4th ASIAN PGPR CONFERENCE

3 - 6 May, 2015, Daewoo Hotel, Hanoi, Vietnam

TECHNICAL PROGRAM

SPONSORED BY

Technical Program

4th Asian PGPR Conference for Sustainable Agriculture

Daewoo Hotel - Hanoi, Vietnam

May 3-6, 2015

Greetings

Prof. Dr. Nguyen Van Tuat
Chairman, local organizing committee, Asian PGPR Society
Vice President, Vietnam Academy of Agricultural Sciences (VAAS), Hanoi, Vietnam

Honorable Dr. M. S. Reddy, FounderChairman, Asian PGPR Society, his excellency Dr. Le Quoc Doanh, Vice Minister, Ministry of Agriculture and Rural Development of Vietnam, distinguished guests, speakers, ladies and gentlemen, a pleasant day to all of you.

It is my great pleasure and opportunity to welcome you all for the 4th Asian PGPR Conference. With the permission from the Ministry of Agriculture and Rural Development of Vietnam, It is honor for VAAS to host the 4th Asian PGPR Conference in our capital city, Hanoi. On behalf of the local organizing committee, I would like to take this opportunity to express my sincere appreciation to all of you for coming to this important event. In particular, I would like to extend my sincere thanks to Prof. Dr. M.S. Reddy, Chairman of the Asian PGPR Society, His Excellency Dr. Le Quoc Doanh, Vice Minister of Vietnam Ministry of Agriculture and Rural Development, and others for their hard work, kind support and help for all the arrangements.Vietnam is prominently agricultural with tropical climate. The share of agriculture sector in gross domestic products (GDP) is more than 25%. During the last 10 years, in spite of successive calamities, Vietnamese agriculture sector annual growth rate was at 4.3% per year' food production was 5.8% (1.3 million tons per year), the coffee output has increased more than 10 times, rubber 5 times, tea 4 times, and the cashew 4 times, etc.

Under the renovation policy, Vietnamese agriculture sector has gained great achievements, shifting from a backward agricultural country which used to import grain and now is the world's second in rice export (Vietnam's rice export in 2014 reached over 7 million tons), the second in coffee and cashew export (following Brazil and Columbia in coffee, India and Brazil in cashew-nut).

In current years, Vietnam has achieved very remarkable results in agricultural sector. For example, Vietnam became the exporter for many agricultural commodities such as rice, coffee, black pepper, cashew nut, fruits, vegetables, etc.

Vietnam has advantages in agriculture due to favorable natural conditions and resources with tropical monsoon climate. The broad and deep international integration (member of WTO), have opportunities to expand markets to USA, Japan and EU. However, we are still facing a number of disadvantages such as typhoons, drought, saline intrusion etc. Crops are significantly attacked by dangerous pests and diseases especially to rice production, competition for prices, quality, food hygiene and safety market mechanisms, globalization require better criteria regarding quality, brand, food hygiene and most farmers still are using the traditional farming practices in small scale with low economic efficiency. Farmer's knowledge and understanding on market and agricultural technology and sciences remain limited. Many challenges are faced with issues such as food security and safety, newly emerging pests, efficiency use of fertilizers, water resourcesand reduce biological diversity and forecasting changes in climate.

Priorities for basic research are to conserve and effectively utilize plant genetic and other agricultural resources. Agri-biotechnology research is also prioritized. Selection and development of varieties for high productivity, good quality, high resistance or tolerance to biotic and abiotic conditions. Integrate Crop Management (ICM) to reach maximum productivity and economic effectiveness for each crop or cropping patterns to mobilize natural, economic, social potentials of each agri-ecological area. Research on GAP to produce food that meet safety requirements, investigate post-harvest loss and technologies for economical water use is important.

Based on these constraints, the Government of Vietnam currently develops the national objectives program for the sector restructuring, aiming to apply innovative technologies in agriculture, particularly in bio- technologies including Plant Growth-Promoting Rhizobacteria.

The Government of Vietnam has issued the Decision No.11/2006/QD-TTg with the general objectives to produce new plant varieties, animal breeds, microorganisms and biological products with high yields, quality and economic efficiency; to develop national capacity in R & D, application of biotech in agriculture and rural areas; to strongly develop modern bio-technologies, focusing on biological technology to approach new sciences such as genomics, bio-informatics, proteomics and nanotechnology in agro-biotechnology; to develop our country's agro-biotechnology to reach the advanced level in the region. Agro-biotechnology shall account for 20-30% of the total contribution of S & T to the increase of agriculture's added value.

We all know that the Asian PGPR Society for Sustainable Agriculture is a scientific society that was formed in 2009 as a non-profit organization to enable scientists, researchers, academicians, government groups, students, farmers, and industry personnel etc. from various agricultural disciplines to meet and discuss their common interests in teaching, research and commercialization of PGPR.

This Conference is an excellent platform for discussion of future research and application of natural beneficial microorganisms as bio-fertilizers and bio-pesticides.

I hope this conference not only bring fruitful results but also build good framework and friendship, harmony and trust. This meeting is a step toward to the realization of our ultimate goal.

I wish you all a valuable and enjoyable stay in Hanoi.

Prof. M. S. Reddy
Founder Chairman, Asian PGPR Society
Auburn University, Auburn, USA

Distinguished guests, ladies and gentlemen, it is indeed an honor for me to convey this message as a founding Chairman of the Asian PGPR Society. It is my privilege to welcome you all for the fourth Asian PGPR Conference for Sustainable Agriculture.

Asian countries: in particular China, India, Philippines, Indonesia and Vietnam are the leading advocates of bio-pesticides and bio-fertilizers for sustainable agriculture. It is our responsibility to show other countries how PGPR research in our geographical region contributes to meeting the agricultural challenges of the rest of the world. I encourage all of you here to bolster the spirit in your colleagues and yourselves as you now enable Asia to become a world leader in the application of PGPR technology to the betterment of our agriculture. The science behind PGPR today holds an important key to a second “Green Revolution” globally to benefit poor farmers in marginal agricultural areas. I am confident that by working together we can overcome the obstacles and seize the opportunities in PGPR technologies in the new millennium. I am taking this opportunity to call upon all stakeholders from the wide range of Asian countries to join hands and use PGPR to make our world a better place to live. Join me and let us see the future we can create with PGPR through this meeting.

I strongly believe that scientific innovations can reach farmers only with purposeful and effective partnerships. So to all the participants in this conference, let me encourage you to share, learn, reach out and build personal relationships throughout this conference that can lead to productive partnerships.

Let me take this opportunity to express my sincere appreciation to VAAS and all our co-sponsors, as well as to all of you for coming here to share and keep abreast of what is new in PGPR technologies

My best wishes to all of you.

Dr.Y. R. Sarma
President, Asian PGPR Society
Former Director
Indian Institute of Spices Research, Calicut, India

I am extremely happy that 4th Asian PGPR Congress is scheduled at Hanoi, Vietnam during 3rd to 6th of May 2015. All of you are aware that Asian PGPR Society is to spread the message of eco-friendly microbial biotechnology among the Asian region to ensure greater interaction among the major stake holders, the researchers, farmers and industry for increased crop production and productivity. While the productive land becomes limiting, the available and most practical option is to increase the productivity of the crops that would ensure the food security and sustainability of the region. PGPR's would be an ideal to fill this gap. I am extremely happy to learn that some of the farmers and end users of the technology are attending this important conference. I place on record my profound appreciation to Prof. M. S. Reddy, Auburn University, USA, General Chairman, for his untiring efforts in realizing the objectives and goals of this Society.

I congratulate the local organizing Chairman, Prof. Dr.Nguyen Van Tuat, Vice President, Vietnam Academy of Agricultural Sciences (VAAS) and his energetic team in meticulously planning this most important event in this great country, Vietnam for the benefit of the Asian region. I am sure this event would trigger the research initiatives of this wonderful PGPR technology towards the food and nutritional security of the region. On behalf of the Asian PGPR Society I profusely thank the farmers, researchers and Agricultural administrators of Vietnam, in providing this opportunity for the Asian PGPR. I wish this conference would provide a wonderful opportunity to all the concerned in coming out with results which are socially relevant and scientifically rewarding. I wish the conference a great success.

YR Sarma

Prof. JosephW. Kloepper
Patron, Asian PGPR Society
Auburn University, USA

On behalf of the world-wide group of scientists engaged in research and development of microbial inoculants for agriculture, I extend a warm welcome to all the speakers and participants at the Fourth Asian PGPR Conference in Hanoi, Vietnam I am proud of Prof. M. S. Reddy's leadership as a founder Chairman to leadeach of you and the Asian PGPR Conference series which are critical parts of the global effort in development of PGPR based technologies. Based on your model of a continent-wide PGPR Conference, the Latin American PGPR Conference formed and held their second conference in Argentina in September 2014. Now the Asian and the Latin American PGPR Conferences join the International PGPR Conference in offering frequent venues for scientific exchange in PGPR R&D. Together, we are all helping to make new discoveries that continue to result in more PGPR-based applications for sustainable agriculture every year.

As you all know, the combination of accelerating climate change and the growing world population continues to challenge agricultural production. Local, regional, and multi-national agricultural product companies are investing in basic research aimed at improving drought tolerance and nutrient uptake. Plant-associated bacteria are being tested for sources of new genes, sources of metabolites that affect plant gene transcription, and as potential inoculants for crops. Studies on PGPR fit very well with these goals, and for this reason, our research area is receiving renewed interest.

Our challenges are to continue providing research needed to realize the potential benefits of PGPR and to bring those benefits to growers. The Asian PGPR Conference is a critical opportunity for exchange of ideas and challenges. I encourage all of you to take advantage of the opportunity to meet colleagues from across the globe, to share research ideas, and to discuss the challenges ahead in implementing your research findings.

With best wishes.

Dr. William D. Batchelor
Patron, Asian PGPR Society
Dean, College of Agriculture
Auburn University, Auburn, USA

I would like to extend my warmest welcome to the distinguished guests, speakers and participants of the Fourth Asian PGPR Conference in Hanoi, Vietnam. As we meet, the world is entering a population cycle that will challenge agricultural production technology like never before. By the year 2050, it is projected that the world population will exceed 9 billion people. It is also expected that favorable global trade policies will continue to create wealth around the world. The size of the global middle class is expected to triple, growing from approximately 1 billion people today to over 3 billion people by 2050. A higher global standard of living is driving up demand for food, resulting in record high global grain prices during recent years. Experts are projecting that by 2050, food production must increase approximately 70-100% to meet demand.

Doubling the world's food supply is the grand challenge for the next generation of agricultural scientists. Land constraints dictate that much of the increased production must come from existing agricultural lands. According to the FAO, past efforts to increase productivity has led to global degradation of farmland at an alarming rate. Future technology must lead to increased production in a sustainable manner.

Approximately 40% of the current world population is engaged in agriculture, and 25% of the world population is small holder farmers living on less than $2.50 per day. Farm size, productivity and poverty are strongly linked. The promise of technologies such as PGPR is that they will provide solutions that will increase the productivity and profits of small holder farmers around the world, thus increasing food supply and reducing poverty in a sustainable way.

As agricultural scientists, the world is looking to us to provide solutions to food challenges that the world is facing. I look forward to the presentations and interactions with the scientists at this conference. Never before have so many people been dependent upon so few farmers for food. We have a lot of work to do!

Dr. David Bergvinson
Director General
ICRISAT – International Crops Research Institute for the Semi-Arid Tropics
Patancheru, Telangana, India

Global nutritional security is the order of the day for a healthier life. With the current pace, global population is expected to reach 9.6 billion by the year 2050. As you all are aware, enhancing food crops productivity is a challenging task being faced by agricultural researchers worldwide. However, the role of sustainable practices in maximizing crop yields is gaining importance especially for smallholder farmers who are resource poor. For boosting crop yields, soil health plays a key role.

We at ICRISAT believe that demand-driven innovations are important to fighting poverty in drylands where over 644 million of the smallholder farmers live. Our mission is to make smallholder farmers prosperous while enabling nutritional security for rural and urban consumers. To achieve this, ICRISAT is adopting Inclusive Market Oriented Development (IMOD) strategies in Asia and sub-Saharan Africa. In this context, biofertilizers and biopesticides contribute to safe agriculture and sustained soil health. Especially the plant growth-promoting rhizobacteria (PGPR) are a group of biofertilizers that contribute to plant and soil health significantly. Use of these beneficial microbes in agriculture is gaining momentum. However, we need to infuse cutting-edge science to accelerate the PGPR research and converting them into agricultural inputs that serve the needs of smallholder farmers who are in need of sustainable technologies.

In Asia, though PGPR research has picked up, there is a need to widen the scope and perspectives of its application to more staple food crops, horticulture, forestry, and plantation crops. Especially, PGPR applications need to be projected as viable alternatives or supplements to chemical fertilizers. At this juncture, the functioning of a body like "**Asian PGPR Society for Sustainable Agriculture**" is critical. Though Asian countries are competing and syndicating in PGPR research, a consolidated plan to bring forth sustainable, scalable and economic solutions to control plant diseases, improve soil health and enhance ecosystem services through PGPR is essential. Asian PGPR Society is instrumental in bringing researchers, academicians and entrepreneurs on to a common platform for exchange of ideas, promoting public-private partnerships (PPPs) and promoting research integration among public and private agencies involved in bio-inoculant research. The biennial Asian PGPR Conferences being held in various Asian countries provides the required platform for integrating ideas, fostering partnerships and creating public awareness with full dedication. Earlier meetings held in Hyderabad, India (2009); Beijing, China (2011) and Manila, Philippines (2013) were extremely successful. I trust that Asian PGPR conferences continue to synergize the public-private R&D in this area towards finding sustainable solutions to farm production problems.

It gives me great pleasure to wish the 4th Asian PGPR Conference organized by the Vietnam Academy of Agricultural Sciences (VAAS) in collaboration with Asian PGPR Society for Sustainable Agriculture a great success. I trust it will be a productive meeting and I look forward to learning about the sustainable solutions that emerge from the meeting that will position smallholder farmers for success across the globe.

Technical Program

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May 3-6, 2015

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Sunday 3, 2015 **2:00 - 9:00 PM**		
2:00 - 5:00 **5:00 - 8:00**	**Registration** **Reception – Planters night**	**Ballroom**
Monday4, 2015		
Opening Ceremony **8:00 - 10:00 AM** **Master of Ceremony: Dr. Bui Quang Dang, VAAS**		
8:10 - 8:20	**Chief Guest – MARD**	**Dr. Le Quoc Doanh** **Vice Minister, MARD**
8:20 - 8:30	**Chairman, Asian PGPR Society**	**Dr. M. S. Reddy** **Auburn University, USA**
8:30- 8:35	**President, Asian PGPR Society**	**Dr. Y. R. Sarma** **India**
8:35 - 8:40	**College of Agriculture, Auburn University**	**Dr. William D. Batchelor** **Dean, Auburn University, USA**
8:40 - 8:45	**ICRISAT, India**	**ICRISAT**
8:45 - 8:50	**Petro Vietnam Camau Fertilizer Joint Stock Company**	
8:50 - 8:55	**BCARC, Saudi Arabia**	**Dr. Ahmad Al-Turki** **Director, BCARC, Qassim University**
8:55 - 9:00	**Vandien Fused Magnesium Phosphate Fertilizer Joint Stock Company**	
9:00- 9:05	**Prathista Industries Ltd., India**	**Dr. K.V.S.S. Sairam** **CEO & President, Prathista, India**
9:05 - 9:10	**Sri Biotech Laboratories Ltd., India**	**Dr. K. R. K. Reddy** **CEO & MD, Sri Bio, India**
9:10 - 9:15	**Binhdien Fertilizer Joint Stock Company**	
	Group Photo & Health Break	

Session 1 **10:00 AM -12:00 Noon** **PGPR(*Rhizobium*, fungi, nematodes, Bt's etc.) use in sustainable agriculture, plantation crops, biofuel, horticultural, forestry & spices** **Moderators: Drs. Peter A. H. M. Bakker & Prathiba Sharma**		
10:00-10:20	Role of public-private partnerships in biopesticides and biofertilizersresearch and development for sustaining agriculture production	**Dr. C.L.L. Gowda** Director, GRSV Consulting Services, Srirampura II Stage, Musuru, India

10:20-10:40	Mycorrhizae, the neglected common denominator in the PGPR-plant interactions	**Dr. H. Antoun** Département des sols etdegénieagroali mentaire & Centrederecherche eninnovationsur les végétaux, Facultédes sciences de l'agriculture et de l'alimentation, Université Laval, Québec, Qc, Canada
10:40-11:00	Biological method for improving germination capacity of melilot seeds	**Dr. I. E. Smirnova** Institute of Microbiology and Virology of the Ministry of Education and Science of the Republic of Kazakhstan, Almaty, Kazakhstan
11:00-11:20	Nanomycorrhiza Plus for Plant Promotion	**Dr. Ajit Varma** Amity Institute of Microbial Technology, Amity University Uttar Pradesh, Sector 125, Noida, India
11:20-11:40	The promise of biological control of insect pests with rhizobacteria	**Dr. Henry Fadamiro** Department of Entomology and Plant Pathology, Auburn University, Auburn, AL, USA
11:40-12:00	PGPR and other microbials in sustainable management of aflatoxin contamination of food crops	**Dr. M. K. Naik** Department of Plant Pathology University Agricultural Sciences, Raichur, India

Lunch
12:00 – 1:00 PM

Session 2
1:00 - 5:00 PM
PGPR as biopesticides, biofertilizers, bioherbicides, bioinsectides & bionematicides
Moderators: Drs. Henry Fadamiro & G. Archana

1:00-1:20	Mass spectrometric evidence for the presence of phytohormones in vermin- -composts and vermicompost tea and their positive effects on plant growth	**Dr. J.W.H. Yong** Singapore University of Technology & Design, 20 Dover Drive, Singapore 138682
1:20-1:40	Production and characterization of *Trichoderma* metabolites: A new approach for selective bioremediation	**Prof. Anita S. Patil** Sant Gadge Baba Amravati University, Amravati, Maharashtra, India
1:40-2:00	Evaluation of a plant growth-promoting rhizobacteria, *Azospirillum lipoferum* with reduced dose of fertilizer on growth and yield of a local rice variety cultivated in Mekong Delta of Vietnam	**Dr. Nguyen Huu Hiep** BIRDI, Cantho University, Vietnam
2:20 - 2:40	Potential use of rhizobacteria in groundnut grown in sandy soil in binhdinh province of Vietnam	**Dr. Nguyen Thu Ha** Soils and Fertilizers Research Institute, Le Van Hien, BacTuLiem, Ha Noi, Vietnam
2:40 - 3:00	*Streptomyces flocculus* (RP1A-12):A potential actinomycete against Groundnut stem rot disease (*Sclerotium rolfsii*)	**Dr. H. Sudini** ICRISAT, Patancheru, Telangana, India
3:00-3:20	Plant-growth stimulation and bio control of fusarium wilt (*F. oxysporum*f. sp. cubense) by co inoculation of banana (*Musa* spp.)	**Dr. M. Kavino** Department of Fruit Crops, Faculty of Horticulture, TNAU, Coimbatore, India

	plantlets with PGPR and Endophytes.	
Health Break ***3:20 – 3:40***		
3:40 - 4:00	Interaction of plant growth-promoting bacteria and microalgae: from basic studies of plant–bacteria interaction to potential biotechnological applications	**Dr. Luz E. de-Bashan** Environmental Microbiology Group, Northwestern Center for Biological Research (CIBNOR), La Paz, B.C.S., Mexico
4:00 - 4:20	Effect of mixed inoculations of plant growth promoting rhizobacteria of chilli on growth and induced systemic resistance of *Capsicum fruitescence L.*	**Dr. Amrutha V. Audipudi** Department of Microbiology AcharyaNagarjuna University, Guntur, A.P., India
4:20 - 4:40	Nanonutrients with Lacto-gluconates based nutritional biofertilizer's for sustainable agriculture	**Dr. N. S. Gangurde** Prathista Industries Ltd, Secunderabad, India
4:40 - 5:00	Plant growth stimulation and biocontrol potential of fluorescent pseudomonads under saline conditions	**Dr. Naveen Kumar Arora** Department of Environmental Microbiology, BBA University, India
Session 3 **5:00 - 7:20 PM** **PGPR in the management of biotic & abiotic constraints** **Moderators: Drs. Rita Grosch & Riyaz Sayyed**		
5:00 -5:20	Chemical properties of locally composts produced in Saudi Arabia and the need for regulations	**Dr. Ahmad Al-Turki** Agriculture College and Veterinary Medicine, Qassim University, Saudi Arabia
5:20 - 5:40	Microbial quality of commercial biofertilizers to increase nutrient use efficiency and crop productivity	**Dr. Didier Lesueur** SupAgro-CIRAD-INRA-IRD, Land Development Dept., Office of Science for Land Development, Bangkok, Thailand
5:40 - 6:00	Diverse role of biocontrol technology in crop protection	**Dr. Pratibha Sharma** Division of Plant Pathology, I.A.R.I., New Delhi, India
6:00 -6:20	Actinomycetes, promising rhizobacteria for biological control of plant diseases	**Dr. Nguyen Thi Thu Nga** Department of Plant Protection, Can Tho University, Vietnam
6:20 -6:40	Role of PGPR in sustainable agriculture: Global climate Change and Water sustainability	**Dr. Rupak K Sarma** Life Science Division, Institute of Advanced Study in Science and Technology, Guwahati-35, India.
6:40 -7:00	Endophytic bacteria as plant growth promoters under biotic and abiotic conditions	**Dr. Vardharajula Sandhya** Department of Microbiology, Agri Biotech Foundation, PJTSAU Campus, Rajendranagar, Hyderabad, India
Poster Exhibits **7:00 – 8:00 PM** **Grand Ballroom 1**		
Dinner		

Long Vy restaurant – 175 Nguyen Thai Hoc street, Ba Dinh district, Hanoi **8:00 - 10:00 PM**		
Tuesday, 5 April 2015		
Session 4 **8:00 - 11:00 AM** **Mechanisms of PGPR** **Moderators: Drs. D. Fernando & Shilpi Sharma**		
8:00 -8:20	The rhizosphere microbiome to the rescue	**Dr. Peter A.H.M. Bakker** Plant-Microbe Interactions, Faculty of Science, Utrecht University, The Netherlands
8:20 - 8:40	Disease suppression effect and rhizosphere competence of *Pseudomonas jessenii* RU47 in various soil types at the field scale	**Dr. R. Grosch** Leibniz Institute of Vegetable and Ornamental Crops (IGZ), Department Plant Health, Theodor-EchtermeyerWeg 1, Germany
8:40 - 9:00	Application of nitrogen fixing bacteria (Azospirillum) as biofertilizer for enhancement of yield of rice (*Oryza sativa)*) in the Philippines	**Julieta A. Anarna** National Institute of Molecular Biology and Biotechnology,University of the Philippines, Los Baños (UPLB), College, Laguna, Philippines
9:00 - 9:20	Environmental and ecological constraints of PGPR functioning	**Dr. G. Archana** The Maharaja Sayajirao University of Baroda, Vadodara, Gujarat, India
9:20 - 9:40	Bioeffectors increase tomato plant growth in soils with low phosphorus-rhizosphere microbiome shifts as potential mode of action?	**Dr. K. Smalla** Julius Kühn-Institut, Institute for Epidemiology and Pathogen Diagnostics, Braunschweig, Germany
Health Break ***9.40-10.00 AM***		
10:00-10.20	Influence of *Cellulomonas*, *flavigena*, *Azospirillum* sp.and *Pseudomonas* sp. on rice growth and yield grown in submerged soil amended with rice straw	**Dr. Mai Vu Duy** College of Agriculture and Applied Biology, Can Tho University, Vietnam
10.20-10.40	Biosynthesis of nanonutrients : A future prospective for higher crop production	**Dr. J. C. Tarafdar** Central Arid Zone Research Institute, Jodhpur, INDIA
10.40-11.00	Airborne communications of bacteria with plant and themselves	**Mr. Joon-hui Chung** Molecular Phytobacteriology Laboratory, Superbacteria Research Center, KRIBB, Daejeon, S. Korea
Session 5 **11.00 AM - 1:00 PM** **PGPR: Formulations, delivery, packaging, efficacy, etc.** **Moderators: Drs. Christian Staehelin & Miss. T. T. H. Le**		

11:00 -11:20	Effect of distillery yeast biomass waste as soil amendment on the population dynamics of PGPR and on the growth of Paddy under pot culture conditions.	**Dr. V. Muralikrishnan** Dept. of Agrl. Microbiology, Faculty of Agriculture, Annamalai University, Tamilnadu, India
11:20 -11:40	Utilization of actinomycetes having broad-spectrum of plant growth-promoting and biocontrol traits in chickpea, sorghum & rice	**Dr. A. Sathya** ICRISAT, Hyderabad, Telangana, India
11:40 -12:00	Plant-rhizobacteria interactions mitigates drought stress	**Dr. ShaikZulfikar Ali** Department of Microbiology, Agri Biotech Foundation, PJTSAU Campus, Rajendranagar, Hyderabad, India.
12:00 -12.20	Rhizosphere bacteria *Bacillus* strains in mitigation of biotic and abiotic stresses in rice under oxic and anoxic conditions	**Miss. T.T.H. Le** University of Hohenheim, Stuttgart, Germany
12:20 - 12:40	Composite effect of various biofertilizers and neem-cake on effectiveness and efficient growth of *Citrus limonia*(Rangpur lime) seedlings	**Dr. Surendra R. Patil** College of Horticulture, Dr. PanjabraoDeshmukh Agriculture University, Akola (M.S), India
Lunch ***12:40 - 1:40 PM***		
Session 6 **1:40 - 4:00 PM** **PGPR: Molecular Communication** **Moderators: Drs. Luz Bashan &Rajendra Singh**		
1:40 - 2:00	Molecular mechanisms in understanding and enhancing biological control of *Pseudomonas chlororaphis*strain PA23 against *Sclerotiniasclerotiorum,* the stem rot pathogen of canola.	**Dr. W.G. Dilantha Fernando** Department of Plant Science, University of Manitoba, Winnipeg, MB, Canada
2.00 - 2.20	Analysing the plant microbiome for control of pathogens	**Dr. Gabriele Berg** Institute of Environmental Biotechnology, Graz University of Technology, Petersgasse, Austria
2:20 - 2:40	Molecular aspects of interactions between plant growth promoting rhizobia and legume host plants	**Dr. Christian Staehelin** School of Life Sciences, Sun Yat-sen University, Guangzhou, China
2:40 - 3:00	Induction of systemic resistance and tolerance against biotic and abiotic stress in Chinese cabbage by cyclic peptides producing *Bacillus vallismortis* strain BS07M	**Dr. K. S. Park** Agricultural Microbiology Division, National Academy of Agricultural Science, RDA, Wanju, South Korea
3:00 - 3:20	The primary transcriptome of plant beneficial rhizobacterium*Bacillus amyloliquefaciens* reveals novel noncoding RNAs involved in sporulation and biofilm formation	**Dr. Ben Fan** College of Forestry, Nanjing Forestry University, Longpan Road 159, Nanjing, China

3:20 - 3:40	Metabolic and gene expression profile underlying the concurrence of P-solubilizing and biocontrol traits in Pseudomonas aeruginosa P4 in response to P-limitation	**Dr. Aditi Buch** CHARUSAT, Changa, Gujarat, India
Health Break ***3.40 - 4:00 PM***		
Session 7 **4:00 - 5:40 PM** **Translational research on PGPR (lab to field success)** **Moderators: Drs. Gabriele Berg &K. S. Park**		
4:00 - 4:20	Non-target effects of agricultural amendments on rhizospheric microbial communities.	**Dr. Shilpi Sharma** Department of Biochemical Engineering and Biotechnology, IIT, New Delhi, India
4:20 - 4:40	Exopolysaccharides based bioformulation from *Pseudomonas aeruginosa*combating saline stress.	**Dr. SakshiTewari** BabasahebBhimraoAmbedkar University, Lucknow, India
4:40 - 5:00	Inoculant formulations for plant growth-promoting bacteria	**Dr. Yoav Bashan** Environmental Microbiology Group, Northwestern Center for Biological Research (CIBNOR), La Paz, B.C.S., **Mexico**
5:00 - 5:20	A novel microbial delivery system for revitalization of plant's rhizosphere	**Dr. K. R. K. Reddy** Sri Biotech Laboratories Ltd., Hyderabad, Telangana, India
5:20 - 5:40	Siderophore producing bioinoculants: for iron nutrition and control of fungal diseases of crops	**Dr. R. Z. Sayyed** Department of Microbiology, PSGVP Mandal's Arts, Science & Commerce College, SHAHADA, Maharashtra, India
5:40 - 6:00	Tea rhizobacteria as a potential biofertilizer and biocontrol agent for sustainable agriculture in Northeast India	**Dr. Jintu Dutta** Institute of Advanced study in science and Technology, Life Sciences Division, PashimBoragaon, Garchuk, Guwahati (Assam), India
6:00 - 6:20	Commercial transfer of technology for sustainable agriculture	**Dr. Ashok K. Rathore** Professor Emeritus, Director Animal Welfare and Veterinary Science Institute, Sam Higginbottom Institute for Agriculture, Technology and Sciences Allahabad, U.P. India
6:20 - 6:40	Biofertilization and Biofortification of Soybean with Zinc by Utilizing Zinc from Native Soil Pool of Vertisols upon Inoculation with Plant Growth Promoting Rhizobacteria	**Dr. Sushil K. Sharma** Directorate of Soybean Research ICAR, Indore, Madhya Pradesh, India
Viewing of Posters **6:40 - 7:30 PM**		
Closing Ceremony & Gala Dinner **Luc Thuy restaurant – 16 Le Thai To street, Hoan Kiem district, Hanoi**		

8:00 - 11:00 PM Master of Ceremony: Ms. Le Ngoc Lan (VAAS), Mr. Jackie Han (HoabinhTourist)		
9:00	**Response from selected participants**	**General**
9:45	**Announcement of the Venue for 5th Asian PGPR meeting in 2017**	**Dr. M. S. Reddy Chairman, Asian PGPR Society**
10:00	**Appreciation message from the organizers**	**Dr. Bui Quang Dang VAAS**

Wednesday, 6 May 2015 Bus Tour 8:00 AM - 5:00 PM Coordinator: Mr. Jackie Han, Events Manager	
7:0 - 8:00 AM	Breakfast
8:00 AM	Assembly in front of Hotel Lobby(Daewo Hotel) - Sharp
8:30 - 10:30 AM	The Plant Protection Research Institute (PPRI)
10:30 - 11:30AM	Soils and Fertilizers Research Institute (SFRI)
12:00-1:00 PM	Lunch at the local ethnic restaurant
1:00 - 3:00 PM	Visit to Vietnam Museum of Ethnology (entry fee 2$/person)
3.00-5.00 PM	Old, New City&Hoankiem Lake Tour
5:00 PM	Back to Hotel
	Shopping
	Dinner on your own

Thursday, 7 May 2015 Departures
Bon Voyage

Abstracts
Oral Presentations (OP)

OP-01

Role of public-private partnerships in biopesticides and biofertilizers research and development for sustaining agriculture production

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Public-Private-Partnerships (PPPs) are important in involving private sectors for harnessing their efficient and enhanced mass production and delivery of consumer products and services. In agriculture, the rationale for these bilateral or multilateral collaborations is to achieve sustainability in agriculture production. In agriculture research and development (R&D), these PPPs are effective in overcoming public sector institutions limited ability in taking research products and technologies effectively to farmers. This paper emphasizes the role of PPPs in biopesticides and biofertilizers research towards attaining sustainability in agricultural production. The challenges faced by the smallholder farmers in Asia-Pacific region; the benefits of integrating modern and indigenous technologies and materials for increased food production is discussed in the paper. Particularly, the role of Plant Growth-Promoting Rhizobacteria (PGPR) in sustainable agriculture production, their mechanisms of action in controlling plant diseases and promoting crop yields were highlighted. The role of Asian PGPR Society in building fruitful collaborations among scientific institutes, private enterprises, industries and academic institutions, and thus promoting PPPs in biopesticides and biofertilizers research are discussed. Lessons learnt from PPPs such as the Hybrid Parents Research Consortia (HPRC) model established by ICRISAT; and the Bioproducts Research Consortium (BRC) partnership with ICRISAT were elaborated. The future of PGPR research and the scope of PGPR as biofertilziers and biopesticides with commercial potential in Asia-Pacific region are discussed. The role of Governments in forging PPPs in R&D for biofertilizers and biopesticides as in case of is emphasized. The future role of Asian PGPR Society in accelerating and revitalizing the existing PPPs and envisaging the future partnerships in biofertilizer sector are discussed.

Key words: Public-Private Partnerships, Biofertilizers, Biopesticides, PGPR and Sustainable Agriculture

OP-02

Mycorrhizae,the neglected common denominator in the PGPR-plant interactions

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The rhizosphere is known as the zone of soil under the influence of plant roots, in which thenumber,identityandactivityofmicroorganismsareingeneralmoreimportantand different from those observed in the bulk soil. This ecological niche, including the rhizoplane (plant root surface), is very rich in nutrients and energy from photosynthesis, present in root exudates and other plant substances. PGPR are defined as therhizosphere competent bacteria promoting plant growth and health, by different direct or indirect mechanisms. However, more than 90% of plantsstablish a symbiotic association with mycorrhizae, which are ubiquitous in soils. It was estimated that in one cubic centimeter ofsoil, up to 100 mof fungal network may be present. Inaddition, since mycorrhizae normally interact with soil bacteria, this symbiosis is considered as a tripartite symbiosis. Therefore, the mycorrhizosphere extended the concept of the rhizosphere, by including the hyphosphere, the soil under the influence of the important hyphal surface. Moreover, the metabolism of a mycorrhizal and non mycorrhizal plant can be very different, resulting in the presence of distinct microbial communities in the root system. The wide spread arbuscular mycorrhizal fungi (AMF) are symbiotic partners of most economically important crops. The different mechanisms of action used by AMF and leading to increases in crop yields using sustainable production systems will be discussed. Abundant reports also illustrate the important beneficial interactions taking place between AMF and PGPR like the mycorrhiza helper bacteria for the improved biological nitrogen fixation. But the outcome of inoculating plants with a combination of AMF and PGPR will greatly depend on the biocompatibility of AMF with the introduced PGPR. Consequently, in developing inoculants to stimulate plant growth and increase crop yields, it will probably be more beneficial to use an inoculum containing selected AMF isolates combined with compatible PGPR.

OP-03

Biological method for improving germination capacity of melilot seeds

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Soil salinization is a limiting factor for plant cultivation in most parts of Kazakhstan. The area of solonets and saline soils in Kazakhstan is 94 million hectares which is about 40% of the country's total area. Melilot or sweet clover (*Melilotus officinalis*) is one of the most promising crops for cultivation in saline soils. Melilot produce high yield of green mass for forage in saline fields. When Melilot grown, there was serious poor seed germination due to its hard seed coat. Development and application of biological methods to improve the melilot seed germination with plant growth-promoting rhizobacteria (PGPR) is an important task of Kazakhstan. In order to develop a biological method for improving germinating capacity and stimulating growth of melilot, strain *21N* was selected from the collection of cellulolytic bacteria. In laboratory and small plot field experiments, it was found that the strain *21N* increases germination up to 70-75%, and stimulates the growth of melilot plants. The strain 2*1N* has appeared to be non-toxic and non-pathogenic to humans and animals and non-phytotoxic. Molecular genetic studies have shown that the strain belongs to the genus *Bacillus* and species *cytaseus*. Our detailed study has shown that the strain significantly improved the germination capacity of melilot seeds due to the

synthesis of cellulase enzymes. The ability of the strain to stimulate the growth of plants is associated with the synthesis of biologically active substances such as B-group vitamins and amino acids. It was also established that the strain *B. cytaseus 21N* was able to fix molecular nitrogen from the atmosphere and supply to the plants. The nitrogen-fixing activity of the strain was examined using different carbon sources. Our results showed that it varies from 15.6×10^{-5} to 60.2×10^{-5} N_2/ml of medium/h. Our study reveal that the mode of action of the strain is when seeds treated with bacteria due to its production of cellulase enzymes, a partial splitting of the hard seed coat occurs and replaces the process of scarification (the micro cracks appear on the hard seed coat). This occurs due to rapid transport of water and dissolved minerals and nutrients to the endosperm of the seed. In addition, biologically active substances synthesized by bacteria and supplemental nitrogen fixed by them, stimulate the further development of the plants and increase resistance to diseases. This leads to an increase in the seed germination and high accumulation of the melilot green mass. Field tests in saline soils of the Aral Sea region have demonstrated high efficiency of the strain. The pretreatment of seeds by *B. cytaseus 21N* increased the germination up to 70-75%, compared to control (32%). Similarly plant height and weight significantly increased compared to control and green mass was more than 8-10 t/ha compared to control. Based on our results, a new biological preparation "Fitobatsiryn" contain strain *B. cytaseus 21N*, produced at the Institute of Microbiology and Virology has been widely used under field conditions to improve seed germination and stimulate growth of melilot and alfalfa in saline soils.

OP-04

Nanomycorrhiza plus for plant promotion

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Zinc deficiency is the global problem and about 50% of cereals grown in nutrition deficient soil are deficient in zinc. Zinc is the vital element for seed germination and its vigor. To deal with this problem the new formulation "Nanomycorrhiza plus" has been evolved. A novel and new member of Sebacinales was mixed with organic Bio- Zinc. The carrier used was inert magnesium sulphite. This formulation was pelleted on seeds surface of pearl millet (*Pennisetum glacum*). The formulation contained the colony forming unit value of 10^8 with 20% of moisture and organic Bio- Zinc (a product of Prathista Industries Pvt. Ltd., Secunderabad) mixed at the rate of 0.01% of total w/v. 0.01% of jaggery solution was sprinkled on the seeds before pelleting. The pelleted substance was kept for overnight in shade for better attachment of the micropropagules. Four different treatments were made a) control; b) nanomycorrhiza alone; c) organic Bio- Zinc treated alone; d) nanomycorrhiza and organic Bio- Zinc. Seventy pelleted seeds were placed in each pot at equidistance in the soil and water was sprinkled in large cemented pots, size 92X35X32. The experiment was performed in the environmentally controlled green house at 25±2ºC with 60% of moisture and light intensity of 10,000 Lux. Experiments were performed in triplicates. Results suggested that seed germination and different growth parameters were significantly increased in the combined treatment of nanomycorrhiza and organic Bio-Zinc compared to individual treatments. This result indicated that a synergic

combination increased the plant growth and enhanced several biochemical parameters and can be beneficial in future to increase the plant yield in nutrient deficient soil.

OP-05

The promise of biological control of insect pests with rhizobacteria

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Insect pests cause considerable losses in crop production. Producerstypically rely on chemical pesticides to protect their crops against herbivorous insects. Intensive use of chemical pesticides may result in manynegativeimpactsincludingtoxicity to humans, environmental pollution, effect on non-target species anddevelopment of pest resistance. Consequently, there is an increasing demand from consumers to reduce the use of chemical pesticides in crop production. Biological control of insectswithentomopathogenic microorganisms (i.e. biopesticides) has emerged as a promising alternative to chemical pesticides. Biopesticideshave many advantages in sustainable pest management including unique mode of action and reduced toxicity to humans. Several formulations of entomopathogenic microorganisms including fungi (e.g., *Beauveria* spp., *Metarhizium* spp. and *Paecilomyces* spp.), nematodes (e.g., *Steinernemaspp. AndHeterorhabditisspp.),* and bacteria(e.g., *Pseudomonas* spp.and*Bacillus*spp.) are now commercially available for control of various insect pests. However, these formulationstypicallyhave limited environmental persistence. Recent research studies have identified certain strains of plant growth-promoting rhizobacteria (PGPR) capable of inflicting toxicity against insect pests either by directly killing insects upon application or viainduced systemic resistance (ISR) in plants. PGPR are beneficial soil microorganisms which can elicit increased rates of plant growth and suppress soil pathogens and plant diseases. In contrast to other entomopathogenic microorganisms, PGPR dwell in the rhizosphere (i.e. plant-root interphase), a factor which could extend their persistence as biopesticides. This paper will present a summary ofthecurrent knowledge regarding the use and role of PGPR in insect control.

OP-06

PGPR and other microbials in sustainable management of aflatoxin contamination of food crops

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Aflatoxin contamination of agricultural commodities has gained global significanceas a result of their deleterious effects on humans as well as animal health and its importance to international trade. As per the FAO estimates, about 25% of the world's food crops are affected by mycotoxins. However, commodities with highest risk of aflatoxin are corn, groundnut and spices. Thepresent investigation is to device sustainable management strategiesfor aflatoxin contamination in groundnut and chilli using potential PGPR,*Pseudomonas fluorescens* and antagonisticfungus,*Trichoderma*along with eco-friendly bio inputs.*Pseudomonasfluorescent* isolate possessing broad spectrum antibiotic genes such as 2, 4 Diacetyl phloroglucinol (DAPG) and phenazine with ability to produce siderophore andanti-microbialcompound such as hydrogen cyanide were selected. Such isolate (EP-5) having induction of systemic resistance was formulated, worked out for shelf life, compatibility with insecticides, fungicides and plant products. The isolate of *P. fluorescens* (EP-5) was used for enriching farm yard manure (FYM) and neem cake and its consortium with *Trichoderma viride* wasused for soil application and foliar spray, under field conditions. The experiment was conducted in University researchfarm for two seasons during *Kharif*2012 and 2013 in both groundnut and chilli crops. The population of *Aspergillus flavus* was monitored throughout the crop season in the treatments imposed over control.Application of neem cake and FYM enriched with consortium of *Trichoderma viride* and *P. fluorescens* with a foliar spray of *P. fluorescens*as a pre-harvest spray brought down the population of*A. flavus* by79 to 90% in chilli fields,subsequently with significant reduction in aflatoxin infection on fruits. Similarly, the population of *A. flavus*was reduced by 68 to 72% in groundnut geocarposphere with significant reduction in aflatoxin incidence as well, thus helps in minimizing aflatoxin contamination in food chain.

OP-07

Mass spectrometric evidence for the presence of phytohormones in vermicomposts and vermicompost tea and their positive effects on plant growth

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Through their decomposing activities, earthworms produced rich organic fertilizers called vermicomposts containing mineral nutrients and anecdotal evidence of biologically active phytohormones.Both vermicomposts and aqueous extracts of vermicomposts, namely vermicompost tea (VT), have positive effects on plant growth. It was postulated that trace amounts of phytohormones in vermicompostsand VT are beneficial for plant growth and development. We therefore screened for the different classes of phytohormones (auxins, cytokinins [CKs], abscisic acid, gibberellins) in vermicomposts and VT using LC-MS/MS after

solid-phase extraction (SPE). The sample preparation of vermicomposts required an additional ultrasound-assisted extraction (UAE) step, prior to the SPE step. This is the first mass spectrometric and therefore unequivocal evidence for the presence of phytohormones in vermicomposts and VT. The phytohormones present in vermicomposts are: N^6-Isopentenyladenine (iP), N^6-Isopentenyladenosine (iPR) and indole acetic acid (IAA), and quantified to be 0.49, 0.53, 79.78 ng g^{-1}, respectively; *trans*-Zeatin (*t*Z) was found to be below the limit of quantitation. The phytohormones present in VT are:*t*Z, iP and iPR, and were determined to be present at 0.06, 3.33, and 0.02 pmol mL^{-1}, respectively. Interestingly, auxins were found in vermicomposts but not found in VT. The successful detection and quantitation of growth promoting phytohormones in vermicomposts and VT provided direct evidence to explain the growth efficacy of applying vermicomposts or VT to enhance plant growth and development.We postulated that iP is a good reflection of the microbial origin for CKs present in vermicomposts and VT due to its importance in CK biosynthesis pathways and high abundance provided by microorganisms. The agronomic performance of the test plants, growing on substrates with varying levels of vermicompost or its tea, is discussed in relation to the presence of CKs.

OP-08

Production and characterization of Trichoderma metabolites: A new approach for selective bioremediation

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At last decade *Trichoderma* sp. has been used as biocontrol agent as it produces a plethora of inhibitory secondary metabolites with biological activities, which includes volatile, nonvolatile and diffusible types. The process of invasion and infection of the ground nuts (*Arachishypogaea* L.) by *Aspergillus* species and subsequent production of aflatoxin is quite complex, but in such situation,the biological control method has been successfully utilized. In the present study 10 speciesof*Aspergilli*were isolated and purified from the rhizosphere of infected *A. hypogaea.* The selections of *A. flavus*and *A. parasiticus* were done assuming their higher aflatoxin production observed at 365nm under UV on coconut agar medium. The four species of *Trichoderma*viz.*T.viride, T. harzanium, T. flavofuscum*and *T. virens* were screened for their antagonistic properties based on co-culture (Dual culture, pathogen at centre and pathogen at periphery techniques) and inverted colonyplate techniqueagainst selectedseven*Aspergillus* species. It has been observed that *T. virens*and*T. harzanium*were more effective in their action of diffusible metabolites, while, *T. flavofuscum* shows the significant results in case of volatile metabolites against aflatoxin producing *Aspergillus* species.In the co-culture system for bioremediation of aflatoxins, *T. harzanium* superiorly control the growth of *A. flavus*(20.94%) with aflatoxin B1 (75%).While in case with *A. parasiticus*inhibition observed as growth (47.91%), Aflatoxin-B1 (86.66%) and G1 (77.77%).The integrated management of aflatoxin wasestablished in field experiment. It has been found out that the use of Trichoderma culture for

twice, 1) in soil and 2) during flowering could provide a better control of *A. flavus*as *T. harzanium* reduces B1 concentration from 31.35068 to 4.8274176 µg/100g) and *A. parasiticus*(from 10.33538 to 1.15804µg/100g) as analyzed by UV and HPLC technique. The trichodermal metabolite production was carried out on the PDA fermentation medium forthreeweeks at 28°C. The fungal metabolites extracted using the solvent partition fractionation method. The extract was dried and separated by optimizing solvent system for TLC. The antifungal activities of purified metabolites were performed by TLC bio autography method against *A. flavus*and *A. parasiticus*. The bioactive band was purified andcharacterized by UV, HPLC and LC-MS, showing harzianic acid and 6-n-pentyl pyrone as antifungal metabolites.

OP-09

Evaluation of a plant growth-promoting rhizobacteria, *Azospirillum lipoferum* with reduced dose of fertilizer on growth and yield of a local rice variety cultivated in Mekong Delta of Vietnam

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The application of mineral fertilizers is the most advantageous and the fastest way to increase crop yields. In the last few decades the rate of nitrogen (N), phosphorous (P) and potassium (K) or NPK fertilizer application has tremendously increased in crop production. The excessive use of synthetic agrochemicals in crop production and in soil fertility management causes residue toxicity and environmental pollution. This is due to low use efficiency of externally applied fertilizers by the plants, long-term application, leaching, and evaporation to atmosphere.Therefore, the reduced use of synthetic agrochemicals in crop production and to maintain soil fertility by alternative means is the subject of investigation. The challenge is to continue sustainable agricultural crop production through minimization of harmful effect of fertilization.Among the different alternatives, researchers hypothesized that plant growth-promoting rhizobacteria (PGPR) could be a substitute to these. A field trial was carried out in acid sulphate paddy soil to study the effect of *Azospirillum lipoferum* as a PGPR on the growth of a local rice variety cultivated in Mekong Delta, Vietnam. The results showed that rice inoculated with *A. lipoferum* with combination of 50% N/ha of inorganic fertilizer improved color leaf index, plant height, length of panicle, number of panicle/m^2, dry weight of straw and rice yield equivalent to those of rice grown with 100%N/ha of inorganic fertilizer without *A. lipoferum* inoculation. Especially, root length of inoculated rice with *A. lipoferum* with 50% N/ha was significantly longer than those of uninoculated rice applied only with 100% N/ha.. Our results suggest that application of *A. lipoferum* with reduced dose of N/ha could promote rice growth and enhance yields compared to higher dose of N/ha without *A. lipoferum*.This gives us an idea about the potentiality of these PGPR strain and their application in rice cultivation to get a better harvest index. Their use will also possibly reduce the nutrient runoff or leaching and

increase in the use efficiency of the applied fertilizers. Thus, we can conclude that the NPK uptake and management can be improved by the use of PGPR in rice cultivation, and their application may be much more beneficial in the agricultural field in Mekong Delta of Vietnam.

OP-10

Potential use of rhizobacteria in groundnut grown in sandy soil in Binh Dinh province of Vietnam

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Groundnut (Arachis *hypogaea* L.) is an important food crop in Vietnam. Binh Dinh province in Vietnam has large area of cultivated groundnut in sandy soil which is low in fertility and drought prone area. Biocontrol using plant growth promoting rhizobacteria (PGPR) may represent a potentially attractive alternative disease management approach since PGPR are known for growth promotion and disease reduction in crops. PGPR are generally considered a heterogeneous group of bacteria that live in the plant rhizosphere, where they contribute to plant growth and improve stands under stress conditions. PGPR can improve growth through various mechanisms and have been introduced to soil, seeds or roots to enhance plant growth and health. The present study was conducted to investigate nitrogen fixing bacteria (*Bradyrhizobium japonicum*), phosphorous solubilizing bacteria (*Bacillus megaterium*), silicate bacteria (*Paenibacillus castaneae*) and polysaccharide synthesized bacteria (*Lipomyces starkeyi*). These bacteria were isolated from rhizosphere and nodules of groundnut. Under greenhouse conditions, our results showed that use of these rhizobacteria reduced 10-20% of NPK in groundnut, improved groundnut growth, increased content of total NPK in the stems, leaves and also increased the yield of 8.3-14.0% compared with control (using 100% NPK and no microbial inoculants). Also reduced 10-20% NPK for groundnut has a positive effect on the density of microbial in the soil, increase the humidity of soil (12.9-19.9%), increased the height of groundnut (5.4-11.9%), enhanced green biomass (4.6-7.4%), more yield (9.0-14.0%) and increased the benefit 5.02-7.00 VND/ha compared with control (using 100% NPK and no microbial inoculants) in the field condition. Our studies clearly show that the use of combination of rhizobacteria tested has the potential to commercialize microbial inoculants for use in groundnut in sandy soil in Binh Dinh province of Vietnam.

OP-11

Streptomycesflocculus (RP1A-12): A potential actinomyceteagainst Groundnutstem rot disease (*Sclerotium rolfsii*)

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Application of actinomycetes for managing soil borne diseases is gaining momentum in present day agriculture. In groundnut, stem rot incited by *Sclerotium rolfsii* is a major soil borne disease with significant pod yield losses worldwide. In our present study, the efficacy of *Streptomycesflocculus* RP1A-12 in inhibiting stem rot disease was established under greenhouse and field conditions. Groundnut rhizosphere actinomycetes were screened against *S. rolfsii* using various *in vitro* assays. The crude extract of superior strain (RP1A-12) was also tested *in vitro* against *S. rolfsii*. Further, RP1A-12 was characterized for growth-promoting traits and for the specific antifungal metabolite production. Greenhouse and field trials were conducted to evaluate the efficacy of crude extracts alone and whole organism of RP1A-12 against stem rot and yield enhancement. Our results indicate RP1A-12 has inhibited *S. rolfsii* up to 68% in dual culture; 78-100% in culture filtrate studies; and 100% with crude extracts (1% concentration). The RP1A-12 has shown to produce HCN, lipase, siderophore and IAA. Greenhouse studies indicated RP1A-12 and its crude extractalone significantly enhanced root length, seedling height and seedling vigor in greenhouse. Further, seedling mortality was recorded up to 22% and 66% with RP1A-12 and its crude extracts alone respectively. Field studies indicated that both RP1A-12 was effective as whole organism as well as crude extract alone in reducing stem rot severity (up to 2.9 each on 1-5 scale) as against control (severity scale of 4.7). Pod yields were up to 1041 kg ha^{-1} each in plots applied with RP1A-12 and its crude extract alone as against 472 kg ha^{-1} in control. Both RP1A-12 and its crude extract were comparatively more effective as combined treatment to seed and soil over their individual applications. Overall, our results suggest the scope of RP1A-12 and its metabolite based formulation in comprehensive management of stem rot disease.

Key Words: Groundnut, stem rot, *Sclerotium rolfsii*, Actinomycetes, *Streptomyces flocculus*

OP-12

Plant growth stimulation and biocontrol of fusarium wilt (*Fusarium oxysporum* f. sp. cubense) by co-inoculation of banana (*Musa* spp.) plantlets with PGPR and endophytes

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In banana (*Musa* spp.), enhanced interest in the use of *in vitro* produced planting material has revolutionized its cultivation by the way of producing homogenous and clean planting material. However, loss of beneficial microorganism such as endophytes through the axenic production of tissue culture plants may probably make them more vulnerable to disease attack in the field than plants derived from suckers. Although tissue culture plants may offer temporary solutions to disease problems in banana, there is a need to develop affordable, sustainable and environmentally friendly management strategies that complement the benefits of clean planting

material offered by tissue culture. These problems could be overwhelmed by the reintroduction of microorganisms or their consortia at the rooting medium under *in vitro* conditions, to protect against diseases, improvement of establishment and overall performance. Plant growth and disease development were tested on the disease susceptible cultivar 'Red Banana' (AAA) after *Fusarium* infection of tissue culture plantlets bacterized *in vitro* (by co culturing with the bacterium) and non-bacterized plantlets. Results revealed that significant differences in both disease suppression and plant growth were obtained between *in vitro* bacterized and non-bacterized plantlets. Among the treatments, banana plantlets treated with mixture of bacterial strains *viz*., EPB 10 + EPB 56 + Pf1 was significantly effective in reducing *Fusarium* incidence under glasshouse and field conditions. It also increased the leaf nutrient status and enhanced growth, bunch yield and the quality of the fruits compared with untreated plants. Since banana, unlike most other seed plants, is solely dependent on propagation by tissue culture for industrial purposes and thus may lose the multiple natural endophytes through sterilization during the micro propagation process. Hence, enrichment of endophytic communities in tissue culture plantlets under *in vitro* conditions would probably benefit the host upon exposure to environmental stress in field plantings.

Keywords: Banana -micro propagated plantlets - *Fusarium* wilt - *in vitro* bacterization - economic yield

OP-13

Interaction of plant growth-promoting bacteria and microalgae: from basic studies of plant–bacteria interaction to potential biotechnological applications

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A simple, quantitative experimental model, offering a convenient and basic approach to studies of plant–bacterium interactions, is proposed. This involves immobilizing a unicellular, freshwater microalga, a species of *Chlorella* that serves as the plant and a plant growth-promoting bacterium (PGPB), a strain of a species of *Azospirillum* of agricultural origin. The two micro-organisms are co-immobilized in small alginate beads to allow close interaction and avoid external interference from bacterial contaminants.Indole-3-acetic acid that is produced by the bacteria has demonstrated its role in enhancing growth rates and population size of the microalgae. This close interaction positively affects nitrogen, phosphorus, carbohydrates, lipid, and photosynthesis metabolisms. All these significant metabolic changes during co-immobilization of the two micro-organisms are interlinked and offer several biotechnological applications. These include wastewater treatment, carbohydrate and lipid production, photosynthetic pigments, and food for human and animals. This model is also a simple and easy to handle tool for basic science biological studies.

OP-14

Effect of mixed inoculations of plant growth-promoting rhizobacteria of chilli on growth and induced systemic resistance of *Capsicum fruitescenceL.*

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In recent years, strategies for development of sustainable agricultural systems of eco-friendly, low input of non-renewable resources and less cost gaining much attention. One such attractive strategy is use of PGPR. Pseudomonas and Bacillus are ubiquitous bacteria in agricultural soils and has many traits that make them well suited as Plant growth-promoting rhizobacteria (PGPR) and mediated biological control indirectly by eliciting induced systemic resistance (ISR). The study was carried out to know the effect of combined inoculations of Plant Growth-Promoting Rhizobacteria (PGPR) on growth and PGP and ISR of chilli. Out of 55 bacterial colonies isolated from chilli rhizosphere, 13 morphologically distinct colonies (AVP1-AVP13) were selected and screened for plant growth promoting traits such as Phosphate solubilisation, Indole Acetic acid, Ammonia, Siderophore, Chitinases and HCN. All 13 isolates exhibited multiple PGP traits and were identified as species of Pseudomonas (AVP1,2,3,4), Bacillus (AVP5,6,7,8,9,10) *Achromobacter* (AVP22) *Klebsiella*(AVP23) and *Stenotrophomonas* (AVP27) based on morphological, biochemical and 16S rRNA gene sequence. AVP 3 showed potential phosphate solubilisation and tolerance to high salt concentration. Only one isolate AVP7 was antagonistic to *Colletotrichum gleosporioides* and *Colletotrichun coccoides*. Seed bacterization of chilli by AVP3, AVP7 and mixed inoculation of AVP3+AVP7 resulted in varied growth response and induced systemic resistance (ISR) under greenhouse condition. All inoculations positively influenced chilli growth. ISR response was negative with isolate AVP3 and positive with isolate AVP7 and very high with mixed inoculation of AVP3+AVP7. Results suggested that PGP traits of bacterial isolates were highly specific and application of mixed inoculation of bacterial isolates with varied specificity can influence growth and ISR more efficiently than application of individual PGP isolate.

Key words: PGPR, ISR, Rhizosphere, Chilli, Mixed inoculation

OP-15

Nanonutrients with lacto-gluconates based nutritional biofertilizer's for sustainable agriculture

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In context to environmentally benign technology, present study was made for biosynthesis and commercialization of nanonutrients with lactogluconate which were used as nanofertilizer for sustainable agriculture. The present invention of nanonutrients biosynthesis and their uses as nanofertilizer is a green ecofriendly approach to enhance crop production. In order to address issues of low fertilizer use efficiency, imbalanced fertilization, multi-nutrient deficiencies issues and decline of soil organic matter, it is important to evolve a nano-based fertilizer formulation with multiple functions. However, the present biosynthesis and commercialization of nanofertilizer is the new way and first time in globe by Prathista Industries as a fourth generation (4 G) technology.

OP-16

Plant growth stimulation and biocontrol potential of fluorescent Pseudomonads under saline conditions

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Stress tolerating strains of fluorescent Pseudomonads were isolated from the semiarid regions of west Kanpur, Uttar Pradesh, India. Strains were monitored for their biocontrol and plant growth promoting (PGP) traits under saline and non-saline conditions. Some of the strains displayed survivability under high salt stress *in vitro* conditions. These strains also displayed efficient biocontrol against dreadful phytopathogen*Macrophominaphaseolina*under saline stress.These strains also demonstrated production of diverse PGP and biocontrol metabolites including phosphate solubilization, Indole-3-acetic acid production, siderophore, pyocyanin, exopolysacharides and salicylic acidup to 500 mM NaCl. *In vivo* pot study and field trials were conducted in semi-arid regions (soil having EC 10 dS/m) of Kanpur Dehat, naturally infested with *M. phaseolina* (10^3 CFU/g soil) taking chickpea (*Cicerarietinum*) and sunflower (*Helianthus annuus*) as a test crop. *Pseudomonas aeruginosa* EK issuppressedcharcoal rot disease incidence in chickpea by 67.65% and 58.45% under non saline and saline conditions, whereas*Pseudomonas aeruginosa*PF23 suppressed disease incidence by 71% and 63 % in sunflower under non-saline and saline conditions.Saline tolerant strains PF23 and EKi also worked efficiently in boosting early seedling emergence, enhancing plant growth parameters, increasing seed weight and mitigating stress in saline affected regions. Thus on the commercial scale, application of these fluorescent pseudomonads might prove beneficial and could be a sound step towards sustainable crop production and reclamation of saline lands. Bio formulations developed frommetabolites of these multifaceted strains may be considered as commercially important for renovation of stressed sites, enhancing plant growth parameters and management of charcoal rot disease incidence in diverse crops under saline conditions.

Keywords: Biocontrol, chickpea, fluorescent Pseudomonads, sunflower and saline stress

OP-17

Chemical properties of locally composts produced in Saudi Arabia and the need for regulations

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Most of the soils in Saudi Arabia, located in aired and semiarid region of Asia, it has a very low amount of organic matter. To improve the organic matter in these soils, organic fertilizers are used, which ameliorate the chemical, physical and microbiological characteristics of these soils. Application of compost, as a rich source of organic nutrition, is favorable. With regard to the importance of this issue; our research was aimed to evaluate the quality and stability of compost locally produced in Saudi Arabia, in the term of chemical characteristics included electrical conductivity (EC), pH, C/N ratio, nitrate and ammonium concentrations, organic matter (OM) and heavy metals levels. The results showed variation in the chemical characteristics of all types of compost under study. Final EC values ranged from 0.6 dSm^{-1} to 25.4 dSm^{-1} and about 93 % exceeded the upper limit set by CCQC and PAS-100. Most pH values were above 7. Ammonium contents were between 178 $mgkg^{-1}$ and 2650 $mgkg^{-1}$ in the final product with 44.4 % above the recommended level, while nitrate contents were between 69.7 $mgkg^{-1}$ and 1157.8 $mgkg^{-1}$ with 22.2 % above the recommended. Concentrations of Zn, Cu, Co, and Pb were in the accepted range. However, Cd and Ni concentrations were exceeded the suggested limit in about 42.8 % and 33.3 %, respectively.

OP-18

Microbial quality of commercial biofertilizers to increase nutrient use efficiency and crop Productivity

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Commercial agricultural inoculants are increasingly being produced and sold in the market worldwide, and are claimed to have a major impact on increasing crop productivity. The main

objective of this research was to characterize and assess the microbial content of biofertilizers obtained from different countries in order to verify whether they fulfill the claims of the manufacturers. The proliferation of the underperforming inoculants can thereafter be prevented, and value can be added to effective products. The microorganisms contained in the commercial inoculants were isolated, purified, and identified by partial sequencing of the 16S rDNA. Results showed that the majority (about 64%) of the products contained one or several strains of contaminants and only 37% of the products could be considered as pure. Forty percent of the tested products did not contain any of the claimed strains but only contaminants and several potential human pathogens were found. Rhizobial products were generally of better quality than the other PGPR-based products. Results highlight the need for better quality control systems to ensure efficacious products reach the end users.

OP-19

Diverse role of biocontrol technology in crop protection

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Biocontrol technology is the use of living systems and organisms to develop useful products, or "any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for specific use.It is an emerging field with a strong foundation in ecosystem development by nature friendly methods for source tracking of environmental pollutants and treatment processes for contaminated soil, water, air, pathogens. The microbial inoculants based applications are involved in IPM processes which play significant role in supporting the damaged ecosystems and play an immense role in the development of critical treatment processes for crop improvement and sustainable agriculture and life forms converting a biological response into a processed signal. This technology is not only the application of biological control agents in the field but also encompasses many other aspects of host, pathogen and biocontrol agents.Integrated Pest Management includes precise studies on disease development host, pathogen and environment interaction. There is an acute necessity to develop and produce smart and innovative biosensor devices for monitoring and plant disease diagnosis and impact regulation of various geological processes and biological processes like unforeseen changes of climate, and fast spreading of fungal, viral and bacterial diseases of agricultural and forest plants. A range of molecules with bio recognition powers are available naturally such as toxins and enzymes released in this process. Another field of application can be used as the sensing receptors in biosensors in the use of microbial inoculants for disease management. The demand for rapid and accurate diagnosis of plant diseases has risen in the last decade. Physical features like Soil pH, calcium level, nitrogen form, and the availability of nutrients play major roles in disease management. Perhaps, early diagnosis of fungal disease, in addition to an accurate classification of the pathogenic fungal type during post-harvest storage is another field which is very work to be achieved through biosensors.A biosensor is an analytical device, used for the detection of ananalyte, but combines a biological component with a physicochemical detector or transducing microsystems and is a powerful alternative to conventional techniques. Fast and accurate sensing technology is the need now-a-days in monitoring different agricultural areas specifically its emerging role in crop protection, detection and identification of diseases.

The nutritional status of the soil and the use of fertilizers and amendments also have significant impacts on the pathogen's environment. Diverse microorganisms secrete and excrete other metabolites that can interfere with pathogen growth and/or activities. Many microorganisms produce and release lytic enzymes that can hydrolyze a wide variety of polymeric compounds, including chitin, proteins, cellulose, hemicellulose, and DNA. To achieve long-term success, genetic engineering projects for recognizing the adaptive balance of pathogen and host where phytoalexins for disease resistance play a vital role. The process requires manipulation of a single or a few genes directly involved in their biosynthetic pathways or involved in their signalling /regulatory pathways.Expression and secretion of these enzymes by different microbes can sometimes result in the suppression of plant pathogen activities directly. Another area of IPM research is bioremediation of polluted soils in different agro ecosystem. Bioremediation is an innovative treatment technology that has the potential to alleviate numerous pesticide contamination problems. Extensive use of pesticides has deteriorated the soil quality by depleting carbon resources. The most popular biocontrol agent *Trichoderma* spp. as well as other biologically safe alternatives may be used to establish themselves in soil and can help degrading the pesticide residue in soil in an ecofriendly manner.The tolerance of *Trichoderma* spp. to fungicides is quite remarkable and its activity is associated with the cellular system of detoxification based on the production of the enzymes for the breakdown of a chemical compound to either fully oxidized or reduced simple molecules. Although many enzymes efficiently catalyze the biodegradation of pesticides, the full understanding of the biodegradation pathway often requires new investigation in depth to decide their fate in the environment.

OP-20

Actinomycetes, promising rhizobacteria for biological control of plant diseases

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Actinomycetes are aerobic Gram-positive bacteria, which are present in high population densities in soil environments, where they play an important role in reducing inoculum of plant pathogens. In this study on biological control of plant diseases using actinomycetes, a total of 187 strains were isolated from the rhizosphere of sesame and vegetables crops. Several of these strains had antagonistic potential against various fungal pathogens such as *Fusariumoxysporum*f.sp. *sesami*(*Fos*), causing vascular wilt on sesame; *Phytophthoranicotianae*,causingPhytophthora blight or black shank disease on sesame; *P. capsici*, causing fruit rot in watermelon, *Colletotrichumgloeosporioides*, causing anthracnose in chilli and *Rhizoctoniasolani* in cabbage. For each pathogen, we selected strains showing large inhibition zones in dual cultures tests for evaluation of their ability to control the diseases *in planta* under greenhouse conditions. In experiments with *Fos*on sesame, soil drench with suspensions of four individual actinomycetestrains (3, 6, 25, 79) or a mixture of these four strains at ten days intervals, resulted

in significant reductions in disease incidence (72, 80, 68, 68 and 64% diseased plants, respectively) compared to the control (96% diseased plants) at 25 days after inoculation. For *P. nicotianae* on sesame, suspensions of actinomycete strains 8, 25, 29, 51 and 89 were applied individually by soil drenching before sowing and combined with collar spraying at one day after pathogen inoculation. All strains significantly reduced the percentage of plant infection, with strains 8, 51 and 89consistently expressing high levels of disease reduction similar to treatment with the fungicide Mancozeb. With respect to *P. capsici*on watermelon, spraying individual suspensions of strains 51, 22 and120 before pathogen inoculation significantly reduced fruit rot compared to the untreated control. Similarly, for *C. gloeosporioides* on chilli, spraying individual suspensions of five actinomycete strains one day before pathogen inoculation gave significant reductions in disease with lesion length on fruits ranging from 1.3 to 2.4 mm compared the untreated control (9.1mm) at four days after inoculation. For *R. solani*in cabbage, soil drenching with suspensions of individual strains 4RM, 54 or 54RM significantly reduced fungal infection compared to the untreated control. Thus, percentages of infected plants were 33, 61 and 56, respectively, compared to 100% in the control treatment. In conclusion, these results clearly show that actinomycetes are promisingagents for controlling fungal plant pathogens and in the future, the mechanisms by which the actinomycetes reduce disease will beinvestigated.

Keywords: Actinomycetes, biological control, plant diseases

OP-21

Role of PGPR in sustainable agriculture: global climate change and water sustainability

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Declining fresh water resource is one of the central challenges for improving food security across the world. Continuous negative impulses of climate change incorporate furlong competition for global water resources that increases vulnerability to food insecurity, particularly in Africa and Asia. Contemporary researches for plant growth and development under restricted water resource are getting significant importance in sustainable agricultural practices. Apart from the conventional plant breeding and transgenic approaches, application of plant growth promoting rhizobacteria (PGPR) commences an ecofriendly approach that get considerable attention to improve drought stress tolerance in crop plants. Relatively few reports have been published on the bacterial ability to induce drought stress tolerance. However, application of prominent PGPR isolates mulching with novel technologies can contribute substantially towards solving global food issues in the rain fed agricultural practices. A massive investigation with green gram rhizosphere adhered fluorescent pseudomonads showed distinct growth and development in the host plant during drought stress condition. A potential consortium of fluorescent pseudomonads showed an elevated production of reactive oxygen species scavenging enzymes and cellular osmolytes; increased root length, shoot length, dry weight, relative water content; and a stronger up regulation of three drought stress-responsive genes, i.e., dehydration responsive element

binding protein (*DREB2A*), catalase (*CAT1*), and dehydrin (*DHN*) in the green gram plants in comparison with the uninoculated control plants under drought conditions. The field experimental data showed an increase in biomass and better growth and development in inoculated and stressed plants when compared with untreated and stressed plants. Thus the fluorescent pseudomonad consortium was proven to be an excellent plant growth promoting (PGP) agent, particularly in the rain fed agro climatic condition of North Eastern India.

OP-22

Endophytic bacteria as plant growth promoters under biotic and abiotic conditions

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There is a growing interest in utilizing endophytic bacteria as plant growth promoting biofertilizers or biological control agents. Beneficial plant–endophyte interactions that promote plant health and development is the subject of study. In order to reduce inputs of pesticides and fertilizers and add value to eco-friendly agriculture, it is important to develop inocula of biofertilizers, stress protection and biocontrol agents. Recent work has investigated the potential microorganisms for the enhanced plant growth under abiotic stresses and controlling of plant diseases and pests. Most of these studies have focused on microorganisms from the rhizosphere/rhizoplane of plants promoting plant growth by free-living rhizobacterial strains, and much still remains to be learned from endophytic bacteria. The bacterial endophytes are believed to enhance the host plant growth and health through mechanisms proposed for plant growth promoting rhizobacteria (PGPR). In comparison with rhizosphere and rhizoplane bacteria, endophytic bacteria are likely to interact more closely with their host plant which live inter and intra-cellularly in plants without inducing pathogenic symptoms, surviving severe external environmental disturbances while interacting with the host biochemically and genetically. Therefore endophytes as elicitors for expression of drought stress-responsive genes inside plant tissues give us clear idea about endophyte mediated drought tolerance in plants which could lead to their large scale applications and minimize the risk to the farmers. The objective of this study is to assess,

1. Whether endophytic bacteria stimulate effective plant growth and shows antagonistic activity against different plant pathogens
2. Whether endophytic bacteria elicit stress responsive genes to enhance stress tolerance in inoculated plants (Maize).

In the present study endophytic bacteria inside the maize seeds and root tissue of different ecosystems were isolated. Isolates were screened based on different colony characteristics and fluorescence as well as non-fluorescence pigmentation. Bacterial endophytes were tested for plant growth promoting traits as well as biocontrol activity against different plant pathogens. Isolates were identified using phenotypic and genotypic characterization. Selected isolates were tested for plant growth promotion on maize. The result suggests the possible role of endophytic bacteria in plant growth and protection which may lead to development of microbe based - ready technology.

Keywords: Endophytes, plant growth, drought stress

OP-23

The rhizosphere microbiome to the rescue

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Microbial communities that are associated with plant roots are highly diverse and harbor large numbers of bacterial and archaeal species. Several functions that are provided by this so-called rhizosphere microbiome are drivers of plant growth and health and include the suppression of infectious diseases. The latter function is prominent in so-called disease suppressive soils, in which susceptible plants are protected from infection by a virulent pathogen. In these soils micro-organisms that are associated with disease suppressiveness have been identified. When applied to disease conducive soils some of these micro-organisms can indeed effectively control soil borne diseases. The mechanisms implicated in disease suppression by these biological control agents include competition for nutrients and space, antibiosis, and induced systemic resistance. For many biological control agents, and especially fluorescent *Pseudomonas* spp., induced systemic resistance has been recognized as a major mechanism of disease suppression. It has been reported for several disease suppressive soils that an outbreak of disease is required for suppressiveness to establish. Pathogen infection can lead to changes in root exudates resulting in modified microbiome composition and activities. Thus it has been suggested that plants recruit a beneficial microbiome upon attack by pathogens. Here we will discuss implications of induced resistance on the ecology of ISR eliciting biocontrol agents and on infection-induced recruitment and functioning of the rhizosphere microbiome.

OP-24

Disease suppression effect and rhizosphere competence of *Pseudomonas jessenii* RU47 in various soil types at the field scale

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Soil-borne pathogens such as the widely distributed basidiomycete fungus *Rhizoctoniasolani* are hard to control. It is well documented that the treatment of plants with beneficial bacteria having the ability to improve plant health is an environmental friendly method to ensure crop productivity. However, the efficacy of bacterial inoculants on productivity shows often a lack of consistency at field scale. A better understanding of factors influencing the biocontrol activity of bacterial inoculants is needed. We assume that the plant species (lettuce, potato) and the soil type affect the ability of the inoculant strain *Pseudomonas jessenii* RU47 to colonize successful the rhizosphere in a sufficient density and its biocontrol effect against Rhizoctonia diseases, respectively. An experimental plot system with three soil types enabled us to investigate the effect of the plant species and the soil type on the rhizosphere competence of the inoculant and its biocontrol activity independent from site factors. The soils of the experimental plot system were stored for more than ten years under similar agricultural management. The inoculant RU47 showed a good rhizosphere competence in lettuce and potato during the whole growth period with significant positive effects on plant health. The rhizosphere competence of RU47 determined by selective plating was not influenced by the soil type. In addition, the effect of RU47 and the pathogens *Rhizoctoniasolani*AG 1-IB and AG 3 on the bacterial community composition in the rhizosphere was studied by denaturing gradient gel electrophoresis of 16S rRNA gene fragments amplified from total community DNA. The inoculant RU47 had negligible influence on the bacterial community composition in rhizosphere of potato, but more pronounced effects in the lettuce rhizosphere. The effects of the pathogen *R. solani* AG1-IB on the bacterial community composition in the lettuce rhizosphere were negligible, whereas *R. solani* AG3 effects in the potato rhizosphere were more pronounced. These differences were likely caused by the different pathogenesis of the two pathogens.

OP-25

Application of nitrogen fixing bacteria (Azospirillum) as biofertilizer for enhancement of yield of rice (*Oryza sativa)*) in the Philippines

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Crop production serves as one of the major sources of food and livelihood for Filipinos. Major crops grown are rice, corn, sugarcane, banana, and vegetables. The total land area cultivated to rice is 4,413,717 hectares and corn is 2,751,212 hectares. However, despite the large area for rice and corn production, the food grain supply in the country is still below full potential and yields remain low because of the continuous use of inorganic fertilizer nitrogen harms the soil since it lowers the natural fertility of the soil, disrupts the existing balance of nutrients and disturbs the microbial flora inhabiting the soil. Nitrogen fixing biofertilizer ***(NFB)*** started with the continuous screening of useful organisms under laboratory conditions resulting to the discovery of two isolates of*Azospirillum* bacteria from the roots of talahib (*Saccharumspontaneum L.*) that enhance the nitrogen intake of plants.***Nitrogen fixing biofertilizer*** is a "timely" product since it is environment-friendly, economical and utilizes bio-degradable materials. There would be reduction in the cost of farm inputs while resulting to higher yields which would offer the farmer higher net income. Field experiments for rice were conducted to determine the effect of ***NFB*** inoculation and nitrogen fertilizers on the growth and yield of rice under lowland condition**.** Grain, biomass yield, tiller count filled and unfilled grains and weight of 100 grains were recorded. The results of the data gathered from the farmer's field, showed 5.40 tons per hectare which involved the inoculation of *NFB* and ½ rate of nitrogen fertilizer based on soil analysis followed by ***NFB*** and full dosage of nitrogen fertilizer. Another experiment was conducted from the farmer's field and data showed high yield in all treatments inoculated with ***NFB*** 3.48 kg and 3.14 kg per hectare. The results of the study revealed that ***NFB*** contributed to the yield of the test plant in these experiments.

Keywords:*Azospirillum,* biofertilizers, rice, maize. Nitrogenfixing,talahib, *Saccharumspontaneum L.*

OP-26

Environmental and ecological constraints on PGPR functioning

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One of the major limitations of PGPR technology is the variation in the benefits obtained upon their field application. This is also true for biocontrol strains of *Pseudomonas* which inhibit phytopathogens by production of different antifungal molecules such as 2,4-diacetyl phloroglucinol (DAPG), pyrrolnitrin (PRN), pyoluteorin (PLT) and phenazines (PHZ). In the present work we have studied the effect of nutritional availability on the manifestation of PGPR trait for biocontrolin different fluorescent pseudomonads strains and its effect on root nodulating rhizobia. We document that the production of antifungal molecules in various strains are differently affected by the environmental factors. Antifungal metabolite production was sensitive to P limitation in some but not all strains and depended on nature of C source. Interactions among two groups of PGPR, biocontrol pseudomonads and root nodulating rhizobia showed thatsomePGPR isolates were tested positive for inhibition against certain rhizobial cultures using ethyl acetate extracts as well as by dual platemethod. Effect of pure antibacterial/antifungal metabolites produced by fluorescent *Pseudomonas* strains showed that rhizobial strain ST1 was sensitive for DAPG, PRN and PLT, followed by *Rhizobium leguminosarum* which was inhibited by DAPG and PHZ while strain IC 3123 did not get inhibited by any of the compounds. Certain rhizobial strains exhibited increased EPS production in presence of the *Pseudomonas* strains. The extracts containing the antifungal metabolites of *Pseudomonas* strains showed varying levels of inhibition of rhizobial cultures. *R. leguminosarum* was found to be the most sensitive rhizobial strain, followed by *Mesorhizobium loti* which were was inhibited effectively by extracts from several *Pseudomonas* biocontrol strains. The *Bradyrhizobium japonicum* strain tested did not get significantly inhibited by extracts of most fluorescent *Pseudomonas* strains. Plant inoculation experiments with selected strains showed that combinations of multiple strains are more effective in plant growth promotion. Thus consortia with several different PGPR combinations can be expected to be better than single inoculants. This work signifies that certain bio-control strains may have adverse effect on the rhizobial populations present in rhizosphere and hence this

criterion should be checked to successfully develop effective consortia. The finding that the ecological interactions may be further controlled by environmental factors is important for understanding the potential field performance of bio-control strains.

OP-27

Bio-effectors increasetomato plant growth in soils with low phosphorus - rhizosphere microbiome shifts as potential mode of action?

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Bio-effectors are viable microorganisms directly or indirectly affecting the plant performance, in particular under non-optimal growth conditions. Bio-effectors might support plant growth in soils with high salinity or low P-content. Low phosphorus availability limits plant growth in many soils across the world and is a common constraint to agricultural productivity. The application of bio-effectors is of increasing interest in a more sustainable agriculture and can likely contribute to a reduction of mineral fertilizers and pesticides used in crop production. A greenhouse experiment was conducted in the framework of the EU-project “BIOFECTOR” aiming to study the effect of four bio-effectors (B1: *Trichoderma harzianum* T-22;B2: *Pseudomonas* sp.; B3: *Bacillus amyloliquefaciens* FB01,B4: *Pseudomonas jessenii* RU47) on the growth of tomato plants in a phosphorus limited soil and their effects on the indigenous rhizosphere bacterial community compared to non-inoculated plants (B0). At each sampling time (t)2, 3, 4 and 6 weeks after sowing, the rhizosphere competence and colonization patterns of the bio-effectors were monitored in rhizosphere samples using colony forming unit counts and confocal laser scanning microscopy(B3, B4). Effects on the bacterial community composition were determined by denaturing gradient gel electrophoresis (DGGE)and amplicon pyro sequencing of 16S rRNA gene fragments amplified from total rhizosphere community DNA of B0, B4 (t=4) and B0, B1, B2, B3, B4 (t4). All bacterial bio-effectors showed a good rhizocompetence and promoted the growth of tomato with B3 and B4 showing the best plant growth promoting activity. The DGGE and amplicon sequencing revealed that only RU47 belonged to the dominant population in the rhizosphere. The UPGMA analysis for DGGE and amplicon sequences showed significant differences between the bacterial community composition B0 and the inoculated samples. Amplicon sequencing allowed us to reveal bacterial genera with significantly increased relative abundance in the tomato rhizosphere compared to the bulk soil and in response to the inoculation. At t4 B4, inoculation caused strong but transient bacterial community changes with strikingly increased abundance of *Gamma*- and *Betaproteobacteria*. The effect of all bio-effectors at t6 revealed that inoculation causes significant increase of the relative abundance of *Bacteroidetes* and *Betaproteo bacteria*. Interestingly, the relative abundance of *Lysobacter* was significantly increased for all bacterial inoculants at t6. Our data showed that inoculants cause major but often transient shifts in the bacterial community that might also contribute to the plant growth promoting effects observed.

OP-28

Influence of *Cellulomonas flavigena*, *Azospirillum* sp. and *Pseudomonas* sp. on rice growth and yield grown in submerged soil amended with rice straw

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Organic toxicity is a common phenomenon in soils with continuous rice grown.. Under these conditions, the growth of rice plant is often stunted and resulted with reduced yields. In our study, we evaluated three plant growth-promoting rhizobacteria (PGPR), such as a cellulolytic bacteria *Cellulomonas flavigena*, nitrogen-fixing bacteria *Azospirillum* sp. and a phosphate-dissolving bacteria *Pseudomonas* sp.on growth and yield of rice cv: IR50404. Experiments were conducted under greenhouse conditions in a randomized complete block design. There were 10 treatments and each treatment was replicated five times. The replicated pot was filled with submerged soil collected from rice field amended with rice straw for rice cultivation in autumn-winter season. Rice seeds treated with PGPR (*Azospirillum* sp., *Pseudomonas* sp.) as a seed soaking and planted in the pots. Microbiological fertilizers containing cellulolytic bacteria *Cellulomonas flavigena* (pellets) was sprayed in the pots. Our results showed that rice plant treated C. *flavigena* + inorganic fertilizer (75N-45P_2O_5-30K_2O *kgha-1*) significantly increased plant height, number of tillers, root weight, 1000 – grain weight, paniclesand rice yields compared with untreated controls (100 N-60P_2O_5-30K_2O *kgha-1*), reduced 25% inorganic fertilizer (25 kg N and 15 kg P_2O_5).

Keywords: IR50404 rice varieties, cellulolytic bacteria *Cellulomonas flavigena*, nitrogen-fixing bacteria *Azospirillum* sp. and phosphate-dissolving bacteria *Pseudomonas* sp, rice straw.

OP-29

Biosynthesis of nanonutrients: Afuture prospective for higher crop production

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The present study demonstrate an eco-friendly and low cost protocol for synthesis of P, Zn, Fe and Mg nanoparticles using cell free filtrate of identified fungi when supplied with aqueous salt solutions. Identification of the fungal isolate was based on nuclear ribosomal DNA internal transcribed space (ITS) identities. Average particle size measurement (Particle size analyzer) was found to be 1.3 to 20.3nm of different nanonutrients used. Transmission electron microscopy

(TEM) and energy dispersive spectroscopy (EDS) revealed the shape and purity of the particle. With the application of recommended doses (10 ppm for Zn, 20ppm for Mg, 30ppm for Fe and 40 ppm for P) on four different crops (cluster bean, mung bean, pearl millet, wheat) in four different seasons (two *kharif* and two *rabi*) at critical growth stage (6weeks old plant), a significant improvement in microbial biomass (13.2-45.8%), which was more under nano-P, was noticed. The beneficial enzyme activities (acid phosphatase, alkaline phosphatase, phytase, dehydrogenase, and esterase) enhance between 9.1 and 90.9% over control. The effect was more under nanonutrients as compared to bio-nutrients. The increase in grain yield over control was varied between 12.0 to 27.6% for cereal (pearl millet and wheat) and between 15.9 to 24.7% for legumes (cluster bean and mung bean). The increase in dry matter yield was observed between 4.5 to 19.6 % for bio-nutrients as compared to 12.6 to35.2% by nanonutrients over control. The results clearly demonstrated better prospective of biosynthesized nanonutrients for higher crop production and the effect of bio-nutrients can be enhanced by mixing with the nanonutrients in equal proportion for the foliar spray, which was more effective on legumes.

Key words : biosynthesis, nanoparticles, bio-nutrients, crop production, beneficial enzymes.

OP-30

Airborne communications of bacteria with plant and themselves

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Certain plant growth-promoting rhizobacteria (PGPR) elicit induced systemic resistance (ISR) and plant growth promotion in the absence of physical contact with plants *via* volatile organic compound (VOC) emissions. In this article, we review the recent progress made by research into the interactions between PGPR and VOC, focusing on VOC emission by PGPR strains in plants. Particular attention will be given to the mechanisms by which these bacterial species elicit ISR. We provide an overview of recent progress in the elucidation of PGPR VOC interactions from studies utilizing transcriptome, metabolome and proteome analyses. By monitoring defense gene expression patterns, performing 2-dimensional electrophoresis, and studying defense signaling null mutants, salicylic acid and ethylene were found to be key players in plant signaling pathways involved in the ISR response. Bacterial VOCs also confer induced systemic tolerance to abiotic stresses, such as drought and heavy metals. A review of current analytical approaches for PGPR volatiles profiling is also provided with needed future developments. Furthermore, to assess potential utilization of PGPR VOCs for crop plants, volatile suspensions were applied to pepper and cucumber roots and were found to be effective at protecting plants against plant pathogens and insect pests in the field. Taken together, these studies provide further insights into the biological and ecological potential of PGPR VOCs for enhancing plant self-immunity and/or adaptation to biotic and abiotic stresses in modern agriculture.

Key Words: PGPR,ISR, IST, volatile organic compounds, headspace.

OP-31

Effect of distillery yeast biomass waste as soil amendment on the population dynamics of PGPR and on the growth of paddy under pot culture conditions

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Yeast biomass, obtained as a byproduct of alcohol industries, is an excellent source of proteins, vitamins, amino acid and nucleic acid. The soil microbial populations mainly rely on the organic sources of nutrients available in their vicinity. The present study aimed to determine the effect of distillery yeast biomass waste at different concentrations on population dynamics of PGPR(*Azospirillum, Azotobacter, Bacillus, Pseudomonas* and *Trichoderma*), seed germination, seedling growth, plant height, root length and yield parameters of paddy under pot culture conditions. The population dynamics of *Azospirillum* increased to 97×10^6 cfu per g in 1 g yeast biomass amended soil while the population dynamics of *Azotobacter, Bacillus, Pseudomonas* and *Trichoderma* increased to 85×10^6 cfu per g, 32×10^6 cfu per g, 53×10^6 cfu per g, 26×10^6 cfu per g respectively in 2 g yeast biomass amended soil on 3rd week of incubation. The growth of PGPR organisms in terms of turbidity were increased in yeast biomass added respective culture media. The highest OD_{520} values were recorded as 1.683 for *Azospirillum* at 1 g yeast biomass, 0.187 for *Azotobacter*, 0.375 for *Bacillus*, 0.988 for *Pseudomonas* and a biomass of 0.834 mg 100^{-1} for *Trichoderma* at 2 g yeast biomass. The addition of yeast biomass waste at 30 g per pot showed significant increase in root length (18.6 cm), shoot length(69.20 cm), number of tillers (5.55), number of grains per tiller (98.39) and grain yield (61.00 g plant^{-1}).

Key words: Yeast biomass, PGPR, shoot and root length.

OP-32

Utilization of actinomycetes having broad- spectrum of plant growth-promoting and biocontrol traits in Chickpea, Sorghum and Rice

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Plant pathogens such as *Sclerotium rolfsii* (causes collar rot), *Fusarium oxysporum* (causes wilt) and *Macrophomina phaseolina* (causes charcoal rot/dry root rot) have a broad host range, affecting several agriculturally important crops including chickpea, pigeon pea, groundnut and sorghum, which are grown under rain fed conditions, leading to significant yield losses. Due to

the broad host range of these fungal pathogens, it has become very difficult for the farmers to grow these crops profitably. Hence, there is a need to have broad-spectrum plant growth-promoting (PGP) and biocontrol organisms for use in different cropping systems for the control of multiple diseases in a single crop and there by the crop productivity can be enhanced in the dry-land agriculture. The main objective of the present study was to identify and evaluate broad spectrum PGP and biocontrol agents and their metabolites with multiple actions against different pathogens so that one biological treatment controls more than one problem apart from promotion of plant growth in chickpea, sorghum and rice.

OP-33

Plant-rhizobacteria interactions mitigates drought stress

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Drought stress is one of the major agricultural problems limiting crop productivity in most of the arid and semiarid regions of the world. This form of abiotic stress affects the plant–water relations at both the cellular and whole-plant level, causing both specific and non-specific reactions and damage. The conventional approaches such as breeding for stress-tolerant cultivars is a time and labor intensive process. Beneficial plant-microbe interactions are frequent in nature, improving plant nutrition or helping the plant to overcome abiotic and biotic stresses. Inoculation of plants with drought tolerant native plant growth promoting rhizobacteria (PGPR) may increase the drought tolerance of plants growing in arid or semiarid areas. Reports suggest that PGPR mitigate the impact of drought stress on plants through production of hormones like abscisic acid, gibberellic acid, cytokinins, and auxin, production of enzyme 1-aminocyclopropane -1-carboxylate (ACC) deaminase to reduce the level of ethylene in the root of developing plants, induced systemic tolerance by bacterially-produced compounds, formation of bacterial biofilms containing sugars and oligo-polysaccharides that play important roles in bacteria-plant interactions by improving water availability in root medium. Our investigation on the effect of sunflower seeds inoculated with *Pseudomonas* sp. Increased the survival, plant biomass, and RAS/RT of sunflower seedlings subjected to drought stress. The inoculated bacteria could efficiently colonized the root adhering soil, rhizoplane, and increase the percentage of stable soil aggregates. At the same time inoculation also increased the compatible solutes and antioxidant status of maize plants under water stress conditions. In a similarly type of study rhizobacteria inoculation changed the elasticity of the root cell membranes which helped the pants to tolerate water deficiency. In recent years, studies have attempted to identify drought stress genes in plants whose expression level were altered upon treatment with the PGPR. These studies indicate that plant-rhizobacteria interactions provides an effectual platform for mitigating drought stress and novel way to improve plant water use efficiency. These new advancements importantly contribute towards solving food security issues in the present scenario of climate change.

Key words: Plant-rhizobacteria interactions, drought stress, induced systemic tolerance, drought stress genes, ACC deaminase

OP-34

Rhizosphere bacteria *Bacillus* strains in mitigation of biotic and abiotic stresses in rice under oxic and anoxic conditions

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Rice is the single most important staple crop in the world, especially in Asian countries where it accounts for more than 90% (450.6 million tons) of the world production. However, rice production systems suffer from a multitude of constraints. The rice root-knot nematode, *Meloidogyne gramicola* is an important pest in several rice growing areas in Asia while iron toxicity, caused by the excessive ferrous iron (Fe^{2+}) in the soil, is one of the major environmental factors limiting production of lowland rice worldwide. The use of microorganisms to tackle pest and disease problems or nutrient disorders in crop production is not new. However, studies on microbes that have mitigation effects on both abiotic and biotic stresses are not well documented. Furthermore, the rice plant, with its intermittent growth stages under both anoxic and oxic condition requires specific antagonists that can survive and thrive under both conditions.

Several *Bacillus* strains, isolated from seeds and roots of rice have demonstrated antagonistic activities against the rice root-knot nematode *Meloidogyne graminicola*. Treatment with *Bacillus* bacteria under oxic conditions in greenhouse reduced galling severity caused by of *M. graminicola* by up to 30%. Studies on the modes of action of the isolate *Bacillus megaterium* against *M. graminicola* revealed that the bacteria reduced nematode penetration and host finding ability.

When subjected to high iron concentration (Fe^{2+}, 1000 mg/L) in the hydroponic solution, rice seedlings inoculated with *Bacillus* strains showed lower level of iron toxicity compared to non-treated plants. Application of *Bacillus* bacteria also reduced leaf Fe content and altered Fe partitioning in plant tissues. The bacterial isolates clearly showed a differentiated interaction with the individual rice genotypes. The mechanisms of the bacteria and their metabolites alone or in combination with specific rice genotypes that lead to the observed positive effects are being investigated by a series of morphological (growth rate, visual scoring, iron plague) and physiological (phytohormone synthesis, enzyme activities and antioxidant levels) assessments.

Key words: Root-knot nematode, *Meloidogyne graminicola*, iron toxicity, leaf scoring, iron partitioning.

OP-35

Composite effect of various biofertilizers and neemcake on effectiveness and efficient growth of *Citruslimonia* (Rangpur lime) seedlings

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In Indian citrus industry, Rangpur lime has a major role in production of export quality Nagpur mandarin. As it is fairly resistant to phytophthora infections, it was highly recommended and popular rootstock in Indian conditions. It has been observed that growth of Rangpur lime seedling in nursery stage is very slow and needs much time to attain buddable size. In present study pot culture, experiment was performed to study the combined effect of biofertilizers on growth of the Rangpur lime seedlings. In the present study, the eleven combinations of inoculums prepared from *Glomus fasciculatum* (*Gf*) (50g and 100g), *Glomusmosseae* (*Gm*) (50g and 100g), phosphate solubilisingbacteria (PSB)3 g and neem cake 20g were given at the time of transplanting of Rangpur lime seedling in polythene bags. The experiment was replicated thrice and laid out in Randomized Block design. The growth of seedling was assessed in terms of seedling height, stem diameter, number of leaves, leaf area, root growth, biomass accumulation, bud take percentage and final survival. We observed significant results in treatment with *Gm*-50 g + *Gf*- 50 g+ PSB- 3g and *Gf*- 50 g+ PSB- 3g + Neem cake 20 g in all respects during pot experimentation. The data recorded at 135 days after transplanting showed that maximum height (58.30 cm), significantly highest stem diameter (0.70 cm),root length (42.50 cm), no. of fibrous roots (236.33) and root density (101.0 ml), highest bud-take (95.33%) and final survival (99.17%) of Nagpur mandarin on Rangpur lime were obtained in *Gm*-50g+ *Gf*-50+PSB-3g/pot which is closely followed by *Gf*-50g+PSB-3g+ Neem Cake-20g/pot.

OP-36

Molecular mechanisms in understanding and enhancing biological control of *Pseudomonas chlororaphis*strain PA23 against *Sclerotinia sclerotiorum*, the stem rot pathogen of Canola

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Canola/oilseed rape (*Brassica napus*) is a major oilseed crop in the world. However, it is subjected to disease by several plant pathogens. *Sclerotiniasclerotiorum*is a major pathogen in many canola growing regions including Canada. As there are no resistant cultivars available, growers spray fungicides to control the pathogen and the stem rot disease. Some of the chemicals used to control this disease have been phased out or banned due to several health and

environmental concerns in the past. Health and environmental impacts of agrochemicals have led to the use of alternative methods of disease control in sustainable crop production systems. One of these alternative methods is the use of biocontrol bacterial strains that are known to play an important role in inhibiting the plant pathogenic fungi and suppressing diseases of crop plants. Various mechanisms of these biocontrol agents involve effective root colonization, production of antifungal metabolites, interfering with fungal pathogenic factors, and elicitation of induced systemic resistance in the host plant. These multiple mechanisms were demonstrated by *Pseudomonas chlororaphis*strain PA23 on Sclerotinia control in canola. Canola is the most important oilseed crop in Canada and at present the #1 cash crop since 2010 surpassing wheat. This bacterium (PA23) produces an arsenal of exometabolites including pyrrolnitrin (PRN), phenazine (PHZ), hydrogen cyanide (HCN), and degradative enzymes. Production of these compounds is controlled at both the transcriptional and posttranscriptional levels by the Gac-Rsm system, RpoS, PsrA, and the Phz quorum-sensing system. A mutant no longer capable of inhibiting fungal growth was identified harbouring a transposon insertion in a gene encoding a LysR-type transcriptional regulator (LTTR), designated *ptrA* (*Pseudomonas* transcriptional regulator). Thus it was inferred that PtrA is a novel LTTR that is essential for PA23 fungal antagonism. Differential protein expression was observed across 16 COG categories suggesting PtrA is functioning as a global transcriptional regulator. Changes in protein expression were confirmed by phenotypic assays that showed reduced phenazine and chitinase expression, elevated flagellar motility and siderophore production, as well as early entrance into log phase. All of these traits have been observed with PA23 *gac* mutants, and for many of these phenotypes, addition of *gacS in trans* resulted in partial complementation of the *ptrA* mutant. Thus a connection appears to exist between PtrA and the Gac two-component system of regulation. Beyond pathogen-suppression, the success of a biocontrol agent is dependent upon its ability to establish itself in a given environment. The advent of molecular techniques to study the genetic basis of biological mechanisms shed light on the characterization and utilization of genes or gene clusters responsible for antibiotic production, gene expression, gene inactivation and gene over expression. The presentation will discuss the methods used to deduce these mechanisms and give recommendations to improve the biological control activity of this strain against Sclerotinia.

OP-37

Analysing the plant microbiome for control of pathogens

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The plant microbiome is a key determinant of plant health and productivity. Plant microbiome discoveries could fuel progress in sustainable agriculture, such as the development of microbial inoculants as biofertilizers, biocontrol, or stress protection products. Although we recognize a growing market for these bio-products, they still have their problems, e.g., short shelf-life, inconsistent effects under field conditions, and risk predictions. The application of “omics”-technologies has allowed for an enormous progression in the development of so-called next-generation bio-products. New tools may have an impact on (i) the detection of new bio-resources for biocontrol and plant growth promoting agents, (ii) the optimization of fermentation and formulation processes for biologicals, (iii) stabilization of the biocontrol effect under field conditions and (iv) risk assessment studies for biotechnological applications. Advances in these aspects could open new perspectives for sustainable agriculture by the development of high impact next-generation bio-products.

OP-38

Molecular aspects of interactions between plant growth-promoting rhizobia and legume host plants

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Nitrogen-fixing rhizobia form symbiotic associations with legumes and the non-legume *Parasponia*. In successfully established symbioses, rhizobial infection, often via root hairs, culminates in formation of nodules, highly specialized root organs of the host plant. Bacteroids in infected nodule cells activate their nitrogenase enzyme complex and fix considerable amounts of atmospheric nitrogen to the host's benefit. Hence, rhizobia are important plant growth promoting bacteria that increase nitrogen contents in agricultural soils and thus contribute to sustainable food production. Nodule formation is the result of molecular communication between invading bacteria and the plant. Host flavonoids in the rhizosphere induce the production of rhizobial lipo-chitooligosaccharides, called Nod factors (NFs). Legumes perceive NFs by NF receptors (LysM domain receptor kinases) and initiate nodulation signaling to express symbiotic genes required for infection and nodule formation. In addition to NFs, various rhizobial strains secrete additional molecules that are required for nodulation in specific strain-host combinations. These symbiotic determinants include surface polysaccharides and effector proteins. The rhizobial type 3 (T3) protein secretion systems, complex protein export machinery with a needle-like extracellular pilus, possesses the capacity to deliver T3 effectors directly into legume host cells. Based on mutant analysis and identification of secreted proteins in bacterial culture supernatants, functional T3 secretion systems have been found to be symbiotically active in various *Sinorhizobium, Bradyrhizobium, Mesorhizobium* and *Cupriavidus* strains. Genes encoding a T3 secretion system have been also identified in genomes of nodule-inducing *Burkholderia* strains. So far investigated, rhizobia appear to express T3 effectors at early symbiotic stages (infection thread formation), but also in fully developed nodules at the stage of nitrogen fixation. Besides identification, symbiotic phenotypes of rhizobial mutants and effector translocation into plant cells, little is known on the biochemical function of rhizobial T3 effectors. In the oral presentation, an overview of recent research work from our laboratory will be presented.

OP-39

Induction of systemic resistance and tolerance against biotic and abiotic stress in Chinese cabbage by cyclic peptides producing *Bacillus vallismortis* strain BS07M

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Cyclic peptides (CPs) from plant growth promoting rhizobacteria (PGPR) and their effect on growth and disease control of plants have been in current research trends. In this study, we presented the *Bacillus vallismortis*strain BS07M (BS07M) as a potential biocontrol agent for disease control and alleviation of abiotic stress such as heat and salinity in Chinese cabbage. Treatment of BS07M improved plant growth in terms of fresh weight and leaf size, and elicited induced systemic resistance (ISR) against soft rot disease in Chinese cabbage. Treated plants showed increased tolerance against salt and heat stresses under greenhouse conditions. One of the CPsderived from BS07was iturin derivatives.Application of BS07M in combination with another potential dipeptide Q3 showed an enhanced affect on disease resistance and abiotic stress tolerance. Real-time PCR analysis showed an enhanced expression of defense-related gene *PR1* in BS07M and Q3 treated plants when challenged with soft rot pathogen *Pectobacterium carotovorum*. Similarly, a combination treatment of BS07M and Q3 in plants subjected to heat and salt stress showed anup-regulation of expression of abscissic acid (ABA) responsive genes *RD29A* and *KIN1*. Expression of hyperosmotic salinity response gene *P5CS* was significantly higher in a combination treated plants under salt stress. The results from this study indicated that BS07M is a potential bio-agent for ISR against pathogens as well as tolerance against abiotic stress with CPs in Chinese cabbage.

OP-40

The primary transcriptome of plant beneficial rhizobacterium *Bacillus amyloliquefaciens*reveals novel noncoding RNAs involved in sporulation and biofilm formation

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Bacillus amyloliquefaciens FZB42 is a representative organism for Gram positive soil bacteria associated with plant roots and beneficial to plant growth. It is of immense importance to understand mechanisms of this class of bacteria adapting to rhizosphere. In this work, employing the differential RNA sequencing (dRNA-seq) technology we systematically analyzed the primary transcriptome of FZB42 grown in media mimicking rhizosphere environment. We determined 4877 transcription start sites for protein-coding genes, corrected mis-annotated genes and analyzed genes differentially expressed at different growth conditions. Furthermore, a large number of *cis*- and *trans*-encoded noncoding RNAs were identified. Characterization of a conserved small RNA Bas01 revealed its functional impact on *Bacillus* sporulation and biofilm formation. Overall, our analysis establishes a *Bacillus* transcriptome structure and improves the molecular understanding of rhizobacterial interaction with host plants.

OP-41

Metabolic and gene expression profile underlying the concurrence of P-solubilizing and biocontrol traits in *Pseudomonas aeruginosa* P4 in response to P - limitation

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Rhizobacteria with multifaceted beneficial effects of plant growth stimulation and biocontrol form a promising group of potential rhizosphere bio-inoculants. Since most agricultural soils are nutrient insufficient, particularly with respect to phosphate (P) availability for plants, multifaceted P-solubilizing rhiobacteria with co-existing biocontrol traits could prove extremely useful in improving plant nutrition status. Most studies on mechanisms for plant growth promotion by these PGPR have focused on multiple beneficial traits measured *in vitro* under ideal conditions, followed by monitoring beneficial effects on plant growth. However, the plant growth promoting traits in a multifunctional PGPR do not work independently of each other and hence the beneficial effects may not be always cumulative. Failure of co-existence of the multiple beneficial traits under a given soil nutrient conditions could be a crucial reason for their poor performance in field conditions. Soil nutrient status, especially with respect to available Pi and nature of carbon source, not only influences the establishment and performance of a bioinoculant in rhizosphere, but also could drastically affect the metabolic framework and physiology of the plant growth promoting bacteria. Considering that both direct and indirect mechanisms of plant growth promotion employed by PGPR are mostly mediated by various primary and secondary metabolites, it becomes relevant to investigate the underlying metabolic alterations in response to nutrient status. In this regard, catabolically versatile fluorescent pseudomonads dominate as PGPR with multiple biocontrol abilities. Many *Pseudomonas* spp. improve plant growth in absence of pathogens by direct mechanisms often associated with mineral phosphate solubilization and/or regulation of the levels of plant growth regulators. However, fewer *Pseudomonas* strains possess co-existing biocontrol and P-solubilizing abilities. Moreover, even in the most efficient biocontrol strain *P. fluorescens* CHA0, production of biocontrol metabolites 2,4 DAPG and pyoluteorin is negatively regulated by gluconic acid, making it difficult for P-solubilization ability to co-exist with biocontrol traits. The present work demonstrates unusual co-existence of P-solubilization and multiple biocontrol abilities under P-

limitation in a laboratory isolate *Pseudomonas aeruginosa* P4. Subsequently this organism has been explored as a model to investigate metabolic framework and alterations that mediate simultaneous secretion of metabolites involved in P-solubilization and biocontrol even under P-limitation. *P. aeruginosa* P4 is an efficient P-solubilizer owing to secretion of high levels of gluconic acid (~45mM), which is a primary metabolite for most pseudomonads. Additionally, it produces a range of secondary metabolites like pyocyanin, siderophores pyoverdine and pyochelin, HCN and indole acetic acid which are implicated in biocontrol and plant growth stimulation. Interestingly, under P-limiting conditions with glucose as sole carbon source, *P. aeruginosa* P4 not only increased gluconic acid production, but also showed a simultaneous increase inpyocyanin (phenazine), pyoverdine, pyochelin as well as IAA production after 72 hr of growth, as compared to P- sufficient condition. Influence of P-limitation on expression profile of selected genes encoding enzymes from known biosynthetic pathways of pyoverdine, pyochelin and pyocyanin as well as from shikimate pathway supplying common precursor for secondary metabolism, suggested enhanced expression of several genes that correlated well with metabolic alterations. These results indicate that in response to P-limitation, *P. aeruginosa* P4 undergoes significant changes in the metabolic framework, probably redistributing the flux through the pathways producing precursors for secondary metabolism. Metabolic channelling of glucose to gluconate production under P-limitation has also been demonstrated earlier. Such metabolic redistributions and the resultant co-existence of multiple beneficial traits could impart a natural advantage to the multifunctional organism in terms of survival and efficient plant growth promotion even under nutrient (P) stress. Such studies may thus prove useful in predicting the actual efficacies of multifaceted PGPR under given soil nutrient conditions; thereby help in identifying efficient bioinoculants for sustainable agriculture.

OP-42

Non-target effects of agricultural amendments on rhizospheric microbial communities

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Agricultural amendments have been used as important means to enhance crop productivity worldwide since ages. The criteria for the choice of amendments has been mostly restricted to its impact on the plant growth and grain yield. A largely ignored aspect has been the non-target effects of such amendments. We have been using polyphasic approach to analyse the risks involved in amendments like pesticides (chemical- and bio-pesticides) and bioinoculants in legumes. Together with targeting various plant growth promoting rhizobacteria (PGPR) we have been performing in-depth analysis of the structure and function of the total rhizospheric microbial community. Of special focus is the nitrogen cycle, the nutrient being crucial from an agricultural standpoint. Using DNA and RNA to target resident and active populations, respectively, we have shown that merely by being of biological origin does not categorize bio-pesticides as "safe". Also, bioinoculants exert a larger impact on the microbial community of the plants' rhizosphere, thereby emphasizing the fact that the non-target effects of the application of bioinoculants contribute equally (as compared to their direct effects) to a positive impact on plant growth parameters.

OP-43

Exopolysaccharides based bioformulation from *Pseudomonas aeruginosa* combating saline stress

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Salt tolerating strain of fluorescent *Pseudomonas* possessing plant growth promoting activity was screened for the production of exopolysaccharides (EPS). EPS production was monitored in the supernatant and its purification was done. Purified EPSwas taken to design talc based bioformulation and its efficacy was checked taking sunflower (*Hellianthus annuus*) as a test crop, under *in vitro* and in *vivo* saline conditions (soil irrigated with 125 mM of saline water). Application of EPS bioformulation significantly enhanced the growth attributes of the plant in comparison to control (untreated seeds) under saline and non-saline conditions. Germination rate, plant length, dry weight, seed weight and seed yield increased remarkably in comparison to untreated seeds. The above findings suggest the application and benefits of utilizing talc based EPS formulation in boosting early seedling emergence, enhancing plant growth parameters, increasing seed weight and mitigating stress in saline affected regions. Such bioformulation may enhance root adhering soil (RAS) to root tissue (RT) ratio, texture of the soil, increase porosity, improve uptake of nutrients, and hence may be considered as commercially important formulation for renovation of stressed saline sites along with increasing growth and production of sunflower crop in salinized soil.

Keywords: Bioformulation, fluorescent Pseudomonas, exopolysaccharidesand*Hellianthusannuus*

OP-44

Inoculant formulations for plant growth-promoting bacteria

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Inoculation of plants with plant growth-promoting bacteria (PGPB) and plant symbionts to enhance performance of plants is centuries old. The majority of field inoculations done today are on cereals. In general, shortly after suspensions of bacteria, the most primitive inoculant, are

inoculated into the soil without a proper carrier, the bacterial population declines rapidly for most species of PGPB. This phenomenon, combined with production of bacterial biomass, the need to sustain activity in the rhizosphere, and the physiological state of the bacteria at application time, can prevent the buildup of a sufficiently large PGPB population in the rhizosphere. These unprotected, inoculated bacteria must compete with the often better-adapted native microflora and withstand predation by soil micro fauna. Consequently, a major role in the formulation of inoculants is to provide a more suitable microenvironment, combined with physical protection for prolonged periods to prevent a rapid decline of bacteria introduced into the soil. Inoculants for field-scale use have to be designed to provide a dependable source of bacteria that survives in the soil and become available to the plant, when needed. The first goal when considering inoculation of cereals with PGPB is to find the best strain of bacteria or a microbial consortium for the intended effect on the target crop. The next step is to design a specific inoculant formulation for specific target plants and a method of practical application, considering the limitations of the growers. Currently, many inoculants are in the marketplace, some that substantially improve yield. In the last decade, several reviews summarized the field of cereal inoculation. Most have concentrated on specific bacterial genera, such as *Azospirillum*, availability of various PGPBs and their modes of action, reduction in the use of fertilizers by supplementation with inoculants, and potential marketing.

OP-45

A novel microbial delivery system for revitalization of plant's rhizosphere

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A novel phyto-stimulant microbial delivery system (Horticaps) is developed through fermentation and state-of-the-art downstream procedures. The promising multi microbial consortia are packed in biodegradable gelatinized capsules for the purpose of root zone activation, improved growth and development in Horti and Agriculture crops. The microbial consortium induces systemic tolerance in plants for a variety of biotic and abiotic stresses and for increased photosynthetic activity resulting in higher crop yields. The consortia improves plant root growth by producing growth promoting substances and protects the seeds and roots from seed and soil borne pathogens through production of anti-bacterial and fungal metabolites and siderophores. The microbes present in this delivery system, solubilizes/mobilizes and increases the uptake of nutrients by the plant. These water soluble capsules were tested across different cropping systems and multiple modes of applications including spot application, drenching, drip irrigation etc. The wide adoptability of this novel innovation, usage and the cost benefit ratio's will be discussed at length.

OP-46

Siderophore producing bioinoculants: for iron nutrition of all and control of fungal diseases of crops

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Consumption of micronutrient deficient foods specially iron deficient food has been the main cause of Iron Deficiency Anemia (I.D.A.) and sickle cell anemia in tribal adivasi population of Maharashtra, India. Although iron is a forth most abundant and common element present in soil, it is rarely found in free form. In order to cope up with iron solubility, microbes have employed high affinity iron chelators called siderophores to solubilize the iron and provide it to the growing crops. Plant diseases lead to deficiency of many essential mineral ions including iron and consumption of such staple food is responsible for causing iron deficiency anemia. Management of these diseases by chemical fungicides has several demerits on the human and agriculture health. Use of rhizobacteria appears to be a sustainable approach to enhance micronutrient (iron) level and to inhibit the growth of plant pathogens.We have successfully demonstrated the use of siderophore producing *Pseudomonas, Alcaligenes*and *Enterobacter* in plant growth-promotion and increase in chlorophyll (iron) content of groundnut, soybean, wheat and medicinal plants. Applications of these rhizobacteria also helped in preventing the iron chlorosis and improvement in overall growth and health of plants. Increased percent germination, root ramification, nodulation, height, foliage and chlorophyll content were achieved only because of seed bacterization with siderophoregenic rhizobacteria. Plant growth-promoting ability of *Alcaligenesfeacalis*and *Psuedomonas fluorescens* was examined in *Arachis hypogea* at various levels viz. plate, pot and field levels. Co-inoculation of *A.feacalis*with *P. fluorescens* NCIM 5096 showed enhanced plant growth promotion in *A. hypogea* than single inoculation with either of these two rhizobacteria. After 90 days of sowing, it resulted in 21.39% increase in shoot length, 16.30% increase in root length, 43.05% increase in chlorophyll content, 22.51% increase in number of pods and 31.25% increase in number of branches.These strains also produced array of antifungal metabolites (AFMs) like siderophore, hydrogen cyanide, chitinase and bacteriocin and exhibited superior antifungal activity against *Aspergillus niger, A. flavus, Fusarium oxysporum, Cercosporaarachichola, Metarhizobiumanisopliae, P. solanacerum* and *Alernaria alternate vis-à-vis* commonly used chemical fungicides like carbistin and bavistin (organo-chlorine) and copper based fungicide; kitazin and bilcop-50. These strains in low (25 μl) concentration inhibited more antifungal activity.We propose the use of such rhizobacteria as bioinoculants to overcome micronutrient deficiencies in crops and to control fungal diseases of crops. Consumption of disease free and iron rich crops will help in preventing IDA and other types of micronutrient deficiency.

Keywords : Antifungal, Bactriocin, HCN, PGPR, *Pseudomonas,* Siderophore

OP - 47

Tea rhizobacteria as a potential biofertilizer and biocontrol agent for sustainableagriculture in Northeast India

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Tea is one of the oldest and important cash crops in India with massive plantation in the northeast corner of the agroclimatic belt. Like any other plantation crop, tea also faces various biotic and abiotic stresses that can reduce the yield up to 50%. Tea fungal pathogens are the major biotic agents that impart drastic loss in crop yield. Extensive use of chemical fungicides has harmful effect on soil health by destabilizing soil fertility and beneficial microbial population.The use of plant growth promoting rhizobacteria (PGPR) as biofertilizer and biocontrol agent is an ecofriendly approach that gets wide attention in sustainable agricultural practices. However, plant growth promoting (PGP) attributes of tea rhizosphere associated microorganisms are still not well studied. With the aim of studying the tea rhizosphere associated PGPR population in Assam tea gardens, we have isolated 217 rhizobacterial isolates. We have screened the rhizobacterial isolates for different *in-vitro* PGP traits and anti-fungal assay. On the basis of *in-vitro* screening we have found that four bacterial isolates, i.e TG1, SN29, KH45 and TT6 showed very efficient in producing different PGP traits *viz* phosphate solubilisation, indole acetic acid production, siderophore production, nitrogen fixation, ammonia production as well as antagonistic activities against different plant fungal pathogens *vizGlomerullacingulata*(MTCC 2033), *Fusariumsolani* (MTCC 3651), *Rhizoctoniasolani* (MTCC 4633), *Exobasidiumvexans*(ITCC 938),*Pestalotiopsistheae*(ITCC 6599), *Colletotrichumgloeosporioides* (KJ767518) and*Nigrosporasphaerica* (KJ767520). Sequence analysis of 16S rRNA revealed their close similarity with *Enterobacterlignolyticus*(TG1), *Bacillus pseudomycoid*es(SN29), *Pseudomonas aeruginosa*(KH45) and*Burkholderiasp.*(TT6). Diverse range of chitinase production was observed in all the four bacterial isolates. Furthermore all the four isolates showed positive amplificationfor glycoside hydrolase 18(GH18) family of chitinase gene. *In-vivo* plant growth promoting and biocontrol activity of the isolates was further confirmed taking tomato as a model plant. These indigenous rhizosphere associated soil microbial inhabitants with wide array of PGP and biocontrol activity could be beneficial for not only tea industry but also other agricultural crops of Northeast India.

Key words: PGPR, Antagonistic activity, PCR, Chitinase gene

OP-48

Commercial transfer of technology for sustainable agriculture

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Humanity is facing its toughest challenge every day, our planet wakes with 200,000 more mouths to feed. Every night, more than 870 million people go to bed hungry. The need to produce more food is already acute, and the world's land, water and energy resources are under unprecedented strain. Nearly 7 million hectares of farmland are lost to soil erosion every year. Many people who produce the world's food are living in poverty. Biodiversity is disappearing fast. And the challenge won't get any easier: by 2050, for example, 4 billion people will be living in countries with water scarcity. Something needs to change we only have one planet, and we're using its resources 50 percent faster than it can take. What we're asking to provide is simply not sustainable. We can't go on like this. Rhizobia are symbiotic diazotrophs (prokaryotic organisms that carry out dinitrogen fixation) that rhizobia benefit. Biological fixation of nitrogen was the leading form of annual nitrogen input until the last decade of the 20th century. It is gaining attention once again as sustainability becomes a central focus to feed a world population of over 7 billion people. The plant supplies the rhizobia with energy in the form of amino acids and the rhizobia fix nitrogen from the atmosphere for plant uptake. The reduction of atmospheric dinitrogen into ammonia is the second most important biological process on earth after photosynthesis. The actual process of dinitrogen fixation can only be carried out by diazotrophs that contain the enzyme dinitrogenase. Nitrogen is the most critical nutrient needed to support plant growth. Unfortunately, atmospheric dinitrogen (78% of air we breathe) is extremely stable due to triple bonds which can only be broken by energy intensive ways. These include electrical N_2 fixation by lightning where oxides of N come to ground with rain, the Haber-Bosch process in industrial fertilizer production, and biological N_2fixation in legumes by bacterial symbionts such as *Rhizobium etli*. Biological fixation of nitrogen was the leading form of annual nitrogen input until the last decade of the 20th century. As sustainability becomes a central focus to feed a world population of over 7 + billion people Professor (Dr.) Mahabal Ram, Wheat Scientist at SHIATS Allahabad India took this novel innovative scientific approach to break the yield barrier in wheat by developing, for the first time, a new source of dwarfing gene (MRD, with long sink size by application of gamma rays. Some of our findings will be discussed.

OP – 49

Biofertilization and biofortification of soybean with zinc by utilizing zinc from native soil pool of vertisols upon inoculation with plant growth-promoting rhizobacteria

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Soybean is a predominant oil seed crop cultivated in Vertisols of central India, wherein, the soils under purview are gradually becoming zinc deficient due to high cropping intensity, non-judicious use of high analysis fertilizers lacking in micronutrients, and the very nature of soils dominated by low organic carbon content, high pH, calcium carbonate and clay content. Zinc is an essential micronutrient for growth and development of microorganisms, plants, animals and human beings. Application of 5 kg Zn ha^{-1} in form of zinc sulphate as an external source to soil is becoming mandatory in soybean crop to mitigate zinc deficiency and to maintain improved grain yield of soybean. Though, the total zinc content in these soils is high, paradoxically its concentration in soil solution is very low for plant uptake. Coupled with low native soil zinc availability is the problem of low use efficiency of applied zinc due to sorption precipitation reactions. Therefore, direct assimilation by plants being an impediment unless through solubilization /mineralization reactions by physico-chemical and biological processes. In the light of the above information, an objective was set to isolate zinc solubilizing rhizobacteria from soybean in order to assess their potential to scavenge plant-available Zn from native soil zinc pool so as to improve nutrient content and productivity by crops (biofertilization) and to enrich seeds/edible portion of crops (biofortification). Some potential zinc solubilizing bacteria like *Acinetobactercalcoaceticus* NKD11,*Bacillus aryabhattai* MDSR7, *B. aryabhattai* MDSR11 *B. aryabhattai* MDSR14, *B. cereus KMR-5, B. endophyticus* MDSR34, *Burkholderia arboris* BK5, and *Pseudomonas mosselii* KDH3, were isolated from rhizosphere soil of soybean as plant growth promoting rhizobacteria possessing zinc solubilization traits. Inoculation of the zinc solubilizing bacteria like *B. aryabhattai, B. endophyticus, B. cereus, and P. mosselii* in soybean had significantly improved crop growth and zinc content is soybean crop by utilizing fixed soil zinc. Inoculation of strains MDSR7, MDSR14, MDSR34, and KDH3 separately in Vertisols under field conditions substantially decreased pH and increased biological activities in rhizosphere soil of soybean. The intense operation of microbial processes in the rhizosphere resulted in depletion of organically complex and bound zinc, calcium carbonate bound zinc (HCl-Zn), and increased in exchangeable zinc and sesquioxide bound zinc in soil. Such enhanced microbial activities coupled with redistribution of zinc in soil zinc pool were expected to be synergistically improved plant growth and zinc assimilation in seeds of soybean. Moreover, inoculation of these strains decreased phytic acid (PA): Zn molar ratio indicating bioavailability of zinc in seeds. This assumes significance as the increased zinc concentration in food has large implication in overcoming zinc malnutrition of rural Indian population.

Abstracts
Poster Presentations (PP)

PP-01

Nanomycorrhiza plus for plant promotion

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Zinc deficiency is the global problem and about 50% of cereals grown in nutrition deficient soil are deficient in zinc. Zinc is the vital element for seed germination and its vigor. To deal with this problem the new formulation "Nanomycorrhiza plus" has been evolved. A novel and new member of Sebacinales was mixed with organic Bio- Zinc. The carrier used was inert magnesium sulphite. This formulation was pelleted on seeds surface of pearl millet (*Pennisetumglacum*). The formulation contained the colony forming unit value of 10^8 with 20% of moisture and organic Bio- Zinc (a product of Prathista Industries Pvt. Ltd., Secunderabad) mixed at the rate of 0.01% of total w/v. 0.01% of jaggery solution was sprinkled on the seeds before pelleting. The pelleted substance was kept for overnight in shade for better attachment of the micropropagules. Four different treatments were made a) control; b) nanomycorrhiza alone; c) organic Bio- Zinc treated alone; d) nanomycorrhiza and organic Bio- Zinc. Seventy pelleted seeds were placed in each pot at equidistance in the soil and water was sprinkled in large cemented pots, size 92X35X32. The experiment was performed in the environmentally controlled green house at 25±2ºC with 60% of moisture and light intensity of 10,000 Lux. Experiments were performed in triplicates. Results suggested that seed germination and different growth parameters were significantly increased in the combined treatment of nanomycorrhiza and organic Bio-Zinc compared to individual treatments. This result indicated that a synergic combination increased the plant growth and enhanced several biochemical parameters and can be beneficial in future to increase the plant yield in nutrient deficient soil.

PP-02

Novel ways to combat verticilliumwilt in *Brassicaceae*

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Verticillium wilt, which causes severe yield losses in a broad range of crops, is currently difficult to suppress. In order to develop a seed treatment against Verticillium wilt for oilseed rape and Brassica vegetables, five *Serratia* and five *Paenibacillus* isolates were compared for their plant growth-promoting (PGP) potential under different plant growth conditions. These strains were selected for their antagonistic properties against fungal pathogens shown by in vitro tests. The selected isolates were applied to the surface-sterilized seeds of oilseed rape and cauliflower using bio-priming. *Serratia* treatment resulted in different levels of PGP under all tested plant growth conditions, while *Paenibacillus* spp. damaged roots when plants were grown in sterile germination pouches. *Paenibacilluspolymyxa* Sb3-1 did not have a significant effect on plant growth in non-sterile soil, however it did promote plant growth in the sterile soil. *Serratiaplymuthica* 3RP8 and *P. polymyxa* Sb3-1 were selected for further testing of their biocontrol effect under field conditions. The study proposes that the choice of growth environments is crucial for the investigation of plant-bacterium interaction. Non-sterile soil was suggested as the ideal medium for use in studying the PGP effect as it best reflects the natural growth conditions.

PP-03

Importance of inoculation time and methods of the fungal antagonists on bio-enhancement of rice against the rice root-knot Nematode *Meloidogynegramicola*

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The use of microorganisms in controlling plant parasitic nematodes is receiving increasing attention as an important alternative for chemical control and even traditional cultural practices. The efficacy of a biological control agents against plant parasitic nematodes not only depends on the particular endophyte but also on the inoculum density, time and type of application. Studies on the long term biocontrol activity of a non-pathogenic and endophytic *Fusarium moniliforme* isolate Fe14 against *Meloidogyne graminicola* have demonstrated a significant reduction in nematode infection when the nematode was introduced to rice plants pre-inoculated with Fe14 ten weeks earlier. In the present study, Fe 14 and two other endophytic fungal isolates, *F. moniliforme* Fe1 and *F. oxysporum* Fo162 and two rhizosphere associated isolates *Fusarium* F28 and *Trichoderma* T30 were also tested for their ability to provide early protection of rice seedlings against *M. graminicola* infection using seed treatment technology. The results showed that the endophytic isolates Fo162, Fe1 and Fe14 did not protect rice seedlings from root-knot nematode infestation while the rhizosphere isolates F28 and *Trichoderma* T30 slightly reduced galling severity by 7% and 19%, respectively. Growth of rice was slightly affected by fungal applications in the presence or absence of the nematode. Application of the isolate Fe14 either by seed coating and/ or soil drenching gave similar levels of biocontrol. However, it was clearly shown that seed treatment using the endophytic mutualistic Fe14 worked well in biocontrol of the rice root-knot nematode when the plants had reached a more matured stage.

Key words: Endophytic fungi, rhizosphere fungi, seed coating, soil drenching

PP-04

Ecological sustainability: Apathway for conservation and development of natural resources

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In the changing world circumstances, with recent development and advances, environmental education is virtually a new source of concern for educator's ad students. Education especially university education obviously to play an important and gradually more vital role towards mitigation of continuing environmental degradation and complexities of population, which poses a great menace to the survival of human life and species on the planet.We are facing a stunning task in linking the ecological security of our country with the live hood of our people. Commitment to sustainability implies a value judgement. The preservation of global environment raises serious issues about the growth and distribution of global income and wealth. The developing countries are obviously not satisfied with their present lot and cannot be expected to sustain their poverty in the name of environmental protection. There is no easy and clear link between the present and future needs. Sustaining the physical environment is not an end itself .what we need to sustain is human life and the environmental debate must have a human perspective. The concept of sustainable development must emphasize not only the present but also the future.Rapid population growth has placed enormous stress on our life support system of land, water flora and fauna and the atmosphere. Due to the inadequate public awareness of their importance, wide spread damage is being done to our great biological diversity. Human activities are therefore producing major changes in the global environment. The decline in environmental quality has howeverunderlined the need for harmonizing the need of economics with those of ecology.

Key words: Sustainability, ecology, environmentand life hood.

PP-05

Impact and assessment of PGPR and earthworm interaction in management of root-Knot nematode, *Meloidogyne incognita* infecting tomato, *Lycopersicon esculentum* Mill.

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The present study was focused to screen and evaluate the biocontrol potential of PGPR strains and Earthworm against root-knot nematode, *Meloidogyne incognita*. Micro-pot experiments were conducted to investigate the effects of a new Indian earthworm species "Jai Gopal" (*Perionyx ceylanesis*) and PGPR strains in management of *Meloidogyne incognita* in glass house

of Bareilly College campus at 28° 20' 49N 79° 25' 19E 252 meters of altitude in India. Readily available culture of three species of PGPR, including *Azotobacter chroococcum* HKN-5, *Bacillus megaterium* HKP-1, and *B. mucilaginous* HKK-1, in Luria-Bertani (LB) broth was inoculated in 15 days old plantlets of susceptible cultivar of tomato (*Lycopersicon esculentum* Mill.) infected with 200 juveniles (J_2) of *Meloidogyne incognita*/pot. Soil of each pot was pre-inoculated with three pairs of young (20 days old) Jai Gopal earthworm. Five sets of experiments with three replicates *viz*; normal control un-inoculated (NCU), normal control with earthworms only (NCE), normal control with PGPR only (NCP), infected control with *Meloidogyne* only (ICM) and treated pots with PGPR, earthworm and *Meloidogyne* (TPEM) were cultured in glass house conditions for next 30 days. All the replicates were harvested to analyze the plant growth parameters like length and weight of shoot and root, chlorophyll content and root-knot index (RKI).Weobserved synergistic effects of dual inoculation of earthworms and PGPR in increasing the plant growth parameters and chlorophyll content and this treatment inhibits the nematode population which is shown by reduced root-knot index over the infected control. On preliminary level, this can be concluded that PGPR strains and earthworm castings enhance the bioavailability of essential nutrients for plant growth and possibly these conditions creates an unfavourable conditions for penetration and multiplication of parasitic nematode, *Meloidogyne incognita*.The study highlights biocontrol potential of PGPR and earthworms in management of root-knot nematodes. PGPR offers an environmentally sustainable approach to increase the yield of crop production and soil health. Extension of this work is in progress to study the interaction of PGPR, earthworm, pathogen and host plant at molecular and genetic level.

Keywords: Plant Growth-Promoting Bacteria, *Perionyx ceylanesis*, *Lycopersicon esculentum*, *Meloidogyne incognita*, *Azotobacter, Bacillus*.

PP-06

Characterization of the type 3 effector NopL from *Sinorhizobium* sp. NGR234, a substrate for mitogen-activated protein kinases

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The bacterial type 3 (T3) secretion system is a multiprotein secretion apparatus that is able to deliver T3 effector proteins directly into eukaryotic host cells. T3 effectors of phytopathogenic bacteria are important virulence factors that subvert plant defense reactions. Similarly, T3 effectors of symbiotic nitrogen-fixing rhizobia can affect nodule formation on roots of legumes. *Sinorhizobium* (*Ensifer*) sp. strain NGR234 produces a number of T3 effectors, called nodulation outer proteins (Nops). Among others, NopL has been studied in our laboratory. Mutant analysis revealed that NopL of NGR234 promotes symbiosis with the host plant *Phaseolus vulgaris* by suppressing premature senescence in nodules. When expressed in plant cells, NopL is targeted to the nucleus. Bimolecular fluorescence complementation analysis and a pull-down assay indicated that NopL forms a protein complex with SIPK (salicylic acid induced protein kinase), a well-characterized mitogen-activated protein (MAP) kinase of tobacco. Accordingly, recombinant NopL was multiply phosphorylated by activated SIPK *in vitro*. Four

phosphorylation sites of NopL expressed in yeast have been identified and all of them possess a conserved serine-proline motif. Senescence symptoms in nodules of *P. vulgaris* were analyzed to determine the symbiotic effector activity of different NopL variants with serine-to-alanine substitutions. An increasing number of substituted serine residues in NopL correlated with progressive loss of effector activity in *P. vulgaris* nodules. In conclusion, our data indicate that NopL is a T3 effector that mimics a MAP kinase substrate to interfere with MAP kinase signaling.

PP-07

Application of inducedsystemic resistance on vegetables by plant growth-promoting rhizobacteria, *Bacillus vallismortis* EXTN-1 in Vietnam

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Treatment of *Bacillus vallismortis* EXTN-1 showed a broad spectrum of resistance to multiple plant pathogens caused by fungal, bacterial and viral pathogens as well as plant growth production. Mechanisms of ISR by EXTN-1 have been reported to oxidative burst, HR, lignifications, production of cyclo-dipeptide derivatives for ISR elicitor and activation of pathogenesis proteins when bacterial endospore suspension of EXTN-1 was treated to various plants. In sub-tropical region, Viet Nam, plant diseases caused by *Ralstonia solanacearum* and *Fusarium solani* are major problems on important vegetables of Tomato and Potato. Bacterial wilt, Fusarium wilt and Foot rot caused by *Ralstonia solanacearum*, *Fusarium oxysporum*, and *Phytophthora capsici* respectively, continue to be severe problems to tomato, potato and black pepper growers in Vietnam. EXTN-1 (*Bacillus vallismortis)* was the most effective, providing a mean level of disease reduction 80.0 to 90.0% against Bacterial wilt, Fusarium wilt and Foot rot diseases under greenhouse conditions *substilis*) also significantly reduced bacterial wilt, Fusarium wilt under greenhouse conditions. Bio-product, EXTN-1 with the greatest efficacy under greenhouse condition was tested for the ability to reduce bacterial wilt, fusarium wilt and foot rot under field condition at Song Phuong and Thuong Tin locations in Ha Tay province, Vietnam. In field condition, EXTN-1provided a mean level of disease reduction more than 45.0% against all three diseases compared to water treated control. Besides, EXTN-1 treatment increased the yield in tomato plants 17.3% than water treated control plants.

Keywords: Biological control, Bacterial wilt, Fusarium wilt, EXTN-1, PGPR-mediated ISR and Tomato, Foot rot

PP-08

Studies on the prevalence of groundnut aflatoxin contamination in Southern Indiaand its biocontrol using *Pseudomonasfluorescens*

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Aflatoxinsarenaturally occurring and highly carcinogenic toxic metabolites produced by *Aspergillus* section *Flavi* group of fungi. Aflatoxincontamination in groundnut results in reduced crop value besides deleterious health effects in humans and animals upon consumingcontaminated food and feed. Our present study is focused to determine the aflatoxin contamination in groundnut mills of Andhra Pradesh and Telanganadistrictsof Southern India; identifya potential *Pseudomonas fluorescens* strain against *A. flavus*; and determine the mode of action of *P. fluorescens*against*A. flavus*. Eight oil mills from Andhra Pradesh (Anantapur district) and Telangana (Karimnagar, Rangareddy, Mahaboob Nagar and Nizamabad districts) were selected and pod samples were collected to assess kernel *A. flavus* infection (on Czapek's media) and aflatoxin contamination (by ELISA). Further, rhizosphere isolates of *P. fluorescens* were screened against *A. flavus* by dual culture studies and by *in vitro* seed colonization (IVSC). The mode of action of *P. fluorescens* (Pf7) against *A. flavus* was confirmed through scanning electron microscopy (SEM). Our results indicated that the pod samples collected from Nizamabad had high kernel *A. flavus* infection (91%); whereas it was lowest in the samples of Mahaboobnagar (42%) in Telangana. Further, aflatoxin levels were highest in the samples of Rangareddy(1205 µg kg^{-1}); whereas lowest in Nizamabad (4.9 µg kg^{-1}). In Andhra Pradesh, aflatoxinlevels were highest in Tadimarri (6148µg kg^{-1}) samples, whereas lowest in Tadipatri (2.2 µg kg^{-1}) of Anantapur. Kernel infection in Andhra Pradesh was up to 60%. The Pf7strain has significantly reducedmycelialgrowthof*A. flavus*, kernel infection and aflatoxin content in IVSC. In SEM, Pf7 significantly inhibited *A. flavus* through frequent coiling, flaccidity, and lysis. Overall, our results suggest the prevalence of aflatoxin contamination in Andhra Pradesh and Telangana at traders'level.Further, the Pf7 strain has potential to reduce the aflatoxin contamination in groundnut.

Key Words: Groundnut, aflatoxins, *Aspergillusflavus*, *Pseudomonasfluorescens*, SEM

PP-09

Integrated disease management of rice sheath blight caused by *Rhizoctonia solani*

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Sheath blight (ShB) is a soil borne disease caused by *Rhizoctonia solani* Kuhn which causes major economic losses to rice cultivation. Plant growth-promoting rhizobacteria (PGPR) which can induce pathogen suppression by antagonism, competition for space and essential nutrients and initiation of systemic induced resistance (ISR), seems promising in the management of ShB disease. In this study, we have evaluated the biocontrol potential of different PGPR strains of *Bacillusspp*. combined efficacy of an elite PGPR strain *Bacillus subtilis* (AP301) with azoxystrobin in managing ShB. Also the combined effect of PGPR and fertilizers (NK) applied at different rates for the inhibition of ShB in rice under controlled environment was tested. Our results indicated that three strains of *Bacillus* (AP301, AP305, and AP52) were effective in mycelia and sclerotial inhibition under *in vitro* conditions. On a detached leaf assay, AP301 (*B. subtilis*) isolate resulted in 65.72% lower *R. solani* lesion spread when compared to control. Fungicidal compatibility studies indicated that azoxystrobin at the recommended rate (R), when used in conjunction with any of the concentrations of strain AP301, resulted in complete reduction of ShB lesions. In pot culture experiments, PGPR combined with N fertilizer applied at half the recommended rate resulted in lowest disease ShB lesion spread up to 2.83±0.15 mm and 2.33±0.16 mm in summer and fall experiments, respectively. For summer experiment, the treatment of PGPR combined with N applied at half recommended rate produced higher yields (23.12±0.33 g) than that of treatments applied using higher N rates (20.55±0.30 and 17.94±0.89 g). Based on our studies, we can conclude that PGPR, when applied with lower rates of N fertilizer had significant effect on ShB disease spread in comparison to treatments with higher rates.

PP-10

Rice sheath blight (*Rhizoctoniasolani* Kuhn) disease management by *Bacillussubtilis* MBI600

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Sheath blight (ShB) of rice caused by *Rhizoctonia solani*causes significant yield losses worldwide. Indiscriminate use of fungicides for ShB management has environmental concerns besides pathogen resistance. Our present study aimed at screening various plant growth-promoting rhizobacteria (PGPR) strains and select an effective strain for suppression of *R. solani* besides enhancing grain yields. Seventy PGPR strains with known activities on other crop-pathosystems were screened *in vitro* against*R. solani* and for growth promotion of rice seedlings. Majority of the strains significantly suppressed the mycelial growth of pathogen, among these four strains completely inhibited sclerotial germination of *R. solani* under *in vitro* conditions. Of, 70 strains, 31 strains significantly suppressed ShB lesions when tested in a detached leaf assay. Among these, one elite strain *Bacillus subtilis* MBI600 was superior. The commercial formulation of MBI600 (Integral®) wasfurther tested for its compatibility with rice fungicides and results indicated that it was compatible with propiconazole. Our field studies to assess the efficacy of Integral® indicated that ShB severity was significantly lower when Integral® was applied as seed treatment (ST) + soil drench (SD) + foliar spray (FS) at 2.2 x 10^9 cfu ml^{-1} (19.2 to 26.5% ShB severity), followed by at 2.2 x 10^8cfu ml^{-1} (24.5 to 29.4% ShB severity) compared to the control (56.2 to 69.7% ShB severity). Highest grain yields were recorded in Integral® treated plots at 2.2 x 10^9 cfu ml^{-1} (5922 to 6207 kg/ha) compared to the control (3925 to 4199 kg/ha). Overall, Integral® significantly reduced the ShB severity, and increased seedling vigor and grain yields in rice under field conditions and seems to have a potential for commercial application for rice ShB disease management.

PP-11

Scanning electron microscopic studies on the interaction between *Bacillussubtilis* MBI600 and *Rhizoctoniasolani* (rice sheath blight)

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Sheath blight of rice by *Rhizoctonia solani* is an important soil-borne disease causing grain yield losses significantly. Plant growth-promoting rhizobacteria (PGPR) are the potential alternatives to chemical control of sheath blight. However, prior to selection of an elite PGPR strain, understanding its mode of action against *R. solani* through ultrastructural studies is important. The present study focused on evaluating the mode of action of *Bacillus subtilis* strain MBI600 (Integral®) on *R. solani* through scanning electron microscopy (SEM). The effects of hyperparasitism and antibiosis by MBI600 was studied using standard protocols. The effect of strain MBI600 on structural integrity of sclerotia of *R. solani* was also studied by dipping sclerotia for 24 h in Integral at 2.20 x 10^9 CFU/ml. Sclerotia were later cut and observed in SEM. SEM studies on antibiosis indicated that strain MBI600 caused significant loss of structural integrity of pathogen hyphae with several deformities, shrivelling, coiling and finally lysis. Hyphae of pathogen remote from inhibition zone as well as in control plates, retained structural integrity. Integral®, when sprayed on *R. solani* mycelium, resulted in colonization of MBI600 on pathogen hyphae, maceration of tissues, shrinking and coiling of hyphae, and finally lysis. Sclerotia of *R. solani* dipped in Integral® resulted in colonization of strain MBI600, thereby causing maceration of inner sclerotial walls. Deterioration of hyphal walls was seen, finally leading to their fragmentation. Sclerotia dipped in sterile water retained structural integrity with intact inner cell walls. Overall, our results indicated that *B. subtilis*MBI600 is effective against mycelial growth and sclerotia of *R. solani*.

PP-12

Preventing moko, panama and black sigatoka diseases in bananas using rhizobacteria from mangrove rhizospheres as biological control agent

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Banana is considered as one of the most important crops being exported around the globe. In terms of gross value of production, bananas are the world's fourth most important food crop after rice, wheat and maize. Presently, there are four major diseases threatening the global banana production. These are Fusarium wilt or Panama disease caused by a fungus, *Fusarium oxysporum* f.sp. *cubense* (Foc), black leaf streak diseases or black Sigatoka caused by a fungus, *Mycosphaerella fijiensis,* bacterial wilt caused by *Ralstonia solanacearum* together with recently emerged *Xanthomonas campestris* pv. *musacearum*, and banana bunchy top disease caused by *Banana bunchy top virus* (BBTV). As these diseases caused serious and expanding threat to banana plantations, farmers and producers struggled to overcome this problem. This study determines the potential use of mangrove marine bacteria as a biological control agent against *Ralstonia solanacearum, Fusarium oxysporum,* and *Mycosphaerella fijensis*. Marine rhizobacteria were isolated from three randomly selected mangrove rhizosphere collected from Lianga Bay, Lianga and Surigaodel Sur. The rhizobacteria were purified and screened using agar plug assay against *R. solanacearum, F. oxysporum,* and *M. fijiensis*. The best isolates (based on its activity *in vitro*) were selected for inoculation to tissue cultured Cavendish banana seedling. In the *in-vivo* testing, 60 tissue cultured banana seedlings were used to test the potential of the *Bacillus* and *Actinomycetes* isolates as biological control agents against *R. solanacearum, F. oxysporum,* and *M. fijiensis.* A total of 76 *Bacilli* and 48 *Actinomycetes* were isolated and screened. Of these isolates, 31 *bacilli* and 15 *actinomycetes* showed inhibition against *R. solanacearum*, 10 *bacilli* and 8 *Actinomycetes* against *F. oxysporum*, and 9 *Actinomycetes* against *M. fijiensis*. The isolates which showed most potential are YS3B1, YS4A5, and YS3A4 for *R. Solanacearum; YS4B1, YS1A3, YS2A5* for *F. Oxysporum;* and YS1A3 and YS2A1 for *M. fijiensis.* Results of the *in vivo* testing showed that the isolates mitigated the infection in tissue cultured bananas. This suggests that the isolate mitigated the activity of the pathogen seeded in the plant rhizosphere. Furthermore, the results suggest that the isolates have protected the plants from these banana diseases by inhibiting bacterial and fungal growth of the pathogen in the soil.

Keywords: Panama disease, Black Sigatoka Disease, *Actinomycetes, Bacillus*, Rhizobacteria

PP-13

Isolation of *Bacillus licheniformis* MH48 with antagonistic activity against plant pathogens

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This work presents the evaluation of the capacity of *Bacillus licheniformis* MH48 against plant fungal pathogens, and establishes its role as a biocontrol agent. In this study, we isolated an bacterial strain MH48 from rhizosphere soil, identified the strain as *Bacillus licheniformis* MH48by the 16S rRNA gene sequence analysis and demonstrated significant antifungal activity against *Rhizoctoniasolani*, *Colletotrichumgloeosporioides*, *Botrytis cinerea*, *Phytophthoracapsici*, *Pestalotiopsiskarstenii*, *Pestalotiadiospyri*, *Glomerellacingulata*.MH48 produced lytic enzymes such as chitinase, β-1,3-glucanase, protease.MH48 showed strong antagonistic activities against the fungal pathogens in dual culture assays. In addition, bacterial culture filtrate of *B. licheniformis* MH48 was highly antifungal activity in inhibiting growths of the fungal pathogens at 50% concentration. As a result, we worked that evidences for antagonism were established by production of antifungal metabolites from *B. licheniformis* MH48. Bacterial crude extract of *B. licheniformis* MH48 with 10mg amount significantly inhibited the fungal pathogens growth. The antifungal crude extracts was purified by silica gel column chromatography, Sephadex LH-20 column chromatography and ODS column chromatography. This work is in progress and the finalpurificationstep. This study suggests that our results demonstrated *B. licheniformis* MH48 as a potential biological control agent for various fungal pathogens management.

Keywords: Antagonistic activity, *Bacillus licheniformis*, Enzyme activity, Plant fungal pathogen, Crude extract.

PP-14

Antagonistic potential of *Bacillus pumilus* L1 against the root-knot nematode, *Meloidogyne arenaria*

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This study was conducted to estimate the potential of *Bacillus pumilus* L1 against the root-knot nematode, *Meloidogyne arenaria*, in both *in vitro* and *in vivo* conditions. *B. pumilus* L1 was found to produce both protease and chitinase. When various concentrations (1-10%) of the bacterial culture (BC) or 4.4 - 22.0 mg/ml of the crude enzymes produced by *B. pumilus* L1 were used to treat *M. arenaria* eggs and second-stage juveniles (J2), inhibition of hatching and J2 mortality were significantly increased under *in vitro* conditions. The hatching inhibition and J2 mortality rate were improved with increasing concentrations of BC and the crude enzymes. Similarly, the effects on hatching inhibition and J2 mortality also increased over time after treatment with BC. Moreover, the crude enzymes caused partial degradation of the eggshell and juvenile body at 22.0 mg/ml concentrations. Furthermore, the pot experiment showed that the application of BC to potted soil caused significant reduction of the number of galls and egg masses in the plant roots as compared to the untreated control 6 weeks after *M. arenaria* infestation. In addition, the simultaneous application of BC and nematode inoculation proved more effective than application 2 days post-inoculation with nematode. Thus, our results demonstrated the ability of *B. pumilus* L1 as a potential biocontrol agent against root-knot nematode, as well as activity as a plant growth promoter for tomato.

Keywords: Biocontrol, Chitinase, Protease,*Meloidogyne arenaria*, Tomato

PP-15

Application of inducedsystemic resistance in vegetables by plant growth-promoting rhizobacteria, *Bacillus vallismortis* EXTN-1 in Vietnam

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Treatment of *Bacillus vallismortis* EXTN-1 showed a broad spectrum of resistance to multiple plant pathogens caused by fungal, bacterial and viral pathogens as well as plant growth production. Mechanisms of ISR by EXTN-1 have been reported to oxidative burst, HR, lignifications, production of cyclo-dipeptide derivatives for ISR elicitor and activation of

pathogenesis proteins when bacterial endospore suspension of EXTN-1 was treated to various plants. In sub-tropical region, Viet Nam, plant diseases caused by *Ralstonia solanacearum* and *Fusarium solani* are major problems on important vegetables of Tomato and Potato. To control these, field experiments were conducted with biocontrol strain, EXTN-1 on Tomato and Potato in Viet Nam during different seasons (summer-autumn-winter). For all the treatments, EXTN-1 showed consistently most successful in disease reduction on Tomato and Potato. The results of field study demonstrate that EXTN-1 was efficiently reducing the disease severity of Bacterial wilt disease and Fusarium wilt on Tomato and potato under field condition. The objectives of this study is to application and elucidation of induce systemic resistance on vegetable plants by *B. vallismortis* in Vietnam. In conclusion, *B. vallismortis* EXTN-1 can be used for yield increase as well as induced systemic resistance on various crops. Furthermore, treatment of EXTN-1 will be extended to other crops in Vietnam.

PP-16

Biocontrol potential of actinomycetes against *Rhizoctonia solani*

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The banded leaf and sheath blight is one of the significant fungal diseases causing major economic losses to corn cultivation. It is caused by *Rhizoctonia solani* Kuhn, a soil-borne fungal pathogen. The fungus is controlled by use of fungicides. However, due to health and environmental implications, utilization of microorganisms for control is a promising alternative. The actinomycete with the ability to synthesize a wide variety of bioactive compounds are good candidates as biocontrol agents against this pathogen. One hundred actinomycetes isolated around mangrove areas in Quezon, Zambales and Bataan, Philippines were initially screened against *R. solani* by agar plug assay. The *R. solani* used as test organism was previouslyconfirmed to cause the sheath blight disease *in vivo*. Results showed that among the actinomycetes tested, 20 actinomycetes showed the highest biocontrol activity, with AR1, AR2, AR3 and AR4 inhibiting *R. solani* with 28.8 mm. 23.65 mm, 23.30 mm and 23.15 mm zones of inhibition, respectively. Greenhouse experiment is presently being conducted to evaluate the efficacy of these actinomycetes as preventive control of *R. solani*

PP-17

Comparative assessment in enzyme activities and characteristics during normal and crab shell composting

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Changes in chemical property (pH, electricalconductivity (EC), C:N ratio, moisture content and organic matter), mineral contents and activities of enzymes were determined during composting of normal compost (Ncom) and crab shell compost (Cscom). The two composts were sampled during process. In the final composts of the two composts, moisture content, organic matter, total N and C:N ratio decreased, whereas the contents of, K, Ca and Mg increased. The pH of the composts increased rapidly till 90 days and EC decreased during composting. In Cscom, the maximum enzyme activities (cellulase, chitinase, proteaseand alkaline phosphatase) were observed each at 30, 30, 0 and 90 days, whereas in Ncom, the highest activities of the studied enzymes were observed at 0 day. In the final composts, the chitinlolytic bacteria increased and also in crab shell compost, they were higher than in normal compost. The maximum of the chitinolytic bacteria in Cscom and Ncom was at 60 and 30 days, respectively. The two composts showed that growth of *Phytophthoracapsici*and *Fusariumoxysporum* were suppressed by PDA medium containingCscom and Ncom water extract, while in Ccom activity of suppression was higher than in Ncom.

Keywords: Compost, Crab shell, enzyme, chitinolytic bacteria, *Phytophthoracapsici*,*Fusariumoxysporum*

PP - 18

The effect of actinomycetes from rhizosphere in controlling fusarium wilt on sesame

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Research on actinomycetes in controlling vascular wilt on sesame caused by *Fusarium oxysporum* fsp.*sesami* (*Fos*) was conducted in laboratory, greenhouse and field conditions. Evaluation 187 actinomycete strains isolated from sesame rhizospheres against *Fos* by dual test on Petri plates, there were 12.3% of the actinomycete strains possessed antagonistic ability to

Fos with inhibition zone 0.1 – 8.3 mm at four days after inoculation, and four Actinomycete strains i.e. 3, 6, 25 and 79 expressed highest antagonistic ability against *Fos.* In greenhouse, application actinomycetes by soil drenching with suspension (10^8 cfu/ml, 5ml/plant) of individual strain (3, 6, 25, 79 separately), or mixture of these four strains at ten days intervals during growing time: all treatments could reduce *F. oxysporum* infection with percentage of infected plants (72%, 80%, 68%, 68% and 64%, respectively) were significantly lower compared to the control (96%) in 25 days after inoculation. In addition, all treatments treated with actinomycetes improve plant height and number of leaves per plant compared to control. The same experiment was surveyed under field conditions. The results showed that the treatments with soil drenching with individual strains (3, 25, 79) could reduce wilt disease on sesame with percentage of infected plants in these treatments lower than compared with control at 35, 45, 55 and 65 days after sowing. The result showed that actinomycetes are effective biological control agents for Fusarium wilt on sesame.

Keywords: Actinomyces, biological control, *Fusarium oxysporum* f.sp. *sesami*, sesame

PP – 19

Isolation of actinomycetes from Balisong Cave and Capiz of Philippines as source of bioactive compounds against plant pathogens

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Caves from the Philippines have been little studied for their potential as sources of novel microbial species and bioactive compounds. Actinomycetes from caves are of special interest because of their versatile metabolic activities and the most important property is its ability to produce various antibiotics valuable for medical, veterinary and agricultural use. They comprise around 80% of all known antimicrobial products. There is an urgent need to find new antimicrobial agents that are effective against plant pathogens and against new emerging infections. The objective of this study is to determine the effectivity of new actinomycete isolates from rare environments. Twelve newly isolated Actinomycetes from soil in Balisong Cave, Pilar, Capiz, Philippines were assayed by agar plug method for the production of bioactive compound against plant pathogens *Ralstoniasolanacearum* (from tomato), *Erwinia corotovora* BIOTECH 1752, *Xanthomonas oryzae* BIOTECH 1782 and *Fusarium oxysporum* (from banana). Eight Actinomycete isolates showed inhibition against *E. corotovora*, the highest and very clear zone of inhibition (zoi) was isolate T2 (11 mm) while Actinomycete isolate S2, S3, S5, T1, T3, T4, and T6 also inhibited *E. corotovora* less than 10 mm zoi. However, *R.solanacearum* was greatly inhibited by actinomycete isolate T3 (11.5 mm zoi)whileactinomycete isolates S2, S3, T1, T2, T4, T5 and T6 showed lower zoi against *R. solanacearum*. *X. oryzae*and *F. oxysporum* was not inhibited by all actinomycete isolates. Bioactive compounds from cave actinomycetes might be a good source of novel antibiotics which might be better and cheaper than the existing one.

Keywords: Actinomycetes, *Ralstonia*,*Erwinia*, *Xanthomonas*

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