dependent decrement in ergosterol content and enhanced leakage of vital cellular ions (Mg^{+2}, K^+ and Ca^{+2}) confirmed fungal plasma membrane as probable site for antifungal action of HAEO. Moreover, HAEO inhibited cellular methylglyoxal (the AFB_1 inducer) biosynthesis in dose dependent manner. HAEO exhibited strong antioxidant activity (IC_{50} value 16.008 µL/mL) which was measured by DPPH (2, 2-diphenyl-1-picrylhydrazyl) free radical assay. HAEO may be thus, recommended as an eco-friendly, biorational plant based preservative for stored spices against fungal and AFB_1 contamination.

OR 6.8

Induction of resistance in mandarin plants against *Fusarium oxysporum* using *Pseudomonas poae* and *Gigaspora gigantea*

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The most extensively grown citrus species in Darjeeling hills is the common mandarin (*Citrus reticulata*). A serious fungal disease of mandarin plants in the subtropical hot and humid climate condition is wilt and root rot complex disease caused by *Fusarium*, *Macrophomina* and *Phytophthora*. One of the most notorious pathogen *Fusarium oxysporum,* occurring in the rhizosphere soil of mandarin plants causes root rot is prevalent in almost all orchards of Darjeeling hills and is one of the major reasons of heavy fruit loss due to decline of health of nursery gown plants. Mycorrhization pattern of the mandarin plants showed three dominant arbuscular mycorrhizal fungi such as *Gigaspora gigantea*, *Glomus fasciculatum* and *Acaulospora* sp. Among the seven plant growth promoting rhizobacteria evaluated on improvement of growth status of mandarin seedlings, *Pseudomonas poae* showed highest growth of the seedlings and also exhibited *in vitro* inhibition of pathogen (*F.oxysporum*). Potential PGPR (*P. poae*) was further tested alone and in combination with AMF (*G. gigantea*) for activation of defense against the pathogen. Root colonization with *G. gigantea* and foliar application of *P. poae,* singly or jointly suppressed root rot of mandarin. Induction of major defense enzymes such as chitinase, b,1-3 glucanase and peroxidase by treatment of AMF and PGPR was evident. In order to determine cell defence responses associated with localized and induced systemic resistance in mandarin plants using bioinoculants, cellular localization of chitinase and b,1-3 glucanase was confirmed by indirect immunofluorescence following treatments with PAbs of chitinase and b,1-3 glucanase and labelled with FITC conjugate. Apple green fluorescence was more prominent towards the cell wall. Ultrathin section of AMF colonized mandarin roots stained with toluidine blue also confirmed successful colonization with *G. gigantea.* Finally immunogold localization of defense enzyme (chitinase) in mandarin roots following colonization with *G. gigantea* and treated with PGPR (*P.poae*) and subsequently challenge inoculation with *F. oxysporum* was confirmed through transmission electron microscopy. Heavy deposition of gold particles were seen in the parts of cell wall of inoculated roots. A few gold particles were also seen in the parts of cell walls that adhered firmly to intercellularly growing fungal hyphae. Observed plant health improvement and disease suppression in mandarin plants may be due to a combination of at least three mechanisms – direct inhibition of the pathogen in the soil, induction of resistance in the host or better nutrient availability.

OR 6.9

Disease dynamics and Yield potential of french bean under different degrees of conservation agriculture system

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The major threat to food security and natural resource management in West Bengal, as well as in India is the problem of land degradation. Soil degradation has led to depriving the country of 1.4% of it's GDP and according to a report of 2019 almost 30% of this country's land is already degraded. Hence, to combat this national threat to the country, scientists have started adopting the conservation agriculture practices. The major objective of this study was to evaluate the effects of mulch management and fertilizer application on yield and disease dynamics of French bean in Nadia district of West Bengal. The experimental design was split plot with fourreplications. The variety used for this study is 'Phalguni', which was planted under sixteen different treatments. These sixteen different treatments are the permutation, combination of different mulching, and nutrient combinations. The different mulch treatments are no mulch (M0), straw mulch (Ms), berseem mulch (MB) and lathyrus mulch (ML) and the different fertilizer combinations are no fertilizer application (N0), N30P30K20 (N1), N60P49K40 (N2) and N90P60K60(N3) combinations. Three major diseases like rust, white mould disease and bacterial blight disease were found in the French bean research plot. Fertilizer and mulch have been shown to have significant effect on each of these three diseases and yield potential of the crop. While quantifying the disease progression with time, rust disease and bacterial blight was found to give the least AUDPC value under straw mulch condition, whereas white mould disease was maximum at the straw mulch condition and no white mould disease was found in case of berseem mulch. Fertilizer application has also played a notable difference in the disease incidence and the disease progression with time, with the least AUDPC value of rust disease (1583.81) and bacterial blight(1936.58) disease in case of N60P49K40 fertilizer application. Similarly in respect of yield, the highest yield (13.28 tonnes/hectare) was obtained in berseem mulch with the combination of N60P49K40 and the lowest yield (8.366 tonnes/ hectare) was obtained in case of no mulch and no fertilizer application. Hence, from the above study we can conclude that berseem mulch along with the N60P49K40 fertilizer combination is the best and has a notable role to play in the disease dynamics and yiled potential of the French bean crop.

OR 6.10
Accumulation of antifungal compounds in Tea Leaf tissues infected with *Alternaria alternata*

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Many plant-extracts have been found to possess antifungal properties. Botanicals, however, are yet to be exploited as anti-infective or anti-infestive agents on a chemical scale. The present investigation reports on evaluation of plant extracts against *Alternaria* blight – a newly recorded disease of tea (*Camellia sinensis*) caused by *Alternaria alternata.* Among the ten varieties tested for screening of disease resistance, Teen Ali 17/1/54 showed most susceptible reaction towards pathogen and this variety was selected for treatment separately with aqueous leaf extracts of three selected plants (*Azadirecta indica, Catharanthus roseus* and *Diplazium esculentum*). Reduction in disease incidence by application of these extracts were also evident. The level of defense enzymes such as phenylalanine ammonia lyase, chitinase and â-1, 3-glucanase was higher in treated and inoculated tea plants in comparison healthy. Immunofluorescence studies of tea leaf sections treated with aqueous leaf extracts of *A. indica*, *C. roseus* and *D. esculentum* exhibited high level of chitinase deposition mainly in the mesophyll tissues. The investigation support the hypothesis that plant extract may induce indirectly plant defense reactions.

OR 6.11
A study on changes in mycellial structure in *Rhizoctonia* sp. and biochemical responses in rice due to the host-pathogenic interaction

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Sheath blight, caused by *Rhizoctonia solani* Kuhn (teleomorph *Thanatephorus cucumeris* (Frank), is an important fungal disease of rice ranking only after blast and the disease occurs through rice production areas of the world, in both tropical and temperate climates. Infection process extends from germination to multiplication of an infective propagule on the surface and within the susceptible host. During the establishment of parasitic relationship different mycelial structure of the pathogen to grow towards the host at different hour after infection. Due to this host-pathogenic interaction a noticeable change in Stress related isoenzymes activity (Peroxidase, Super oxide dismutase Chitinase and Glucanase) were observed in infected rice plant. The main purpose of the study was to observe the infection structure formation at different hour after inoculation and found a relation with the stress related isoenzymes activity change in rice plant according to formation of infection structure at different hour after inoculation. 36h after infection appresorium formation was observed. High level of fluctuation in Pathogenesis related isoenzymes activity was observed after 36h and 48h after infection. So, for host pathogenic interaction in rice-Rhizoctonia system 36h after infection to 48h after infection are very crucial period.

OR 6.12
Chemical control of Bacterial leaf spot, *Cercospora* leaf blight and Dieback of chilli vis a vis weather factor on disease severity.

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Field experiment was carried out to evaluate the efficacy of different dosages of Kasugamycin 3% SL in the Chilli field along with Azoxystrobin 23% SC and premix chemicals Metiram 55% + Pyraclostrobin 5% WG at their different doses at university instructional farm, Bidhan Chandra Krishi Viswavidyalaya, Jaguli, Mohanpur, Nadia, West Bengal, India.during rainy and winter season 2018. 3 different doses of pre-mix fungicide of Kasugamycin 3% SL @ (22.5g, 30.0 g and 37.5 g a.i. / ha) Azoxystrobin 23% SC @ 125g a.i.ha^{-1}and Metiram 55% and Pyraclostrobin 5% WG @ 1050 g a.iha^{-1}were applied three times in the field against Bacterial leaf spot, Cercospora leaf blight and Dieback. Uniform plant populations were maintained and 3 sprays of each chemical with desired concentration were given starting from 30 days after transplanting at 10 days interval. Minimum disease severity of three diseases were observed in the plots sprayed with Kasugamycin 3% SL at a concentration of 37.5gm a.i.ha^{-1}(8.0%) BLS, (9.5%) CLS and (8.7%) dieback. In case of fruit yield it was observed that application of Kasugamycin 3% SL at a concentration of 37.5 gm a.i.ha^{-1}produced maximum fruit yield (32.0 q/ ha) followed by the same chemical at 30 gm a.i.ha^{-1}(31.6 qha^{-1}) in comparison to untreated control. Metiram 55% and Pyraclostrobin 5% WG @ 1050ga.i. ha^{-1}also produced fruit yield 29.0 qha^{-1}followed by the Azoxystrobin 23% SC at a concentration of 125g a.i./ha. The pooled analysis of individual weather variables with bacterial leaf spot disease severity on it was noticed that average temperature(r= 0.778 – 0.786), average relative humidity (r= 0.700-0.785) and total rain fall (r=0.731-0.795)positively where as bright sunshine hours (r= -0.481 to -0.556) and was negatively and significantly correlated with disease severity irrespective of different treatment combinations.

OR 6.13
Influence of different dates of sowing on diseases progression of Leaf Spot of Strawberry

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Leaf spot of Strawberry (*Fragaria x Ananosa*.Duch) caused by *Neopestalotiopsisclavispora*, is gaining importance in this region particularly North-eastern states as well as in West Bengal region. But due to the devastating damage caused by leaf spot and fruit rot disease without proper management strategy. The farmers are losing their interest towards this high value crop. Among the two different dates of planting of eight numbers of varieties showed that Sabrina followed by Gili produced less disease and maximum yield and yield attributes. Effect of five weather parameters (Tmax, Tmin, RHmax, RHmin, soil temperature and BHS), increase in Tmax (23.8 to 30.9^{0}c), Tmin (6.0 to 15.4^{0}c),ST (12.6 to 20.3^{0}c), disease severity was increased significantly and it was observed in all the varieties. Whereas, RHmax negatively and BSH positively insignificantly correlated. The prediction equation showed that in each varieties the disease severity depends upon the positive influence of Tmax and RHmin in combination with negative influence of Tmin, RHmin with a few exceptions. Whereas, BSH showed negative influence on five varieties (Sabrina, Barak, Gili, Winter Down, Crystal) and positive in other three varieties (Hadar, Sabrina 1 and Sweet Charlei). During this period of disease

development weather variables were Tmax (23.8 to 30.9^{0}c),Tmin (6.0 to 15.4^{0}c),ST (12.6 to 20.3^{0}c),RHmax (95.1-99%) and BSH (4.9- 6.8 hrs).

OR 6.14

Prevalence of Chrysanthemum white rust from Eastern part of India and its management

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Puccinia horiana Henn. has quarantine importance and is one of the most important fungal pathogens of Chrysanthemum cultivars grown for cut flower or potted plant production in several regions of India & world. Chrysanthemum (*Chrysanthemum coronarium*)seedlings are imported from Karnataka, where Chrysanthemum white rust (CWR) is prevalent(Sriram et al.2015). In consequence to the continuous import of seedlings, high incidence of White rust of Chrysanthemum was documented over Nadia district of West Bengal during the month of December, 2017. Among the major cultivated varieties, "Marigold" was found to be severely infected (Severity value – 91.09 %), while the variety "Orange" was found to be completely immune to white rust infection. Symptoms of CWR were characterized by the waxy white coloured matured rust pustules on the abaxial surfaces of leaves accompanied with yellow spots observed on the axial surface in the infected Chrysanthemum plants. Polymerase Chain Reaction conducted with purified DNA using specific primer pairs (Ph-F2/Ph-R1) generated the desired single amplicon of approximately 242 bp and confirmed the incitant as *Puccinia horiana*. Evolutionary relationship was inferred from analysing the 1300 bp region of 18S rDNA, ITS1, 5.8S rDNA, ITS 2 of 60s ribosomal sub unit with primer pairs ITS5-Rust1. Phylogenetic tree constructed using Mega 7.0revealed *Puccinia horiana* West Bengal isolates (Accession no: MH347231, MH346507& MH342643) to be most closely related with Asian & European *P. horiana*isolates.As, pathogen goes unidentified during seedling stages, quarantine measures exercising early detection with PCR is necessary to prevent further national & international dissemination of Chrysanthemum white rust. Propiconazole proved to be a promising fungicide to restrict the spread of the disease under filed conditions.

OR 6.15

Diversity of *Phoma* Sacc. in the phyllosphere of eastern Himalayan Siwalik forest

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The present study reports in situ occurrence of fossil epiphyllous fungal species of Phomites (comparable to cosmopolitan filamentous modern plant pathogen Phoma Sacc.) on the cuticular surface of different compressed angiospermic leaf remains recovered from the Siwalik sediments (middle Miocene to early Pleistocene; ~ 13-2.5 Ma) of Arunachal Pradesh and Dajeeling, eastern Himalaya. Here, we describe fossil species of Phomites based on morphometric features of fruiting bodies i.e. pycnidia. The fungi are recovered from the host leaves having close affinities with the extant Dipterocarpus Gaertn., Shorea Roxb., (Dipterocarpaceae), Albizia Durazz., Amherstia Wall. (Fabaceae), Dysoxylum Blume (Meliaceae), Actinodaphne Nees, Litsea Lam. (Lauraceae) Macaranga Thouars (Euphorbiaceae) and unknown Poaceae Barnhart. The in situ recovery of different Phomites on the diverse angiospermous leaf cuticles suggests the existence of a host-ectoparasite interaction in the ancient forest of Arunachal sub-Himalaya during the Mio-Pleistocene time. In addition, the occurrence of aforesaid fungal morphs in appreciable numbers indicates a warm and humid tropical climate favored by high rate of precipitation during Siwalik sedimentation.

This observation is also in conformity with our earlier published qualitative and quantitative climatic data obtained from the study of different megafossil plant remains using Climate Leaf Analysis Multivariate Program (CLAMP).

OR 6.16

The Role of inducers in inducing resistance against alternaria Leaf Blight in various mustard genotypes

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Alternaria leaf blight being a major concern on mustard whose control largely depends on the application of chemical pesticideshoweverit is not the long term solution due to environment concern and risk due to fungicide residues. Under these circumstances, Induced resistance is one of the most dominant mechanism in managing the disease by increasing the activity of various defense related enzymes and non-enzymatic antioxidants. The role of inducers *viz.* Benzothiadiazole (BTH),Salicyclic acid (SA), Jasmonicacid (JA) and Hydrogen peroxide (H_2O_2) at three different concentrations *viz.* low, medium and high *i.*e., BTH (0.25 mM, 0.75 mM, 1.5 mM); H_2O_2 (1%, 2%, 3%); JA (1mM, 2.5 mM, 4 mM) & SA (0.5 mM, 1 mM, 2 mM)were assessed on induction of resistance against Alternaria leaf blight of mustard in three different varieties *viz.* resistant, moderately resistant and susceptible and their effect on non-enzymatic antioxidant defense related compounds such as chlorophyll, total soluble proteins, proline, total phenols, starch, total sugars in net house conditions.BTH(1.5 mM) was found to be effective in enhancing the activity of several non-enzymatic antioxidant defense compounds and physiological trait *i.*e., chlorophyll content followed by SA, JA and H_2O_2. Significantly high concentration of chlorophyllcontent(31.11 - 43.38 SPAD) was recordedin healthy plants in comparisionto diseased plants (25.89-40.28 SPAD). In healthy plants total soluble proteins(13.30-26.44 mg/g), total sugars (41.36-85.11 mg/g), starch (136.46-222.28 mg/g) were maximum in comparison to inoculated plants recorded as (9.69-22.59 mg/g), (36.72-76.38 mg/g), (124.32-211.20 mg/g) respectively. Lower amount of phenols and low accumulation of proline were recorded in healthy plants 5.4-15.47 mg/g and 9.64-21.84 µmol/g respectively when compared with infected plants 10.61-18.14 mg/g and 16.09-26.58 µmol/g respectively at 18 DAS or 3DAI.

OR 6.17

Study on occurrence of chalkbrood disease by *Ascosphaera apis* in the colonies of european honey bee, *Apis mellifera* in West Bengal

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This study conducted to demonstrate the occurrence of chalkbrood disease caused by fungus *Ascosphaera apis* in the colonies of European honey bee, *Apis mellifera* in West Bengal condition. Study was conducted in three apiaries with an average number of 37.67 hives with a percentage of 14.02 infected hives, whereas the percentage of infected frame per hive was 33.13. Out of 31 samples tested, the presence of characteristic cyst of *Ascosphaera apis* was found in 27 samples, indicating the average positive sample percentage of 86.61. In our condition, the disease is not very common, as well as beekeepers do not attach so much importance because there are other problems such as Varroa mite infestation that cause greater damage to their hive population. It is therefore necessary to take action to prevent it from appearing in a more devastating form in the near future.

OR 6.18
Evaluation of resistance, phenolic compounds and enzymatic response in cucumber to *Pseudoperonospora cubensis*

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Cucumber (*Cucumis sativus* L.) is widely cultivated in many parts of the world. Cucumber production is threatened by heavy incidence of downy mildewdisease, caused by *Pseudoperonospora cubensis* (Berk. and Curt.) Rostow, that is responsible for substantial yield loss in the tropics. Identifying and deploying tolerant germplasm are required for cucumber geneticists to develop promising hybrid/variety against this disease.To identify resistance sources, 11 cucumber cultivars were screened against *Pseudoperonospora cubensis*, under open field conditions. The Percent Disesase Index (PDI) was recorded at 7 days interval. The plant disease defence related enzyme activities like Total Peroxidase (POX), Polyphenol oxidase (PPO), Phenylalanine Ammonia Lyase (PAL) activities and total phenol content (PC) were evaluated before and after inoculation. Significant differences in the biochemical parameters were observed between resistant and susceptible cultivars. The resistant varieties contained higher enzymatic activities and higher phenol content than the susceptible varieties, both before and after inoculation. The biochemical parameters were observed to have increased significantly after inoculation in resistant varieties as compared to the susceptible varieties. Increased Peroxidase, Polyphenol oxidase, and Phenylalanine Ammonia Lyase activities and higher phenol content might be responsible for reduced sporangial multiplication, which would lead to disease resistance. These findings can be utilized as promising criteria in varietal screening trials in breeding programs.

OR 6.19
Recombinant begomoviruses, betasatellites and divergent alphasatellitesare associated with cotton leaf curl disease outbreak in Northwest India

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Cotton leaf curl disease (CLCuD), caused by whitefly transmitted monopartite begomoviruseswith association of betasatellite and alphasatellites, is a serious constraint for cultivation of cotton in Northwest (NW) Indian states Haryana, Punjab and Rajasthan. CLCuD was surveyed for last six successive years from 2012 to 2017 and disease incidence was estimated. The overall incidenceswere 37.5, 63.6, 38.8, 56.1, 44.8 and 58.6% in 2012 to 2017 respectively. The disease outbreak was higher of 77.5 in Haryana followed by 59.2% in Rajasthan and 54.1% in Punjab in 2013 in comparison to disease occurred in the other seasons.Infected cotton samples were collected from NW India.Thirteen CLCuD associated begomovirus (CABs)isolates were characterized based on complete genome sequencing. Complete genome was amplified through RCA, cloned, sequenced and analysed. Based on sequence analysis, eight present begomovirus sequences were found to be member of Rajasthan (Ra), one of Faislabad (Fai) and another of Pakistan (PK) strain of *Cotton leaf curl Multan virus* (CLCuMuV); and five sequences are member of Burewala (Bu) strain of *Cotton leaf curl Kokhran virus* (CLCuKoV). But CLCuMuV-Ra strain is detected as predominant strain occurring in most of the cotton growing areas of NW India. Ten present begomovirus sequences were detected as recombinants, where CLCuMuV-Ra strains are strong recombinants. Complete genome sequences of betasatellite and alphasatellite were obtained from CLCuD-affected cotton plants, sequenced and analysed. The present betasatellite sequences were found belonging Cotton leaf curl Multan betasatellite (CLCuMB) and all were recombinants. Three alphasatellite species, Cotton leaf curl Burewalaalphasatellite (CLCuBuA), *Gossypium darwinii* symptomless alphasatellites (GDarSLA) and Croton yellow vein mosaic alphasatellite (CrYVMoA) were obtained, and most of the alphasatellites were recombinant. The present study demonstrated that the complex interaction of recombinant CLCuMuV-Ra strain, recombinant betasatelliteCLCuMB and divergent alphasatellitesis associated with CLCuD outbreak in NW India.

OR 6.20
Investigation on biocontrol mechanism of the fungus Chaetomium globosum against bipolaris sorokiniana causing spot blotch of wheat using RNA-SEQ approach

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Chaetomium globosum Kunze (Family: Chaetomiaceae) has been recognized as internationally emerging biocontrol fungus. It mycoparasitizes the various pathogens and produce antifungal metabolites which suppress the growth of many soil and seed borne phyto-pathogens. A number of basic research articles

have been published related to antagonistic activity however molecular events and identification of biosynthetic pathway are not yet explored in C. globosum. Therefore, in this study we have performed the global transcriptome profiling of C. globosum strain Cg2 during interaction with the *Bipolarissorokiniana* isolate BS112 causing spot blotch of wheat in order to gain insight into the potential underlaying biocontrol mechanism. The platform (Illumina HiSeq 2X (151) bp) yielded an average of 20-22 million reads with 50-58% GC. The final assembly resulted in 45,582 transcripts with 27,957 unigenes. Transcriptome analysis displayed distinctly different transcriptional profile in the interaction of Cg2×BS112, out of which 6109 unique DEGs were expressed. The heat map and cluster categorization suggested an increase in the expression levels of genes encoding secondary metabolites and other CAZYmes such as lyases, chitinases, â-1,3-glucanases and proteases etc. We identified various genes of biotechnological value encoding proteins with functions such as polyketide synthase & non ribosomal peptides (NRPs) synthase: glutathione dehydrogenase, histone-lysine Nmethyltransferase, aminotran_1_2 domain-containing alkaloid, terpene cyclase, putative steroid-binding protein 3, catalase-peroxidase (CP) associated with secondary metabolite and antibiotic biosynthesis genes. To check the reliability of the RNA-Seq data, RT-qPCR was performed using 15 randomly chosen genes. The expression profiles were in complete agreement with the RNA-Seq data for about 15 genes evaluated. To unravel the interaction further metabolomic profiling was done which showed that *C. globosum*strain Cg2 produced variety of antifungal secondary metabolites such as trans-limonene oxide, dodecene, cyclohexadiene, heptacosanol and octadecanoic acid which may be involved in the antagonisms. The present work is the first effort worldwide to unravel the biocontrol mechanism to report their probable role in antagonism of *C. globosum* against *B. sorokiniana*. It will facilitate improvement of the annotation of gene models in the draft C. globosum genome.

OR 6.21

Begomovirus and its satellite associated with yellow vein mosaic disease and detection of virus resistant copy number in Okra (*Abelmoschus esculentus* (L.) Moench) varieties in West Bengal, India

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Yellow vein mosaic virus (YVMV) is the most wide spread disease in okra (Ladies finger) across India. Both yellow vein mosaic virus (BYVMV) and okra enation leaf curl have (OELCV) so far been reported from West Bengal, India. In our recent survey, severe infection with complete yellowing, stunting with severe mottling of leaves has been noticed in several farmers' field in the state West Bengal, India and found hundred percent crop losses. The infected samples from the several fields were subjected to PCR based detection using begomovirus specific primers and proved the presence of begomo virus in all samples. Further, rolling circle amplification (RCA) of DNA of infected sample restricted with K*pn*1 and cloned. The whole genome sequence comprising 2743bp of nucleotide (GenBank accession no. MN005041) confirmed the infection of Mesta Yellow Vein Mosaic Virus (MeYVMV) in okra. MeYVMV Krish1, W.B. isolate showed 99.59% identity with Mesta Yellow Vein Mosaic Virus, Jalgaon, Maharashtra isolate and appeared very close to OELCV but distantly related with BYVMV. The additional amplified sequences of 1355bp (GeneBank accession No MK844301) showed 94.18 to 98.30% identity with several isolates of BYVMV betasatellite isolates reported in India. It is speculate Analysis of Nuclear Localization Signal (NLSs) and its 3D protein prediction of CP sequences unveiled the key amino acids in the corresponding amino acid sequences of MeYVMV, BYVMV and OELCV required for systemic infection, viral particle formation and insect transmission. Some promising varieties of okra were screened and detected YVMV copy number using standardized markers (Fluorescently labeled) and the allelic ratio ranged from 2.2 to 3.1 which proved the varieties were heterozygous with moderately resitant to YVMV. Here, we report the presence of MeYVMV and satellite virus of BYMV which constitute a novel association in okra. These molecules, in addition to sharing some genetic features with OELCV, contain nucleotide stretches of begomoviral origin, presumably the remains of recombination events involved in their origin.

PP 6.1

Cultural and biochemical aspects of *Botryodiplodia theobromae* causing Tip Blight of *Draceana fragrans victoriae*

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Draceana, is basically a houseplant, used as an ornamental which creates a relaxing atmosphere with various health benefits. All these superior characters add to the value of the plant. However, the foliage which is considered as the economic part is damaged by various diseases, of which tip blight is an important one. Various carbon containing media *viz*. Potato dextrose agar (PDA), Czepek's Dox Agar (CDA) and Oat meal agar (OMA) was used to study the radial growth of *Botryodiplodia theobromae* from *Draceana*. Among these three carbon media, the most effective medium for its rapid growth was PDA medium followed by OMA and CDA media. Significant differences were not observed in the colony morphology of the fungus using the various carbon containing media. But the data showed that the growth rates differed significantly in all the dates of observations. There were significant differences not only among all the media used but also on a particular medium considered. Bioassay was conducted using four fungicides *viz.* Blitox, Mancozeb, Chlorothalonil and Difenoconazole with six different concentrations including control. It was found that EC50 value of Difenoconazole was 5.861µg per ml which was found to be most effective followed by Chlorothalonil, which was 129.4 µg per ml and the EC 50 values for Mancozeb and Blitox was at par. *i.e.* 269.8µg per ml and 267.9µg per ml respectively.

PP 6.2

Epidemiology and field level screening of germplasm against collar rot disease of Lentil, incited by *Sclerotium rolfsii*

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Lentil (*Lens culinaris* Medik) is one of the most nutritious legume crops of India as well in West Bengal. However, the productivity of the lentil in West Bengal condition is comparatively low due to various biotic and abiotic stresses. Among the biotic factors, collar rot *(Sclerotium rolfsii*) is very common in all the major lentil growing areas and caused yield losses upto 44.40%.To overcome the problem, a number of management approaches have already been evaluated and recommended. Among the various disease management strategies, use of resistant germplasm is one of the most efficient strategies for management of collar rot disease of cowpea. Therefore, it is necessary to know the severity of the disease and factors associated with them in crop field and to identify, develop and recommend cost effective suitable management to each location looking into the prevailing conditions. Keeping this background, the present investigations were made to identify the germplasms tolerant to collar rot diseases of lentil in West Bengal, to study of pathogenicity of *S. rolfsii* in lentil at different temperatures for identification of optimum temperature required for epiphytotic development by *S. rolfsii.* Experimental findings showed that collar rot incidence in lentil was high in Nadia (7.71 %) district followed by Murshidabad (7.36%), Malda (4.13%) and Birbhum (3.0 %). Among the different blocks of four lentil growing districts of West Bengal, the comparative collar rot incidence was higher in Sagardighi block of Murshidabad (22%) and DSF, BCKV, Nadia (19.5%) whereas disease incidence was lower in Labpur block of Birbhum (2.0 %) and Chakdah block of Nadia district (3.0%). Local variety and Moitree occupied 40% and 26.67% lentil growing areas of this region, espectively. The average disease incidence was found to be higher in HUL57(14.5% ; disease ranged 4-25%) followed by IPL406(10.0%), Moitree (9.67% ; disease ranged 1.0 -40%), KLS9-3(8.0%), Asha (6.0% ; disease ranged 2.0 – 16.0 %)) and Local variety (5.39% ; disease ranged 0.0 – 30.0%). Whereas less disease incidence was observed in Ageti (1.0%) and KL-320 (2.5% ; disease ranged 1.0-4.0%).Around 143 lentil germplasm accessions collected from International Centre for Agricultural Research in the Dry Areas (ICARDA), Syria were screened against collar rot pathogen under field condition. No genotypes were found to be immune but eleven genotypes were found highly resistant to the disease. Sixty two genotypes were found to be moderately susceptible while, thirty nine genotypes were found to be susceptible and thirty one genotypes were found to be highly susceptible against the disease under natural infection condition The highest lesion development was observed at 28°C (2.8 cm) followed by 35°C (1.8 cm). The least lesion development was observed at 19°C (1.3 cm). The area under lesion progress curve (AULPC) was highest at 28°C (74.4) followed by 35°C (45.6).

PP 6.3
Effect of reactive oxygen species and antioxidants in Hemibiotrophy of *Bipolaris sorokiniana*

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Spot blotch of wheat has emerged as a serious disease in Indo-Gangetic plains.The disease is known to cause yield losses up to 50% as well as deterioration in seed quality.The causal agent of spot blotch of wheat is *Bipolarissorokiniana*which is the anamorph while *Cochliobolus sativus* is the teleomorph. Reactive oxygen species (ROS) and antioxidants are produced at the site of attempted invasion and is one of the most rapid defence reactions to pathogen attack.The exposure of plants to unfavourable environmental conditions increases the production of reactive oxygen species (ROS) such as, singlet oxygen ($^1O_2$), superoxide ($O_2^{\bullet-}$), hydrogen peroxide (H_2O_2), and hydroxyl radical ($OH^\bullet$). To study the role of the antioxidant enzymes,effect of Superoxide Dismutase (SOD)(1400 µM/ml) and Catalase (2000 µM/ml)on germination of spores of *Bipolaris* was investigated. Secondly, germ tube growth and invasion of the pathogen was higher in plants leaf infiltrated with inhibitors of catalase, hydroxyl ion and lignin *viz.,* copper sulphate, L-arginine and piperonylic acid. Hence ROS play a key role in plant defense against pathogens since the growth of thegerm tube of spores was slowed down in SOD and infiltration of inhibitors of ROS and lignin have resulted in increased disease incidence.

PP 6.4
Defence responses of two solanaceous crop plants against *Rhizoctonia solani* involve similar defense pathways

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*Rhizoctoniasolani*Kühninfects a broad range of hosts, spreadingrapidly through water and soil. Total yield loss in different crops is moderate to severe due to poor resistance in host and lack of effective control measures.In this report, AG1-IA isolate of *R. solani*, has been studied in detail during its pathogenesis in two different hosts from solanaceae family, namely tomato and tobacco.Stages of host tissue invasion and disease development have been recorded trough time courses. In the case of tomato, defence response has been compared in two varieties using different physiological and biochemical parameters. Electrolyte leakage,lipid peroxidationand total phenol content were differentially altered in the susceptible variety compared to the tolerant variety over the entire time course studied.In tobacco also disease progression was studied in detail along with defence response against *R. solani*. Disease progression and defense response of these two economically important solanaceous plants were compared. This study gives further insight about the disease development and disease progression of *R. solani*rot in different sonlanaceouscrop plants.This will also improve our knowledge about the defence responses of solanaceous plants against *R. solani.*

PP 6.5
Study of plant-pathogen interaction between *Brassica juncea* and *Alternariabrassicicola*and evaluation of host defence response

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Blight disease caused by *Alternariabrassicicola* (Schwein) Wiltshire is animportant disease of Brassicaceae all over the world. The Indian mustard, *Brassica juncea*, (L.) Czern and Coss., is one of the oilseed crops in India that is worst affected by *Alternaria* blight resulting into nearly 50% yield loss.In the present study,host-pathogen interaction of *B.juncea*with*A. brassicicola*has been evaluated. Various microscopic techniques like scanning electron microscopy (SEM), confocal laser scanning

microscopy(CLSM) and light microscopy have been utilized to study hyphal progression, invasive structures as well as entry points to the inner host tissue. To study the host defense response,different histochemical analyses,likecallose deposition, phenol content and peroxide accumulation, were utilized to assess the defense response of *B.junceaa*gainst *Alternaria* blight. This study gives detailed insight about fungal invasion strategy as well as host defence mechanism against this necrotrophic fungus. This study will pave the way to in-detail molecular analysis of this pathosystem which can lead to development of tolerant variety of *B. junceaa*s well as other Brassicaceae crops.

PP 6.6

***Paraconiothyrium variabile* being detected as causal incitant for Black leaf spot of tropical orchid Mokara**

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The mokara orchids have been a boon to the orchid industry of Eastern India. Survey of diseases was conducted during September to November of 2017 across Hooghly district of West Bengal, India. The orchids were infested with different types of symptoms *viz.,* oval to helical black leaf spot on Mokara orchids. Isolation of the fungus using PDA media showed golden yellow coloured mycelial growth. Growth was very slow in all five tested media. The best media for the growth of pathogen was found to be Potato dextrose agar & carrot agar media whereas the growth was highest at 25- 30^{0}C temperature. The colour of mycelia and growth pattern varies greatly from media to media. Among five tested medium sporulation occurred only in PDA medium after 22-25 days of inoculation. Microscopic studies revealed transparent, elongated and aseptate conidia. The size of the conidia measured were about 3.2-3.7 ìm × 1.4-1.8 ìm (average 3.5 × 1.6 ìm). Polymerase Chain Reaction conducted with the purified DNA using primers specific to ITS region (ITS1 and ITS4) resulted an amplicon approximately of 900 bp. Consensus of 855 bp was developed by bi-directional sanger sequencing. NCBI BLAST tool finally confirmed the fungi as *Paraconiothyrium variable* with 100 per cent identity and 0.0 e value. Bioassay study revealed the least EC50 value with 10 ppm for Hexaconazole 5% SC. Early detection using PCR and chemical control with Hexaconazole should be taken as management strategy to combat the Black leaf spot of Mokara.

PP 6.7

A rhizospheric antagonist from Darjeeling for successful mManagement of causal complex of Pseudobulb Rot in boat orchid

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Boat orchid (*Cymbidium* spp.) is an orchid of great horticultural value cultivated extensively in Eastern Himalaya, India. The commercially important part pseudobulb and roots shows a typical rotting symptoms which causes huge losses due to an epidemic called pseudobulb rot that develops during monsoon months. Three pathogens were consistently isolated from the diseased samples: viz. *Pectobacterium carotovorum* sub sp. *carotovorum, Fusarium oxysporum* and *Mucor hiemalis* f. sp. *hiemalis*, in the early, middle and later phases of disease progression, respectively. The apparent synergistic activity of the three pathogens seems to be the cause of the uncontrolled causal complex. It is an interesting report on host-pathogen combination as three pathogens act in sequence toward ultimate demolition of the host. A rhizobacteria, identified as a fluorescent *Pseudomonas*, strain BRL-1, showed both *in vitro* and *in vivo* antagonistic activity against all these phytopathogens. The antagonistic activity of the biocontrol agent is linked with the production of antimicrobial compounds like siderophores, proteases, chitinases and indole acetic acid (IAA). In the pot assay the talc-based formulation of the antagonist not only control this causal complex but also induced more vigorous growth of the plant.

SESSION VII : Microbes in Societal Upliftment

LL 7.1

Potential of Microbes in Waste Management, Human Health and Societal Upliftment

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Millions of microbes including fungi, bacteria, viruses, phytoplasma, nematodes etc. exists in nature. Fungi is considered to be the most predominant microorganisms on this earth. As per one of the estimate 1.5 million species of fungi did exist but only 5% of the fungi are known to the mankind. Many of these fungi are reported to cause several diseases in plants, human beings and animals but some of these fungi are beneficial too. Mushrooms are such fungi whose approximately 10,000 species are macroscopic, hypogeous or epigeous, can be picked up by hands, seen by naked eye and highly edible. These fungi are blessed with varieties of enzymes which can easily degrade the highly complicated compounds like cellulose, hemi cellulose and lignin present in most of the plant wastes, industrial wastes and forests wastes. These mushroom fungi play a key role in degradation of forest wastesand giving rise the most nutritious fruit bodies of the wild fungi called edible mushrooms. This is how these fungi help in recycling of the forest wastes and maintains the balance in the natural forest ecosystem. These fungi can be saprophytic, parasitic and mycorrhizal (ecto and endo). Many of these fungi have now been domesticated and commercialised for human consumption, health, physical fitness and improving the socio-economic conditions of the peoples.

In India, a large volume of plant agro wastes (620 million tons) is generated every year as a result of agricultural activity which is roughly 15% of the total biomass produced in grassland as well as cultivated land.These biomass are produced by the plants as a result of photosynthesis activity. Similarly, number of agro based and other industries produce different kind of industrial wastes. In forest areas, lot of deciduous trees, perennial trees shed their leaves, felling of wood logs gets accumulated and degraded by mushroom fungi. It has been estimated that about 2/3rd of the biomass production occurs in forests areas (65%). Net productivity of plant dry biomass is reported to be 155.2 billion tons in a year. Most of these bio mass is not being properly utilised. It is either burnt (50 million tons in Punjab alone) or lying waste and causing environmental pollution particularly during monsoon season.These plant wastes, industrial wastes, forests wastes etc. can be beautifully recycled by mushroom fungi into

the valuable and best qualityfood with full of nutritional and medicinal values.

Mushrooms have enormous medicinal value.Biologically active compoundsof mushrooms primarily include Polysaccharide (50 types have been isolated),Tri-terpenoids (more than 100 types), Lentinan, Adenosine, Ling Zhi 8, PolysaccharideKrestine (PSK), Polysaccharide Peptide (PSP), Entadeninebuteric acid.These compounds exert their medicinal influences on their users. The most significant medicinal effect of mushrooms and their metabolites is their antitumor property. They are basically biological response modifier (BRM). BRM action is accomplished by immunopotentiation (by amplification of immune system) and immune modulation by activating macrophages, cytotoxic, T cells and producing Natural Killer cell (NK Cell). When mushroom bio-actives are used along with radiotherapy & chemotherapy in cancer cases, it reduces the side effects of those therapies. Mushrooms are known for anti glycemic activity as well where adenocine in mushroom stimulates insulin receptors to mobilise blood glucose to liver for storage and enhances utilisation of glucose by peripheral tissues. Thus, controls diabetes and rightly called as 'delight for diabetics'.

Mushroom farminghas become one of the most proven income generating enterprise in different parts of the country to double or triple the farmers income within a year. It is the important source of food, nutrition, income and employmentsecurity in rural sector of the society particularly in Chhattisgarh state which is pre-dominated by tribal community. Mushroom spawn production, crop production, mushroom processing and marketing can be the independent activity for employment generationin a small, medium or large scale. Mushroom cultivation in Chhattisgarh has been promoted by ICAR-AICRP on Mushroom at IGKV, Raipur, Krishi Vigyan Kendras (KVKs) and constituents Colleges of the university by establishing 14 Mushroom Spawn Laboratory and Mushroom Crop Production units in 14 KVKs (Bastar, Dantewada, Bijapur, Kanker, Dhamtari, Mahasamund, Rajnandgaon, Kawardha, Janjgir, Korba, Korea, Ambikapur, Raigarh, Bilaspur). Besides this, there are three colleges of our university namely SKS College of Agriculture and Research Station, Rajnandgaon, KL College of Horticulture, Rajnandgaon and SK College of Agriculture and Research Station, Kawardha which have established mushroom spawn and crop production units under my supervision as State Nodal Officer and promoting mushrooms in a big way by preparing student entrepreneurs, women SHGs and unemployed youths.

Oyster mushroom is one which is most pre dominantly cultivated in Chhattisgarh State by the tribalsalmost round the year due to ease of cultivation technology, availability of spawn, less time required for cultivation, low technical know howrequired and cheap availability of agro waste(>130 lakh tonnes of agrowaste in CG) mainly paddy straw, wheat straw substrates, mustard straw, sugarcane baggase, chickpea straw etc.Oyster mushroom is practiced by >1000 individual women /Women SHGs, >250 entrepreneurs in Dhamtaridistt. are promoted by Sri Rajeev Lochan Agro Invention Producer Co. Ltd., Megha (Dhamtaridistt.) whose members are involved in mushroom spawn production, oyster mushroom crop production, processing and marketing, >200 farmers in Rajnandagoandistt. by SHGs are practicing oyster mushroom production and processing. Similarly, paddy straw mushroom is demonstrated by our KVK, Janjgir and gradually picking up well in Janjgir-Chapa, Dhamtari, Mahasamund and Raigarh districts which are well connected by road to Odisha State. The farmers in these areas are growing paddy straw by procuring the spawn from our KVKs as well as Cuttack areas by regular bus services. At Janjgirdistt., >500 farmers have made the Mushroom Federation called "AnndataBahuuddeshiya Society"at Behradih of Janjgirdistt. in which 50 farmers groups are working and compelled Distt. Collector to provide the outlet in Heart Place of the Janjgir town for sale of their mushroom and mushroom based products.This mushroom federation is registered under Deptt of Cooperative and growing paddy straw mushroom in a big way. The farmers are very well supported by the District Collector. Similarly, Raj Mushroom KisanNidan Club Training and Research Centre, Pathiapali is supporting paddy straw cultivation by >250 farmers of Mahasamunddistt. In the same way, the Department of Forest, Pithora(Mahasamund) under our technical guidance is involved in training and cultivation of oyster and paddy straw mushroom to >300 farmers at Pithora Nurseryof the Forest Department. They have established a big Mushroom Spawn Production Unit in their nursery under my guidance and supervision.

Under CG State Rural Livelihood Mission(SRLM) i.e. LIFE-MGNREGA Project, we trained 6308 farmers who have given their consent to follow mushroom as an income generating activity. Under this project, the farmers/labourers who have continuously served for 100 days in MGNREGA project without break were considered to be one who is the poorest and most needy person in the society and required to be supported by the government on top priority. The family members who showed their interest in mushroom cultivation were identified by the officials from SRLM and these farmers were imparted residential training of six days by 12 KVKs of Chhattisgarh during 2016-2017& 2017-2018 under my guidance and close supervision as Director, Extension Services, IGKV, Raipur.Under this project, 432 farmers/labourers were trained by us by organising 6-day residential training programmes by 12 KVKs (Surguja, Bijapur, Dhamtari, Bastar, Raigarh, Korba, Rajnandgaon, Gariaband, Janjgir-Chapa, Kanker, Narayanpur and Bilaspur). Many ofthe farmers trained by us are now growing mushrooms in their household in a small scale. Similarly, Chhattisgarh State Skill Development Authority has identified Mushroom Production as an important income generating activity as a result we have been given the target to impart training on Mushroom Production Technology to the school dropouts who passed 8th class/rural youths/farmers who are interested in mushroom growing.In the present paper, attempt has been made to recycle the wastes easily available in bulk quantity using strength of the mushroom fungi, promoted its health benefits to the mankind and tried to train/demonstrate mushroom cultivation technology in a small, medium or large scale for the livelihood upgradation in all classes of the society.

OR 7.1

GC-MS analysis of Biochemical constituents in fruit body of *Agaricusbisporus*

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The present study aims to investigate the bioactive components in two different stages of fruit body of edible mushroom *Agaricusbisporus.* Fruit Body of *A. bisporus* grown in paddy straw-based compost formulation was harvested separately at two different stages (pin head and mature) and ethanolic extract was made for GC-MC analyses. GC-MS-TIC spectrum analysis revealed that the presence of phenolic derivatives, organic acids and essential fatty acids in the ethanolic extract of *A. bisporus*fruit body which are associated with some beneficial health activities like antioxidant. Fumaric acid, acetic acid, malic acid were also detected as organic acids. Pyrazin, a phenolic derivative responsible for antidiabetic activity was detected in this edible

mushroom. In pin head stage total 58 compounds were detected which includes unsaturated fatty acids, phenolic derivatives, alkaloids, terpenoids, steroids, carbohydrate derivatives while total 69 compounds including terpenoid, alkaloids and organic acids were detected in extract of mature fruit body. Ergosterol derivative was detected as highest peak in both stages of fruit body. Tumeron,a medicinally important compound was also detected only in ethanolic extract of mature fruit body.

OR 7.2

Ethnomycological knowledge and utilization by the bodo and adivasi communities of Kokrajhar District, along the Assam- West Bengal Border of Assam, India

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As a result of a survey work being conducted in Kokrajhar district,BTAD,Assam along the Assam West Bengal Boarder from May,2018 to Sep,2019,a total of 6 edible macrofungi were reported.The study was done on the utilization of wild edible fungi by the Adivasi and Bodo Community of this district. The communities are traditionally much endowed with the knowledge of unveiling the secrets of nature and utilization of resources of their surroundings.Among different wild edible microfungi,6 commonly occurring species were recorded, namely *Volvariellavolvaceae*, *Lentinuspolychrous*, *Termitomyce-sheimii*,*Cantharellus* sp.,*Pleurotus* sp.,and *Macrolepiota procera* belonging to the families Plutaceae, Lentinaceae, Tricholomataceae, Cantharellaceae, Pleurotaceae and Agaricaceae respectively.

The collected species were identified based on their morphological characteristics and the traditional method of the recipe preparation by the said community was discussed.

OR 7.3

Assesment Ofantioxidant and Antibacterial activities of methanolic extracts of mycelium and exopolysacchraide of two different Pleurotus species collected from Tripura

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The purpose of this study was to evaluate the antioxidant and antibacterial activities of two different *Pleurotus* species (*Pleurotus* Sp.1 and *Pleurotus* Sp.2) collected from the two different regions of Tripura. Specimens were identified, extracted in methanol and screened for their antioxidant activities using stable free radical DPPH method. The highest scavenging activity was recorded for *Pleurotus* Sp.2. Antibacterial activity of methanolic mycelium extracts of two different mushrooms were determined in-vitro against four pathogenic bacteria (two gram positive and two gram negative) following disc paper method (Collins and Lyne, 1987) using different concentrations (10, 20 and 50 µl/disc).The concentration (IC50) showed highest inhibition zone in both mushrooms. To assess the antimicrobial activity of the exopolysacchraide extracts of two different isolated mushrooms, different bacterial strains (gram positive and gram negative) were selected. The inhibition zone measurements of different mycelial extracts indicate that methanolic mycelial extract has better inhibitory activity on the growth of gram-positive bacteria than gram-negative bacteria. Whereas the exopolysaccharide extract of two different samples has better inhibitory activity on gram negative bacteria than gram positive bacteria. The two different extracts (mycelial and exopolysaccharide) of the same sample exhibit two different types of inhibition zone against gram negative and gram positive bacteria. These mushrooms can be used in therapeutic purpose.

OR 7.4

Effect of different carbon and nitrogen sources on Exopolysaccharides (EPSS) production of *Pleurotus flabellatus* and evaluation of biological properties

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Pleurotus species gain a tremendous interest due to its nutritional and various medicinal applications. The specific goals of this research work to evaluate the effects of different carbon and nitrogen sources for mycelial biomass, average growth rate and exopolysaccharide (EPSs) production, estimation of total carbohydrate content and antioxidant activities of EPSs and determination of antibacterial properties of various extracts of *Pleurotus flabellatus*. The starch (3.84±0.43 g/L and 0.55±0.21 g/L/day) and peptone (1.57 ±0.87 g/L and 0.22±0.12 g/L/day) were the best (p<0.05) carbon and nitrogen sources respectively for better mycelial growth and average growth rate of *P. flabellatus*, whereas EPSs production was highest in sucrose (3.467±0.96 g/L) and beef extract (6.00±0.59 g/L). The highest amount of carbohydrate from EPSs was observed in starch (3.39 mg/100g) and peptone (4.05±0.08 mg/100g) medium (p<0.05). The highest free radical scavenging activities of EPSs were observed in glucose (83.80±0.87%) and calcium nitrate (89.01±1.61%) at 16.0 mg/ml concentration (p<0.05). The broth extract of *P. flabellatus* showed highest (p<0.05) antibacterial activity against *B. subtilis* whereas EPSs extract showed lowest activity against *B. subtilis* but all three types of extract showed no activity against *S. aureus*. Therefore, more research work is necessary to find out the active chemicals constituents of EPSs and their functional relationships.

OR 7.5

Exploration of some wild mushrooms found in Manipur for ligninolytic activity

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Lignin is a class of complex organic polymers that form key structural materials in the support tissues of vascular plants and some algae. In contrast to other biopolymers, lignin is resistant to degradation and acid- and base- catalysed hydrolysis. Mushrooms can produce lignin degrading enzymes like lignin peroxidase, manganese peroxidase and laccase which have low substrate specificity and thus can degrade many organic compounds which are somewhat similar to lignin in structure. In the present study some wild mushrooms were randomly collected from different parts of Manipur. They were morphologically identified and then cultured in malt extract agar and potato dextrose agar media. They were screened for the presence of lignin degrading enzymes by using Guaiacol oxidising activity test, RBBR dye decolorization test and Congo red dye decolorization test. A total of 11 different wild mushroom species were collected out of which only six mushroom samples could grow in laboratory conditions in pure culture.All the cultures

showed positive response to linin degradation and they were *Schizophyllum sp., Ganoderma sp., Irpex sp., Pycnoporous sp., Pleurotus sp.* and *Lentinus sp*. The low specificity of extracellular enzymatic complexes and the possibility to use toxic compounds as the growth substrate make mushrooms more advantageous in bioremediation processes when compared to other microorganisms.

PP 7.1
Role of microbes in organic farming for sustainable Agro-Ecosystem

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Organic farming is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators, genetically modified organisms; livestock feed additives and can increase farm productivity, repair decades of environmental damage and knit small farm families into more sustainable distribution networks leading to improved food security. It is a holistic production management system that promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity is hence important. Microbial communities play an important role due to their involvement in many different soil processes and functions and they are the engines driving nutrient transformation and release, as well as being directly and indirectly involved in many other ecosystem services such as erosion control by formation of stable soil aggregates, decomposing organic matter and soil structuring or unwanted insect pest, weed and disease regulation. Microbes and their activities have pervasive, remarkably profound and generally positive effects on the functioning, health and well being of human beings, the whole of the biological world, and indeed the entire surface of the planet and its atmosphere. In farming systems, microbes play a pivotal role as the main dynamic forces. Soil is the base of many of the biological processes, *viz*., biological nitrogen fixation, residue decomposition, mineralization/ immobilization turnover, nutrient cycling, and denitrification, which are regulated by microbes. They are harnessed and processed in a way to hook the beneficial effects on soil and structure the soil-biological relation in an ameliorating manner. Today's farmers are interested in using soil and plant microbial inoculants to maintain the microbial equilibrium to enhance soil fertility and promote agro-crop production. Beneficial microorganisms control the soil microbiological equilibrium in ways that can promote plant growth, yield and quality of crops and improve soil health and enhance resistance against phytopathogens *etc*. which in turn influence the agro-production efficiency as all are closely linked. Therefore, the application of soil beneficial microbes through traditional and advanced approaches using organic manures, bio-fertilizers, bio-pesticides, bio-herbicides, bio-insecticides *etc.* has become a promising new technology in organic farming system so that human race and nature may be benefited by maintaining sustainable agro-ecosystem.