Virtual 6th ASIAN PGPR NATIONAL CONFERENCE

On

Advances in PGPR Technology for Betterment of Agriculture & Environment (APTBAE - 2021)

September 3-4TH 2021






Organized by

Department of Microbiology, Barkatullah University, Bhopal, India

In Association with

Asian PGPR Society for Sustainable Agriculture (APSSA),
APSSA- India Chapter, Indian Council of Agricultural Research (ICAR),
Indian Phytopathological Society (IPS), Microbiologist Society India (MSI),
M.P. Council for Science & Technology (MPCST) & The National Academy of Sciences, India

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Preface

Dear Participants,

The concept of "Black Box" in the realm of Rhizosphere has undergone a sea change during the last decades owing to its interplay in the context of plant productivity linked sustainability goals. From mere study of microbial population structure in root zone we now have detailed profiles of communities of both culture lessons and non culturables, and in several model plants their functional and regulatory attributes. This we owe to the development of various tools of *in situ* study as also progress in the sphere of data analytic as applicable to genome sequencing and the likes. This however does not astray us from our primary goal, viz. disease reduction and improved productivity under the influence of both biotic and abiotic stresses. In doing so researchers dealing with molecular microbial ecology perspectives have placed special attention towards plant growth promotory populations present in rhizosphere and endorhizosphere milieu. So much so that this has resulted now in availability of several commercial products that are a success story in the domain of both biofertilizer and biocontrol systems. To this end it is now clear that a detailed understanding of bacterial communities in soil ecosystem by way of not only their resident members but a comprehension of inter species dialogue will make rhizosphere biology science move the mankind closer to achieve true sustainable development goals.

It gives me absolute pleasure to present the e-abstract book for your reading. The broad discussion topic of this conference Advances in PGPR technology for Betterment of Agriculture and Environment has been covered under five themes viz., theme I: PGPR and other microbes for plant growth support, theme II: PGPR and other microbes that confer disease control, theme III: PGPR and other microbes for stress tolerance, theme IV: PGPR and other microbes based technology for crop improvement, theme V: IPR, patents and commercialization aspects of PGPR and allied technology. The categorization of these themes is based more on the advanced research carried in the field of PGPR and its societal impacts. The total numbers of abstracts contained in this book are one hundred and twenty three out of which seventeen are from speakers working in PGPR field including two abstracts are evening talks followed by one hundred and four abstracts prepared for poster presentations from participants from various institutes of the country. A quick glance at the abstracts indicates that direct plant growth promotory events and alleviation of environmental stress are gaining much attention.

The compilation of this volume is a combined effort of faculties and scholars associated with this conference who are gratefully acknowledged.

Bhavdish N. Johri
(Chairperson NASI, Bhopal Chapter)





VIRTUAL 6th ASIAN PGPR NATIONAL CONFERENCE ON ADVANCES in PGPR TECHNOLOGY for BETTERMENT of AGRICULTURE & ENVIRONMENT

DEPTT. OF MICROBIOLOGY, BARKATULLAH UNIVERSITY

DAY 1 :- 3RD SEPTEMBER, 2021

INAUGURAL SESSION

Time : (9:30 AM to 10:30 AM)

✷ **Saraswati Vandana** 9:30 AM - 9:35 AM	**Lighting of Lamp**
✷ **Welcome Address** 9:35 AM - 9:45 AM	**Prof. (Dr.) Anil Prakash** Chairman, Organizing Committee
✷ **Address by** 9:45 AM - 9:50 AM	**Prof. M.S. Reddy** Chairman Asian PGPR Society for Sustainable Agriculture, Auburn University, USA
✷ **Address by** 9:50 AM - 9:55 AM	**Dr. Riyaz Sayyed** President, India Chapter of Asian PGPR Society
✷ **Address by** 10:00 AM - 10:10 AM	**Prof. R.J. Rao** Vice Chancellor, Barkatullah University, Bhopal
✷ **Release of e-Abstract Book** 10:10 AM - 10:15 AM	**By Dignitaries Present Online**
✷ **Address by** 10:15 AM - 10:25 AM	**Chief Guest** **Dr. S.K. Malhotra** Commissioner of Agriculture, Ministry of Agriculture, Government of India, Delhi, India.
✷ **Vote of Thanks** 10:25 AM - 10:30 AM	**Dr. Sunil Kumar Snehi** Asst. Professor, Dept of Microbiology, BU, Bhopal

Zoom link: https://us02web.zoom.us/j/6374789015?pwd=MndUUnRwVFpra2VkY2V6VHpqcUZvQT09
Meeting ID: 637 478 9015 | Passcode: 123456





TECHNICAL SESSION-1

(10:30 AM-12:00 Noon)

PGPR and other Microbes for Plant Growth Support

Convener:

Dr. Anil Kumar Sharma
Department of Biological Sciences &
Director Extension Education
G.B. Pant University of Agriculture & Technology,
Pant Nagar Uttarakhand, India

Moderator: **Ms. Himani Chaturvedi**

Invited Talk-1:
10:30 AM-11:00 AM (IST)
(3:00 PM-3:30 PM AEST)

Dr. Vadakattu Gupta
Senior Principal Research Scientist, Commonwealth Scientific and Industrial Research Organization, Canberra, Australia

Topic: Rhizosphere functional microbiology and plant Performance

Invited Talk-2
11:00 AM -11:30 AM (IST)
(8:30 AM-9:00 AM EEST)

Prof. Martin Romartschuk
Environmental Biotechnology, Faculty of Biological and Environmental Sciences, University of Helsinki, Finland

Topic : Microbial diversity and bioactive substances in disease suppressive compost

Invited Talk-3
11:30 AM -12:00 Noon IST
(8:00 AM- 8:30 AM EEST)

Dr. Enrique Monte
Professor of Microbiology, Institute for Agribiotechnology Research (CIALE), lab 2, Campus of Villa mayor University of Salamanca, Spain

Topic: *Trichoderma* to support plant growth, but it can do more too.





TECHNICAL SESSION-2

(12:15 PM-2:15 PM)

PGPR and other Microbes that Confer disease Control

Convener:	**Dr. Udai B. Singh** Scientist (Plant Pathology), ICAR-National Bureau of Agriculturally Important Microorganisms, Kushmaur, Mau Nath Bhanjan, Uttar Pradesh, India
Chairperson	**Dr. D.J. Bagyaraj** NASI Sr. Scientist & Chairman, CNBRCD, Bangalore, Karnataka, India
Moderator	**Ms. Nandini Singh**
Invited Talk-1 12:15 PM-12:45 PM (IST) **(07:45 AM-08:15 AM BST)**	**Prof. Tofazzal Islam** Professor, Institute Of Biotechnology and Genetic Engineering (IBGE), Bangabandhu Sheikh Mujibur Rahman Agriculture University, Gazipur, Bangladesh **Topic:** Biological control of wheat blast disease by seed endophytic *Bacillus* species
Invited Talk-2 12:45 PM -1:15 PM (IST) **(3:15 PM-3:45 PM MYT)**	**Prof. Hesham A.EI Enshasy** Bioprocess Engineering Department, Faculty of Chemical and Energy Engineering, Director, Institute of Bioproduct Development (IBD), Universiti Teknologi, Malaysia **Topic:** Technology Platform Design for *Bacillus* spp. production as biological control agent: From Petri dish to bulk powder production
Invited Talk-3 1:15 PM-1:45 PM (IST) (**12:45 PM-1:15 PM UZT**)	**Dr. Dilfuza Egamberdieva** Head Research Joint Lab Ecosystem and Biomes, National University of Uzbekistan, Tashkent, Uzbekistan **Topic:** The Plant Microbiome interactions under extreme environment.
Invited Talk-4 1:45 PM-2:15 PM IST	**Dr. Birinchi Kumar Sarma** Department of Mycology and Plant Pathology Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India **Topic:** PGPR stimulates specific transcription factors in pigeon pea in salinity affected soils for lowering of wilt severity





TECHNICAL SESSION-3

(2:30 PM-4:00 PM)

PGPR and other Microbes for Stress Tolerance

Convener:	**Dr. Sushil K. Sharma** Principal Scientist (Agricultural Microbiology), ICAR-National Institute of Biotic Stress Management, Baronda, Raipur, Chhattisgarh, India
Chairperson	**Dr. S.C. Dubey** Assistant Director General (PP & B) Indian Council of Agricultural Research, Krishi Bhavan,New Delhi, India
Moderator	**Ms. Smriti Saxena**
Invited Talk-1 2:30 PM-3:00 PM (IST)	**Dr. Udai B. Singh** Scientist (Plant Pathology), ICAR-National Bureau of Agriculturally Important Microorganisms, Kushmaur, Mau Nath Bhanjan, Uttar Pradesh, India **Topic:** Translation research in biological control: Concept to Application
Invited Talk-2 3:00 PM-3:30 PM (IST)	**Dr. S. Krishna Sundari** Department of Biotechnology, Jaypee Institute of Information Technology, Noida, Uttar Pradesh, India **Topic:** Remarkable roles of PGPM in residual pesticides detoxification and abating abiotic stress
Invited Talk-3 3:30 PM-4:00 PM (IST) (12:00 PM-12:30 PM CEST)	**Prof.(Dr.) Corné M.J. Pieterse** Professor Plant-Microbe Interactions, Director, Institute of Environmental Biology Department of Biology, Science Life, Faculty of Science, Utrecht University, The Netherlands **Topic:** The root microbiome and plant health





EVENING LECTURES

(6:00 PM-7:00 PM)

Convener	**Prof. Anil Prakash** Head, Department of Microbiology Barkatullah University, Bhopal, Madhya Pradesh, India
Chairperson	**Dr. Tapan Kumar Adhya** Professor, School of Biotechnology, KIIT University Bhubaneshwar, Odisha
Moderator	**Ms Himani Chaturvedi**
Invited Talk-1 6.00 PM-6:30 PM (IST) (**1:30 PM-02:00 PM BST**)	**Dr. Rodrigo Mendes** Head of Research and Development Embrapa Environment Brazilian Agricultural Research Corporation, Ministry of Agriculture, Livestock and Food Supply, Embrapa Environment, Jaguraviuna SP, Brazil **Topic :** The rhizosphere microbiome as an extension of the plant defense system
Invited Talk-2 6.30 PM-7:00 PM IST (**2:00 PM-2:30 PM BST**)	**Dr. Harsh P. Bais** Associate Professor Department of Plant and Soil Sciences, Delaware Biotechnology Institute University Of Delaware, 15-Innovation Way Newark, DE-19711, USA **Topic:** The role of benign root microbiome in plant defense and health





DAY-2 : 4th September 2021

TECHNICAL SESSION-4

(10:00 AM-11:30 AM)

PGPR and other Microbes Based Technology for Crop Improvement

Convener :	**Dr. S. Krishna Sundari** Department of Biotechnology, Jaypee Institute of Information Technology, Noida, Uttar Pradesh, India
Chairperson	**Dr. Naveen Arora** Head, Department of Environmental Science School of Environmental Sciences Baba Saheb Bhimrao Ambedkar University Lucknow, Uttar Pradesh, India
Moderator	**Ms. Smriti Saxena**
Invited Talk - 1 10:00 AM-10:30 AM (IST)	**Dr. Alok Adholeya** Former Program Director, Sustainable Agriculture TERI and Former Director, TERI-Deakin Nanobiotechnology Centre, TERI, India **Topic:** Role of nanotechnology in agriculture: Translational and adaptation challenges.
Invited Talk-2 10:30 AM - 11:00 AM (IST) **(3:00 PM - 3:30 PM AEST)**	**Dr. Peter McEntee** Head of Research and Development, New Edge Microbials, Pty Ltd., based in Albury, New South Wales, Australia. **Topic:** From Lab to the Field: Commercial formulation, production and marketing of microbial inoculant products to agriculture
Invited Talk-3 11:00 AM-11:30 AM (IST)	**Dr. K. Annapurna** Former Head, Division of Microbiology, ICAR-Indian Institute of Agriculture Research, New Delhi, India **Topic:** Microbial formulations in sustainable agriculture Quality Monitoring Tools





TECHNICAL SESSION-5

(12:00 Noon - 2:00 PM)

IPR, Patents and Commercialization aspects of PGPR and Allied Technology

Convener:	**Dr. Meenu Saraf** Director, University School of Sciences, Professor and Head, Department of Microbiology and Biotechnology, Coordinator Clinical Research Programs, University School of Sciences, Gujarat University, Gujarat, India
Chairperson	**Dr. D.K. Maheshwari** Former Vice Chancellor, Gurukul Kangri University, Haridwar, Uttarakhand, India
Moderator	**Ms. Nandini Singh**
Invited Talk-1 12:00 Noon - 12:30 PM (IST) **(3:30 PM-4:00 PM KST)**	**Dr. Tongmin Sa** Professor, Agriculture Chemistry Department Chungbuk National University, Cheongju, South Korea **Topic:** Urgent need for designing biofertilizers to cope with global warming
Invited Talk-2 12:30 PM -1:00 PM (IST)	**Dr. Dweipayan Goswami** Assistant Professor, Department of Microbiology and Biotechnology, University School of Sciences, Gujarat University, Ahmedabad, Gujarat, India **Topic:** Prospects of computational studies in studying next level of plant-microbe interactions
Invited Talk-3 1:00 PM-1:30 PM (IST)	**Prof. H.B. Singh** Professor of Biotechnology, GLA University, Mathura, Uttar Pradesh, India **Topic:** Intellectual property right, commercialization, technology transfer & regulatory requirements of PGPR
Invited Talk-4 1:30 PM-2:00 PM (IST) **(9:00 AM-9:30 AM BST)**	**Dr. Shraddha Gang** Lecturer of Academic Research Practices in Appled Biosciences Department of Health and Life sciences, Coventry University, Coventry, United Kingdom. **Topic:** Resurgence of microbial application for regenerative agriculture: A global perspective





VALEDICTORY PROGRAM

(2:00PM- 3:00PM)

❍ **Welcome Address**	**Prof. Anil Prakash** Organizing Chairman, APTBAE 2021
❍ **Address by**	**Dr. Riyaz Sayyed** President, India Chapter of APSSA
❍ **Address by**	**Dr A. M. Deshmukh** President, Microbiologists Society, India
❍ **Concluding Remark**	
❍ **Felicitation & Prize distribution**	
❍ **Address by Vice Chancellor**	**Prof. R.J. Rao** Vice Chancellor, Barkatullah University, Bhopal
❍ **Address by Chief Guest**	**Dr. Pranjib Chakrabarty** Member (Plant Sciences) Agricultural Scientists Recruitment Board DARE, Ministry of Agriculture and Farmer's Welfare, GOI, New Delhi
❍ **Vote of Thanks**	**Ms Apekcha Bajpai** Organizing Secretary, APTBAE 2021





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Dr. Abhilasha Bhavsar
Dr. Durgesh Gupta

EVENING LECTURES

Chairperson :-

Dr. Tapan Kumar Adhya

Convener :-

Prof. Anil Prakash

Speakers:-

1. Dr. Rodrigo Mendes
2. Dr. Harsh P. Bais





Abstract (EL 1)

The rhizosphere microbiome as an extension of the plant defense system

Rodrigo Mendes

Laboratory of Environmental Microbiology, Embrapa Environment, Rodovia SP340 km 127,5, Jaguariúna SP, 13918-110, Brazil
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Microbial communities associated to plant roots play a pivotal role in the functioning of the host by influencing their nutrition, tolerance to abiotic stress and protection against pathogens. Soilborne pathogens try to colonize the rhizosphere before infecting the plant roots striving to break through the protective microbial shield and to overcome the innate plant defense mechanisms. During the invasion of the root system by a pathogen, two microbiological layers of defense are activated in the presence of the invader. The first layer is the rhizosphere microbiome, which is activated to prevent the root infection. However, if the pathogen is able to overcome this first line of defense reaching the inner plant root tissues, a second microbiological layer is activated in the endosphere. The rhizosphere and endosphere microbiomes work as an extension of the plant defense system by increasing in abundance specific beneficial microbial taxa and activating antagonistic functions in the presence of the pathogen, which results in plant protection. In this context, the classical view on plant diseases represented by a disease triangle where the host, the pathogen, and the environment interact with each other resulting in disease or not is recently challenged by a more complex holistic view including the presence of complex microbial communities in the pathosystem – the plant microbiome. Therefore, we propose adding a fourth vertex in the disease triangle, resulting in a disease pyramid, including the host, the pathogen, the environment and the microbiome as key elements to determine the fate of plant diseases.

Keywords: rhizosphere microbiome, endosphere microbiome, microbiological defense, soilborne pathogens

Abstract (EL 2)

The role of benign root microbiome in plant defense and health

Harsh Bais
Department of Plant and Soil Sciences, University of Delaware, 311 AP Biopharma, 590 Avenue 1743, Lab 357, Newark, DE 19713
hbais@udel.edu

Plants associate with benign microbiome of late, the functional significance of plant-associated microbiome has revealed the importance of plant-associated microbes in plant health and defense. Our rhizosphere biology research is focused on understanding the biological significance of plant associated microbiome. Utilizing the standard plant models such as Arabidopsis and Rice, we have tested the functional importance of benign plant growth promoting rhizobacteria in alleviating plant defense and growth. Our research is taking a multidisciplinary approach by interfacing plant biology and chemistry to unravel the underground communication process.

THEME - I





PGPR and other microbes for plant growth support

Chairperson :-

Dr. J. Kumar

Convener :-

Dr. Anil Kumar Sharma

Speakers:-

1. Dr. Vadakattu Gupta
2. Prof. Martin Romartschuk
3. Dr. Enrique Monte

SPEAKER'S ABSTRACT





Abstract (IL 1.1)

Rhizosphere functional microbiomes and plant performance

Vadakattu V.S.R. Gupta

CSIRO Agriculture & Food, Locked Bag 2, Glen Osmond, SA 5064, Australia
Gupta.Vadakattu@csiro.au

Plant-microbiome interactions, both above and below ground, play a critical role in several plant essential functions. Rhizospheres harbor diverse microbiomes that are spatially and temporally dynamic, influenced by plant and soil bio-physical environment and have a major impact on plant health through interactions on growth and development, facilitation of nutrient uptake and ability to tolerate biotic and abiotic stresses. During the last two decades, there has been a renewed interest in exploring the dynamics of the microbiomes, using *omics* tools, for its composition and organismal interactions occurring in the complex spatial structuring at the root-soil interface and their key drivers during the crop growth. It is now known that structural and functional diversification of root-associated microbial communities exist within crop varieties and wild and domesticated accessions of barley, wheat, maize, pearl millet, canola, peas, *Arabidopsis* etc.

Our research targets the identification of key drivers of microbiome diversity and functionality along with understanding of spatial and temporal factors that operate under field conditions. Rhizosphere microbiome assemblage is both soil type and host species dependent, in terms of composition and abundances of specific functional groups and could be modulated by management. For example, (i) within cereal crops and perennial grass species there is a plant type and variety specific enrichment of specific members of soil microbiome both in terms of total bacteria and diazotrophs, (ii) clear differences in bacterial and fungal microbiomes exist between the domesticated modern bread wheats, landraces and wild relatives within the Triticeae, (iii) a diverse array of rhizosphere microbial communities that are well connected are involved in the continued effective expression of disease suppression. Overall, the aim is to develop better connection between „descriptive genomics and „functional microbiome that would allow deliberate selection of beneficial microbiomes through either targeted management, designer interventions or specific selection of crop genotypes.

Key words: Rhizosphere, Microbiomes, Diazotrophs, Plant health, Designer intervention

Abstract (IL 1.2)

Microbial diversity and bioactive substances in disease suppressive compost

Martin Romantschuk

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Compost can be considered as a soil conditioner that contributes to soil fertility, structure, porosity, organic matter, water holding capacity, and suppression of soil borne disease in plants. Disease suppression by composts is a fairly recently established alternative use of composts. The interest in suppressive composts has increased due to concern over pesticide use, increasing pesticide resistance, and lack of chemical control against disease or disease resistant plant cultivars.

In studies performed in India and in Finland we aimed at clarifying the reasons for suppressiveness of certain compost products and common denominators among functional composts, with the further goal to be able to control the composting process in a desired direction and to provide tools for predicting and determining the disease suppressive activity of sampled composts.

In Finland 21 mature commercial composts were screened for their ability to decrease strawberry crown rot caused by *Phytophthora cactorum* and cucumber wilt disease caused by Pythium sp. Seven composts showed distinct suppressiveness capacities. The results indicated that suppressiveness was observed more commonly in biowaste composts than in composts made from manure. Nine of these composts were found to be potentially suppressive against Pythium in cucumbers. Sequencing results indicated the potential roles of bacteria Acidobacteria Gp14 and fungal Cystobasidiomycetes in the suppression based on abundance in composts with strong and lower/absent disease suppression ability. Also the abundance of Actinobacteria was associated positively with suppressiveness.

Seven Indian composts were studied for biocontrol of *Fusarium oxysporum*. Phylogenetic analysis of bacterial 16S rRNA gene and fungal ITS rRNA sequences common in the active composts suggested that high abundance of Actinobacteria correlate with suppressiveness, while fungi grouping phylogenetically close to *F. oxysporum* appear to have the similar effect. Bioactive substances linked to microbial activity were searched for and specific organic acids were identified as candidates for suppressiveness activity. A link between producing organism and substance was as yet not attempted, however.

Taken together the results indicate that certain bacterial and fungal groups, possibly via produced active substances, can suppress *Pythium* and *Phytophtora* –diseases while the abiotic conditions might be less important.





Abstract (IL 1.3)

Trichoderma to support plant growth, but it can do more too

Enrique Monte and Rosa Hermosa

Institute for Agribiotechnology Research (CIALE)
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Trichoderma is a fungal genus that include versatile biocontrol strains which have very good skills against a large number of pathogens in many crops and different parts of the plant under very diverse environmental and edaphic conditions (Lorito *et al.*, 2010). However, compared to other ways of biocontrol, *Trichoderma* application has built the capability of promoting plant growth (Hermosa *et al.*, 2012). The presence of potential fungal preys and plant root-derived nutrients in the rhizosphere helped *Trichoderma* spp. to colonize plant roots, boosting the evolution to endophytism and further positive interactions between *Trichoderma* and plants. *Trichoderma* capacities as indirect biocontrol agents, inducing systemic defense of plants (officially considered a plant protection product trait), or as plant growth promoters (biostimulation) are determined by the host, depending on which capacities the plant wants to tap (Hermosa *et al.*, 2013). In this context, the registration depends on the microbial trait that the manufacturer is targeting, so the current legal regulatory framework does not reflect the range of benefits of *Trichoderma*. Since the role of *Trichoderma* is to regulate plant fitness costs associated with balancing defense and growth, adequate registration procedures based on the scientific understanding are urgently needed. Intensive work has been carried out to decipher how *Trichoderma* interconnects plant development and defense responses, acting on the nodes that regulate the trade-offs needed to achieve a balance between growth and defense, and also how the effect of *Trichoderma* is inherited by the offspring (Medeiros *et al.*, 2017; Morán-Diez *et al.*, 2021).

PARTICIPANT ABSTRACT





Abstract (1.1)

Crc regulates membrane glucose dehydrogenase (mGDH) during succinate mediated catabolite repression in *Acinetobacter* sp. SK2

Shalini Rajkumar* and Krishna Bharwad
Institute of Science, Nirma University, Ahmedabad – 382481, Gujarat, India
Presenting author: shalini.rjk@nirmauni.ac.in*

The use of phosphate solubilizing bacteria (PSBs) for mineral phosphate solubilization (MPS) is a potential eco-friendly approach to improve world food production. Despite their great significance in soil fertility improvement, PSBs have yet to replace chemical fertilizers in agriculture. Availability of various carbon sources in the soil leads to carbon catabolite repression (CCR) which hinders the plant growth promotion activity of applied PSBs. CCR of utilization of various carbon sources in *Pseudomonas* and *Acinetobacter* is regulated by catabolite repression control protein (Crc). This study aimed at investigating the molecular basis of Crc mediated regulation of succinate mediated catabolite repression (SMCR) on MPS. The present work details the repressive effect of succinate on MPS in *Acinetobacter* and how identification and deletion of *crc* lead to derepression of MPS in presence of succinate.The tri-calcium phosphate and rock phosphate solubilizing ability of *Acinetobacter* sp. SK2 was due to secretion of gluconate. In the presence of succinate, the MPS ability was significantly attenuated. This was in correlation with 90% decrease, in the membrane glucose dehydrogenase (mGDH) activity of cells grown in glucose+succinate. Thus, mGDH enzyme, catalyzing the periplasmic glucose oxidation to gluconate, is under catabolite repression by succinate. Gene expression study showed increased expression of *crc* in CCR condition (i.e. glucose+succinate). Hence, the deletion mutants of *crc* was generated to check the effect of absence of Crc on CCR of mGDH and MPS. Increased phosphate solubilization up to 44% in glucose+succinate grown *Δcrc* compared to glucose grown cells, which was totally repressed in wild-type. Derepression of MPS in *Δcrc* when grown in glucose+succinate, signifies its regulatory role in CCR of MPS of *Acinetobacter* sp. SK2. The regulation of the carbohydrate utilization pathway and its consequences needs to be considered prior to application of PSBs in fields. Furthermore, development of SMCR-relieved strains will better serve in field and also help to understand how the phenomena of CCR is regulated.

Keywords: Mineral phosphate solubilization (MPS), mGDH, Crc, Succinate mediated catabolite repression (SMCR)

Abstract (1.2)

Production of ammonia in rhizospheric bacteria isolated from chickpea field

Ragini Mendhe, Pramod W. Ramteke and Dayanand Gogle
Department of Molecular Biology & Genetic Engineering
RTM Nagpur University, Nagpur, Maharashtra, India
Presenting author: rmendhe56@gmail.com

The rhizosphere is the part of the soil ecosystem where plant roots, soil and the soil biota interact with each other. These interaction are often of benefit to plants, improve soil fertility and enhance the degradation of soil contaminants. Extensive use of chemical fertilizers has led to widespread degradation of agricultural soil. Production of ammonia is one of the important attributes in rhizospheric bacterial population that has promise to replace chemical fertilizers. The present study was undertaken to find out production of ammonia among rhizospheric bacteria isolated from chickpea field. Of 164 isolates tested, 122 (74.4%) isolates produced ammonia and 38 (23.1%) were highly ammonia producers. Moderate and low level of ammonia production was noted in 39 (23.7) and 45 (27.4%), respectively. Additionally, around 98% of isolates showed tolerance to wide range of pH 5-9. Further studies are in progress on these bacteria in promotion of different crops under wide range of pH.

Abstract (1.3)

Augmentation of *Triticum du*rum (var.Poshan) by a rhizoshperic yeast

Baishali Roy*, Anand Nighojkar
School of Biotechnology, Devi Ahilya Vishwavidyalaya, Indore*
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Plant growth promoting microorganisms are being utilized as bioinoculants in agriculture since several years. These microorganisms are responsible for enhanced crop productivity and offer a better substitute to harmful chemical fertilizers and supplements. Development of bioinoculants requires the presence of diverse traits that can help its colonization and survival in rhizosphere. This study was aimed to identify and evaluate some potential microorganisms from the rhizosphere of *Triticum durum* (var. Poshan). Initially microorganisms were screened on different media and tested for their specific plant growth promoting traits including production of IAA, ammonia, cellulose and P solubilisation activity.

Two bacteria IS4 and IS5, two fungus IF1 and IF2 and one yeast PY1 were selected according to their PGP attributes for further studies. The effect of yeast PY1on germination and other plant growth parameters was studied in petri dish on paper and soil. The results show augmentation of plant growth parameters, with significant increase in root length and shoot length as compared to untreated seeds of wheat. The fresh and dry weight of root and shoot of treated and untreated plant was also compared. The positive effect on plant growth of yeast can further be studied in consortia with other plant growth promoting microorganisms.

Abstract (1.4)

Plant Growth Enhancing Substances by Solid State Fermentation

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Various agroindustry by-products are generated viz., paddy husk, peanut shell, corn cob, sawdust, bagasse, wheat straw, pressmud, etc. These agroindustry by-products are just burnt or disposed to the landfills. They can be converted into value-added products viz., compost, animal feed, single cell protein, enzymes, etc. by solid state fermentation using plant growth promoting rhizobacteria. The plant growth promoting rhizobacteria produce plant growth substances. The work here describes solid state fermentation using bagasse as a substrate for production of plant growth promoting substances by *Herbaspirillum* sp. viz., indole acetic acid, enzyme - chitinase, iron chelating compounds - siderophores, solubilisation of mineral - potassium, etc. The indole acetic acid production was 20 (µg/ml), the zone of clearance which indicated chitinase and siderophores production was 1.4 and 1.9 cm respectively on 20th day. The potassium solubilisation was also more on 20th day which was 1.1 cm. These plant growth promoting substances can be used for the plant growth. The production of plant growth substances by solid state fermentation using *Herbaspirillum* sp. will be eco-friendly, economical, easy and also help in the management of bagasse by converting into value-added product. Further pot and field experiments to study the effect of plant growth substances on the plant growth need to be carried out.

Keywords: Agriculture, Economical, Eco-friendly, Sustainable, Vermicompost





Abstract (1.5)

Efficacy of native *Rhizobium* isolates on growth and yield of summer groundnut

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Nitrogen is one of the major nutrients required for growth and productivity of groundnut (*Arachis hypogaea*). Groundnut can form N fixing symbiotic association with root nodule bacteria ,*Rhizobium* ; in a process that can fix N for crop. Due to lack of infomation on the diversity of indigenous *Rhizobium* populations of summer groundnut, the study was undertaken to find out efficient isolate, which can enhance groundnut production in eco-friendly manner. In answer to that, groundnut nodule and soil samples were collected from 100 locations from the summer groundnut cultivating area of summer groundnut. Total 138 isolates grew on CRYEMA media were selected showing typical mucilaginous *Rhizobium* type colonies. Selected 5 isolates out of 138 were further characterized for different PGP traits *viz*. *nif* gene detection, P solubilization, siderophore production, different enzyme production etc and out of which, two most efficient isolates with multiple PGP traits were selected. The 16S rDNA sequencing of the two isolates was carried out; both native isolates were conformed as *Rhizobium* with NCBI genebank accession numbers KU836508 & KU836509, respectively. Based on the result from different plant growth promotion trait characterization, isolates C 10 and J 14 were selected for further studies and designated as *Rhizobium huautlense* AAUGNR I & *Rhizobium giardinii* AAUGNR II. Efficacy of two native isolates were assessed through three year consecutive field experiment and it was found that, the set of treatments receiving application of *Rhizobium* isolate GNR II along with FYM (10 t/ha) shown significant effect on different yield and growth attributes of summer groundnut. Highest pod (3,207 kg/ha) and haulm (5,515 kg/ha) yield were recorded in T_5 (10 t/ha FYM + *Rhizobium giardinii* AAUGNR II) and found at par with RDF chemical fertilizer. Thus, the native *Rhizobium* isolates along with quality manure can curtail use of chemical fertilizer.

Keywords: *Rhizobium*, Groundnut, characterization, efficacy

Abstract (1.6)

Phosphate solubilization by a rice endophytic *Pseudomonas* sp.

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Endophytes reside in the intercellular spaces and vascular systems of the host plant, enhance growth of plants by supply of nutrients through phosphate, nitrogen, macro/micronutrient, siderophore, plant growth regulator (e.g. IAA, GA, cytokinin, phenolics) etc. metabolism, control pests or pathogens, trigger host defense mechanisms like induced systemic resistance (ISR), systemic acquired resistance (SAR) etc., degrade xenobiotics etc., which are the rationales of the investigation. Isolation of phosphate solubilizing bacteria from endophytic region of rice cv. Swarna Sub-1. Phenotypic and genotypic characterization of the isolate (E1) *Pseudomonas* sp. Quantitative analysis of P solubilization. PGP functionalities of the organism. Plant growth promotion in laboratory, pot and field conditions. The endophytic isolate of Swarna Sub-1 (SS1) was identified by phenotyping, genotyping and 16S rDNA sequencing. Mineral phosphate solubilizing (MPS) ability of the bacteria *Pseudomonas* sp. E1 was studied on NBRIP broth. Quantitative analysis of P solubilization was undertaken following Olsen *et al*. (1954). PGP activities like siderophore, indole and ammonia production were assessed following Schwyn and Neilands (1987), Bric et al. (1991) and Agbodjato et al. (2015). Role of the bacteria to enhance rice crop production was tested in laboratory, pot and field conditions. *Pseudomonas* sp. E1 solubilized Ca-phosphate (514.26 µg/ml), Zn phosphate, rock phosphates and slag, and also tolerated 6% NaCl. Besides P solubilization (PS), it also produced indole, siderophore (5.3 mg/g dr. wt.) and ammonia which would promote growth of plants. The bacterium mineralized P by acid (40.46 U/ml) and alkaline phosphatase (63.14 U/ml) and organic acid (malic acid, lactic acid, tartaric acid etc.) production. E1 bioprimed plants had enhanced shoot length (20.6%) in the laboratory, and promoted growth and production in pot and field conditions. The isolate would be helpful for maintenance of soil health and nutrition under salt stress conditions and might be used as bioinoculants/biofertilizers.

Keywords: Phosphate solubilization, rice, endophyte, *Pseudomonas* sp.

Abstract (1.7)

Plant growth-promoting rhizobacteria (PGPR): Their potential use of agriculture

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Bacteria that colonize plant roots and promote plant growth are referred to as plant growth-promoting rhizobacteria (PGPR). The PGPR effects can occur via local antagonism to soil-borne pathogens or by induction of systemic resistance against pathogens throughout the entire plant. The rhizomicrobiome is of great importance to agriculture owing to the rich diversity of root exudates and plant cell debris that attract diverse and unique patterns of microbial colonization. Microbes of the rhizomicrobiome play key roles in nutrient acquisition and assimilation, improved soil texture, secreting, and modulating extracellular molecules such as hormones, secondary metabolites, antibiotics, and various signal compounds, all leading to enhancement of plant growth. The microbes and compounds they secrete constitute valuable biostimulants and play pivotal roles in modulating plant stress responses. Inoculating plants with plant-growth promoting rhizobacteria (PGPR) or treating plants with microbe-to-plant signal compounds can be an effective strategy to stimulate crop growth. Furthermore, these strategies can improve crop tolerance for the abiotic stresses (e.g., drought, heat, and salinity) likely to become more frequent as climate change conditions continue to develop. The multifunctional PGPR-based formulations for commercial agriculture, to minimize the use of synthetic fertilizers and agrochemicals.
Keywords: PGPR, Rhizomicrobiome, Agriculture and Uses

Abstract (1.8)

PGPR – Boon to agricultural practices

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Plant growth-promoting rhizobacteria (PGPR) are a group of bacteria that colonize in the plant roots and promote plant growth. They acts as biocontrol agents and their antagonistic features control plant pathogens thereby indirectly promoting plant growth. Rhizobacteria induce resistance via the salicylic acid-dependent SAR pathway (Systemic Acquired Resistance). Genera *Pseudomonas* and *Bacillus* of rhizobacteria are well known for their ability to trigger ISR

(Induced Systemic Resistance) and also for their antagonistic effects. A major threat to crop plants are fungal phytopathogens. Research study revealed various plant diseases are caused by more than 60 fungal phytopathogens, which incur great loss of 30 % crop yield. To control these diseases, different methods of chemotherapy have been employed. PGPR have been found as an eco-friendly, effective and sustainable replacement to the chemical fungicides. There are many eco-friendly approaches which reduce plant diseases with low cost. One of them is using PGPR strains that acts as an efficient nematode biocontrol. Rhizomicrobiome microbes play important roles in nutrient assimilation and acquisition, improving soil texture modulating extracellular molecules such as hormones, secondary metabolites etc. This review article also focuses on antifungal traits such as lytic enzymes, siderophores, hydrogen cyanide and antibiotics of PGPR beside biotechnological attributes of PGPR on disease resistance, and iron nutrition. In 21st century agriculture, PGPR-based technology is used as a roadmap for agricultural practices.

Keywords: antagonism, siderophore, SAR, ISR, phytopathogens

Abstract (1.9)

Exploring siderophore producing microbes from mangroves

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Iron is an essential element for the growth of almost all living organisms including plants and animals. In response to this condition, most microorganisms have evolved adaptive mechanisms that can solubilize iron. One such strategy is the production of Siderophore. Siderophores are small molecules that can easily bind to ferric iron. As a chelating agent they transport iron molecules inside the bacterial cell. Siderophores have been classified as hydroxamate, carboxylate, catecholate and mixed type. In this study, bacteria, fungi and actinomycetes were isolated from different sample of Mangrove trees and Pneumatophore of mangrove and were characterized by quantitative and qualitative tests. Siderophore production was detected & quantified using Chrome Azurol Sulphonate (CAS) assay while the siderophore characterization was through $FeCl_3$ (Iron perchlorate test), Tetrazolium, Csaky, Arnow s and Chemical tests. The presence of siderophore in liquor content was detected by quantitative assay. Influence of different environmental factors such as pH, Temperature, Carbon source, Nitrogen source, Organic acid and Salt concentration on siderophore were studied. Isolates were examined on specific production medium, extracted by ethyl acetate, diethyl ether and chloroform. The extracted siderophore exhibited antimicrobial activity against bacterial and fungal isolates.

Abstract (1.10)

Finger millet (*Eleusine Coracana*) endophytic bacteria influencing host plant growth and metals solubilization

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Objective of the present study was to isolate and screen the zinc and iron solubilizing endophytic bacterial isolates from finger millet (*Eleusine coracana*) varieties and also to analyze their plant growth promoting effect on finger millet and Zinc/Iron uptake. Finger millet is a staple crop of the Uttarakhand and southern states of India and have high nutritional value. The roots and shoots of finger millet plants are the houses for endophytic bacteria, which positively promotes the plant growth either by direct or indirect mechanisms without causing any harmful effect on the host plant such as phosphate solubilization, ammonia excretion and production of phytohormones (IAA), several microbial metabolites, siderophores etc. Several endophytic bacterial strains were isolated from roots and shoots of the following cultivars of the finger millet -PRM-1, VL-348, VL-352. These bacterial strains were purified and identified on the basis of biochemical tests. Based on the biochemical characterization most of the endophytic isolates belonged to the genus *Bacillus* and *Pseudomonas* sp. Selected isolates were also screened for Zn and Fe solubilization. The plant growth enhancing potential metal solubilization features of endophytes showed that the selected bacterial isolates can be employed as bioinoculants for finger millet crop which will help in up taking more nutrients and result in higher plant growth and yield.

Keywords: Finger millet, endophytes, plant growth, metal solubilization

Abstract (1.11)

Efficacy of Plant Growth Promoting Rhizobacteria as a Bioinoculant for Vegetable (Tomato)

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It is a well known fact that in India 70% of the population is directly or indirectly involved in agriculture and allied activities. Since independence agriculture has got a status of primary sector but always treated by all the government as a secondary sector or even below that. Bio-fertilizers are microbial inoculants consisting of living cells of microorganisms like bacteria, algae and fungi alone or in combination which may help in increasing the crop productivity, stimulating

plant growth or in decomposition of plant residues. Tomato seeds of two varieties are inoculated with PGPR in 4 sets and 1 set as control for each variety. Control plant is with no bacterial treatment. All such control and experimental sets are sown in seed bed in proper way. At 33 days after seedling transplantation there was substantial difference in shoot height which were clearly visible due to inoculation of PGPR in experimental sets. Seeds treated with PGPR promotes early plant growth. The study concluded that the plant growth promoting rhizobium (PGPR) has shown positive effect on entire plant body. A visible effect on growth and cluster has been observed. The plant has shown substantial improvement at first picking time. The fruit of PGPR plants are high in weight nearly 8% to 15% as compared to control. The fruit has a good shine and colour and has also shown very good toughness for transportation and durability. The use of PGPR as bio-inoculants is definitely having remarkable effect on increase in revenue to farmers which ultimately leads to benefit of farming community and thereby boosting our national income.

Keywords: PGPR, Microbial inoculants, Tomato, and Quality Improvement

Abstract (1.12)

Plant Growth promotion by Siderophore producing *Achromobacter Xylosoxidans*

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Iron is involved in such important biological processes as reproduction, photosynthesis, N2 fixation, methanogenesis, H_2 production and consumption, respiration, gene regulation, DNA biosynthesis and repair and detoxification of free radicals. Iron is abundant in the earth s crust, but is poorly bioavailable due to its low solubility in aerobic environments at neutral pH. Siderophores are low molecular weight chelators, with a very high and specific affinity for Fe (III), typically greater than Ksp = 1030. Over 500 different siderophores have been identified and are produced by various organisms ranging from microbes to plants. Most siderophores are approximately 600 Da in size, but have been observed as small as 200 Da and as large as 2000 Da.

This study aims to screening and procurement of siderophore producers from soil & aquatic ecosystems by primary and secondary screening methods. Optimization of siderophore production using Plackett Burman design method. Characterization studies of siderophore produced using HPTLC, FTIR and Mass spectroscopy. Assessing the plant growth promoting ability of siderophore producing *Achromobacter xylosoxidans.* 36 isolates were obtained from screening of 18 different samples ranging from Rhizospheric soil, Terrestrial Soil and Aquatic niches. 10 isolates were selected on their ability to produce siderophore in a range of 40- 70% SU yield. The chemical characterization of CW2 isolate produced siderophore can be summarized to contain hydroxamate as well as catecholate siderophore .Further the statistical method of Plackett Burman worked to be an powerful tool for optimization of siderophore from CW2 raising the yield to 1.2grams /L and yielding an 90% increase as compared to its original yield . Isolates CW2 was identified as *Achromobacter xylosoxidans* by conevntional biochemical & molecular methods. *Achromobacter xylosoxidans* based bio-fertilizer and bio-fungicide was effective as it was capable of not only enhancing the plant growth but also the quality of the fruit was free from infestations and contains high nutritional content of iron finding applications in herbal medicinal preparations.

Keywords: Siderophores, *Achromobacter Xylosoxidans*, Plackett Burman Method, Enchanced Plant Growth

Abstract (1.13)

Pseudomonas monteilli (MN759447), a promising siderophore producer from *Dalbergia sissoo* Roxb. forest ecosystem

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Dalbergia sissoo Roxb. (family Fabaceae) is a large deciduous multipurpose timber tree. This high value cash tree is facing heavy mortality rate in its natural as well as plantation forests, induced by poor soil fertility. Iron scarcity in *Dalbergia sissoo* Roxb. leads to IDIC (Iron deficiency induced chlorosis) which makes it more susceptible to fungal pathogens and lepidopteron attack. Since *Dalbergia sissoo* Roxb. provides valuable timber as well as enriches soil nitrogen, its large scale decline incurs huge economic loss. Several rhizosphere dwelling bacteria secrete ferric iron chelating agents, siderophores under iron deficient conditions. The siderophore positive bacteria are significant as plant growth promotion and bio-control agents.

Siderophore production in twenty shishamtree rhizosphereic bacteria was assayed qualitatively and quantitatively via CAS assays. Out of twenty isolates, ten were siderophore positive and identified as *Pseudomonas, Streptomyces* and *Burkholderia*. Amongst 10 sid positive strains, one strain *Pseudomonas monteilli* (MN759447) produced upto 80.36% SU. Further characterization and two stage optimization (single factor optimization and response surface methodology) studies revealed that *Pseudomonas monteilli* is a promising siderophore producer. as The major siderophores produced by *Pseudomonas monteilli* were identified as derivatives of Pseudomonine and salicyclic acid through FTIR and LC-MS studies . In an *invitro* dual culture assay, *Pseudomonas monteilli showed more than 40% anatagonistic activity* against four fungus isolated from shisham rhizopshere *Aspergillus caliodoustus, Talaromyces verruculos, Fusarium oxysporum* and *Talaromyces pinophilus*. To our knowledge this is the first report on isolation, identification and characterization of siderophore producing bacteria from *Dalbergia sissooRoxb* forest eco-system. Since application of siderophore producing bacteria as bio-inoculant is of immense importance in both field crop as well as tree based ecosystem. This strain *Pseudomonas monteilli* can be developed as commercial bio-inoculant.

Abstract (1.14)

In vitro, seed germination and plant growth promoting applications of pigment produced by _Rhodococcus kroppenstedtii_

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The worldwide increase in population increases the demands of food production. But environmental damage causes problems in agriculture and depletion of food. Plant Growth-Promoting Rhizobacteria (PGPR) include a highly diverse variety of soil bacteria, which when grown in association with a host plant, results in stimulation of growth of the host plant due to increased mobility, uptake, and enrichment of nutrients in the plant. Thus PGPR has many beneficial effects on the soil environment. *Rhodococcus kroppenstedtii* is one of the novel organism isolated from the soil sample collected from soyabean field, produces red pigment. The pigment extracted from isolate was found to enhance the germination of wheat (*Triticum aestivum*), and mung (*Vigna radiata*) seeds and hence enhances the growth of plant. The objective of the present study was to check the effect of pigment extracted from *Rhodococcus* on the seed germination and plant growth promotion abilities of different selected seeds.

The experimental data obtained indicated that germination of mung and wheat seeds were observed in seeds coated with concentrated pigment; growth was greatly enhanced with better germination in experimental test as compared to control seeds. Similarly, increase in the morphological properties-root length and shoot length of plants were observable in the pots containing seeds coated with the pigment as compared to untreated seeds which served as control. This data clearly indicated that pigment enhanced germination efficiency and growth in plants. *Rhodococcus kropenstedtii* is one of the plant growth promoting rhizobacteria was found to produced red pigment having potential seed germination and plant growth promotion activities.

Keywords: PGPR, *Rhodococcus kroppenstedtii*, Seed germination, Plant growth promotion

Abstract (1.15)

Optimization of phosphate solubilization efficiency of *Talaromyces trachyspermus* by Plackett-Burman and Response Surface Methodology

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Phosphorus is one of the essential components needed for the metabolic activities and for the growth of any plant. Phosphate solubilization by plant growth promoting microorganisms is the important factor for development of sustainable agriculture system. *Talaromyces trachyspermus,* fungal endophyte, isolated from *Withania somnifera* medicinal plant, showed extensive solubilization of Tri-calcium phosphate in NBRIP medium. It was observed that the solubilization was due to drop in pH. Acidification was due to production of organic acids by the fungi. The effect of different medium components on the solubilization of phosphate was determined using the Packett-Burman design. It was observed that glucose and sodium nitrate had significant effect on phosphate solubilization. Considering the Plackett-Burman results, the response surface methodology was used for optimization of these medium components along with tri-calcium phosphate on P-solublization. The analysis from RSM revealed that the optimum values for the tested variables were 1.5% glucose, 0.005% sodium nitrate and 1% tricalcium phosphate. Phosphate solubilization of 295 µg/ml was observed as comparison to original level of 157µg/ml, which was a 1.87 fold increase. High Resolution Orbitrap Liquid Chromatography Mass Spectrometer analysis it was observed that citric acid and lactic acid, gallic acid and palmitic acid were the major acids found to be responsible for enhancing the P solubilization.

Keywords: Phosphate solubilization, Plackett-Burman, Response Surface Methodology, Organic acids, *Talaromyces trachyspermus*





Abstract (1.16)

Evaluation of Rhizosphere fungi from medicinally important plants showing plant growth promoting traits

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Medicinal plants have been used extensively in complementary medicines for disease prevention and treatments. The demand for these medicines has been increasing in recent times which lead to the overexploitation of medicinal plants for their bioactive compound. Thus to conserve endangered medicinal plant and to enhance productivity and quality of medicinal plant novel strategies for conservation has to be applied. A large variety of fungi is recognized in the rhizosphere soil of medicinal plants that showed significant effect in secondary metabolite alteration and uptake of plant nutrirents. Inoculation with microbes may enhance the growth of medicinal plants, nutrient uptake, and the content of medicinal compounds. However, the diversity, function and applications of microbes to medicinal plants have received little attention so far. To investigate rhizosphere fungal diversity of medicinal plants namely *Butea monosperma, Tinospora cordifolia, Gmelina arborea, Celosia argentea* showing PGP trait. The results indicated the presence of 45 fungal communities. Among fungal phyla Ascomycota, Zygomycota and Deuteromycota were abundantly associated within rhizospheres of all plants. In the present study isolates of medicinal plant rhizosphere of University campus possess various plant growth-promoting (PGP) properties that are IAA, siderophore production, phosphate solubilization, thus may provide multifaceted beneficial effects on plant growth and health. From this study it is clear that rhizospheric soil possess diverse group of fungi. With the arrival of molecular and "omics" tools, a far better understanding of the plant-microbe association might be acquired which could play an important role in drafting the future "biofertilizers" for medicinal plants.

Keywords: Rhizosphere, plant growth-promoting, medicinal plants, siderophore, phosphate solubilization

Abstract (1.17)

Characterisation of plant growth promoting bacteria isolated from volcanic soil

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Many bacteria which are present in soil exhibit the properties of plant growth promotion but the problem lies when these properties are inadequate for plants during a stress environment. This potential problem has led researchers to extend their horizons into extreme environments for the search of potential soil bacteria that possess multiple plant beneficial traits as well as abiotic stress tolerance abilities. The current study inculcates this particular objective of assessing bacteria isolated from soil of extreme environment in this case volcano soils. The screening of these isolated bacteria was done on the basis of plant growth promoting traits and also the ability to mitigate stress. Total of eight isolates namely NBRISH4, NBRISH6, NBRISH10, NBRISH11, NBRISH13, NBRISH14, NBRISH16 and NBRISH26 were screened out. These potent eight isolates were able to withstand various stresses like temperature (up to 45 _C), drought (up to 60% Poly Ethylene Glycol 6000) and salt (up to 2 M NaCl) all performed under in vitro conditions. The isolates were further screened in vitro for their survival rate through colony count method and for plan growth promoting attributes such as IAA production, phosphate solubilisation, biofilm formation, alginate and exopoly-saccharide production abilities under different stress such as temperature, drought and salt which are broadly categorised under the term abiotic stress. These screenings of potent isolates when further applied to seed treatment of maize plants (in vivo) depicted a significant enhancement in the root and shoots length and also in the traits like fresh, dry weight and number of leaves per plant. Furthermore, the potential eight isolates were identified on the basis of partial 16S rRNA gene sequences. Among all the isolates, finally it was concluded that NBRISH6 identified as *Ochrabactrum* sp. was most potent towards mitigating abiotc stress tolerance and PGPR attributes.

Keywords: Plant growth promotion; Abiotic Stress; Volcanic Soil; *Ochrabactrum* sp.

Abstract (1.18)

Screening of phosphate solubilizing microorganisms from diverse soil samples: A promising approach as biofertilizers

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Phosphorous (P), an essential nutrient element is the second most important element after nitrogen. It is unavailable to plants because in the soil it is mostly present in the fixed form. The presence of phosphate microorganisms increases the crop productivity as phosphorus is one of the essential nutrient for crops. Phosphate solubilising microbes are used as biofertilizers for their capacity to solubilize fixed phosphate in soil and make it available to plants. In the present work diverse soil samples, *viz*. agricultural soil, garden soil, forest soil, were collected from rhizospheric regions of plants and subjected to the study for screening of phosphate solubilizers. The screening of phosphate solubilizing microbes was carried out by enrichment culture technique followed by isolation on Pikovskaya s agar medium and modified Pikovskaya s agar medium containing bromophenol blue. The phosphate solubilising microbes were screened by plate assay method for their tendency to produce yellow zone/halo of phosphate solubilisation on modified Pikovskaya s agar medium. The relative efficiency of isolated strains was carried out by selecting the microorganisms which are capable of producing a halo/clear zone on plates due to the production of organic acids into the surrounding medium and their Phospahte Solubilizing Efficiency (PSE) was determined. Several phosphate solubilizing bacteria, including actinomycetes and fungi were isolated and characterized. The morphological, cultural and biochemical characteristics of bacteria were used for identification of isolates using Bergey s Manual of Systematic Bacteriology, while fungal identification was based on the study of colony characteristics and microscopic features. From the 34 isolates screened, isolate designate P1 was found to show good phosphate solubilising activity on Pikovskaya s agar medium.

Most of the isolated phosphate solubilizing microorganisms were species of the genera of *Bacillus*, *Pseudomonas, Streptomyces*, *Aspergillus*, *Penicillium* and *Trichoderma* . The unidentified yeast P1 showed remarkable phosphate solubilising capacity. The present work is an attempt to explore species which are responsible to solve the problem of soil fertility.

Keywords: Screening, Phosphate Solubilizing Microorganisms, Pikovskaya's medium.

Abstract (1.19)

In vitro studies on the effect of chitinolytic bacterial consortium on plant growth promotion in groundnut by roll towel method

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Nutritionally groundnut is valued for the high-quality edible oil, easily digestible proteins, and it s a good source of vitamin E, K and B, with considerable amount of important mineral elements such as phosphorus, potassium, and calcium. Hence the present *in vitro* studies were conducted to evaluate the plant growth promoting ability apart from the biocontrol potential of chitinolytic bacterial consortium on groundnut by roll towel method. The chitinolytic bacteria which were capable of producing chitinase enzymes *viz., Bacillus subtilis*, *Bacillus licheniformis*, and *Pseudomonas fluroscens* were isolated from the rhizosphere soils of groundnut crop. The culture filtrates of none of the chitinolytic bacteria showed any inhibitory effect on the germination of groundnut seeds and in general all the treatments induced the plant growth promotion *viz.,* shoot and root length significantly over untreated check as revealed by the data. Among the chitinolytic bacteria-based biocontrol agents tested individually and in combination, the combination of culture filtrate of Treatment, T_9 - *B. subtilis* (*Bs*$_1$) + *B. licheniformis* (*Bl*$_3$) + *P. fluorescens* (*Pf*$_4$) @ 10 ml/Kg of seed recorded the maximum germination per cent of 96.67 per cent, the same treatment increased the shoot and root length to the maximum with 8.03 and 9.67 cm, respectively and recorded a vigour index of 1711.76. This was followed by dual inoculation treatment, T_8 recorded numerically superior values with 93.33 per cent germination and 7.60 and 9.07 cm shoot and root length, respectively and a vigour index of 1556, which was on par with the treatment, T_2 - Carbendazim 50%WP as seed treatment @ 4g/Kg of seed. Hence it is concluded that the consortium of chitinolytic bacteria without chemical fertilizers as demonstrated in this study improve plant growth promotion, better nutrient uptakes and enhanced the crop yield was observed.

Keywords: Chitinolytic Bacterial Consortium, Plant growth promotion

Abstract (1.20)

Isolation and characterisation of feather degrading microrganism(s) from khandesh region

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This present investigation is intended to isolate and characterize feather degrading microorganism from soils of Khandesh region. Proteolytic enzymes which hydrolyze insoluble keratins more efficiently than other proteases are called keratinases produced keratinolytic bacteria. Keratinase producing microorganisms have the important industrial applications in fermentation technology. These protein byproducts may be used as animal and livestock feed, and as leather filling agents. Keratinase can be used for preparation of vaccine for Dermatophytosis, for pharmaceutical enhancement of the nail treatment.They are also useful for the degradation of prion and prion like proteins.Microorganisms that were isolated and tested for their capability to grow on feather meal agar (FMA). Influence of various parameters on enzyme activity of the organisms was investigated. pH 7 was optimum for maximal enzyme activity than pH5and pH 9. The optimum temperature for enzyme activity was 37^0 C. The effects of metal ions Zinc, $CaCl_2$ and $MgCl_2$ were found to be the activators and $HgCl_2$ was the inhibitor for the enzyme.

Key words: keratinase, enzyme activity, fermentation, proteolytic

Abstract (1.21)

Isolation of plant growth promoting bacteria from fermented panchagavya and their effect on *Vigna radiata*

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Panchagavya mentioned in ancient Indian scripts, is a mixture of five cow products viz. cow dung, urine, milk, curd and ghee containing many beneficial microorganisms. Two selected bacterial isolates (RK-1 and RK-7) from the fermented panchagavya were studied for gibberellic acid (GA) and phosphorus (P) solubilization. Initially, RK-1 produced 0.81 mg/mL GA and was

increased to 5.70 mg/mL after media optimization. RK-7 was able to solubilize considerable amount of tricalcium phosphate (213.36 µg/mL). The effect of RK-1, RK-7 pure cultures and mixed culture (RK-1 plus RK-7) on *Vigna radiata* was studied in pots.

The application of pure as well as mixed culture showed the considerable positive effect on the growth of *Vigna radiata*. The mixed culture increased about 2.07, 2.16, 1.50, 7.50, 2.50, 2.72 times fresh weight, dry weight, shoot length, root hair numbers, leaf numbers and leaf area respectively on 20th day. The bacterial isolates (RK-1, RK-7) of fermented panchagavya have a potential to be used as biofertilizer.

Keywords: Bacteria, Biofertilizer, Fermented panchagavya, *Vigna radiata*

Abstract (1.22)

Study of microbial population in okra rhizosphere soil as affected by bioinoculant

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An experiment was carried out involving *Azotobacter* and PSB inoculation with the objective to assess the inoculation effect on germination percentage of okra and microbial population in okra rhizosphere. The study involved characterization of *Azotobacter* and PSB isolates, where *Azotobacter* isolate in Jensen s medium produced white translucent, nearly round, convex and gummy colonies while PSB isolated on Pikovskaya′s agar media produced creamy to yellowish round with entire margin and, showing clear zone surrounding the colony growth. Both the isolates showed positive reaction for starch hydrolysis, catalase test. TSI test showed glucose, lactose and sucrose fermentation occurred with *Azotobacter* whereas in PSB no fermentation was seen. The results revealed that the application of *Azotobacter* and PSB along with vermicompost and 75 % NPK produced highest germination percentage and microbial population in okra rhizosphere soil. The results of germination clearly showed that significantly highest germination (96.87%) was recorded in treatment T_5 (75% NPK+Vermicompost+*Azotobacter*+PSB) and was remained at par with all other treatments except treatment T_1 (control, 100% NPK, inorganic) which recorded lowest germination (85.73%). The *Azotobacter* population per g of soil was significantly maximum recorded $48.54x10^4$ was found in T_5 (75% NPK+Vermicompost+*Azotobacter*+PSB).The minimum *Azotobacter* population $18.41x10^4$ was found in T_1 (100% NPK). The PSB population was significantly maximum recorded $21.14x10^4$ was found in T_5 (75% NPK+Vermicompost+*Azotobacter*+PSB). The minimum PSB population 6.14×10^4 was found in T_1 (100% NPK). From the present investigation and with the cost-effective point of view it can be inferred that an application of 75% NPK + vermicompost + *Azotobacter* + PSB observed to be beneficial in enhancing vegetative growth and microbial population of okra.

Keywords: Okra, *Azotobacter* and PSB





Abstract (1.23)

Mining Barnyard millet rhizospheric microorganisms for functional plant health promoting traits

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Barnyard millet *(Echinochloa spp.*) is one of the most under-researched crops grown in the submontane Himalayan region where this crop occupies a special place as food and fodder. In the present study, rhizospheric soil of barnyard millet was collected from four different districts of Uttarakhand namely, Chamoli, Pauri, Pithoragarh and Almora. Enumeration of microbial population was done on five different media (Pikovaskaya, Nutrient agar, Potato Dextrose Rose Bengal agar, king s B, Actinomycetes agar). Four out of 176 isolates were selected on the basis of growth ihnhibition of three fungal pathogens. Four bacterial isolates namely, AA17, AA12, MA13, and MN8 were further screened for biochemical properties including amylase, siderophore, chitin hydrolysis, xyalanase, ammonia production etc. All the isolates were positive for one or other properties. Effect of individual isolates and consortium was analyzed on germination and growth promotion in tomato. Significant effect was observed in consortium in comparison to individual bacterial isolates and control. Thus barnyard millet can be a potential source of plant growth ptromoting bacteria which can be used as a bioinoculant for economically important crops.

Keywords: Bioinoculants, Plant growth promoting rhizobacteria, Barnyard millet

Abstract (1.24)

Inoculation of phosphate solubilizing bacteria promotes vigor in two different wheat genotypes by stimulating soil enzyme activity

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In present study 18 phosphate solubilizing bacteria (PSB) from *Dalbergia sissoo* Roxb. forest soil were examined for their soil health and plant vigor parameters. To evaluate this two superior wheat genotypes e.g. UP 262 and PBW 502 were chosen. Post inoculation three soil enzyme activities viz., Fluroscein di acetate hydrolysis (FDA), alkaline phosphate (AP) and urease were monitored. Comprehensive statistical analysis that includes two way ANNOVA (Analysis of Variance) by R-software, correlation analysis between enzymatic parameters and soil enzyme and individual treatment analysis by SPSS software revealed that upon inoculation of 18 PSB there was a positive impact on soil enzyme activity which in turn promotes various plant vigor parameters in both wheat genotypes. In FDA, response of majority of PSB were positive but maximum response was seen in bacteria L3 and P2 e.g. 333002 and 334002 nmol gm^{-1} respectively which was significantly higher as compared to uninoculated control (28791 $nmol^{-1}gm^{-1}$). Similar trend was found in other two soil enzyme activities and these results were further verified by *invitro* phosphorous quantification in NBRIP medium. All 18 PSBs showed positive response on plant vigor parameters of both wheat genotypes. Positive correlation analysis (r=+0.8) between soil enzymes and plant vigor clearly indicates that there is a direct influence of soil enzyme activity on wheat vigor.

Keywords: PSB, Genotypes, R-software, Soil enzymes

Abstract (1.25)

Characterization of rhizosphere borne potash releasing bacteria and their reflections in quality and yield of banana cv. Rasthali

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A sizable quantity of inorganics that are added to the soil gets complexed with the ions and are temporarily unavailable to plants leading to accumulation of excess chemicals that affects soil quality, microbial community, eco-balance of environment. The phenomenon of fixing of plant nutrients is significant in huge nutrient demanding crops like banana. This issue could be resolved with the application of plant growth promoting microbes that could transform the nutrients from unavailable form to plant available form. This work focussed on potash releasing bacteria, since banana demands huge quantity of potassium from the soil for its normal growth and development. To characterize and identify potash releasing bacteria from banana rhizosphere and its reflections on quality and yield of banana under reduced fertilizer level. Isolated potash releasing bacteria from banana rhizosphere by plating techniques using Aleksandrov medium and characterized based on 16S r DNA gene sequence. The reflection of these potash releasers on quality and yield of banana was done with field experiment. Yield attributing parameters *viz*., days for shooting, days to harvest after shooting, number of hands per bunch, number of fingers per hand, weight of fruits and weight of bunches; Quality parameters *viz*., pulp weight, length and girth of fruits, peel weight, pulp to peel ratio and TSS in pulp were recorded using standard protocols. The potash releasing bacterial isolates, KRB KKM1 and KRB KKM 2 were identified as *Rhizobium pusense* and *Stenotrophomonas maltophila* respectively. Both the isolates were positive for IAA and siderophore production. The isolate KRB KKM1 was able to release 100.42 mgL^{-1} inorganic potassium on 16 days after incubation and that of KRB KKM 2 it was 129.35 mgL^{-1}. Mean number of hands per bunch (10.33), number of fingers per hand (14.22), fruit weight (89.46g) and subsequently the yield of 30.46 t ha^{-1} was higher in plants that received 75% of recommended NPK (110:35:330g NPK/plant)+5 g *Azospirillum*+5g phosphorus solubilizer + 2 ml potash releasing bacteria (1ml each of KRB KKM 1&2 holding 10^{10} cells ml^{-1}) per pit at the time of planting and on 5th month of planting. A higher content of 479.45 mg $100g^{-1}$ of fruit pulp compared to control revealed the influence on potash releasers on quality of banana. Field experimentation with banana Cv.Rasthali in red lateritic soil revealed the significant influence of the Potash Releasing Bacteria on yield and yield attributing parameters of banana. With the present study, it is concluded that the potash releasing bacterial combination, *Rhizobium pusense* KRBKKM1 and *Stenotrophomonas maltophila* KRBKKM 2 along with *Azospirillum*, phosphobacteria and 75% RDF could be recommended as biofertilizer for banana.





Abstract (1.26)

Investigating the applicability of selected plant growth promoting microbes in pesticide bioremediation by *in silico* characterization, modelling, and docking

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Unrestricted and excessive pesticide use in agriculture has extremely negative effects on the environment along with being toxic to different organisms. It has been demonstrated that some microorganisms degrade pesticides due to the presence of pesticide hydrolyzing enzymes. Such microbes can be used to decontaminate pesticides effectively and economically. Before onsite bioremediation, *in silico* studies can identify the potential microbes that can degrade a specific pesticide. This study aims at identifying and comparing the pesticide-degrading potential of some selected plant growth promoting microorganisms using *in silico* approach. *Trichoderma* and *Pseudomonas* are selected as representative plant growth fungi and bacteria, respectively.

The presence of key enzymes involved in OPP degradation such as *alkaline phosphatases*, *carboxyesterases*, *OP hydrolases* (PTE/PON1/SsoPox), *and monooxygenases* was evaluated in *Trichoderma harzianum*. Among all the OP hydrolases only PON1 types of hydrolases TAPON1were found in *Trichoderma harzianum*. Pfam domain searches of TAPON1-like enzymes in *Trichoderma harzianum* revealed an *aryl esterase* domain that is reported to be involved in organophosphate degradation. Multiple alignment and phylogenetic analysis of various OP hydrolyzing enzymes disclosed their diverse sequences. TAPON1like protein found in *T. atroviride* and *T. harzianum* showed more than 65.23 percent identity. TAPON like protein in *T. harzianum showed* peripheral likelihood.

Homology modeling of protein three-dimensional structures was done by MODELER 10.1, model with lowest DOPE score (-39229.25) was selected for docking studies. Modeled proteins have been docked with 20 hazardous organophosphate pesticides showed binding of monocrotophos at its active site at serine 424. Monocrotophos docked to the hypothetical protein with a reasonable score of -2.4. Comparative studies of the structure of pesticide hydrolyzing enzymes from fungus and bacteria showed discernible differences.

Key words: Molecular modeling, Docking, Pesticides, Pesticide hydrolyzing enzymes, Plant growth promoting microorganisms, Bioremediation

Abstract (1.27)

Assessment of plant growth promoting and bio-control abilities of diazotrophic group of rhizobacteria through physiological and biochemical studies

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Presenting author: Sonam Shaheen

Plant productivity rely on nutrients supplements in agriculture fields. In agriculture soil water and fixed nitrogen are most common limiting factor which affects the plant growth and its productivity. It require successful management of assets and improving the soil fertility while maintain the natural resources. Use of Plant Growth Promoting Rhizobacteria can play an important role toward achieving the objectives of sustainable agriculture. Diazotrops group of bacteria are known for their nitrogen fixing ability but lesser explored growth promotion attribute along with abiotic and biotic stress tolerance in the agriculture system with this scope we have isolated diazotrophs group from the agriculture fields and they were named as PGPM 6-10. Based on biochemical test these isolates were found to belonging of diazotrophs groups and further we have identified by 16S rRNA gene sequence analysis. For plant growth promotion traits, we have screened indole acetic acid production, gibberellic acid production, phosphate solubilisation activity and for bio-control activity we have attempted to see the production of ammonia, bio-film formation and lytic enzymes secretion like lipase and protease. All isolates were positive for these tests, but higher activities were shown by PGPM9. Based on 16S rRNA gene analysis PGPM9 was found as *Brevibacillus* spp. Bangel method used to attain antagonistic activity and results were obtained in % growth inhibition of pathogen. PGPM9 was effectively supressing three major root pathogens: *Macrophomina phaseolina* (↓53%) followed by *Sclerotium rolfsii* (↓36%) and *Fusarium oxysporum* (↓21%). PGPM 9 showed maximum tolerance against salt 50mM to 1000mM. LD50 and MIC value were calculated as tolerance towards pesticides with monocrotophos and dimethoate. For dimethoate. *Brevibecillus* spp. (PGPM9) showed 110ppm LD50 (MIC190ppm). Plant bio-assay was also done with bajra root length and shoot lengths were showed higher length as compared to control with PGPM9. These strains have the promote plant growth and suppress plant disease and able to tolerate different complex element which affect the growth of bacterial spices as well as plant productivity. The study suggested that the *Brevibecillus spp.* has PGP activity was having with different characteristic to survive under different stress condition and promote plant growth *in vivo*.

Key words: Plant Growth Promoting Rhizobacteria, *Brevibacillus* spp., monocrotophos and dimethoate

Abstract (1.28)

Role of rhizospheric pseudomonad BSP9 and its biosurfactant as a green approach to increase yield of *Brassica juncea*

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Agricultural productivity is a worldwide concern and in the race of enhancing crop productivity, humans are adversely impacting the environment by applying high amounts of agro-chemicals. To obviate this problem, sustainable agronomic methods like use of plant growth promoting rhizobacteria (PGPR) and their metabolites in form of bioinoculants is the best possible substitute. In the present study, novel bioformulations were developed using a rhizospheric pseudomonad BSP9 and its biosurfactant to check their impact on various growth promoting attributes of *Brassica juncea.* Biosurfactant producing strain BSP9 was isolated from rhizosphere of *B. juncea* and was checked for its plant growth promoting (PGP) properties. Further, biosurfactant was produced, extracted and purified and its structural characterization (FTIR and LC-MS) was carried out. Talc based bioformulations were developed using BSP9 and was amended with biosurfactant in various concentrations. Field trials were conducted using *B. juncea* as test crop and plant growth parameters were calculated. Biosurfactant producing strain BSP9 showed potent PGP attributes. A semi purified dark brown coloured residue (2.5 g/L) obtained after extraction was purified through TLC that showed two spots (retention factor Rf= 0.44 and Rf= 0.75) both having mobility similar to glycolipids. Structural characterization of the biosurfactant through FTIR also suggested the presence of functional groups typically belonging to glycolipids. Similarly, LC-MS analysis showed characteristic rhamnolipidic moieties (a type of glycolipid) in the extracted biosurfactant including different homologues of mono-rhamnolipid congeners and a di-rhamnose congener. Field trials showed substantial increase in all growth parameters of *B. juncea* plants treated with prepared bioformulations with reference to control. From the study, it can be concluded that use of BSP9 and its rhamnolipid biosurfactant is a novel technique for enhancing productivity of *B. juncea.* Owing to its multiple PGP properties, biosurfactant producing ability and non-pathogenic nature, it can serve as an eco-friendly and sustainable approach to increase crop productivity and minimize our dependence on agro-chemicals.

Keywords: PGPR, biosurfactant, bioformulations, *B. juncea*, agricultural sustainability

Abstract (1.29)

Conjoint effect of organic matter and biofertilizers with nitrogen fertilization on growth and productivity parameters of okra (*Abelmoschus esculentus*) in relation to physico-chemical and biological properties of soil

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A field study was carried out to evaluate the conjoint effects of organic matters such as neem seed cake and biofertilizers like *Azospirillum brasilense* and *Glomus fasciculatum* singly as well as concomitantly along with the various recommended doses of inorganic nitrogen fertilizer on the growth and productivity parameters of okra in relation to physico-chemical as well as biological properties of soil. Significant improvement was observed in growth and yield attributes such as height as well as weight of plant, photosynthetic leaf area, number of flowers per plant, ascorbic acid content and chlorophyll content of okra in different treatments as compared to untreated control plants which seems to be due to the presence of growth promoting substances present in neem seed cake as well as in *A. brasilense* and *G. fasciculatum*. Concomitant inoculations of neem seed cake and biofertilizers along with different recommended doses of inorganic nitrogen significantly influenced the physico-chemical properties in terms of bulk density, electrical conductivity, water holding capacity and organic carbon as well as soil biological properties. Soil applications with neem seed cake significantly increased the population of beneficial microorganisms in all the treatments which seems to be due to conversion of organically form of nitrogen into inorganic form. Agronomic parameters such as plant nitrogen, phosphate and potassium and available soil nitrogen, phosphate and potash increased significantly due to combined applications of organic matter and biofertilizers. Individual effect of *A. brasilense* was found more prominent than *G. fasciculatum*. This study suggest that the soil amendment of organic matter and biofertilizers are not only to provide necessary macro-and micronutrients but also to supplement growth promoting substances that sustain soil fertility in this field without altering the natural population of various beneficial microorganisms. Such type of organic farming is better, economic and sustainable and also provides the best alternatives to hazardous agrochemicals.

Keywords: Neem seed cakes, *Azospirillum brasilense*, *Glomus fasciculatum*, okra, growth promoters





THEME - II





PGPR and other Microbes that Confer Disease Control

Chairperson :-

Dr. D.J. Bagyaraj

Convener :-

Dr.Udai B.Singh

Speakers:-

1. Prof. Tofazzal Islam
2. Prof. Hesham A.El Enshasy
3. Dr. Dilfuza Egamberdieva
4. Dr. Birinchi Kumar Sarma

SPEAKER'S ABSTRACT





Abstract (IL 2.1)

Biological control of wheat blast disease by seed endophytic probiotic *Bacillus* species

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Magnaporthe oryzae Triticum pathotype (MoT) causes devastating wheat blast disease, which results yield loss of wheat up to 100%. Fungicide application for controlling wheat blast is unreliable and resistance sources for breeding blast resistant variety are limited. This study aimed to discover antagonistic seed endophytic bacteria and evaluate their performances in biocontrol of wheat blast disease. Out of 660 bacteria screened, three strains of seed endophytes viz. BTS3, BTS4 and BTLK6A strongly inhibited MoT fungus *in vitro* and suppressed wheat blast disease *in vivo*. Artificial inoculation at seedling stage revealed that strains BTS4, BTS3 and BTLK6A control 89, 88 and 85% of wheat blast disease, respectively compared to mock-inoculated control. However, application of BTS4, BTS3 and BTLK6A strains protected 68, 65 and 60% field-grown wheat, respectively when they were artificially inoculated with conidia of MoT at the heading stage. Using whole-genome sequencing, we identified these potential biocontrol agents as *Bacillus subtilis* subspecies *subtilis* BTS3, *B. velezensis* BTS4 and *B. velezensis* BTLK6A. Genomics analysis and laboratory assay revealed that biocontrol of wheat blast by these seed endophytic probiotic bacteria was associated with secretion of diverse antifungal compounds against MoT and the induction of systemic resistance in the treated wheat plants. Further large-scale field studies are needed before recommending them for the practical application as novel biologicals for the biocontrol of wheat blast.

Key words: *Bacillus velezensis*, wheat blast, biocontrol, bioactive secondary metabolites, genome sequencing.

Abstract (IL 2.2)

Technology Platform Design for *Bacillus* spp. production as biological control agent: From petri dish to bulk powder production

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Plant diseases caused by insect, bacteria, and fungi are main threat to sustainable food production in global level and account for yearly estimated losses from 10 up to 40% of planted crops. Since decades, toxic chemicals have been extensively used in controlling plant diseases. In spite of their efficient and fast results in crop protection during the early years of applications, however, most of these chemicals are toxic and carcinogenic which cause many health problems for human and animals, and create imbalance in natural biodiversity in the whole biological system. In addition, with extensive uses of chemicals many pests acquire resistance and higher concentrations (beyond the safe level) need to be applied. Therefore, this method will be inefficient in the near future. Therefore, special interest were paid in using biological control as safe and efficient method in pest control. Biological control involves the uses of different organisms to control plant pathogens. Among different microbes uses, bacterial strains especially from genus *Bacillus* find many applications in controlling different types of insects and other diseases causative agents. However, large scale production and formulation of biological-control-based products are still of great challenge. In upstream, microbes should be easily grown in cost-effective culture medium in high cell density culture to produce appropriate amount of biomass and/or biological product. In addition, the final product needs to be in stable formulation to withstand storage and have appropriate shelf-life. In this presentation, we will discuss the bioprocess development and techno-industrial platform design for some *Bacillus* spp. We will give examples for some products we have developed from laboratory level up to large scale industrial scale of webtable powder formulation.

Abstract (IL 2.3)

The plant microbiome interactions under extreme environment

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Plant and soil microbiome has been extensively used for improvement of plant growth, stress tolerance, and soil productivity under various abiotic stress conditions. Plant rhizosphere is a nutrient rich ecosystem for microbes, where they colonize and use nutrients and proliferate. It is reported that plant growth promoting rhizobacteria (PGPR) are able to colonize the rhizosphere, the root surface, or even superficial intercellular spaces of the plants and facilitate to develop a beneficial association with the plants. Over the past decades, plant associated microorganisms have been utilized for enhanced plant growth and resistance to versatile abiotic stresses such as drought, salinity and temperature maintaining agricultural productivity. It is believed that PGPR effect on plant growth and physiology directly or indirectly through several mechanisms. The traits include the production of phytohormones such as auxins and gibberellins, production of low molecular weight organic acids and exopolysaccharides, production of siderophores, synthesis of osmoprotectants, exopolysaccharides, 1-aminocyclopropane-1-carboxylate (ACC) deaminase, modulation of antioxidant enzymes antagonism against phytopathogens and synthesising cell wall degrading enzymes such as pectinase, β-1,3-glucanase, and chitinase. Others have indirect roles protecting the plant against soil – borne diseases, which are mainly caused by pathogenic microorganisms, maintaining nutrients availability to plants and upregulation of antioxidant enzymes which protect plants from oxidative stress. The microbial inoculants also modify physiological processes in pants, e.g. biosynthesis of organic acids, soluble sugars, antioxidant enzymes. Other important activities root associated bacteria use in plant growth stimulation and stress tolerance are modulation of proline synthesis, activation of plant defense mechanisms reducing the toxicity of reactive oxygen species. These microbes need to be explored and utilized in agro-ecosystems, particularly those facing the impact of abiotic stresses. These microbes have a great biotechnological potential to improve soil productivity and plant health under various soil conditions.

Key words: plant microbiome, stress response, rhizosphere, metabolites

Abstract (IL 2.4)

PGPR stimulates specific transcription factors in pigeonpea in salinity affected soils for lowering of wilt severity

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Transcription factors belonging to the families WRKY and ERF are known to participate in defense signalling against various biotic and abiotic stresses in plants. We evaluated transcriptional regulation of biotic stress responsive pigeonpea (*Cajanus cajan*) CcWRKY and CcERFs under salinity stressed conditions and the influence of a PGPR strain *Pseudomonas fluorescens* OKC was recorded. We observed that among the 35 tentatively identified biotic stress responsive CcWRKY genes, 26 were highly *Fusarium udum* responsive, 17 were better NaCl responsive and 11 were dual responsive to both *F. udum* and NaCl. The results also indicated that CcWRKY genes play a vital role in the defense signalling against *F. udum* and some of the *F. udum* responsive CcWRKYs (at least 11 in pigeonpea) are also responsive to abiotic stresses such as NaCl. Similarly, expression analysis of 34 tentatively identified CcERF genes in pigeonpea revealed preferential transcript accumulation patterns of the CcERF genes in different treatments. 32 and 30 CcERFs genes responded well to individual stresses of *F. udum* and NaCl, respectively. However, three CcERF genes were observed to be important for resistance to *F. udum* and one gene *CcERF14* is singled out as the most important dual responsive gene under the combined challenge of *F. udum* and NaCl. We concluded that stimulation by plant beneficial microbes such as *P. fluorescens* OKC can help pegionpea to defend itself against the two stresses (*F. udum* and NaCl) through enhanced expression of the stress responsive CcWRKY and CcERF genes when the stresses are prevalent individually.

PARTICIPANT ABSTRACT





Abstract (2.1)

In vitro evaluation of bioagents as seed treatment on dominant seed mycoflora of chilli

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Chilli is important spice crop grown in India having commercial and therapeutic value. Seed borne pathogens of chilli reduce quality, quantity and longevity of seeds and transmit various diseases. Hence, *in vitro* study was carried out on efficacy of seed treatment on chilli (var.GVC101,GVC111) by bioagents and their effect on seed germination, seedling vigour and on the dominant seed mycoflora (*A. niger*, *Colletotrichum* sp. and *Fusarium* sp.) by paper towel method. Results revealed that, GVC101 seeds pre-treated with *A. niger* followed by treatment with *P. fluorescens+B. subtilis* @6+6g/kg seeds showed weight (0.98mg,0.31mg) and vigour index (292.43). Seed treatment with *P. fluorescens+B. subtilis* @6+6g/kg seeds also showed higher seed germination (90.00%), seedling fresh, dry weight (0.62mg,0.24mg) and vigour index (234.63) in seeds pre-treated with *Colletotrichum* sp.. While in seeds pre-treated with *Fusarium* sp. followed by *T. harzianum+P. fluorescens* @5+6g/kg seeds exhibited higher seed germination (96.00%), seedling fresh, dry weight (1.10mg,0.19mg) and vigour index (283.27). In GVC111, seeds pre-treated with *A. niger* and treatment with *T. harzianum+P. fluorescens* @5+6g/kg seeds showed higher seed germination (93.33%), seedling fresh, dry weight (0.98mg,0.21mg) and vigour index (282.29). In seeds, pre-treated with *Colletotrichum* sp. and treatment with *T. harzianum+P. fluorescens* @5+6g/kg seeds exhibited higher seed germination (88.00%), seedling length (2.27cm), seedling fresh, dry weight (0.64mg,0.28mg) and vigour index (199.37). While, in seeds pre-treated with *Fusarium* sp. and treatment with *P. fluorescens+B. subtilis* @6+6g/kg seeds exhibited higher seed germination (94.00%), seedling fresh, dry weight (1.17mg,0.32mg) and vigour index (275.77).

Abstract (2.2)

Isolation and screening of phyllosphere bacteria against *Exserohilum turcicum* of maize

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Maize (*Zea mays* L.) is one of the important cereal crops of the world and world's third leading cereal crop, after wheat and rice. Among the foliar diseases, turcicum leaf blight incited by the

fungus *Exserohilum turcicum* (Pass.) Leonard and Suggs has become a major threat and results in severe reduction in grain yield to an extent of 28 to 91 per cent. With the development of ecological agriculture, the impact of over use of chemical fungicides on environment and food safety has become a serious concern. Keeping in view the importance of the crop and lack of adequate information on beneficial effects of phyllosphere microflora in the management of turcicum blight of maize, the present study was done. Microbial interactions in the phyllosphere suppress and stimulate the colonization and infection of tissues by plant pathogens, increase disease resistance and the productivity of agricultural crops, thus phyllosphere microorganisms can play an important role in growth promotion of plants. Isolated twenty-two phyllosphere bacteria by dilution and leaf imprint method and screened this phyllosphere bacteria against *E. turcicum* by dual culture technique under *in vitro* for all the isolates. Results revealed that nine isolates were effective over test pathogen. Among the nine isolates, isolate P9 recorded maximum growth inhibition of 44.09 per cent among all the bacterial isolates followed by isolate P16 (41.60 %) and isolate P4 (21.07 %). These phyllosphere bacteria can be used as alternate Biological control tool for the control of plant diseases. The potential isolate P16 of phyllosphere bacteria were sent to Eurofins for further characterization at molecular level by 16S rRNA gene sequencing for identification. Based on the sequencing, the phyllosphere isolate P16 identified as *Bacillus amyloliquefaciens*.

Keywords: Bacteria, *Exserohilum turcicum*, Maize, Phyllosphere microflora

Abstract (2.3)

Biological Control of Sheath blight disease (*Rhizoctonia solani* KUHN) of Rice by PGPR

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Sheath blight is a devastating disease caused by *Rhizoctonia solani* Kuhn in rice crop. Biocontrol agents have great demand now-a-days as they are replacing chemical pesticides to a large extent as they are cost effective, ecofriendly and easily available. *Pseudomonas* and *Bacillus* isolates were found promising in suppression of *R. solani* and increasing in the plant growth. Thirty bacterial strains (15 *Pseudomonas* spp. and 15 *Bacillus* spp.) were isolated from the phylloplane and rhizoplane samples of rice obtained from different regions of Khammam and Rangareddy districts of Telangana state. The isolates *in vitro* were characterized biochemically employing IMVIC tests, oxidase test, catalase test, H_2S production, starch hydrolysis, gelatin liquefaction and ammonia production. Further, all the 15 isolates of *P. fluorescens* were screened *in vitro* for plant growth promoting attributes *viz.,* ammonia production and IAA production. All the isolates produced ammonia and strong production was seen in the isolates PF2, PF12 and PF14.





All the15*Bacillus* isolates were screened for plant growth promoting attributes IAA production. All the thirty isolates were further screened for assessment of antagonism *viz*., siderophore production and HCN production. All the *Bacillus* isolates excluding B2, B6 and B9 produced siderophores and strong production was found with the PF2, PF14 and B12 isolates. HCN production was observed in all isolates of *Pseudomonas* and *Bacillus* and strong production was seen in PF2, B7 and B11 isolates. *In vitro* screening of bacterial isolates against *Rhizoctonia solani* was carried out by dual culture technique and agar-well method. Among *Pseudomonas* isolates, all of them inhibited the mycelial growth of *R. solani.* Significantly highest per cent inhibition was found with PF2 (54.50 %) and all *Bacillus* isolates inhibited the mycelial growth of *R. solani* compared to control. The antagonists were tested for their growth promoting activities under laboratory and green house conditions. The seedling vigour and germination per cent significantly increased in seed treatment with *P. fluorescens* and *Bacillus* isolates. The potential *Pseudomonas* and *Bacillus* isolates (PF2 and B7) were further evaluated for their disease suppression ability under greenhouse conditions. Foliar spray with *Pseudomonas* spp. (2 x 10^9 cfu/ml) 24 hours before pathogen inoculation + Foliar spray with *Bacillus* spp. (2 x 10^9 cfu/ml) 10 days after pathogen inoculation significantly reduced sheath blight incidence.

Keywords: Sheath blight, biochemical characterization, *Pseudomonas fluorescens, Bacillus* spp., biocontrol

Abstract (2.4)

Chitinolytic and Anti-fungal Potential of Commercial Biocontrol Agent "Sanjeevani"

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The present study was undertaken with the concept in mind that many of the commercial biocontrol products in the market failed to give desired results in the field application. Therefore, a commercial product must be checked for its property of interest or a claimed biocontrol attribute claimed in the marketed product. This was the reason we aimed to isolate a biocontrol agent from commercial biocontrol product "Sanjeevani". The methods utilised were isolation of biocontrol agent (fungi) from the product, screening of chitinolytic activity, its optimization, partial purification, immobilisation, enzyme characterisation in free and immobilised state, and potential of enzyme to antagonise the plant pathogens. It was observed that enzyme from the isolated fungi identified as *T. viride* showed a very good chitinase activity, while immobilised enzyme also showed chitinase activity. The study clearly depicted that the enzyme extracted from this biocontrol fungi was active and able to show many kinetic parameters.The chitinase produced by *T. viride* is inducible in nature and is influenced by medium components.





The optimum conditions that enhanced the chitinase production were reported at pH 7.0, temperature of 30C, and 5 days of incubation. Colloidal chitin induced more chitin's along with yeast extract among plethora of sources. It also inhibited some of the pathogenic fungi tested in plate assay. *T. viride* isolated from this biocontrol product also showed antagonistic effects against various plant pathogens proving chitinases as the source of this antagonistic activity. To conclude, *T. viride* produced chitinase and played an important role in controlling fungal plant pathogens. The use of *T. viride* based products such as "Sanjeevani" is not only safe for the farmers and consumers but its also good for the environment.

Abstract (2.5)

Antagonistic performance of native strains and commercial formulations of bio control agents on *Rhizoctonia bataticola* (taub.) butler, the causal agent of dry root rot of groundnut

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Dry root rot caused by *Rhizoctonia bataticola* (Taub.) Butler is responsible for economic losses to an extent of 80% in groundnut where dry conditions prevail during the rainfed season. Therefore, an attempt was made to identify the best bio control agent for the management of *R. bataticola*, by evaluating native strains of bacterial and fungal bio agents and commercial formulations of *Trichoderma harzianum* and *Pseudomonas flourescens.* Fungal bio agents (native and commercial) were found to be more effective in controlling the dry root rot pathogen under *in vitro* conditions than the bacterial bio agents. Among the fungal bio agents TrCF2 (commercial formuation of *T. harzianum* from UAS, Dharwad) exhibited better performance under *in vitro* so, it was used in field studies in single and combination treatments along with best performing fungicide and organic amendments. The field treatment involving the sole application of bio agent as seed treatment (TrCF2) yielded 2031.11 kg ha^{-1} whereas the combination treatment along with fungicide and organic amendment yielded 3797.77 kg ha^{-1} respectively. Bio agents in combination with fungicides and organic amendments gave highest disease control and greater yield under field conditions.

Bio control agents prove to be an efficient alternative to fungicides in disease management. They also promote the plant growth and are environment friendly and help in reducing the usage of plant protection chemicals.

Keywords: Groundnut, Dry root rot, Bio agents, *T. harzianum, P. flourescens*

Abstract (2.6)

Studies on Pectinase producing fungi, its evaluation on plant growth in association with pathogenic fungi

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Hydrolytic enzymes of plant growth promoting microbes play an important role the biological control of plant diseases. Pectinases play a dual role during the interaction between the fungus and the host plant. Pectin degradation may contribute to fungal virulence but may also induce defense gene expression in the host plant. This study focuses on the isolation and screening of pectinase producing fungi collected from different samples. To study the enzymatic and biocontrolling activities of the selected fungus. To determine the effect of the isolated pectinase producing fungi in interaction with various phytopathogenic fungi on plant growth. Samples of soil were collected from agricultural fields. They were plated onto Pectinase screening agar medium for the isolation of bacteria and fungi. Colonies showing large zones of hydrolysis were selected for further studies. The selected isolate was then tested for various plant growth promoting activities. Like hydrolytic enzyme production, Ammonia production and HCN production. Various sets of pot experiments were carried out with the selected fungus and other plant pathogenic fungi, crude pectinase and also controls. One fungus showed high zone of Pectin hydrolysis and also showed the presence of catalase, cellulase, lipase, gelatinase, amylase and HCN production and that was identified as belonged to *Aspergillus* spp. Experiments were conducted using the *Aspergillus* spp. and other phytopathogenic fungi, both in association, to evaluate their combined effects on the growth of wheat seedlings. From the above observations we have determined that the pectinase producing fungi interacts variably with the phytopathogenic fungi and the host plant and soil bacteria in association. The role of pectinases in the different aspects of the interaction between plants and pathogenic fungi and PGPR are to be further evaluated.

Keywords: biological control, virulence, phytopathogenic

Abstract (2.7)

In vitro evaluation of PGPR *Pseudomonas* against paddy stem rot causing pathogen *Sclerotium oryzae*

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A total of twelve isolates of paddy stem rot causing pathogen *Sclerotium oryzae* and twelve native bacterial isolates from soil rhizosphere of paddy were collected from various localities of Andhra Pradesh. The pathogen isolates were isolated by root bit method and rhizosphere bacteria were isolated by serial dilution and spread plate method. Pathogen isolates were identified by based on cultural and morphological characters and *Pseudomonas* isolates were identified by morphological, cultural and bio-chemical characterization. The pathogenecity of *S.oryzae* isolates were tested by the blotting technique. The potential antagonistic bacterial isolates were identified based on their inhibition ability of *S. oryzae* in dual culture technique. The isolates of *Pseudomonas fluorescens* shown highest inhibition of 97.66% against virulent pathogen isolate under *in vitro*. PGPR *Pseudomonas fluorescens* not only helpful in the disease management but also promotes growth, increase the germination per centage, improve vigour and viability ultimately affect the yield.

Keywords: *Pseudomonas fluorescens*, Inhibition, *Sclerotium oryzae*, Pathogenecity and Vigour

Abstract (2.8)

Screening for Siderophorogenesis of *Trichoderma asperellum* isolates on P-CAS medium and characterization of siderophores

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Siderophore (from Greek iron carriers) are defined as relatively low molecular weight ferric ion specific chelating agent elaborated by bacteria, fungi and plants under low iron stress. Role of this siderophorogenesis is to scavenge iron from the environment and to make them mineral which are almost essential to microbial cell. Micro-organisms growing under aerobic conditions need iron for a variety of functions like reduction of oxygen for synthesis of ATP, reduction of ribotide precursors of DNA, for heme formation and they play vital role as competitor to phytopathogens by scavenging iron.This iron deficiency inhibits the growth of phytopathogens by inhibiting the synthesis of nucleic acids and sporulation of the pathogens. These are proved to

promote even plant growth and in biocontrol mechanism by lysis of fungal mycelium in addition to competition for iron. Siderophores are mainly of four types *viz.,* catecholates, hydroxamates , carboxylates and mixed ligands). Catecholate or phenolate siderophores are cyclic tri-ester of 2,3-dihydroxybenzoylserine.oil fungi produce ferrichromes which are again five groups mainly acetyl (ferrichrome, ferrichrome, ferricrocin and ferrichrysin), malonyl (malanichrome), trans-b-methylglutaconyl (ferrichromeA), trans-anhydromevalonyl (ferrirubin) and cis-anhydromevalonyl (ferrirhodin). These were differentiated due to higher expression of siderophore biosynthesis genes due to lower Fe concentration and there by leads to higher concentration of siderophores. Coprogen type siderophores are specific siderophores produced by *Trichoderma* spp. In recent era usage of these siderophores in medical field for treatment of malaria, cancers, removal transuric elements like aluminium and vanadium from human body, as deodorants, cosmetics, biocontrol agents for fish pathogens became an alternative for hazardous chemicals. With an objective of eco-friendly management of stem rot of groundnut incited by *Sclerotium rolfsii* Sacc. potential native *T. asperellum* isolates from groundnut regions of Rayalaseema region of Andhra Pradesh were screened for siderophorogenesis on P-CAS (Potato Dextrose Agar with modified Chrome Azurol S medium).Generally CAS plates will be used for siderophore detection but later replaced with modified CAS method. With an aim to screen expression of siderophores without Pipes/succinate/Kings B medium fungus preferred medium i.e 900 ml of PDA was amended with 100ml of CAS indicator solution and plated to 50% and remaining 50% of the plates were plated with PDA. A 6mm mycelial disc of ten isolates of *T. asperellum* (GT_1, GT_4, $GT_{11,}$ GT_{15}, GT_{23}, GT_{25}, GT_{60}, GT_{61}, GT_{NT} and $GT_{W38(2)}$ were placed on PDA portion whereas control was maintained without culture. These were incubated at 28 ^{0}C for five days and observations for colour change of blue CAS plates to orange, yellow, red or purple were recorded. Simultaneously fungal discs of all these isolates were grown in Grimm Allen medium for 15 days then culture filtrate was centrifuged and sediment was further characterized biochemically into hydroxamates or catecholates or carboxylataes. On this Potato dextrose Agar amended modified CAS medium there were changes in the colour from blue to yellow, orange (light or dark), light red indicated siderophorogenesis by *T. asperellum* isolates but no isolate has formed purple colour indicating absence of catecholate which was proven even in culture filtrate method also. No isolate was found to produce catecholates as no change in yellow colour in $FeCl_3$ test .But they produced hydroxamates (deep red colour formation in tetrazolium test) or carboxylates (disappearance of pink colour). As these ligands have multifunctions not only in plants but also have applications in medical field, there is a need to quantify or detect siderophores using HPLC or GCMS like advanced techniques for their further exploitation.

Keywords: Siderophores, *Trichoderma asperellum,* CAS, hydroxamates, catecholates, Carboxylates





Abstract (2.9)

Effect of biocontrol agent and fungicide on microbial count and enzymatic activities of rhizospheric soil in soybean cropping system

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Fungal infection in soybean crop poses a biotic stress on crop, which disturb the microbial activity that adversely affect the crop yield. In present research, we studied the effect of seed dressing with various combinations of *Pseudomonas* and carbendazim on microbial count and enzyme activity in the rhizospheric soil infested with *Rhizoctonia solani.* In this experiment (T1) containing only $1x10^6$ CFU gm^{-1} of *Rhizoctonia* in soil, (T2) containing *Pseudomonas (*$4.1x10^8$CFUgm1), T3 (T2+carbendazim@0.05%), T4 (T2+carbendazim@0.1%), T5 (T2+carbendazim@0.15%), T6 (T2+carbendazim@0.2%) was prepared at the time of sowing. The bacterial and fungal count was examined 60 days after sowing.The *Rhizoctonia* count (34 $x10^6$ CFU gm^{-1}) seen in T1 while *Rhizoctonia* ($4.3x10^6$ CFU gm^{-1}) was observed in T3 that was 87% lower than T1. The treatments T2, T4, T5, and T6 had shown 29, 87, 89 &100% reduction in *Rhizoctonia* population. Treatments T2, T3, T4 exhibited maximum bacterial population (48× 10^8 CFU gm^{-1}) .The treatment T5, T6 showed (38× 10^8 and $25X10^8$ CFU gm^{-1}) bacterial count which was 20% and 69% lower than T2. The treatment (T2, T3, and T4) has shown 9%, 4.9%, 15.5% increase in Acid Phosphatase, Alkaline Phosphatase and Dehydrogenase activity respectively as compare to control. The treatment (T5, T6) has shown 6%, 5%, 6.6% increase in Acid Phosphatase, Alkaline Phosphatase, and Dehydrogenase activity respectively as compare to control. This enhanced microbial number, enzyme activity and reduced fungal pathogen count in T3 has significantly improved the nutrient supply to the plant, which has improved the growth and yield attributes of cropping soybean.

Abstract (2.10)

Antagonistic potential of indigenous rhizobacteria against foliar blight pathogens of wheat *Bipolaris sorokiniana* and *Alternaria triticina*"

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There is increased interest in biological control of foliar blight pathogens affecting the wheat production and growth worldwide. Thereby, the goal of this study was to evaluate the six wheat rhizospheric bacteria (P10, UP11, MH13, MP17, MH12 and MP14) for antagonism and

biocontrol potential against two foliar blight pathogens; *Bipolaris sorokiniana* and *Alternaria triticina* causing wheat spot blotch and leaf blight respectively. All six bacteria had strong *in vitro* antagonistic activity (50%-69%) and produced various antifungal enzymes. Polyphasically, the isolates P10, UP11, MH13, MP17, MH12 and MP14 were identified as *Bacillus velezensis* (MN099430.1), *Bacillus subtilis* (MN099431.1), *Bacillus sp.* (MN099432.1), *Streptomyces sp.* (MN099435.1), *Lysinibacillus sp.* (MN099433.1), and *Staphylococcus epidermidis* (MN099434.1) respectively. During *in vivo* pot trial, there was significant reduction in spot blotch incidence in wheat plants treated with the isolates P10 (T2) and UP11 (T3) with 48.66% and 50.33 % DI respectively. Likewise, percent reduction in the incidence of leaf blight by P10 (49.26%) and UP11 (50.33%) was also significant. The GC-MS analysis identified 29 and 30 chemical compounds in the ethyl acetate extract of isolate P10 and UP11 respectively. Amongst the identified compounds, isobutylhexahydropyrrolo [1, 2-a] pyrazine-1, 4-dione was the most abundant in the GC-MS profile of both the strains. An *in silico* interaction study between the bacterial compound isobutylhexahydropyrrolo [1, 2-a] pyrazine-1, 4-dione (a ligand) with ceratoplatinin, aphytotoxic protein of fungus *B. sorokiniana* revealed a strong interaction (ΔG-6.76) between ligand and protein. This highlighted the significant role of this metabolite produced by antagonistic wheat strains in the control of pathogens. Further studies are necessary to test the effectiveness of potential bacterial antagonists under different environmental conditions before these two strains are exploited at commercial scale.

Keywords: Biocontrol, Antagonistic activity, Rhizobacteria, *Bipolaris sorokiniana*, *Alternaria triticina*

Abstract (2.11)

Prospect of pesticide tolerant PGPRs for disease management caused by *Macrophomina phaseolina* (Tassi.) Goid. and growth promotion in *Vigna unguiculata* (L.) Walp.

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Vigna unguiculata (Cowpea) suffer from several diseases caused by *Macrophomina phaseolina* from seedling till harvest. Frequent use of fungicides though diminish disease incidence, affects human and agricultural health. Import of exotic PGPRs in heavily pesticide infested soil may not survive or express disease suppressive and plant growth promoting (PGP) properties.





However, some PGPRs develop tolerance after long exposure to pesticides, using as substrates for nutrient and energy with subsequent degradation and can effectively be exercised for bioremediation of contaminated soils along with disease control and PGP activities. Our study aims in *Macrophomina* disease management of cowpea by six pesticide tolerant non pathogenic isolates of rhizobacteria including species of *Bacillus* and *Pseudomonas.* Following formula correlating change in DSI with time in different cultural conditions, revealed progressive increase of DSI in treatments without bacteria, hydropriming or only pathogen. Treatments with *B. cereus, P. donghuensis* or *P. aeruginosa* showed less DSI in same time compared to others. HI of plants found maximum in treatment with *P. aeruginosa.* DSI and HI were inversely proportional and high significant correlation coefficient was found at 1% level. Pod yield plant^{-1} were high in *Pseudomonas* and *B. cereus* treated plants under sterile, non sterile and field condition. PGPRs augmented defensive enzyme production in plants. Selected pesticide tolerant PGPRs have disease control and plant growth promoting ability which may be exploited for sustainable agriculture and bioremediation of contaminated soil.

Key words: Cowpea, DSI, HI, *M. phaseolina,* Pesticide-tolerance; PGPR

Abstract (2.12)

Bacterial mediated induced systemic tolerance (IST) in plants under abiotic stress

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Plant growth-promoting bacteria (PGPB) are capable of alleviating environmental stress and eliciting tolerance in plants to promote their growth. PGPB-elicited physical and chemical changes in plants result in enhanced tolerance to drought, salt, and other factors that have been described as a form of induced systemic tolerance under abiotic stress. The use of PGPB requires precise understanding of the interactions between plant-bacteria, among bacteria-microbiota, and how abiotic factors influence these relationships. During my lecture, I will present a research study focused on to determine the role of salt tolerant plant growth-promoting bacteria (PGPB) *Sphingobacterium* BHU-AV3 in improving salt tolerance in tomato through investigating the physiological responses of tomato roots and leaves under salinity stress. In this study, tomato plants inoculated with BHU-AV3 and challenged with 200 mM NaCl exhibited less senescence, positively correlated with maintenance of ion balance, lowered reactive oxygen species (ROS) and increased proline content compared to non-inoculated plants. BHU-AV3 inoculated plant leaves were less affected by oxidative stress as evident from reduction in superoxide contents,





cell death and lipid peroxidation. The suppression of salinity induced ROS levels in BHU-AV3 inoculated plants was associated with the increased antioxidant enzyme activities along with their isoforms [peroxidase (POD), polyphenol oxidase (PPO) and superoxide dismutase (SOD)] in plant roots. Additionally, BHU-AV3 inoculated tomato roots exhibited higher proteins expression involved in (i) energy production [ATP synthase]; (ii) carbohydrate metabolism [enolase]; (iii) thiamine biosynthesis protein; (iv) translation protein [elongation factor 1 alpha]; and antioxidant defence system [catalase], compared to non-inoculated plants under salt stress. Improved tomato health and growth under NaCl stress in *Sphingobacterium* sp. BHU-AV3 inoculated plants along with physiological evidences from tomato roots established the role of *Sphingobacterium* sp. BHU-AV3 as salinity stress reliever in tomato.

Keywords: Plant growth promoting bacteria, Plant physiology; Salt tolerance; Tomato

Abstract (2.13)

Paenibacillus lentimorbus demonstrstes biocontrol agents *Sclerotium rolfsii* through autophagy induction

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Plants use a variety of strategies to protect themselves from biotic stress, including the formation of reactive oxygen species (ROS), the activation of pathogen-related proteins, and cell death. Some plant growth promoting rhizobacteria (PGPR) have been identified as bio-control agents that protect crops from diseases. Several defense-related genes were activated with ROS generation in tomato in the biocontrol activity of PGPR Paenibacillus lentimorbus (B-30488) against Sclerotium rolfsii, as previously shown. Using PGPR, we investigate another option, namely the involvement of autophagy in improving tomato defence. In B-30488-treated healthy and infected plants, confocal imaging revealed the presence of an acidotropic dye Mono Dansyl Cadaverine (MDC) colored autophagosomes. Plants treated with the autophagy inhibitor chloroquine had entirely destroyed these autophagosomes. The results were also confirmed using transmission electron microscopy to examine the ultrastructure of leaf tissues. qRT-PCR was used to detect increased expression of autophagy-related genes in B-30488 primed fungal infected tissues relative to controls. The results of ROS accumulation, fluorescence, confocal and transmission electron microscopy, and gene expression analyses demonstrated that utilising B-30488 as a biocontrol agent induced autophagy, suggesting that it may have a role in improving disease resistance in tomatoes. Overall, the current study found that B-30488 has a function as a biocontrol in improving disease resistance in tomatoes, as well as assisting in a better knowledge of fungal pathogenesis, which will be important in designing novel disease control strategies.

Keyword: PGPR; Autophagy; patghogen; *Paenibacillus lentimorbus;* qRT-PCR





Abstract (2.14)

Autophagy induced by Paenibacillus lentimorbus protects tomato from *Sclerotium roflsii* infection

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Induction of pathogenesis related proteins, production of reactive oxygen species (ROS) and cell death are some of the mechanisms employed by plants to protect themselves from biotic stress. Biocontrol activity of several plant growth promoting rhizobacteria (PGPR) has been known which is utilised to protect crops against pathogens. *Paenibacillus lentimorbus* (B-30488), a PGPR has previously shown biocontrol activity against *Sclerotium rolfsii* through upregulation of defense related genes by ROS induction in tomato. We also intend to study the role of autophagy in upregulation of defense related genes using PGPR. Autophagosomes stained with an acidic dye Mono Dansyl Cadaverine (MDC) were seen in B-30488 treated healthy and infected plants through confocal microscopy. When an autophagy inhibitor chloroquine was used, the autophagosomes disappeared in plants. Transmission electron microscopy for ultrastructural analysis of leaf tissues was done to further confirm the results. qRT-PCR was performed to monitor enhanced expression of autophagy-related genes in B-30488 primed fungal tissues as compared to control. It was observed through results of ROS accumulation, fluorescence, confocal and transmission electron microscopy and gene expression analysis that B-30488 was capable of inducing autophagy, hence suggesting its role in increasing disease resistance in tomato. The present study therefore was indicative of role of B-30488 as a biocontrol agent in increasing disease resistance in tomato. The study also improved our understanding about fungal pathogenesis which may be useful in developing new strategies for disease control.

Keywords: PGPR; TEM; MDC staining; disease resistance; gene expression analysis

Abstract (2.15)

Analysis of the consortium based bacterial formulations for the management of blast disease (*Pyricularia Oryzae*) in rice

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Rice blast caused by *Pyricularia oryzae* is a major disease affecting rice production grown in upland and wetland rice. Application of beneficial bacteria as seedling root dip and spraying method to protect against the disease may be an alternative strategy to chemical control. This research was aimed to explore the bacterial consortium that may control blast disease on rice plants. In this study, the following bacterial cultures and their consortiums were used: *Bacillus firmus*, *Serratia marcescens*, *Pseudomonas aeruginosa*, *Bacillus cereus*, and its combination for their suppression ability against *P. oryzae* under in-vitro conditions. The results showed that *Bacillus firmus* and consortium *Bacillus firmus*, *Bacillus cereus*, and *Pseudomonas aeruginosa* significantly reduced the mycelial growth of *P. oryzae* with the percentage inhibition of 73-85% and 66-83%, respectively. Further greenhouse testing conducted with use of formulative preparation of the two selected best treatments using talc, and palm oil suspension based carriers showed that spraying with suspension formulation had good effect in suppressing blast disease compared with that of other carriers evaluated.

Keywords: Rice, Blast disease, Consortium of bacteria, *Bacillus firmus*, *Pseudomonas aeruginosa*, *Pyricularia oryzae, Serratia marcescens*

Abstract (2.16)

PGPR: A promising approach towards the fungal infection control of chilli plant

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Fungal infections since years have been known to cause various devastating infections in vegetables and crops. Chilli (*Capsicum annuum L.)* is one of the important vegetable as well as spice being used for various purposes throughout the world. Chillies are low in sodium and

cholesterol free, rich in vitamins A and C, and are a good source of potassium, folic acid and vitamin E. Chilli contains Capsaicin, which makes brain to release a neurotransmitter and secretion of endorphin (natural painkiller). Chilli has been found to be infected with various fungal, viral and bacterial diseases and among them one of the fungal disease anthracnose is very prominently found in chilli. *Colletotrichum sp* is the causal organism of anthracnose and has been found to be the sole reason for the loss of 50%-60% of the total yield worldwide. The plant has also been found to be infected with various other fungal phytopathogens like *Fusarium oxysporum*, *Rhizoctonia solani*. Since last few decades PGPR has gained attention of researchers for being an excellent biocontrol agent to control soil-borne and foliar fungal diseases of various crops. In our study, we have collected the rhizospheric soil sample of chilli plants from Nimar region and Hoshangabad of Madhya Pradesh and have done the screening of isolates against four fungal phytopathogens (*Colletotrichum gloeosporioides, Colletotrichum capsici, Fusarium oxysporum and Rhizoctonia solani*) respectively. Some of the isolates have shown promising antagonistic activity against the phtyopathogens in-vitro. The analyses of growth inhibiting property of the isolates were suggestive for their use as effective microbial biocontrol agents against fungal phytopathogens of Chilli.

Keywords: Fungal Phytopathogens, PGPR, Chilli, Biocontrol

Abstract (2.17)

Allelochemicals in biocontrol of *Sclerotium rolfsii* induced collar rot of cucumber

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Bacillus subtilis strain and *Lysinibacillus fusiformis* were tested for percent inhibition of radial growth of the phytopathogen *Sclerotium rolfsii* by dual culture plates exhibiting 70 and 57.6% growth inhibition. The two bacterial strains tested positive for siderophore production, volatile organic compounds like hydrogen cyanide, antibiosis by lipopeptides like subtilin, bacillomycin. Fungal cell wall degrading enzymes like β1,3 glucanase, chitinase produced by the rhizobacteria diffused into the soil mileau to degrade soil borne fungi *Sclerotium* by attacking the glycosidic bonds between glucan and chitin residues and their respective cross linking.

Though antagoniostic molecules produced by the rhizobacteria serves as the first line of defense raged by the biocontrol bacteria against the soil dwelling fungi , *Sclerotium rolfsii* but on the contrary the iron chelating compound siderophores along with the lipopeptides induce resistance in cucumber. Lipopolypeptides facilitate biofilm formation by *Bacillus subtilis* that improves competitive ability to colonise plant roots while suppressing the growth of other pathogenic bacteria and fungi in the rhizosphere by production of secondary metabolites. Field experiments with the biocontrol agents showed that a dual combination of Lysinibacillus-Bacillus could suppress the pathogen to the extent of 60% as indicated by the biocontrol efficiency, the disease severity being rated as 50%

Keywords: Bacillus , Sclerotium rolfsii, lipopolypeptide

Abstract (2.18)

Role of bacterial endophytes in disease suppression and plant growth promotion of *Musa acuminata*

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Presenting author: Shilpi Singh

Endophytes are a group of symbiotic microorganisms that live in symbiotic relationships with plants and produce secondary metabolites that protect the plant from phytopathogens. India is the world's largest producer of bananas, and in order to meet market demand, a large number of chemical fertilizers are used. Because India is the world's top banana grower, a huge amount of chemical fertilizers are used to keep up with demand on the global market, which is expensive and might be detrimental to the environment. Endophytic bacteria colonization is required for the development of the plant's natural defense system, the successful use of endophytic microorganisms as bioinoculants reduces the demand of chemical fertilizers. Invitro Micropropagation is essential for meeting worldwide market demand. Microbial contamination is one of the most common problems in the In-vitro culture method for mass production of disease-free planting material, resulting in the entire loss of time, medium, and explants. Endophytic bacterial inoculants induced in micropropagated *Musa acuminata* plantlets are being studied for their potential to stimulate plant growth in order to overcome these difficulties. Endophytic microorganisms have enormous potential for maintaining plant health and environmental conditions in order to ensure agricultural sustainability. The purpose of this research is to evaluate the inoculation of endophytic bacterial inoculants in micropropagated *Musa acuminata* plantlets under Invitro conditions as well as their biological control ability. The research also examines how micropropagated plants can activate their innate immune response to various pathogens.

Keywords: Endophytic bacteria, *Musa acuminata*, Bioinoculants, Agricultural sustainability

Abstract (2.19)

Biocontrol potentials of PGPM of arid zone in managing plant pathogens

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Arid soils are inhibited by a large variety of flora and fauna, some of which are beneficial to human beings, while the rest are enemies. Of the soil inhibiting microorganisms that are pathogenic to plants, include bacteria, actinomycetes, nematodes, fungi and some other microbes. Microbes naturally present in soil and root rhizosphere are not always harmful by causing diseases to plants but sometimes serve as biological control agents of various significantly important plant pathogens. The mechanisms through which these bio agents operates is either by direct action against the pathogen i.e. antagonism which includes parasitism, antibiosis, competition and/or indirectly by reducing host susceptibility and includes exudation, altered rhizosphere, induced resistance, hipovirulence, PGPR, etc. Studies were initiated to explore biocontrol potentials of microorganism in order to develop a cost effective and practical management strategy in augmenting disease control. Analysis of large number of soil samples collected from different parts of the region led to isolation of native bio-control agents viz., *Trichoderma harzianum, T. longibrachiatum*, *Aspergillus versicolor*, *A. nidulans*, *Penicillium oxalicum*, *Bacillus firmus*, *B. tequilensis* and *Streptomyces mexicanus* from different agricultural systems. These bio-control agents have proved their antagonistic ability in repeated laboratory tests. In the next step, information was required to be generated for their field efficacy on most commonly grown crops, trees and their effect on resident microflora in order to ascertain whether any bio-agent has adverse effect on native organisms. Several physical, chemical, and biological factors affect the survival and functioning of bio-agents in the soil. Soil moisture stress and high temperature are the major abiotic factors that affect their performance in arid ecosystem. Inadequacy of soil organic matter further aggravates the problem as the bio-agents depend on organic matter for energy and growth. Microbial inoculation in soil also influences the activity of indigenous microflora, ultimately having a bearing on their own survival. This is because the introduced biocontrol agents must adhere to the plant roots, compete for space and nutrients released through root exudation, and must be able to occupy the new niche in sufficient numbers so as to exert its effect on the host plant. Often, the native inhabitants of soil, which are better adapted to the environmental conditions, out compete the inoculated population. Development of an effective native microbial inoculant thus requires the presence of multiple fitness traits that can facilitate its colonization and survival under harsh environmental conditions. An effort has been made to summarize the research carried out at the Central arid zone research institute, Jodhpur for the last three decades to isolate, identify and investigate role of biocontrol potential of native microorganism in managing important plant pathogens.





Abstract (2.20)

Management of rice blast by using plant growth promoting rhizobacteria and chemical fungicides

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Rice is one of the most important staple food crops in the world, with China and India being the lead producing countries. Rice is infected by many diseases, among which the blast disease (*Pyricularia* oryzae) caused severe yield loss and became the major production constraint in all rice-growing areas. To manage the rice blast, a field experiment was conducted by using Plant Growth promoting Rhizobacteria and newer fungicides. Among the different treatments tested, the disease incidence was found to be reduced substantially in the seeds treated with *Pseudomonas fluorescens* (liquid formulation) 10 ml/ kg of seed + Azoxystrobin (0.1%) spray (16.32%) whereas the control plot recorded 42.78% incidence. Increased yield was noticed in the *Pseudomonas fluorescens* (liquid formulation) 10 ml/ kg of seed + Azoxystrobin (0.1%) spray treatment (4980 kg/ha) whereas the control plot recorded comparatively less yield (3700 kg/ha respectively). Presence of blast inoculum in the harvested seeds was tested through Agar Plate method. Percentage of blast infection was found to be reduced substantially in the seeds harvested from the plots treated with *Pseudomonas fluorescens* (liquid formulation) 10 ml/ kg of seed + Azoxystrobin (0.1%) spray (8 % respectively) whereas the seeds from control plot recorded 96 % infection.

Keywords: Blast, PGPR, Fungicide

Abstract (2.21)

Potential of endophytic bacteria Pseudomonas florescens and Bacillus velezensis in protecting tomato plants against Fusarium wilt

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Fusarium wilt is one of the major diseases caused by pathogenic *Fusarium oxysporum* (Fo) strains. Wilts are a major threat for agriculture and Fo ranks among the 10 most devastating fungal plant pathogens worldwide. Endophytic bacteria colonize host tissues internally without causing damage or eliciting disease symptoms. They are known to exert beneficial effects on host plant using various direct and indirect mechanisms. They are known to stimulate plant growth by preventing the deleterious effects of phytopathogenic microorganisms, acting as biological control agents, which can exert their activity by direct antagonistic effects on pathogenic organisms or indirectly, by eliciting plant defence responses. This study focuses on the antagonistic potential of endophytes isolated from tomato plant. Total 36 endophytes isolated from tomato plants collected from Bhopal Region of Madhya Pradesh were tested for their ability to antagonize *Fusarium oxysporum* in vitro. Only eight isolates were found to have antagonistic activity against the pathogen. The two isolates showing maximum inhibition were chosen for further studies. They were identified as *Pseudomonas florescens* and *Bacillus velezensis*. Further, they were tested for various plant growth promoting attributes like siderophore production, indole acetic acid production, phosphate solubilization, HCN production and ammonia production. Seed germination and vigour index were found to increase in seeds treated with selected isolates. It was observed during the study that the consortia of both the isolates significantly reduced the infection percentage as compared to bacterial strains alone.

Keywords: Bacterial endophyes, Fusarium wilt, antagonism, tomato plant, plant growth promotion

Abstract (2.22)

In vitro Estimation of Phytochemicals & flavonoids in *Citrus sinensis* & study their Antimicrobial & Antioxidant activity

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Orange (*C. sinensis*) peel flavonoids have antibacterial, antioxidant, anticancer, anti-inflammatory, and antiviral effects. However, there is a scarcity of information in the literature about orange peels flavonoids. So, we estimated phytochemicals in hydro-methanolic extract of *citrus* peel and separated the flavonoids by Column chromatography and confirmed with TLC and HPLC. After that we evaluated the antimicrobial, antioxidant and nitric oxide scavenging activity. The MIC value of flavonoids against *E. coli, B. subtilis, S. aureus* and *P. aeruginosa* is 19.40, 20.48, 12.45 and 21.44µg respectively. The IC_{50} value of flavonoids for antioxidant and Nitric oxide scavenging activity is 121.4 and 0.88µg respectively. In the current study, *Citrus* peel flavonoids were found to have antibacterial, antioxidant, and nitric oxide scavenging action in methanolic extracts. This study suggests that *C. sinensis* flavonoids could be exploited as an antibacterial and antioxidant source in future.

Keyword: *Citrus sinensis,* Flavonoids, Antimicrobial activity, Antioxidant and Nitric Oxide scavenging activity

THEME - III





PGPR and other Microbes for Stress Tolerance

Chairperson :-

Dr. S.C. Dubey

Convener :-

Dr. Sushil K. Sharma

Speakers:-

1. Dr. Udai B. Singh
2. Dr. S. Krishna Sundari
3. Prof.(Dr.) Corné M.J. Pieterse

SPEAKER'S ABSTRACT





Abstract (IL 3.1)

Translational Research in Biological Control: Concept to Application

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Our ever-expanding global population relies on successful crop production for food. However, many factors reduce crop yield. The biotic stresses include plant pests (including insects, mites, plant parasitic nematodes), pathogens (e.g., viruses, bacteria, fungi), and weeds are major problems in crop production causing a share of the total global yield losses of up to 34% and pose particularly significant risk to food security. These pest and pathogens exhibit distinct feeding strategies and based on feeding strategies they are characterized into three major groups, i.e. Those that feed off living tissue are known as biotrophs, those that kill and feed off dead tissue are known as necrotrophs and those that exhibit a biphasic feeding strategy, initially colonizing as a biotrophic pathogen then switching to necrotrophy once infection is established, are known as hemibiotrophs. In order to minimize crop losses, chemical, biological, and cultural means side by side with the use of resistant plants are management strategies in use. Among them, biological control measures are environment friendly and safer approach to crop protection. Microbial inoculants in conjunction with other defense strategies such as MTI and ETI play vital role in fend-off invading pathogens. Further, their antimicrobial secondary metabolites represent an invaluable source of bioactive molecules which can be used as such or serve as chemical frameworks for developing new antimicrobial compounds for various applications including crop protection against pathogens. Because many rhizosphere microorganisms triggering ISR can also inhibit growth of a pathogen directly, their capacity to suppress disease may involve more than one mechanism. With the advancement of science, „omics based investigations are making an important impact on the current understanding and application of microbial agents used for plant disease control. Here, several microbial inoculants including *Trichoderma*, *Bacillus* and *Pseudomonas* have been extensively studied using a variety of research approaches, including genomics, transcriptomics, proteomics, metabolomics, etc. These omics-generated novel findings are being successfully translated into new/improved product/technologies which can be used in crop protection measure. We present an overview of the latest discoveries on the *interactome* and *metabolome*, of the diverse biotic interactions established by these microbes, and of their proven or potential importance to agriculture and industry.

Keywords: Translational Research; Biological Control; Interactome; Metabolome; Biotic interactions; Microbial inoculants

Abstract (IL 3.2)

Deciphering the pesticides impact pyramid for optimizing plant and soil health

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Pesticides and their use for control of plant diseases with a goal to kill pests and improve productivity is as old as the genesis of modern agriculture. It is a well established fact that use of pesticides is almost unavoidable given the present practices in agriculture. However it is an equally important fact that while the primary goal of pesticide usage is met with, to some extent, there is a huge dividend the environment has to pay year after year. This is because the pesticides applied leave more than 90% as residues in various environments impact soil, plant, water, air and human environments to different degrees. The manuscript explores the impact of pesticides and proposes the concept of Pesticides Impact pyramid. The four faces of the polyhedron are represented as the impact of pesticides on Humans, Plants, Water, Air and the base of polyhedron as the impact of pesticides on the Soil. A detailed discussion of the impact of pesticides on each of the 5 faces is presented. Introduction of Plant Growth Promoting Microbes in such a scenario and how their introduction facilitates better health and yield in agriculture context is presented with provision of real-time experimental data. The manuscript is a strong proponent of applying PGPM for sustainable and organic agriculture practices.

Key words: Pesticides Impact pyramid, Plant Growth Promoting Microbes, Pesticides, agriculture productivity, soil health

Abstract (IL 3.3)

The root microbiome and plant health

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In nature, plants are attacked by a multitude of pathogens and pests that cause major crop losses in agriculture. To protect themselves, plants can activate a sophisticated immune system. Moreover, plants nurture a large community of root-associated microbiota, which provide them with essential services, such as enhanced nutrient uptake, growth promotion, and protection against pathogens. Research in the Plant-Microbe Interactions group at Utrecht University is focused on understanding plant-beneficial functions encoded by the root microbiome and the role of plant genes facilitating these functions. Recently, we demonstrated that upon foliar pathogen infection, plant roots recruit a consortium of synergistic microbes to their rhizosphere that in turn trigger an immune response in the whole plant body. We also discovered that coumarins in root exudates play an important role in the chemical communication between plant roots and the root microbiome. With our research we aim to provide a rational basis for developing sustainable microbiome-based strategies for disease resistance in next-generation crops that produce more with less input of fertilizers or pesticides.





PARTICIPANT ABSTRACT





Abstract (3.1)

Potential multi stress tolerant plant growth promoting rhizobacteria (PGPR) as a biofertilizers enhance sustainable agriculture and environment during abiotic stresses

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Biofertilizers is an economically, environmentally beneficial for lower production cost. Plant growth promoting rhizobacteria (PGPR) can be used as biofertilizers and biocontrol agents in agriculture, forestry, and environmental rehabilitation. PGPR as Biofertilizers facilitates the overall growth and yield of crops in an eco-friendly manner. The usage of potential multi stress tolerant PGPR as a biofertilizer is helps to replace hazardous chemical fertilizers, pesticides, and other agrochemicals and to reduce the harmful impact of various stresses on plant growth, agricultural yields, reduce chemical contaminant in soil and improve soil fertility. Screening and characterization of stress tolerant bacterial strain is significant trait to development of biofertilizers for enhance agricultural yield and environmental *rehabilitation.* since the performance of PGPR is constrained by abiotic stresses including drought, salinity, heavy metals, temperature, and pH in the soil. PGPR can enhance plant stress tolerance by an array of mechanisms that encompass the production of ACC deaminase, regulation of the hormonal balance of cytokinins, gibberellins, production of EPS, and microbial biofilm formation for protection from external stresses such as drought, salinity, heavy metals, etc., the primary screening will be focused on drought, salinity and heavy metal tolerance and molecular characterization of selected strains by 16S rRNA gene sequencing. The ACC deaminase activity of the selected strains will be observed and the presence of *acdS* gene will be confirmed. PGP trait and green house experiments will be done for these strains to identify multi potent Plant growth promoting Rhizosphere bacteria. miRNA analysis will be performed for multi stress response in plants and potential multi stress tolerant PGPR strains. These physiological, biochemical and molecular characterization will help to predict potential ecofriendly multistress tolerant PGPR. We hypothesized that potential PGPR as a Biofertilizers will enhance sustainable Agriculture and environment during Abiotic stresses.

Keywords: Plant growth promoting rhizobacteria, Biofertilizer, Agriculture, Environment, Abiotic stresses

Abstract (3.2)

Presence of Vitamins, Minerals, Phytohormones and Polyphenols: An Abstract

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Moringa oleifera, a plant from the family Moringacea is a major crop in Asia and Africa. *M. oleifera* leaves are the most widely studied and they have shown to be beneficial in several chronic conditions, including hypercholesterolemia, high blood pressure, diabetes, insulin resistance, non-alcoholic liver disease, cancer and overall inflammation. The existing limited information on human studies and *M. oleifera* leaves is also presented.

Vitamins

Fresh leaves from *M. oleifera* are a good source of vitamin A. It is well established that vitamin A has important functions in vision, reproduction, embryonic growth and development, immune competence and cell differentiation. *M. oleifera* leaves also contain 200 mg/100 g of vitamin C, a concentration greater than what is found in oranges. *M. oleifera* fresh leaves are a good source of vitamin E, with concentrations similar to those found in nuts.

Polyphenols

The dried leaves of *M. oleifera* are a great source of polyphenol compounds, such as flavonoids and phenolic acids. Flavonoids, which are synthesized in the plant as a response to microbial infections, have a benzo-γ-pyrone ring as a common structure. The main flavonoids found in *M. oleifera* leaves are myrecytin, quercetin and kaempferol, in concentrations of 5.8, 0.207 and 7.57 mg/g, respectively. Quercetin is a strong antioxidant, with multiple therapeutic properties. It has hypolipidemic, hypotensive, and anti-diabetic properties in obese Zucker rats with metabolic syndrome. Phenolic acids are a sub-group of phenolic compounds, derived from hydroxybenzoic acid and hydroxycinnamic acid, naturally present in plants, and these compounds have antioxidant, anti-inflammatory, antimutagenic and anticancer properties. Chlorogenic acid (CGA) is an ester of dihydrocinnamic acid and a major phenolic acid in *M. oleifera*. CGA has a role in glucose metabolism. It inhibits glucose-6-phosphate translocase in rat liver, reducing hepatic gluconeogenesis and glycogenolysis.





Anti-Inflammatory and Immunomodulatory Effect

The extract of *M. oleifera* leaves inhibited human macrophage cytokine production (tumor necrosis factor alpha (TNF-α), interleukin-6 (IL-6) and IL-8), which were induced by cigarette smoke and by lipopolysaccharide (LPS). Further, it was reported that both *M. oleifera* concentrate and isothiocyanates decreased the gene expression and production of inflammatory markers in RAW macrophages. The extracts of *M. oleifera* leaves stimulated both cellular and humoral immune responses in cyclophosphamide-induced immunodeficient mice, through increases in white blood cells, percent of neutrophils and serum immunoglobulins. In addition, quercetin may have been involved in the reduction of the inflammatory process by inhibiting the action of neutral factor kappa-beta (NF-kβ) and subsequent NF-kB-dependent downstream events and inflammation. Further, fermentation of *M. oleifera* appears to enhance the anti-inflammatory properties of *M. oleifera.*





Abstract (3.3)

In vitro Studies on the Rhizosphere and Phyllosphere bacteria and their tolerance to abiotic stress

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Due to increase in both human population growth and environmental pressure it is necessary to raise agricultural productivity without enhancing environmental footprint. In particular, PGPB may improve plant growth either directly or indirectly by decreasing the inhibitory effects of various pathogenic agent. PGPB (plant growth promoting bacteria) is what at present is proving itself to be more promising better option. Sample collection from rhizosphere and phyllosphere of *Carica papaya.* Bacterial isolation on various media. Screening of PGPB for various plant growth promoting mechanisms was carried out. Tolerance of the selected bacteria to abiotic stresses salt and heavy metals was also be observed. Direct Plant growth promoting characteristics like: Nitrogen fixation, phosphate Zinc and Potassium solubilization, Production of IAA and other hydrolytic Enzymatic Activities, Caseinase, Lipase, Cellulase, Amylase, Gelatinase, Pectinase Ammonia and HCN production were also studied. Growth of the selected bacteria in presence of various salt and heavy metals like Nickel chloride and Cadmium chloride are determined. Various colonies were selected and then subjected to the analysis of PGP tr aits. Two out of Four bacteria showed promising results giving most of the characteristics positive. Then they were evaluated for tolerance to heavy metal and salt stresses. Out of which we found that 3.1 a gram negative rod was able to grow in presence of (5mg/ml of NaCl concentration) and also tolerated (4 mg/ml $NiCl_2$ and 3mg/ml of $CdCl_2$concentration). The bacteria coded 3.1 can be used to enhance plant growth in contaminated soils and hence be applied as plant growth stimulants for better agricultural practices for a sustainable environment. Further evaluation of this strain for plant growth promotion will be carried out.

Keywords: Environmental footprint, rhizosphere, Phyllosphere, Abiotic stress

Abstract (3.4)

Antibiotic resistance among rhizospheric bacteria isolated from chickpea field

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The usage of antibiotics in agriculture has been attributed to the spread of antibiotic resistant soil bacteria population including rhizospheric bacteria. The present study was undertaken to screen 170 rhizospheric bacteria isolated from chickpea field for their resistance to commonly used antibiotics viz. amphicilin , streptomycin, teracycline and chloramphinicol. Around 60% isolates exhibited resistance to both amphicilin and chloramphinicol. Resistance to streptomycin and tetracycline was observed in 48% and 45.3% isolates, respectively. Further studies to delineate the role of antibiotic resistant rhizospheric bacteria in enhanced plant growth and yield under degraded soil is under progress.

Abstract (3.5)

Functional validation of *OsNAM* gene in *Arabidopsis* shows its crucial role in plant-PGPR interaction by providing tolerance to abiotic stress and phytohormone crosstalk

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Salt stress is one of the key limitations that affect crop yield and development. Plants adapt and respond to salinity complex mechanisms that concern morpho-physiological, biochemical, and molecular changes. Alteration in the expression of various genes is known to occur during numerous abiotic stresses and confers stress tolerance. Recently, some known PGPR has also been used to alleviate the consequences of abiotic stresses; however, the molecular basis of such a relationship remains undeciphered. Therefore, the present study was aimed to interpret the PGPR, *Bacillus amyloliquefaciens*-SN13 -induced crosstalk among salinity and phytohormones in *OsNAM*-overexpressed *Arabidopsis* plants. Phenotypic data indicated increased root length, leaf size, rosette diameter, and biomass in transgenics than WT plants. The membrane integrity and osmolyte concentration under salinity were better under transgenic plants as compared to WT.

Modulation in ABA, IAA, and GA content in inoculated plants supported our findings on *Arabidopsis*–SN13 interaction indicating positive effects of SN13 on transgenic plants. Further, gene expression analysis of stress-responsive genes like *AP2/ERF, ARF2, GST* and, *ERD4* showed differential expression and their positive alteration in transgenic *Arabidopsis* exposed to salt stress in inoculated as compared to uninoculated WT. Overexpression of *Bacillus amyloliquefaciens* SN13-responsive *OsNAM* gene in *Arabidopsis* reveals its crucial role in beneficial plant and PGPR interaction by conferring abiotic stress tolerance and phytohormone regulation.

Keywords: *Arabidopsis;* No apical meristem (NAM); Overexpression; PGPR; Phytohormone; Salinity

Abstract (3.6)

Multiple roles of drought tolerant *Ochrobactrum* sp. in homeostasis maintenance in *Zea mays* under drought stress

Priya Jaiswal*, Shashank Kumar Mishra , Sankalp Misra, Vijay Kant Dixit , Puneet Singh Chauhan

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Drought stress globally effects agro-ecosystems. Drought has a negative impact on physiological, biochemical and molecular aspects of plants. In order to combat abiotic stresses PGPR are being employed which possess direct and indirect mechanisms of plant growth promotion under abiotic stress. The purpose of this study was to illustrate the role of *Ochrobactrum* sp. NBRISH6 inoculation on *Zea mays* "Maharaja" under drought stress via anatomical, physiological, metabolic, and molecular methods. The effect of NBRISH6 inoculation using maize as a host plant was characterized under greenhouse conditions in deficit water stress. Inoculation of NBRISH6 significantly lowered the expression of genes involved in the abscisic acid synthesis, deficit water stress-response, osmotic stress, and antioxidant enzyme activity (superoxide dismutase, catalase, ascorbate peroxidase, guaiacol peroxidase, and polyphenol oxidase). Phytohormones, i.e. indole acetic acid (IAA) and salicylic acid (SA) levels, intercellular CO_2 concentration, simple sugars, amino acids, aliphatic hydrocarbons, and the number of shrunken pith cells were modulated in maize roots inoculated with NBRISH6. The NBRISH6 inoculation also improved the plant vegetative properties like root and shoot length, dry weight of root and shoot, nutrients, xylem cells, root hairs, vapor pressure deficit, intrinsic water-use efficiency, photosynthesis rate, and total chlorophyll as compared to untreated plants. This study provides valuable insights into role of PGPR during drought stress and how they improve plant growth and physiology.





Abstract (3.7)

Mitigation of nutrient stress through modulating carbohydrate metabolism by PGPR Bacillus amyloliquefaciens in rice

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Nutrients are vital for proper growth and development of plants. For improving soil fertility, chemical fertilizers are being used in excess posing serious risk on the environment and public health. Plant growth promoting rhizobacteria (PGPR) is emerging as an eco-friendly alternative for enhancing soil fertility and crop production. The purpose of this study was to illustrate the role of two PGPR strains viz. *Baccilus amyloliquefaciens* SN13, *Paenibacillus lentimorbus* B-30488 and their consortium in alleviation of nutrient stress in rice (*Oryza sativa* L. var. IR-36). The effect of PGPR inoculation on nutrient stress using rice as host plant was characterized under controlled condition in growth chamber. Physiological, biochemical and agronomical parameters were observed. Total soluble sugar, electrolytic leakage, proline content, malondialdehyde content, relative leaf water content was modulated in control rice seedlings. The level of the analysed defense enzymes was also reduced significantly upon inoculation with PGPR. Bacterial inoculation also improved the uptake and partitioning of macro-micro nutrients. To explore the mechanism associated with PGPR induced nutrient stress tolerance in rice the gas chromatography-mass spectrometer (GC-MS) was used to determine the relative abundance of metabolites. On basis of physiological and biochemical analysis along with GC-MS data the seedlings inoculated with SN13 were comparatively healthier from other treatments and showed more tolerance to nutrient stress. Expression of various metabolism-related genes and transcription factors were analysed in SN13 inoculated seedlings under nutrient deprived and sufficient conditions, that further validated the ability of PGPR to mitigate nutrient stress in rice seedling through alteration in carbohydrate metabolism. This study facilitates the understanding of mechanism involved in PGPR induced tolerance to nutrient stress in rice.

Keywords: Nutrient stress, PGPR, GC-MS, Gene expression

Abstract (3.8)

Holistic approach of plant growth promoting rhizobacteria (Ochrobactrum sp.) on Maize (Zea mays) tolerance towards water stress

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Plant growth promoting rhizobacteria (PGPR) are usually considered economical and eco-friendly biofertilizer since the past few decades signifying its propitiousness for future sustainable agriculture. The rationale behind is that they improve plant health facing various biotic and abiotic stresses by influencing nutrient uptake, several morpho-physiological changes that eventually enhances the latter's stress tolerance ability. However, their putative involvement with underlying mechanisms in drought stress (WS) in plants has never been understood in a holism and therefore, needs immediate attention. This study was carried out to unearth the different mechanisms led by the potential impact of PGPR on the plant response towards WS. For the same, we considered previously established PGPR (*Ochrobactrum* sp. NBRISH6) for its effect on Maize (*Zea mays*"Maharaja") under WS conditions. A mélange of morphological, physiological, biochemical, metabolical, molecular, and ecological approaches were contemplated for PGPR treated plant response to WS. The results suggested that PGPR significantly enhance the WS tolerance ability in Maize with the influence on combination of mentioned mechanisms. The outcome shall strengthen our understanding of PGPR influence on plants by providing an insight into the multiple mechanisms involved in relieving environmental stresses such as WS. The integrated approach used in the study shall become a robust scaffold for the commercial usage of PGPR in further agriculture purposes.

Keywords: *Ochrobactrum* sp.; drought stress; *Zea maize*; PGPR

Abstract (3.9)

A comparative analysis to reveal the complex mechanism involved in nutrient stress tolerance in rice (Oryza sativa L. var. *Sarju-52*) induced by plant growth promoting rhizobacteria

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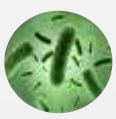
Deficiency of nutrients cause extreme damage to crops. In order to achieve maximum production in agriculture, a sufficient supply of nutrients is essential. Disproportionate/excessive use of fertilizers harm humans as well as environment. Plant growth-promoting rhizobacteria (PGPR) are reported to improve plant health under biotic and abiotic stresses. Therefore, the present study was done to see how PGPR, viz *P. lentimorbus* B-30488 (B-30488), *B. amyloliquefaciens* SN13 (SN13), and consortia, affect the growth of rice var. *Sarju-52*, when grown under inadequate nutritional conditions. The objectives of this study are: (1) To exploit and compare the potential of PGPR, viz B-30488, SN13 and their consortium, to ameliorate stress-induced by nutrient starvation. (2) Untargeted metabolite profiling and gene expression analysis to understand the complex mechanism involved in PGPR induced low nutrient stress tolerance. The individual PGPR treatments showed comparatively better performance than consortia in morphological, physiological, biochemical, and nutrient analysis. Metabolites such as oleic acid, mannitol, and ethyl iso-allocol were accumulated significantly under starved conditions. Under suboptimal nutrient conditions, ribose, glucose, fructose, trehalose, palmitic acid, and myristic acid were accumulated significantly in PGPR inoculated seedlings. The significantly altered pathways due to PGPR inoculation under suboptimal nutrient conditions mainly belonged to carbohydrate and fatty acid metabolism. Interestingly, amongst all the treatments, SN13 inoculated seedlings performed comparatively better. PGPR deploy metabolic re-programming to enhance its nutrient use efficiency, tolerance, and growth under suboptimum nutrient conditions in *Sarju-52*. Some of the identified metabolites can be promising biomarkers for improving low nutrient stress tolerance in Rice. The data provide information that may, with further investigation, help to understand pathways underlying low nutrient stress tolerance in Rice.


Abstract (3.10)

Exploring the potential of microbes in drought stress alleviation in wheat

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Drought stress is considered as one of the major agricultural obstacle which creates various changes in morphological, physiological, biochemical and molecular attributes of crop plants. Generation of free radicals and reactive oxygen species (ROS) such as super oxide radicals, hydrogen peroxide, singlet oxygen and hydroxyl radicals in plant cells are major consequences of drought. Higher amount of ROS may cause oxidative damage to plant. Plant growth promoting microbes can alleviate drought stress by modifying biochemistry of plant. Herein, present study was designed to elucidate the role of plant growth promoting microbes for amelioration of water stress in wheat. A pot experiment was conducted using randomised complete block design with 3 replications for exploring the effect of inoculation of BioNPK (microbial product) and *Archaea* on osmoprotectant and MDA (malondialdehyde) in wheat under water stress (50% F.C.). Total soluble sugar, protein, proline, Glycine betaine and MDA content in wheat root and leaves were determined. Microbial inoculation significantly decreased proline, glycine betaine and lipid peroxidation in wheat roots and leaves over the uninoculated water stressed (30%FC) control. Whereas, sugar and protein content were significantly enhanced due to microbial inoculation. Microbial inoculation created multifarious modulation in osmoprotective substance in wheat plant under water stress (30% F.C.).

Abstract (3.11)

Paenibacillus lentimorbus reduces nutrient deficiency in Cicer arietinum L

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Utilization of PGPR as an alternate and efficient technology in nutrient limited conditions will be helpful for sustainable chickpea production. Alteration in gene expression and metabolic profile under nutrient stress condition in chickpea also supported the stress amelioration capability of B-30488. To evaluate nutrient deficiency induced stress amelioration ability of B-30488 on chickpea plants and the possible mechanism involved in it. To determine the optimum nutrient concentration for chickpea growth, the screening experiment was performed under hydroponic conditions. Further, an extended plant test was conducted under green house with four different

treatments in chickpea plants namely N+ for nutrient sufficient, N+ + B for nutrient sufficient inoculated with B-30488, N− for nutrient deficiency, and N− + B for nutrient deficiency inoculated with B-30488. Determination of photosynthetic pigments, relative water content and membrane integrity were determined. Estimation of total proline content and total soluble sugar along with antioxidant enzymes assays and assessment of oxidative stress index were also estimated. Quantification of nutrient elements in chickpea was assessed under each treatment. Results demonstrated that plants inoculated with B-30488 showed positive modulation in physio-biochemical behavior and mineral nutrient uptake for better growth and development. Alteration in gene expression and metabolic profile under nutrient stress condition in chickpea also supported the stress amelioration capability of B-30488. Principal component analysis statistically proved that improved growth performance of chickpea plants under nutrient stress was mainly due to B-30488 induced modulation of metabolic pathways. Chickpea plants inoculated with *P. lentimorbus* B-30488 displayed greater flexibility and tolerance to nutrient deficiency due to PGPR induced alteration in gene expression and metabolic pathways.

Keywords: *Paenibacillus lentimorbus*, PGPR, *Cicer arietinum*

Abstract (3.12)

Extensive alteration in gene expression of *Bacillus amyloliquifaiciens*-rice under salt stress

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Transcriptome analysis through high throughput sequencing and discovery of candidate genes involved in plant-PGPR interactions can thus help us to better understand the complex networks that regulate root-rhizosphere signaling. To decipher the molecular mechanism underlying benefcial microbe-plant interaction in rice crop exposed to salt stress. Phenotypic characterization of rice seedlings based on important abiotic stress markers such as relative water content and electrolyte leakage were determined in leaf and root samples. Root samples were used for total RNA extraction using Spectrum™ Plant Total RNA Kit (Sigma, USA) which was then subjected to DNase treatment using TURBO DNase (Ambion, USA) for removal of DNA contamination. RNA-Seq libraries were prepared using the True-SeqTM RNA sample preparation kit (Illumina CA, USA). qRT-PCR was carried out using 2X Brilliant III SYBR® Green Q PCR (Agilent Technologies, USA) on a Stratagene Mx3000P (Agilent, USA) with cycling conditions and replications. Finally, ttransformation of OsNAM and OsGRAM gene in *Saccharomyces cerevisiae* and stress tolerance assays were performed. During stress, inoculation with SN13 significantly increased biomass, relative water content, proline and total soluble sugar in rice while decreased lipid peroxidation and electrolyte leakage. Extensive alterations in gene expression were also observed in rice root transcriptome under stress in the presence of SN13. Rhizobacteria induced changes in expression of a considerable number of photosynthesis,

hormone, and stress-responsive genes. To validate RNA-seq data, qRT-PCR was performed for selected diferentially expressed genes representing various functional categories including metabolism, regulation, stress response, and transporters. Results indicate qualitative and quantitative diferences between roots responses to SN13 under stressed and unstressed conditions. The comparative transcriptome study revealed that the plant response at the molecular level on *B. amyloliquefaciens* inoculation suggesting it as a potential microbe to be used as bioinoculants.

Keywords: PGPR; *Bacillus amyloliqifaiciens*; qRT-PCR; salt stress

Abstract (3.13)

Characterization of plant growth-promoting alkalotolerant *Alcaligenes* and *Bacillus strains* for mitigating the alkaline stress in *Zea mays*

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The potential of plant growth regulating microorganisms present in the degraded soil can be explored towards the purpose of identifying and developing stress tolerant strategies for enhanced crop productivity. The present study aimed to isolate and characterise alkaline stress-tolerant and plant growth-promoting bacterial strains from moderately alkaline soil (pH 8–9), strongly alkaline soil (pH 9–10), and very strongly alkaline soil. Further, total 68 bacteria were isolated, and screened for multiple plant growth promoting (PGP) attributes. Among these, 42 isolates demonstrating at least three plant growth promoting PGP traits were selected for further assays. Out of 42, 15 bacterial isolates were selected based on enhanced maize plant growth under greenhouse experiment, and 16S rRNA gene sequencing revealed *Bacillus* spp. as a dominant genus. Furthermore, based on improved seed germination percentage and biomass of maize (*Zea mays* L.) under alkaline stress conditions *Alcaligenes* sp. NBRI NB2.5, *Bacillus* sp. NBRI YE1.3, and *Bacillus* sp. NBRI YN4.4 bacterial strains were selected, and evaluated for growth-promotion and alkaline stress amelioration under greenhouse condition. Amongst the selected three plant growth promoting rhizobacterial (PGPR) strains, *Bacillus* sp. NBRI YN4.4 significantly improved the photosynthetic pigments and soluble sugar content, and decreased proline level in inoculated maize plants as compared to uninoculated control under stress conditions. Moreover, significantly enhanced soil enzymes such as dehydrogenase, alkaline phosphatase and betaglucosidase due to inoculation of *Bacillus* sp. NBRI YN4.4 in maize plants grown in alkaline soil attributes to its role in improving the soil health. Therefore, alkaline stress tolerant PGPR NBRI YN4.4 can be useful for developing strategies for the reclamation of saline/sodic soils and improving the plant growth and soil health in sustainable manner.

Keywords: Alkaline pH; *Bacillus*; Land degredation; 16s rRNA gene; PGPR

Abstract (3.14)

Abiotic stress tolerant *Jeotgalicoccus huakuii* NBRI 13E confers plant growth promotion and salt stress amelioration

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The present study aimed to characterize the potential of abiotic stress tolerant bacterial strain *Jeotgalicoccus huakuii* NBRI 13E as a microbial formulation for growth promotion and salt stress amelioration in maize. NBRI 13E was evaluated for abiotic stress tolerance and plant growth promoting (PGP) attributes under normal and salt stress condition. Phylogenetic characterization of NBRI 13E was conducted using 16S rRNA gene analysis. Plant growth promotion and rhizosphere colonization by NBRI 13E were also determined under greenhouse conditions. Field experiment was performed to assess the ability of NBRI 13E in enhancing growth, and yield of maize crop in natural stressed (highly alkaline soil; pH 10.2) soil. NBRI 13E demonstrated abiotic stress tolerance by with minimum ~ 4 Log_{10} CFU ml^{-1} for ten days and different PGP attributes in the presence of up to 1 M NaCl under *in vitro* conditions. Greenhouse experiments revealed that inoculation of NBRI 13E not only enhances the overall plant growth but also able to ameliorate salt stress in the tested host crops. Modulation in defense enzymes, chlorophyll, proline and soluble sugar content in NBRI 13E inoculated plants evident it's potential to mitigate the salt stress. The rhizosphere competent ability of NBRI 13E was observed in the range of 5.80–6.10 Log_{10} CFU g^{-1} in okra, maize, and tomato rhizosphere soil under the salt stressed condition for 45 days. Furthermore, field evaluation of NBRI 13E inoculation using maize was carried out with recommended 50 and 100% chemical fertilizer controls, which resulted in significant enhancement of all vegetative parameters and total yield as compared to respective controls. The study suggested for the first time that*J. huakuii*can be used to develop a bioinoculant formulation to ameliorate abiotic stresses and enhanced crop productivity.

Keywords: Abiotic stress; defense enzymes; *Jeotgalicoccus huakuii*; maize; PGP attributes

Abstract (3.15)

Rhizospheric salt tolerant *Bacillus* spp. promote *Zea mays* growth under salt stress by modulating ethylene metabolism

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Plant growth promoting rhizosphere (PGPR) bacteria are ubiquitous to virtually all terrestrial plants and are well known for their ability to enhance plant growth and productivity even under different environmental stress conditions. Some salt tolerant PGPR bacteria induce plant growth and reduce the negative impacts of salt stress through regulation of some biochemical, physiological, and molecular features. Here, we examined the propitiousness of three indigenous salt-tolerant PGPR strains *viz. Bacillus subtilis* (NBRI 28 B), *B. subtilis* (NBRI 33 N), and *B. safensis* (NBRI 12 M) for plant growth promotion and stress amelioration in *Zea mays*. NBRI 12 M exhibits maximum results for *in vitro* growth promotion and salt tolerance at 1 M salt (NaCl). Furthermore, all of the three *Bacillus* strains showed maximum plant growth promoting and salt stress ameliorating ability through successful colonization and mitigation of adverse effect of ethylene by modulating 1-aminocyclopropane-1-carboxylic acid (ACC) accumulation, ACC-oxidase (ACO), and ACC synthase activities under salt stress. Inoculation of these *Bacillus* spp. also shown to induce plant response for defence enzymes and other biochemical activities such as chlorophyll content, proline, soluble sugar under salt stress. Among three *Bacillus* strains, NBRI 12 M was observed to show maximum results for plant growth promotion in the greenhouse experiments as well. Thus, the outcomes of this comparative study represent for the first time that PGPR *Bacillus* strains are versatile in nature and are able to induce plant growth promoting (PGP) attributes under adverse environmental conditions along with high rhizosphere competence which alleviate salt stress by reducing the ethylene level in the host plant.

Keywords: PGPR; Defence enzyme; PGP attributes; Rhizosphere colonization

Abstract (3.16)

Exploitation of agro-climatic environment for selection of 1- aminocyclopropane-1-carboxylic acid (ACC) deaminase producing salt tolerant indigenous plant growth promoting rhizobacteria

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The indigenous agro-climatic environment has always been unexplored in the context of selecting efficient plant growth promoting rhizobacteria. However, native microflora has an advantage of local adaptation, they have rarely been explored and thus, exploited for proficient bioinoculants. A comprehensive survey for 09 agro-climatic zones of Uttar Pradesh, India was conducted to isolate and characterize salt tolerant 1-aminocyclopropane-1-carboxylic acid (ACC) deaminase possessing plant growth promoting (PGP) rhizobacteria for salt stress amelioration in rice. Isolation of salt tolerant bacteria was performed from arable soil of nine different agro-climatic zones. Isolated bacterial strains were screened qualitatively on the basis of ACC deaminase activity. Further, *in vitro* seed germination test in rice was conducted to select promising strains. Estimation of PGP attributes of selected isolates along with their abiotic stress tolerance ability was performed. The selected bacterial strains were identified based on 16S rRNA sequencing analysis. Finally, the selected bacterial strains were quantitatively estimated for having ACC deaminase activity and there *in vitro* effect on rice biomass and alleviation of ethylene stress was estimated. Out of 1125 isolated bacterial strains, 560 isolates were subjected for bacteria coated seed germination assay under 100 mM salt (NaCl) stress resulting to 77 isolates which were further evaluated for seed germination assay, PGP and abiotic stress tolerance ability *in vitro*. This evaluation revealed 15 potent rhizobacteria representing each agro-climatic zone and salt stress mitigation in vitro. This study provides a counter-intuitive perspective of selection of native microflora for their multifarious PGP and abiotic stress tolerance abilities based on the agro-climatic zones to empower the establishment and development of more suitable inoculants for their application in agriculture under local stress environments.

Keywords: PGPR; ACC deaminase; indigenous; agro-climatic zones

Abstract (3.17)

Drought inducible changes in chickpea root protein expression

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The present study mainly focused on protein profiling of chickpea root using two-dimensional gel electrophoresis (2-DE) and MALDI-TOF MS/MS together with a high-performance database search.The effect of drought and its tolerance mechanism, a comparative roots proteomic analysis of chickpea seedlings grown under hydroponic conditions for three weeks, performed at different time points using 2-Dimensional gel electrophoresis (2-DE). Protein spots were identified through MS spectrometer using a 4800 Plus MALDI TOF/TOF Analyzer. The real-time PCR analysis for selected genes using Fast SYBR Green PCR Master Mix (Agilent Technologies, USA) was performed. Western blot of some selected proteins was performed to validate the protein abundance data obtained from the proteomic analysis on Stratagene Mx3000P (Agilent, USA). PD-Quest analysis revealed 110 differentially expressed spots which were subjected to MALDI-TOF/TOF and 75 spots identified with a significant score. These identified proteins classified into eight categories based on their functional annotation. Proteins involved in carbon and energy metabolism comprised 23% of total identified proteins include mainly glyceraldehyde-3-phosphate dehydrogenase, malate dehydrogenase, transaldolase, and isocitrate dehydrogenase. Proteins related to stress response contributed 16% of total protein spots followed by 13% involved in protein metabolism. ROS metabolism contributed 13% (glutathione S-transferase, ascorbate peroxidase, and thioredoxin), and 9% for signal transduction (actin-101, and 14-3-3-like protein B). Five percent protein identified for secondary metabolism (cinnamoyl-CoA reductase1 and chalcone-flavononeisomerase 2) and 7% for nitrogen (N) and amino acid metabolism (glutamine synthetase and homocysteine methyltransferase).This study represents a small part of the chickpea root proteome, and detailed studies in the future on the identified proteins may help to understand the mechanism of drought tolerance. The information on root proteins using comparative proteomic analysis could practically be useful for developing biomarkers for genetic diversity analysis.

Keywords: Drought; Proteomics; Chickpea; MALDI-MS/MS; Western blotting

Abstract (3.18)

Current status of fertility indicators associated with arsenic-contaminated paddy fields soil

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Soil with heavy metal contamination harshly affect in rice cultivation land and the groundwater. In agricultural land for soil manipulation, Microorganism present in soil should be manifested to heavy metals. This presented work investigate the effect of heavy metal on microbial activity and community composition in cultivable soil of West Bengal State of India. This study revealed that heavy metal contamination affects soil fertility by negatively influencing its indicator except the soil total organic content which shows significant positive correlation with the heavy metals. The increase in heavy metal availability led to the decrease in nutrient growth limiting factors (N and P) and activity of different soil enzyme. In case of functional diversity of soil, all the considered diversity indices exhibited no specific pattern along with the availability of heavy metals. Soil with low microbial functioning will surely impact its ineptness to the growing crop. Among all the bacterial community c-Proteobacteria is most abundant. In soil functional diversity there is no remarkable change with heavy metal availability. The bacterial diversity and diversity resulted from C-source utilisation under heavy metal stress was complex and did not showed any specific pattern along with the availability of heavy metals. Observing all the results, we can conjecture that arsenic contamination is worsening the soil quality and hence needs importunate of concerned soil scientist and agronomists.

Keywords: Arsenic; Heavy metal; Microbial diversity; DGGE; Soil fertility

Abstract (3.19)

Comparative Proteomics approaches reveal PEG induced drought response in rice root

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Dynamic variations in protein abundance appear to be a frequent approach to dealing with abiotic stressors, which can be best investigated via proteomics. Drought response must be understood in order to unravel signalling pathways that will allow for improved adaptation. Rice (*Oryza sativa* L.) exhibit several adaptive and acclimatization strategies to combat environmental conditions such as drought. In this study, a thorough proteome characterization of rice root proteins was carried out under PEG-simulated drought stress conditions in order to better understand the mechanism underlying it. PDQuest analysis and MALDI-TOF MS-MS analysis was taken in account to rule out the 78 differentially expressed proteins spot among the 510 protein spots followed by 125 differentially regulated spots. These 78 differentially expressed proteins, which were involved in various biological pathways such as bioenergy and metabolism (29%), cell defence and rescue (22%), protein biogenesis and storage class (21%), miscellaneous function (19%), and cell signalling (9%), as well as some hypothetical proteins, made a significant contribution to drought regulatory mechanisms. During drought stress, 10 of the 78 differently expressed proteins were shown to be differentially regulated in all four phases. We hypothesize that improved drought adaptation may be due to increased protein synthesis, cell defence, and superior homeostasis. These results may help to speed up the functional determination of drought-responsive proteins. Numerous additional drought-responsive proteins still need to be addressed with technological advancements, which may aid in better understanding of the drought response in rice.

Keywords: 2DE; MALDI-TOF MS-MS; PEG; Drought stress

Abstract (3.20)

Effect of PGPR Co-inoculation on the growth of Maize plant (*Zea mays* L.) under drought stress

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PGPRs (Plant growth promoting rhizobacteria) are cultured microbes from rhizobiomes used to enhance plant responses against stresses such as biotic or abiotic. The extraction and characterisation of a total 8 bacterial isolates were cultured from the root rhizosphere of soil beneath maize plant, *Zea mays* L. (Poaceae family, Common name - Corn). The PGPR strain was further classified based on its cultural, morphological, and biochemical features such as ACC deaminase activity, auxin synthesis, inorganic phosphate solubilisation, and siderophore generation. In addition, the PGPR isolates were also evaluated for their antagonistic activity against standard cultures. Further, pot test showed that the PGPR treated seeds exhibited the higher growth as compared to untreated seeds. The findings of this research suggest that the PGPR bacteria can be utilised as bioinoculants and bio fertilisers for maize plant cultivation as they enhanced the growth of maize plant by inducing plant growth promoting properties like-IAA production and phosphate solubilization, respectively.
Keywords: Auxin synthesis, ACC deaminase, PGPR, *Zea mays*

Abstract (3.21)

Characterization of Arsenic and Cadmium Resistant Bacterial Diversity from Industrial and Mining Affected Area of Chhattisgarh

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Being an industrial state, the soil and water of Chhattisgarh are thickly contaminated with heavy metals, especially from arsenic (As) and Cadmium (Cd). In the present study, we isolated 108 arsenic and 58 resistant bacteria (both from soil and water) from 26 samples collected from 20 villages/city different industrial and mining sites of Chhattisgarh to explore the heavy metal bacterial diversity. Further, 24 potential isolates out of 108 for their ability to tolerate a high level of arsenic. The 16S rRNA gene sequencing of the of bacterial isolates revealed that they belong diverse genera including *Bacillus, Enterobacter, Klebsiella, Pantoea, Acinetobacter,*

Cronobacter, Pseudomonas, and *Agrobacterium*. Furthermore, atomic absorption spectroscopy (AAS) of the sample obtained from bioremediation assay revealed that *Klebsiella pneumoniae* RnASA11 was able to reduce the arsenic concentration significantly in the presence of arsenate (44 %) and arsenite (38.8%) as compared to control. Further, out of 58 bacterial isolates, 15 bacterial isolates were able to grow in presence of 40 mM cadmium chloride. However, finally five selected isolates were identified by 16S rRNA gene sequencing belonged to the genus *Serratia liquefaciens, Klebsiella quasipneumoniae subsp. similipneumoniae, Klebsiella pneumoniae, Pantoea dispersa* and *Enterobacter tabaci*, respectively. Among these two best culture *Serratia liquefaciens* BSWC3 and *Klebsiella pneumoniae* RpSWC3 were testes for their bioremediation efficiency individually as well as in mixed culture. Atomic Absorption spectrophotometer analysis of samples revealed that cadmium (Cd) tolerant bacterial isolates BSWC3, RpSWC3 and Combination of BSWC3 and RpSWC3 were significantly reduce of cadmium concentration i.e. 44.46%, 40% and 50.92%, respectively as compared to control. These bacterial isolates can be exploited for bioremediation of arsenic and cadmium contaminated sites.

Abstract (3.22)

Comparative efficacy of soybean bradyrhizobial strains and AM fungi for moisture stress tolerance in soybean by modulating antioxidant enzymes, osmolytes and improving nodulation, nutrient uptake and plant fitness

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Soybean (Glycine max L. Merrill) is emerging as one of the fastest-growing oilseed crops in the world. Due to having high protein (40%) and oil (20%), it is being used as potential feed for animals. Drought stress is the most important factor limiting the productivity of soybean. Breeding varieties for drought stress tolerance is a long-term approach. The uses of microbial intervention are known to confer tolerance in soybean and could be a viable and short-term solution to cope up with stresses. The potential application of microbes especially, bradyrhizobia and arbuscular mycorrhizal fungi (AMF) can help in nutrient mobilization and confer tolerance to plants by alleviating adverse effects of stresses. In the present study, we evaluated 03 promising soybean bradyrhizobial species recovered from root nodules of higher trehalose

accumulating soybean genotypes (*B. daqingense, B. liaoningense* from PK-472, B. *japonicum* from JS 93-05 soybean cultivars) with AMF and commercial local rhizobial strain along with uninoculated control in a pot trial using completely randomized design. The treatment consisted of 06 inoculations evaluated in soybean (cultivar JS 95-60) for moisture stress tolerance abilities (by withholding water on R5 stage till plants showing wilting). The efficacy of inoculations was carried out by determining different parameters such as nodulation (nodule biomass, leghaemoglobin content in nodules), root biomass, N content in the root and seed of soybean, grain yield, and physiological and stress tolerance parameters such as chlorophyll content, proline, relative water content (RWC) lipid peroxidase (MDA), superoxide dismutase (SOD) & Ascorbate peroxidase (APX) in plants. Results indicated that plants inoculated with rhizobial strains and AM fungi has improved nodulation, physiological and plant growth parameters when compared to control and local commercial strain. However, under both stress and normal conditions, the plants inoculated with *B. daqingense* followed by *B. liaoningense* and AMF had higher nodulation, N&P content, plant physiological and fitness parameters as compared to other inoculations. Amongst all, *B. daqingense* strain has been found to be the superior strain in promoting nodulation, plant fitness and mitigating moisture stress in soybean and hence, can be utilized for large scale field evaluation trials.

Keywords: Soybean rhizobia, AM fungi, moisture stress, plant fitness

Abstract (3.23)

Potential of Cyanobacteria for Zinc Bioavailability in saline soils

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Bioinoculants are highly promising for sustainable agriculture, in resolving challenges of agro-ecosystem and complex environmental problems. Cyanobacteria are most reliable as bioinoculants due to their high biomass yield, oxygenic photosynthesis, growth on no-arable lands, all water sources (contaminated or fresh), and soils exposed to erosion, salinization and nutrient depletion. Zinc is an essential micronutrient for soil fertility and its deficiency leads to physiological stress in plants. Substantial quantity of applied inorganic zinc in soils is often converted to insoluble zinc forms. Cyanobacterial transformation of complex soil zinc to plant available Zn, contributes to plant nutrition and growth promotion. Zinc is accumulated by Cyanobacteria through solubilization, mobilization, and concentration. Cyanobacteria employ several mechanisms like EPS production, polyphosphate granules, enzymes, Organic acids, methylation, decrease in pH, metallothionines and polymers of cell wall and capsule for soil zinc





bioavailability. Improved Cyanobacterial bioinoculants can be easily mass cultivated as ZSB. So it can be concluded that Cyanobacteria have a great potential as bioinoculants for zinc bioavailability in soils, as they are pioneers of colonization, eco friendly and sustainable even in alkaline soils. They suit the present agro ecosystem advocating organic farming and environment safety. Genetic improvements of Cyanobacteria, involving metallothionines and metal accumulation are the future perspective of this work. Cyanobacteria isolated from saline soils are enriched in selective media under optimum conditions, as monoaxenic cultures. Isolates are tested for zinc accumulation in different concentrations of zinc solutions enriched with consortia. AAS, FTIR, HPLC studies of the zinc solutions before and after growth is compared. Zinc bioavailability of each consortium is assessed, potential cultures are maintained for bio fertilizer production.

Keywords: Cyanobacteria, bioavailability, metallothionines, EPS, ZSB, AAS, FTIR, HPLC

Abstract (3.24)

Unrevealing the plant microbiome for mitigating drought stress in soybean

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Meeting the food demand of ever-growing population in the context of a changing climate and increasing environmental concerns of the excessive use of synthetic chemicals and fertilizers is a major challenge for the plant scientists. Soybean is the most important legume oilseed, food, feed and protein crop being gown throughout the world. Its productivity is largely depending on functioning of soybean microbiome encompassing plant growth promoting microbes performing various soil functions with plants as key drivers involved in nutrient cycling crucial for nitrogen, carbon and phosphorus transformations. The efficiency of soybean plant microbiome for nutrient transformations and sustainable crop yields depends on performance of candidate microbes inhabiting inside the plant (root, steam, seed etc.,). Soybean productivity particularly in India is

very low largely due to low and erratic rainfall and often affected by moisture stress. Therefore, the identification of climate resilient and moisture tolerant soybean bacterial endophytes need to be recovered and exploited. In present study we have recovered 27 potential isolates from root, seed and stem of drought tolerant soybean lines and have characterized them based on plant growth promoting traits under simulated moisture stressed conditions under *in vitro* using polyethylene glycol. The isolates were screened for plant growth promotion and stress tolerance parameters such as production of plant hormone-Indole acetic acid and ACC deaminase (1-aminocyclopropane1-carboxylic acid), phosphate solubilization, proline, siderophore and exopolysaccharides. The results indicated that out 27 potential bacterial endophytes, 09 endophytes (03 each from root, seed and stem parts) were found to be tolerant at 30% PEG 6000 (-1.07 MPa), higher production of ACC, IAA, proline, siderophore and exopolysaccharides as well as in phosphate solubilization. These isolates are being characterized based on FAME and 16S rRNA gene sequencing and novel strains will be further evaluated based on qPCR assays for ACC deaminase producing specific genes.

Keywords: Soybean, endophytic bacteria, moisture stress, plant health, nutrient mobilization

Abstract (3.25)

PGPR for abiotic stress management in Soybean crop

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Soybean (Glycine max L.) is an important oilseed crop around the world. Soybean growth, development and productivity are affected by changing environments that induce biotic and abiotic stresses. In soybean, salinity acts as a major abiotic stress that increases electrolyte leakage as well as Na+ and proline content in plants, and adversely affects plant physiology. Root-colonizing non-pathogenic bacteria can increase plant resistance to biotic and abiotic stress i.e.,plant growth promoting rhizobacteria PGPR are naturally occurring soil bacteria that aggressively colonize plant roots and benefit plants by providing growth promotion And essential for the ecosystem, and microbes are the natural partners that accommodate in plants to combat with antagonistic environment.The effect of PGPR like Bradyrhizobium and pseudomonas can be seen by different biochemical activity which in result show the presence of different enzymes. These enzymes work in reduction of biotic and abiotic stess of sybean and gives higher yield. NRC-138 JS-9752 SKFPS-11 DS3-108 NRCSL-1 NRC-136 MACS-1493 RKS-18 NRC-130 RSC-1103 NRC-147 NRC-137 BAUS-103 PS1611 RSC-1107 NRC-132





PS1613are the isolates in which gram staining Catalase, urease , Oxidase, amylase screening for temperature, pH, and salt were conducted . All stress tolerant isolates produced IAA(Indole acetic acid).PEG (6000) at OD 570 nm test is also conducted to get acquainted with the tolerance of stress. The best native stress tolerant isolates of soybean *Bradyrhizobium* and *Pseudomonas fluorescens* were RKS-18, SKFPS-11, BAUS-103. This functional diversity displayed by the isolates can be utilized for the legume crop production by cross inoculation.

Keywords: IAA, PGPR, PEG, Abiotic stress

Abstract (3.26)

Drought stress alleviation by ACC deaminase producing rhizobacteria isolated from soybean rhizosphere

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Most of the agricultural crops are affected with limited availability of the fresh water for irrigation. 1-aminocyclopropane-1-carboxylic acid (ACC) deaminase producing bacteria with multifarious plant growth promoting traits enhances plant growth and development under adverse environmental stress conditions by regulating plant ethylene levels. Additionally, these rhizobacteria have potential to solve future global food security problems. The present study, was conducted to study the efficacious functioning of ACC deaminase producing rhizobacterial strains on morphological and biochemical characteristics of Soybean. In the present study twenty rhizobacterial strains were isolated from disease resistant variety of soybean and were screened for ACC deaminase activity. Out of which, only five bacteria isolates, were able to convert ACC into ammonia and α-ketobutyrate, displaying ACC deaminase activity by producing more than ~500 nmol of α-ketobutyrate mg protein^{-1} h^{-1}, and assessed for multifarious plant growth promoting (PGP) traits including ammonia, indole acetic acid (>35 µg mL^{-1}), hydrogen cyanide (HCN) production and inorganic calcium orthophosphate (>70 µg mL^{-1}) solubilization. Besides PGP traits, these four bacterial isolates (AKAD 1-2, AKAD 1-3, AKAD 3-1, and AKAD 3-7) improved in vitro drought tolerance in response to drought stress (-0.73 Mpa). The bacterial strains AKAD 1-2, AKAD 1-3, AKAD 3-1, and AKAD 3-7 were identified as *Pantoea agglomerans* (MH304295), *Bacillus subtilis* (MH304311), *Bacillus cereus* (MH333217), and *Bacillus licheniformis* (MH304284) respectively on the basis of 16S rDNA gene sequencing and were assessed for growth promoting potential in soybean seedlings under well watered and drought stress conditions through pot experiments. Rhizobacteria treatment mitigated the negative effects of drought stress and increased shoot length (16%-68.6%), root length (40-108%), 14.87-42.69%, 11.36-67.3%, and 11.77-45% increase in proline, sugar, and protein content of soybean seedlings subjected to drought stress. However, these bacteria could be an effective bio-formulator for crop health improvement in drought-affected agricultural fields.

Keywords: PGPR, Drought stress, Rhizobacteria, Soybean, ACC deaminase

Abstract (3.27)

Screening and characterization of salt tolerant endophytes from the roots of wheat plant

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Salinity is a major global issue that inhibits plant development by inducing water stress, specific ion effects, and nutrient imbalance resulting in lessened crop growth and ultimately the harvestable yield. The area of salt affected non-arable lands is increasing day by day; however saline areas might have a tendency to be productive land with the help of beneficial soil microorganisms and for the same a wide range of adaptations and mitigation strategies are needed to be adapted to cope with such influences. The objectives of the research included isolation, screening, and characterization of bacterial plant growth promoting endophytes (PGPE) from the roots of wheat plants and to assess their effect on the plant growth and their productivity under salt stress conditions. Fresh and undamaged wheat samples were collected from agricultural areas of Northern India and bacterial endophytes were isolated from surface sterilized roots. Bacterial isolates were checked for nitrogen fixation activity, salt tolerance property, and other plant growth promoting (PGP) traits such as siderophore production, IAA production, accompanied by the solubilization of phosphorus (P), zinc (Zn), and potassium (K). Pot trials were also done to study the PGP responses of selected endophytes by taking wheat as an experimental crop. In the present study, a total of 42 endophytic bacteria were procured and the isolate PD25 was selected on the basis of PGP attributes for further experimental work. The endophyte was found to colonize and significantly enhance the plant growth under saline soil conditions in comparison to untreated experimental control. The data obtained from the research work signifies the prominent involvement of microorganisms in the agricultural sector and suggests that the novel bioformulations developed by these advantageous PGPE can be a potential development strategy in intensifying crop productivity in saline soils in the future.

Keywords: Sustainable agriculture, Salinity, Endophytes, Nitrogen, Bioformulation.

Abstract (3.28)

Characterization of exopolysaccharides extracted from salt-tolerant *Pseudomonas entomophila* PE3 and its role in promoting growth and yield of sunflower under salinity stress

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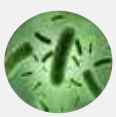
Climate change and increasing anthropogenic activities have led to salinization of lands in almost 100 countries including even the Polar regions. The sustainable solutions are limited and use of salt-tolerant plant growth promoting rhizobacteria (ST-PGPR) can be an economical and effective approach to dilute the toxicity of salts in plants. The study aims to isolate potential ST-PGPR and identify the role of metabolites such as exopolysaccharides (EPS) in eliciting resilience against salinity and promoting plant growth. The work also signifies the effect of salinity on composition and properties of EPS. Potent salt-tolerant strain PE3 was isolated from saline soil and various plant growth promoting (PGP) attributes were checked. Characterization of EPS was done through colorimetric assay and FTIR analysis. Novel bioformulation using selected strain (PE3) and its EPS was applied to sunflower plants under salt-stressed field conditions and the effect was observed. The selected strain PE3 was found to be tolerant up to 8% NaCl and was able to maintain PGP properties up to 4% NaCl. EPS production was highest at 2% NaCl and was concluded as the most dominant response of PE3 to salinity. The extracted EPS exhibited salt-tolerance traits including phenolic content, antioxidant activity, reducing power, sodium chelating ability, flocculation and emulsification activity. Further, EPS showed presence of functional groups including free carboxyl, hydroxyl, methylene, carbonyl, o-acetyl linkage and phosphorylated proteins and salinity changed the presence and absence of the groups. Field study showed significant improvement in growth and salt-resilience properties of treated sunflower plants as compared to untreated control. The combination of EPS and bacteria showed best results in comparison to solo treatments. EPS is an important metabolite to mitigate salt stress in plants and development of microbe based novel bioformulations using the metabolite can adorn the effectivity of PGPR.

Keywords: Salinity stress, ST-PGPR, Exopolysaccharides, Sunflower plants, Novel bioformulation


Abstract (3.29)

Salt-tolerant *Enterobacter hormaechei* subsp. *xiangfangensis* as a potential zinc solubilizer

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Salinity is the major abiotic stress affecting agricultural productivity in arid and semi-arid regions. In saline soils, due to high pH, the bioavailability of zinc is radically decreased which affects the yield and quality of crop production. To assess in vitro zinc solubilization potential of *Enterobacter hormaechei* subsp. *xiangfangensis* for better Zn uptake in plants. In this study, 62 bacteria were isolated from the rhizosphere of the wheat plant and tested for their salt tolerance and Zn solubilizing activity. Amongst them, one bacterial isolate SPJ-43 showed high salt tolerance (up to 8% NaCl) and the highest *in vitro* zinc solubilization. Further molecular identification of isolate by 16S rRNA analysis confirmed it to be *Enterobacter hormaechei* subsp. *xiangfangensi. In vitro* zinc solubilization potential of *E. xiangfangensis* on Bunt and Rovira medium amended with normal (without NaCl), 5%, and 8% NaCl concentrations and different salts of Zinc including ZnO, $Zn_3(PO4)_2$, and $ZnCO_3$ were assessed. Quantitative estimation of zinc solubilization by *E. xiangfangensis* using atomic absorption spectroscopy (AAS) was performed. *E. hormaechei* subsp. *xiangfangensi* showed zinc solubilization index (ZSI) of 3.8 (without NaCl), 3.71 (5% NaCl) and 3.2 cm (8% NaCl) in ZnO respectively. For $Zn_3(PO4)_2$, ZSI were 4, (without NaCl), 3.34 (5% NaCl), 3.4 cm (8% NaCl) respectively. When $ZnCO_3$ was used, ZSI were 5, (without NaCl), 4 (5% NaCl), 3.6 cm (8% NaCl) respectively. Quantitative estimation of zinc solubilization by *E. xiangfangensis* using AAS showed 48.6 (without NaCl), 61.8 (5% NaCl) and 76.3 ppm (8% NaCl) solubilization in ZnO. For $ZnCO_3$ solubilization were 67.4, (without NaCl), 77.0 (5% NaCl), 89.0 ppm (8% NaCl). While $Zn_3(PO4)_2$ solubilization were 15.4, (without NaCl), 7.2 (5% NaCl), 8.4 ppm (8% NaCl) respectively. The bacteria were also found to reduce the pH of inoculated broth which indicated the production of organic acids involved in *in vitro* zinc solubilization under salt conditions. *E. xiangfangensis* also showed multiple plant growth promoting activities including IAA, siderophore production and phosphate solubilization. Hence, this salt-tolerant *E. xiangfangensis* strain can be used as a bioinoculant that would also help in enhancing the bioavailability of zinc in plant grown under salinity stress.

Keywords: Zinc solubilizing bacteria (ZSB), *Enterobacter xiangfangensis,* Salinity, PGP.





Abstract (3.30)

Potential of *Pseudomonas* sp. in plant growth promotion and micronutrient biofortification of wheat under drought stress

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Drought is a major abiotic stress that has a devastating effect on crop development and nutritional content as it reduces chlorophyll, water status, osmolyte accumulation, carotenoids concentration, scavenging ability and agronomical factors of the plants. However, PGPR has the ability to give drought endurance to the plants, which can help to minimize the effects of drought in an eco-friendly and sustainable manner. Hence, the present investigation was performed in search of potential drought tolerant PGPR. During the current study, all bacteria were subjected to drought tolerance and plant growth promoting capacity. Among all *Pseudomonas* sp showed outstanding results in terms of ACC deaminase activity, i.e. 4.710±0.01 µM/mg/hr -ketobutyrate, IAA production i.e. 94.50.04 g/ml, and exopolysaccharide production i.e. 14.930.040 mg/mg protein. Furthermore, the drought tolerance conferring capacity of *Pseudomonas* sp. was proven by an in situ pot experiment. *Pseudomonas* sp. primed with seeds had the highest percent harvest index i.e. 31.06 % and retained more biomass compared to non-inoculated plants across all treatments. Furthermore, *Pseudomonas* treated plants also significantly increased with zinc and iron content of the grains. Additionally, the *acdS* gene was confirmed in *Pseudomonas* sp., through PCR amplification of *acdS* gene which is involved in the synthesis of the ACC deaminase enzyme, that decreases elevated ethylene levels under drought. The above results confirming the ability of the *Pseudomonas* sp. to augment plant growth promotion and micronutrient biofortification of wheat under drought stress Hence after field trials the *Pseudomonas* sp. could be developed as a potent drought tolerant PGPR that might be employed as a bio-inoculant to boost zinc and iron biofortification and crop yield under drought stress.

Keywords: PGPR, Biofortification, Drought tolerant, Wheat





THEME - IV





PGPR and other Microbes Based Technology for Crop Improvement

Chairperson :-

Dr. Naveen Arora

Convener :-

Dr. S. Krishna Sundari

Speakers:-

1. Dr. Alok Adholeya
2. Dr. Peter McEntee
3. Dr. K. Annapurna

SPEAKER'S ABSTRACT





Abstract (IL 4.1)

Role of nanotechnology in agriculture: Translational and adaptation challenges

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Nanomaterials are being produced and used in various sectors worldwide however use in Agriculture is a recent initiative. Toxicity of nano materials is a global concern particularly occupational hazard and safe use has been a challenge. Life cycle assessment studies conducted so far provides mixed results. On the other hand, regulatory systems are mostly under development across developed or developing countries. In view of these current situations developing products and processes for agriculture remains a major challenge. It is necessary that regulatory systems must be simultaneously developed. India took a major lead by not only supporting research in this area since more than a decade but also developed and released a policy document for regulators to take advantage across the board and remain prepared for regulating upcoming products and enable and encourage innovation across academia and industries. Developing safe product for agriculture is critical. Training and capacity building of researchers or research entrepreneur s is a key requirement to enhance translational success towards product or process development with adequate data to support regulation. Presentation shall elaborate on each of the above point.

Abstract (IL 4.2)

From Lab to the Field: Commercial formulation, production and marketing of microbial inoculant products to agriculture

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There has been a recent surge in interest and investment in microbial inoculants. This has been driven by projections of significant increases in global food needs and the increasing pressure to reduce reliance on synthetic fertiliser and pesticide use. However, converting potential biostimulant organisms/agents identified in research laboratories into the delivery of cost-effective products to farmers is a complex challenge faced by inoculant manufacturers. The commercial formulation and production of biostimulant products requires the co-ordination and integration of a host of physical, chemical and biological parameters. This begins with the isolation and screening of potential strains in laboratory tests, proof of concept testing in greenhouse trials, the evaluation of strain safety, the development of cost-effective nutrient formulations for mass production in fermenters, field trial testing, through to product registration and marketing. Importantly, these products must be easily incorporated into farmers existing production systems. All of these stages involve substantial costs. Moreover, suitable strains need to be able to be grown successfully in the "comfortable" environment of liquid culture but be able to survive, function and persist in varied, often harsh, soil environments. It is no secret that unpredictability in the efficacy of many biological products presents huge challenges for both manufacturers and farmers. The successful biostimulant producer needs to not only understand the production aspects of biostimulant manufacture, but also to build successful relationships with advisors, retailers and farmers. This is driven by having an evidence-based understanding of the situations under which their products will successfully establish and function in the field, providing simple, cost-effective strategies to producers.

Abstract (IL 4.3)

Microbial formulations in sustainable agriculture- Quality and monitoring tools

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The promising results of plant growth promoting bacteria (PGPB) at the laboratory scale have stimulated their biotechnological use as bioactive components in diverse bioproduct formulations (biofertilizers or bio-inoculants) that have been commercialized to improve the health and yield of crops. However, the success of PGPB technology has been challenged by the lack of consistent responses under agronomic conditions, owing to different soils, crops and climatic conditions. The farmers' preference of biofertilizers remains limited due to the poor level of quality, which often failed to perform under field
Conditions. The present quality standards of biofertilizer are a major concern, as there is no international agreement for them. None of the developed or developing countries enforce strain authentication of the biofertilizers, though several molecular and immunological tools are available to detect the strains at different stages of production
as well as under inoculated conditions. It is widely accepted that the effectiveness and prevalence of PGPB under field conditions depend on their versatility and adaptation to environmental changes as well as their ability to colonize and compete with other members of the indigenous plant microbiome (e.g., bacteria, fungi, archaea, protozoa, etc). Therefore, the tracking and monitoring of the PGPB used for plant, soil or seed inoculation is crucial for determining the factors influencing their efficient behavior under changing and complex field conditions.

PARTICIPANT ABSTRACT





Abstract (4.1)

Advances in PGPR Technology for Banana Cultivation for Betterment of Agriculture and Environment of *Khandesh* in *Tapati* river basin

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The diversified species of arbuscular mycorrhizal fungi (AMF) belonging to the genera *Glomus*, *Gigaspora*, *Sclerocystis, Scutellospora* associated with the corporate R & D banana *Musa paradisiaca* (dwarf Cavendish AAA, var. *Shrimanti*) orchards on a medium black alluvial soil, deficient in org. C, N and P; infected the roots severely (69.2 %), showed elevated (69.8 g^{-1} soil) spore density, increased soil microbial density (245 x 10^8 $cfug^{-1}$), produced siderophores (58.2 %) and reduced nematode population (2.3 g^{-1}) in the mycorrhizosphere of plants for integrated plant nutrition management (IPNM) system as compared to chemical fertilizers alone (traditional farming; 41.4 %, 45.9 g^{-1}, 60 x 10^6 $cfug^{-1}$, 18.4 % and 6.7 g^{-1}, respectively) and other test treatments. The native AMF association and application of microbial consortium of plant growth promoting rhizobacteria (PGPR) in the matrix of soil conditioner (SC) enabled proper nourishment and protection of crop in IPNM treatment as compared to traditional way that was evident from (a) reduced plant mortality, (b) enhanced greenery, (c) improved nutrients uptake, (d) elevated finger number and (e) overall vigor and robustness. Hence, microbial consortium approaches through judiciously designed IPNM system revealed the (i) relatively increased banana productivity, functional suckers and recyclable biowaste, (ii) least occurrence of fusarial wilt and negligible evidence of sigatoka, (iii) saving of chemical fertilizers and (iv) permitted control over soil fertility in producer's favor over traditional cultivation practices. Cluster development approach to these advances in PGPR technology for banana cultivation have resulted into betterment of agriculture and environment of *Khandesh* in *Tapati* river basin

Keywords: PGPR, IPNM, AMF, Soil Conditioner, Banana, *Shrimanti*





Abstract (4.2)

Enhancing the antinematode activity of bacterial based lipopeptide by integrating with plant growth-promoting rhizobacteria

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The bacteria secrete lipopeptide molecules which are known as a natural product antibiotic. Recently, research on lipopeptide molecules is a growing interest that acts as resistance to plant pathogens. The doses of isolated surfactin molecule of various concentrations viz., 35ppm, 25ppm, 15ppm, and 5ppm, respectively, were used in *in vitro* study for analysis of egg hatching inhibition and J2s mortality of root-knot nematode, *M. incognita*. The cell suspensions ($1.2x10^8$cfu/mL) of plant growth-promoting rhizobacteria (PGPR), *B. subtilis* (MTCC441) and *Pseudomonas putida* (MTCC102) were used in J2s inoculated tomato. Root-dip treatment of tomato seedlings in the crude lipopeptide (35 ppm) was also performed to analyse biocontrol potential. MALDI-TOF MS analysis was conducted to determine specific lipopeptide molecule. Data showed that per cent mortality was 85% in 35 ppm concentration of surfactin solution at 96 h of the exposure period. The maximum ovicidal activity was 83.97% when incubation made in 35 ppm concentration for the same exposure period. We noted that plant growth attributes along with biochemical parameters were significantly improved by using the PGPR suspension in tomato seedlings. We also recorded the reduction in egg masses, nematode population, and root galling. The J2s penetration in tomato roots was effectively managed by using the root-dip experiments. The surfactin's mass peak was determined at m/z 1058 $[M+Na]^+$ by MALDI-TOF MS. These results indicate that bacterial cells can be used as the potent versatile source to deal with nematode infection and a rich source of bioactive compounds with antinematode activity.

Keywords: Bacterial strains; Surfactin; MALDI-TOF MS; *M. incognita*; Management; Nematocidal activity

Abstract (4.3)

Diversity and functions of volatile organic compounds produced by rhizospheric bacteria isolated from sugarcane field

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Bacterial volatile organic compounds (VOCs) have emerged as a cheaper, effective, efficient, and an eco-friendly alternative. They play significant role in promoting plant growth by regulating the synthesis or metabolism of phytohormones. We conducted an experiment to investigate the effect of volatile organic compounds (VOCs) produced by the plant growth promoting bacteria isolated from the rhizosphere of the sugarcane field. We observed a significant increase in biomass of *Nicotiana benthamiana* under the experimental conditions. *N. benthamiana* plants showed the expression of plant growth required for the biosynthesis or metabolism in roots and leaves in response to bacteria VOCs. Our finding suggests that VOCs promote plant growth by triggering growth hormone activity and provide the understandings of different mechanism of plant growth promotion. This will help to develop the suitable technologies and guidelines for crop protection and management.

Abstract (4.4)

Role of Chitinases in the Development of Transgenic Plants and as a Bio-control Agent of Plant Pathogens: Recent Developments

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Chitinolytic enzyme (chitinases) is a group of enzyme that degrades chitin into low molecular weight oligomer and N- acetyl-D-glucosamine (NAG) monomer components by breaking the glycosidic bonds. The enzyme chitinase is broadly found in fungi, bacteria, archaea, crustaceans, invertebrates and also in higher plants. Fungal plant diseases are one of the major problems to agricultural production. Plant chitinase have antifungal activity to several fungi containing chitin

component in cell wall. Biological control of phytopathogens provides an alternative for management of fungal disease without any negative impact on environment. Manipulations of cloned chitinase gene in transgenic plant play a significant role in plant defense. Chitin and chitinolytic enzymes has an extensive range of applications currently in morphogenesis, biocontrol agent, preparation of single cell protein (SCP), bioconversion of water, mosquito and nematode control, bio-pesticides, pharmaceutical and in medicinal field. Using protein engineering and biochemistry we can produce chitinases with particular features that will make them more useful in the development of transgenic plants and for the biocontrol of phytopathogens.

Keywords: Phytopathogens, transgenic plants, biocontrol.

Abstract (4.5)

Synthesis of Green Nanoparticles: Antagonistic Studies for Biocontrol of plant pathogens

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Nanoparticles can be synthesized by physical and chemical methods, but have many drawbacks such as high energy requirements, are expensive, and also form toxic byproducts. Thus an alternative for the fabrication of nanoparticles is a biological route that is environment friendly and cost effective. Objectives of present study are: 1. To synthesize metal nanoparticles by microbial routes. 2. Characterization of synthesized metal nanoparticles. 3. To evaluate antifungal activity of synthesized metal nanoparticles against Plant pathogens. 4. To evaluate antioxidant activity of synthesized metal nanoparticles. In the present study, various soil samples were collected using standard microbiological protocols from Navsari and Dang district of the South Gujarat region. Isolation of bacteria was carrying out using different culture media like Nutrient agar, R2A agar, and Actinomycetes ag ar. These different bacteria were studied for their morphological, colonial and biochemical characteristics. Total 10 isolates were selected for the green synthesis of nanoparticles. Bacteria were subjected to growth in Luria Bertani media.
After 24 hours of incubation period supernatant was collected from the broth culture for the synthesis of Silver, Copper and Zinc nanoparticles. 9 ml of 1mM $AgNO_3$/ $CuSO_4$/ $ZnSO_4$ solution was mixed with 1ml of supernatant and incubate in dark for 24 hours at room temperature. The formed nanoparticles were characterized by initial visual observation of the change in color.





Characterization of Silver, Copper and Zinc particles was done by Uv- Vis spectroscopy and Fourier transform infrared spectroscopy (FTIR). Further characterization will be carried out by SEM and Particle size distribution. Bactericidal activities of biosynthesized AgNPs were determined by Kirby Bauer method. The green synthesized AgNPs, CuNPs, and ZnNPs exhibited strong antifungal activity against plant pathogenic fungi. Antioxidant activity was exhibited by 3 isolates. Testing of these nanoparticles for biocontrol of plant diseases will further be evaluated. Prospecting for new substances and research on the production, formulation and delivery would boost commercialization of such biocontrol agents.

Keywords: Nanoparticles, Bactericidal, Biocontrol

Abstract (4.6)

Molecular cloning of *COMT* and *CCoAOMT* genes in *Sorghum bicolor* for altering lignin content and obtaining better biofuel yield

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Lignin, one of the major components of plant secondary cell wall. The bioenergy produced from cellulose is obstructed by polymer of lignin which crosslinks with cellulose. The biofuels are non-polluting and safe to the environment. Upstream processing of separation of lignin is the major step in the production. The composition of lignin is modified by molecular cloning of *COMT* and *CCoAMT* genes (these genes expression produces monolignols which polymerize to form lignin), the modification include alteration of lignin biosynthetic pathway at different steps, so that the upstream procedure of biofuel production is easier and less cost effective. Hence, the lignin can be easily separated from cellulose which helps in production of biofuel. The separated lignin is used in formation of activated carbon, binders, motor fuel, sorbents, etc.

Key words: Lignin, Cellulose, Cloning, Biofuel production.

Abstract (4.7)

Role of PGPR in Sustainable Agriculture

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Food production asper the demands of growing population is the major challenge now across the globe. Industrialisation, urbanisation, civilisation are the major reasons as they cause destruction of Agriculture land. With the reduction of Agriculture land food production decreased. The need of the hour in todays world is increasing food production with limited agricultural land resources. In initial stages chemical fertilizers used for increase in productivity but resulted in loss of fertility of soil and effected human health negatively. Due to this usage of organic manures, bio fertilizers came into focus. In this context Plant growth promoting rhizobacteria contribute a lot in sustainable agriculture increasing productivity and soil fertility. PGPR Bacteria also relieves the plants from biotic and abiotic stress. Commercially Markets are increasing for the biofertilizers in which microorganisms are the major constituents which in parallel helps in soil conservation. Out of Many microorganisms rhizobacteria plays significant role in plant growth providing the required nutrients. Biofertilizers helps in sustaining soil structure, increases productivity and effects human health positively

Abstract (4.8)

Exploiting plant growth promoting activities of actinomycetes for sustainable agriculture

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Plant Growth Promoting Rhizobacteria (PGPR) are considered as the biological agents for improving plant growth. Actinomycetes play an important role in growth promotion of plants and also a major role in biogeochemical cycles. A lot of research has been carried out using bacteria and fungi as PGPR but use of actinomycetes as potassium solubilizer is less explored area, so in reference to above context potassium solubilizing actinomycetes were isolated which could be used for development and formulation of new technology for non

polluting farming practices and biofertilizer. The objective of this study was to isolate and screen potassium solubilizing actinomycetes from ceramic industry soils. Total 22 potassium solubilizing actinomycetes were isolated, out of which two isolates (KSA 16 and KSA 09) gave highest solubilization of insoluble potassium source i,e feldspar in liquid medium. The selected isolates were able to produce plant growth promoting substances like IAA (22 ppm , 10 ppm respectively) and Gibberellic Acid (GA).This two isolates were selected for further studies for promising future prospects.

Keywords: Solubilization, Actinomycetes, Potassium, Fertilizer, PGPR .

Abstract (4.9)

Nanomaterial ecotoxicity towards enzymatic activity of plant growth promoting soil microbes

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The applications of nanomaterials are increasing in various fields due to their tremendous output. The high surface to volume ratio characteristic enhanced their activity many folds in comparison to their bulk counterparts. Nanomaterial have shown positive and negative impact on biological matter through affecting their biochemical activities. The engineered nanomaterials have shown mixed effect on microbial physiology and their enzymatic activities, which play a significant role in different biogeochemical cycles. High concentration of metal nanoparticles has also shown negative impact by disorganization of microbial community structure, which affects the soil fertility and food chain system due to role of microbes in disintegration of complex substrates. Various synthesized nanomaterials have shown their role in induction or suppression of different microbial enzymatic activities such as dehydrogenase, phosphates, urease, nitrogen fixation and ammonia oxidation and influenced related microbial community. In the present study we discussed about the role of various engineered nanomaterials in distracting the microbial community structure, Further, the impact of such nanomaterial on different microbial enzymatic activity has also been presented. We also highlighted the negative impact of nanomaterial on microbial physiology and ecotoxicity to soil microbial flora.

Abstract (4.10)

Bacillus - novel genera of PGPR by its bio-prospecting properties

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Research in the area of plant microbe's interaction (PMI) has opened up a fascinating world of remarkable diversity not only in terms of the rhizobacteria but also in terms of the beneficial microbe and their effects involved in agriculture. Numerous species of *Bacillus* flourish in the rhizosphere of plants and activate or stimulate plant growth by plethora of mechanisms. In recent times, chemical fertilizers and pesticides are indispensable for higher yield of crops, impart hazardous effect on soil-microbe-ecological balance and residual problem. This has diverted the attention of researchers toward alternate methods plant disease control. The present study was carried out to evaluate and characterize of various PGPR properties and induction of defense related enzyme by cellulolytic bacteria *Bacillus amyloliquefaciens* isolated from soil rhizosphere in singly and consortia assortment against *M. Phaseolina* (Tassi.) Goidanich. *B. amyloliquefaciens* was isolated from the soil-rhizosphere using NA and purified by TSA (Hi-Media) with endospore stain kit. Single colony was taken for selection of the isolates. 16S r- DNA gene was PCR amplified with Forward (5'-AGAGTTTGATC CTGGCTC-3') and Reverse (5'-GGTTACCTTGTTACGACTT-3') primers in ABI 3730xl sequencer. Amplicon electrophoresed in 1% Agarose gel and visualized under UV by BLAST of NCBI. Among isolated strains *Bacillus amyloliquefaciens* (AB909000) showed the best effect in phosphate solubilisation efficiency (73.33%), seed germination (96.66%) and seedling growth of jute, almost near the highest ability to pathogen inhibition (74.26%), reduction of stem rot disease severity (62.9%) in the green house test. It was unique compared to all parameters and enhanced the activity of defence enzyme peroxidase (PO) even after challenge inoculation, has tremendous potentiality to control notorious pathogen *M. phaseolina* and plays unique role in plant growth promoting activities (IAA, Siderophore, HCN) in jute by its novel properties over the others.

Abstract (4.11)

Inoculation of Zinc Solubilizing Rhizobacteria Modulate Zinc Bio-fertilization and Bio-fortification in Wheat Crop

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Zinc and other micronutrients are needed for optimum growth and development of plant. Contrary to chemical zinc fertilizers, use of zinc solubilizing bacteria is an alternate option to enrich different components of crop plants with zinc. The present study was designed to select potential zinc solubilizing rhizobacteria from rhizosphere soil of chickpea crop of eastern Uttar Pradesh and to further assess their impact on magnitude of zinc assimilation in wheat crop. Of the 15 isolates, CRS-9, CRS-17, CRS-30 CRS-38 isolates produced net soluble zinc in broth to the tune of 6.10, 5.90, 5.63 and 5.60 µg ml^{-1}, respectively, in zinc phosphate with corresponding pH being 4.48, 5.31, 5.20 and 4.76.These four bacterial isolates were identified as *Bacillus glycinifermentans* CRS-9, *Microbacterium oxydans* CRS-17, *Paenarthrobacter nicotinovorans* CRS-30 and *Bacillus tequilensis* CRS-38 on the basis of morphological, biochemical and 16S rRNA gene sequencing basis. In a microcosm experiment, after 30 days of sowing of wheat, 8 *TaZIP* transporter genes were expressed maximally in roots with concomitant accumulation of higher zinc content in bacterially inoculated plant as to compare absolute control. Out of four strains tested, two bacteria *B. tequilensis* CRS-38 and *P. nicotinovorans* CRS-30 improved seed germination (%), vigor indices (2-2.5 folds), plant biomass, grain yield (2.39 g $plant^{-1}$), biofertilized shoot and biofortified grain with Zn (54.25 µg g^{-1}) of wheat crops. To the best of our knowledge, this is the first report of presence of zinc solubilization trait in *B. glycinifermentans* CRS-9, and *M. oxydans* CRS-17and *P. nicotinovorans* CRS-30.

Keywords: Rhizobacteria, Wheat, Zinc phosphate, Biofortification, Biofertilization, Zinc solubilizing rhizobacteria

Abstract (4.12)

Effective utilization of certain dried weed leaves as an alternative carrier for *Rhizobium* bioinoculant

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Altering the rhizosphere microflora by seed or root or soil inoculation with specific organisms has long been recognized as a practical possibility, however, formulation inadequacies, nonavailability of good quality inoculums, and increasing cost of carrier materials are often the most common barriers to the commercialization and widespread adoption of bio inoculants. The carrier-based bio inoculants produced in India generally suffer from short shelf life, poor quality, high contamination, and low and unpredictable field performances. Therefore, it is necessary to develop an alternate low-cost formulation of bio inoculants and in this context formulation of different carrier-based bioinoculant *viz.,* dried weed leaf powder-based carriers could play a significant role. Consequently, keeping these perspectives, the present study was planned to improve the quality of *Rhizobium* bioinoculant using different low-cost formulations. The long-term storage of *Rhizobium* bioinoculant under dried weed leaf powder-based formulations was studied for twelve months. Among the three different dried weed leaves, the *Calotropis gigantia* showed maximum rhizobial population followed by *Eichornia crassipes* and *Ipomoea carnea*. The *Rhizobium* population recorded in *Calotropis gigantia* during the 6th month was 9.64×10^{8} CFU g^{-1} which was followed by *Eichornia crassipes* (8.47 ×10^{8} CFU g^{-1}) and 8.26 ×10^{8} CFU g^{-1}in *Ipomoea carnea* dried leaf powder-based formulations. The observation continued up to nine months shows a satisfactory rhizobial population in *Calotropis gigantia* with 8.93 ×10^{8} CFU g^{-1} and was significantly superior to the other dried weed leaf powders.

Keywords: *Rhizobium, Calotropis gigantia, Ipomoea carnea,* and *Eichornia crassipes*

Abstract (4.13)

Shelf life studies on the survival of *Azospirillum Lipoferum* bioinoculant in lignite carrier with different organic amendments

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A study was conducted to evaluate the survival of *Azospirillum lipoferum* bioinoculant in sterilized lignite by adding certain organic amendments such as, sawdust, paddy straw powder, wood charcoal, farmyard manure and poultry manure. The survival of *Azospirillum lipoferum* bioinoculant, were estimated at monthly intervals over a storage period of six months. From the studies, the carrier lignite was chosen as the best carrier among different carrier materials tested, based on the survival of *Azospirillum*, moisture content and pH. The results revealed that all the amendments tested were able to increase the surviving population of *A. lipoferum* when compared to lignite. Among the different amendments, saw dust at 2% level was found to record a maximum population of 9.80 Cfu g^{-1} of carrier on the 6th month of storage followed by paddy straw powder 9.55Cfu g^{-1}, poultry manure 9.40 Cfu $g^{-1,}$ farmyard manure 9.03 Cfu g^{-1}, poultry manure 9.40 Cfu g^{-1}, farmyard manure 9.03 Cfu g^{-1}, and wood charcoal 8.40 Cfu g^{-1}. It is also observed that, the population of *A. lipoferum* increased up to 3rd month in lignite with amendments, whereas in lignite alone, the population increased only up to 1st month of storage. The statistical analysis revealed that, the reduction in the population was not significant in lignite plus amendments, but in lignite alone showed statistically significant reduction in population of *A. lipoferum*.

Keywords: *Azospirillum lipoferum*, Organic amendment, Shelf-life enhancement

Abstract (4.14)

Postbiotics produced by plant beneficial bacteria for betterment of agriculture and environment

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Soil consists of heterogeneous group of microorganisms such as bacteria, fungi, algae, protists which balance the nutrient cycling, soil fertility and environment. However, the continuous use of chemicals in agriculture resulted in environmental degradation, including climate change, biodiversity loss, soil and water pollutants. The use of plant beneficial microorganisms (PBM) and their fermented products, termed postbiotics are gaining importance for plant growth, biotic and abiotic stress mitigation, biofortification of nutrients. With this focus, we have worked to characterize bacteria from different sources and evaluate for production of different postbiotic molecules of PBM such as hormones, enzymes, organic acids, cell free supernatant, exopolysaccharides, biosurfactants for plant growth promotion, heavy metal tolerance, antifungal activity and atrazine biodegradation. Few potential bacteria were identified as *Bacillus subtilis*, *Bacillus amyloliquefaciens*, *Bacillus velezensis, Bacillus mojavensis*, *Bacillus cereus*, *Stenotrophomonas maltophilia*, *Pantoea allii*, *Pseudomonas lini*, *Pseudomonas migulae* and *Rhizobium undicola* using 16srRNA sequence. Hence, formulation of microorganisms along with different postbiotic molecules for their specific applications is the new paradigm to manage and stimulate healthy plant microbiome to augment crop productivity.

Keywords: Bacteria, Postbiotics, Plant growth, Antifungal, biodegradation

Abstract (4.15)

Impact of *Acetobacter* isolates in sweet corn (*Zea mays L. saccharata*) in field experiment.

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The present experiment was carried out in Department of Soil Science and Agricultural Chemistry at IGKV, Raipur, Chhattisgarh in the year 2017-18. It comprised in experiments in order to select effective local isolate$_{(s)}$ of *Acetobacter*. Forty-five *Acetobacter* isolates were isolated from 63 soil samples collected from sweet corn growing areas of Chhattisgarh. Out of forty five isolates the best ten were selected for field experiments. Under field experiment the highest green cob yield was recorded 8524.79 kg/ha followed by 7766.04 kg per ha, and stover yield was observed 8036.82 kg/ha followed by 7519.73 kg per ha, due to seeds inoculated with local *Acetobater* isolate no.18 and 16 respectively and lowest was associated with control (3478.54 kg/ha.). The highest total sugar content was observed with isolate no. 18, (8%). The highest nitrogen uptake was observed with isolate no. 16 (161.60kg/ha) whereas, the lowest was observed with isolate no.31 (112.52 kg/ha).

Abstract (4.16)

Influence of Organic and Biodynamic Manures on Soil Microbial Dynamics and Soil Nutrient Parameters in Chrysanthemum (*Dendranthema grandiflora* Tzvelev) cv. Thai Chen Queen

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Excessive use of inorganic fertilizers in raising of crops is deleterious to soil health and environment. Application of organic and biodynamic manures help to maintain soil fertility, soil microbial population and quality flower production. Keeping in view, an experiment was conducted at Model Floriculture Centre, GBPUAT, Pantnagar, during 2018-19 and 2019-20 to study the response of effects of organic nutrient management practises on the biological properties of soil in chrysanthemum cv. Thai Chen Queen. The experiment consisted of sixteen treatment combinations plotted using a randomised block design, replicated thrice. During chrysanthemum harvest, soil treated with Panchagavya 6 % + common basal dose (T_7) had

considerably higher bacterial, fungal, and actinomycetes populations, as well as more N-fixers and P-solubilizers than the other treatment combinations. Additionally, the impact of organic farming practises on soil health in the region was investigated using basic soil parameters. The results indicate that when 6% Panchagavya along with common basal dose is applied, both the microbial population and essential nutrients increased in soil. The pH, E.C and organic carbon concentrations were all close to neutral.

Keywords: Chrysanthemum, Panchagavya, Jivamrita, Bio-fertilizers, Soil microbial population, Soil nutrient parameters, Organic farming

Abstract (4.17)

Synergistic effect of vermicompost and bioaugmentation of liquid based biofertilizer on growth of *Cucumis sativus* var. Green sikhar SPL. (Cucumber)

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Presenting author: Anjulata Suman Patre

The field used in this study was from a site situated of Allahabad School of Agriculture, University campus of SHIATS. Before starting an experiment, composite of soil samples from the surface 0 to 20 cm depth were collected and analyzed for physical and chemical characteristics. The data recorded during course of investigation were analyzed statistically using sample standard deviation one way analysis of variance. Vermicompost, is a mesophilic biodegradation product where biofertilizers are commonly known as microbial inoculants that enhance plant growth. *Pseudomonas aeruginosa* was characterized as a gram negative rod shaped bacteria showing positive biochemical test. *Pseudomonas aeruginosa* was assayed for phosphate, Zinc, Potassium solubilization in different media it produce IAA, Auxin, HCN and it showed PQQ independent activity. Phosphate solubilization index was higher in NBRIP (3.44±0.19) as compared to PVK media (1.51±0.02). *Pseudomonas aeruginosa* had a shelf life of 70 days. Physico-chemical analysis of vermicompost had increase in Carbon%, Nitrogen%, Calcium from 0 to 60 days of maturation as (4.10, 0.66, 0.08 and 1.60) pH changed from 7.5 to 6.9. Physico-chemical properties were recorded as Nitrogen (0.041%), Potassium (0.073%), Organic carbon (0.066%), and Phosphorus (0.650%). Vermicompost + Carrier Based *Pseudomonas aeruginosa* Biofertilizer showed best *Cucumis sativus* for all growth parameters *viz* seed germination (%), shoot length (10.83±0.2, 10.53±0.3), leaf length (5.69±0.07), number of fruit (1.13±0.11) and root length (21.33±2.80). In conclusion use of vermicompost and *Pseudomonas aeruginosa* as biofertilizers enhanced growth of yield of *Cucumis sativus.*

Keywords: *Pseudomonas aeuroginosa*, PGP activity, Carrier based biofertilizer, Vermicompost, *Cucumis sativus* Green shikhar

Abstract (4.18)

Development and characterization of *in-silico* based EST-SSR markers in *Withania somnifera* & *Centella asiatica*

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Simple sequence repeat (SSR) markers obtained from expressed sequence tags (ESTs) are primary resources for gene discovery and mapping. The objective of the work presented here is to develop EST based SSR markers in, *Withania somnifera* (Ashwagandha) and *Centella asiatica* (Brahmi) and to study it. Both the plants are medicinally important and contain several alkaloids, essential proteins, and metabolites. In this study, a total of 742 *Withania somnifera* EST sequences & 4501 *Centella asiatica* EST sequences retrieved from dbEST database in FASTA format . (http://www.ncbi.nlm.nih.gov/nucest) on 17 June 2020, among these EST-SSRs, for *Withania somnifera* 335 SSRs identified 306 repeat units for mononucleotide repeats, 11 repeat units for dinucleotide repeats and 18 repeat units for trinucleotide repeats. Where, for *Centella asiatica*, there were 1389 SSRs identified 1122 repeat unit for mononucleotide repeats, 171 repeat units for dinucleotide repeats, 91 repeat units for trinucleotide repeats and 5 repeat units of tetranucleotide repeats. The most abundant repeat motifs found in this study are AG/CT (58.5%), AAG/CTT (29.5%) & AAAG/CTTT (40%) for dinucleotide, trinucleotide & tertranucleotide repeats, respectively. Out of these SSR-containing ESTs, a total of 260 primer pairs were designed for *Withania somnifera* and 780 primer pairs were developed for *Centella asiatica*. After the BLAST alignment of EST-SSR, their functions were identified and were characterized based on that. Many metabolically active proteins and enzymes were identified in both plants out of which a total of 52 protein structures were predicted. In conclusion the results of this study demonstrate that genotyping *Withania somnifera* & *Centella asiatica* accessions with microsatellite markers can quickly reveal the genetic diversity among accessions as the polymorphic EST-SSR markers constructed in this study will considerably enhance the number of informative microsatellite markers available for genetic analysis.

Keywords: Expressed Sequence Tag, Simple Sequence Repeats, *Withania somnifera* and *Centella asiatica*

Abstract (4.19)

Deciphering the potential of PGPR and their consortium on wheat productivity improvement grown under different geographical locations

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Wheat (*Triticum aestivum* L.) is an essential staple food crop for mankind. All over the world it's is grown in about >200 million hectares and just meet 21% of its global demand. Moreover, in present situation world agriculture is suffering from a number of problems such as reduced nutrients in soil, temperature of top soil, pathogen attack and poor agronomical practices, are responsible for reduction in crop quality and quantity. Various techniques are practicing to combat this problem but these are associated with their own limitations. In this context, current research targets for the exploitation of potential plant growth promoting rhizobaetria (PGPR) and their consortium as they are safe, inexpensive, effective and has long-lasting approach with ultimate solution for assisting plants through enhancing their growth and yield in a sustainable manner. Therefore, current research aims to find potential PGPR and development of their consortium for wheat improvement at different geographical locations of Uttarakhand. Initially eighty-four bacterial cultures were isolated and screened for *In vitro* plant growth promoting (PGP) traits. Quantitative expression of PGP traits were also measured for selection of potential bacterial isolates. The compatibility of potential bacterial isolates was evaluated with each other for the development of consortium. Bacterial isolates and consortium were found to possess multiple PGP traits i.e. phosphate solubilization, siderophore production, zinc solubilization, potassium solubilization, indole acetic acid and exo-polysaccharide production. Furthermore, potential bacterial isolates and their consortium were assessed for their plant growth and yield promoting potential on wheat under field conditions. The outcomes of the trials confirmed the efficiency of bacterial isolates through enhanced yield and other agronomical parameters over control. The results of the study concluded that after further evaluation under field demonstrations these potential bacterial isolates and consortium can be utilized as plant probiotic agents to enhance quality and productivity of wheat in a more eco-friendly manner to improve sustainable agriculture.

Keywords: PGPR, Wheat yield, Plant growth promotion, Consortium

Abstract (4.20)

Bacterial mediated zinc biofortification of two rice varieties grown in Terai region of Uttarakhand

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Bacterial significance is broadly ascertained as an eco-friendly approach for enhanced productivity of food crops. Formulations of agriculturally important bacteria especially zinc solubilizing bacteria (ZSB) having plant "probiotic traits" is in trend to rectify the issue of zinc (Zn) scarcity in plants. As natural biostimulants, they also encourage plant growth and diminish the massive dependence on the extensive application of chemical fertilizers. The organic acids produced by ZSB solubilize the insoluble form of Zn in nearby soil and consequently plants readily taken up the solubilized Zn. In our study, one prospective bacterial strain *Burkholderia cepacia* BMRR126 showed potential Zn solubilizing activity along with other plant growth-promoting activities under in vitro assays. The treatment containing *Burkholderia cepacia* BMRR126 + ZnO (zinc oxide) supplement (@60kg/hectare) augmented the overall plant growth and yield of two paddy varieties (*Pusa Basmati-1* and *Pant Dhan-18*) in comparison to untreated control under field trial. Moreover, the similar treatment also showed 1.52 fold and 1.44 fold increment of the Zn content in the grain part over untreated control for both paddy varieties *Pusa Basmati-1* and *Pant Dhan-18,* respectively. The soil parameters of treated plots such as pH, EC, organic carbon, NPK, and available Zn were also positively influenced under single bacterial treatments as well as treatment containing bacterial strain + ZnO supplement compared to uninoculated control. Outcomes of the present study indicate that ZSB with a low-cost resource of Zn supplement (ZnO) can augment the amount of Zn in the edible portion of the plant. Moreover, the study also illustrates the proficient role of ZSB as a biostimulant to accomplish the task of Zn biofortification of paddy in a sustainable manner.

Keywords: Zinc solubilizing bacteria, biofortification, rice, ZnO (zinc oxide)

Abstract (4.21)

Enhanced production of native AMF in sorghum pot cultures amended with organic substrate and *Burkholderia arboris* as assessed through AM-signature lipids

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To meet UN 2030's agenda for Sustainable Development Goals, the use of non-renewable bioresources is being advocated globally to ensure food security and resource sustainability while minimizing environmental impact. Exploitation of the soil microbiome, particularly arbuscular mycorrhizal fungi (AMF), which are associated with more than 80% of terrestrial plants, is known to improve plant growth by enhancing mineral nutrition, confer stress tolerance, and sustain ecological equilibrium. These fungi are climate resilient and perform several soil eco-functions and services. However, due to its obligatory nature the large scale multiplication is tedious and it still relies heavily on growing plant roots. Nonetheless, substrate-free culture techniques (hydroponics and aeroponics) and *in vitro* cultivation methods have been attempted, but due to low germinability and lack of information on biology of native strains, these methods are less attractive, viable and profitable to AM inocula production companies. The traditional approach of multiplying locally adapted AM strains using substrate-based pot cultures is widely used around the world. We previously reported on the use of soybean processing mill wastes such as hulls, along with vermi-compost, to improve AM propagules. We tested this modified substrate combination on sorghum roots with *Burkholderia arboris*, a mycorrhizal helper bacteria, to see whether it could boost AM production even more. As a result, the current study aimed to look into the impact of *Burkholderia arboris* on the production profile of native AMF in soil: sand mix amended with hulls and vermicompost on sorghum. Treatment consisted of AMF, *Burkholderia arboris*, as well as mixtures of the two along with an uninoculated control were used under sterilized and unsterilized conditions. The experiment was laid out in a 4×2 factorial completely randomized design using 15 kg black gusseted bags. The pots were raised on sorghum for 120 days and AM parameters (root biomass, spore density, root colonization, glomalin and 16:1ω5c AM signature phospholipids and neutral lipids) were analyzed. Results indicates that irrespective of conditions, the addition of *Burkholderia arboris* to AM pots has significantly enhanced the AM production analyzed in terms of spore density, root colonization, glomalin and 16:1ω5c AM signature phospho- and -neutral lipids. Unsterilized conditions, on the other hand, resulted in significantly higher production. It is concluded that Burkholderia arboris has been found to stimulate AM production in sorghum raised in soil: sand-organic waste-manure, particularly under unsterilized conditions, and can thus be incorporated in soybean hulls-organic substrate potting mixes to achieve higher AM production in pot cultures.

Keywords: Organic substrates, soybean hulls, AM-signature lipids, mycorrhiza helper bacteria

Abstract (4.22)

Use of fermented substrate refuge as potential carrier in developing PGPM

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For a sustainable agriculture system, it is essential to use renewable inputs that are beneficial to the plant and do not cause any damage to the environment. One possible way is to minimize the use of chemical fertilizers and replace them with biofertilizers. Bio-fertilizers are products that contain live microorganisms, which have direct or indirect beneficial effects on soil structure, plant growth, and crop yield. Plant-beneficial microorganisms appear to be an important alternative to chemical fertilizers and an element of sustainable, scientific, and agricultural efforts to develop healthier soils and food. Industrial production based on fermentation of a broad range of products such as protein fortification of agro-industrial by-products, enzyme production, and biological control agents are widely reported. Organic residues can potentially be used to produce a variety of value-added products, including biofuels, biomass, enzymes, and bio-supplements. The study aims to explore the potential of using fermentation substrate refuge as a carrier for bioformulants. It has been reported that such a type of fermentation refuge provides physical support, and the nutrients present does provide an alternative and added value in the plant growth promotion properties. Amending such substrates with chosen plant growth promoting microbes (PGPM) would further enhance the overall plant growth and yield. Sustainable agricultural practices focuses on soil management, provides better nutritional support to plants, better control pathogens while maintaining and improving the supply of nutrients in the soil and, as a result, increasing the productivity of agricultural soils. These practices are largely driven using bioinoculants to improve crop productivity and health. This review presents an overview on transforming the fermented refuge into biofertilizers and understanding their impact on agricultural improvement. Such bio-recycling practices are also an important component of sustainable resource management while enhancing soil fertility and long-term productivity and are also cost-effective.

Keywords: Sustainable agriculture; biofertilizer; plant growth promotion; organic residues, PGPM

Abstract (4.23)

A study on ground status of bioformulations use and applications by farmers in two states from Northern part of India

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Agriculture is one of the most important sectors in the world. It not only provides food for the increasing population, but it also provides employment for people. The majority of the population is completely dependent on the agricultural sector. Several types of agrochemicals are utilized in the production of large quantities of agricultural crops. These agrochemicals are beneficial in terms of increasing agricultural production, but they can have detrimental consequences. Pesticides are used to control agricultural pests; however, they cannot be disregarded because of their detrimental impact on the environment. The present study was carried out in several places, and information was collected through interviews, questionnaires from local farmers, informal discussions, and field observation. The survey explored perceptions of farmers, suggestions given by kisan help center and Information given by retailers. Pesticide information, farmer's knowledge, and the impact of pesticides on human health were all discussed. The results showed that pesticides are mostly used for vegetables and fruits (22%), rice (21%), and wheat (17%). It was also found that farmers had not received any training about pesticides, most of the farmers did not have a clear knowledge, and use pesticides based on the information which is given by the other sources. It was also observed that most of the farmers do not take any precautions or take partial precautions during pesticides application, resulting in respiratory issues, headaches, weakness, skin issues, eye problems, and other issues. Survey has clearly pointed out that there is a huge knowledge gap between the advances of bioformulation research and industry as compared to the practices in filed on a day to day basis. Such studies serve as an eye-opener for researchers working in the area of PGPR research the significance of education the end users on real time yield impacts of PGPR research. It is required to develop strategies to take the bioformulation based products to the door-step of farmers.

Keywords: Agriculture, Pesticides, Farmers, Population.

Abstract (4.24)

Simultaneous saccharification and fermentation of lignocelluloses

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Simultaneous saccharification and fermentation processes for producing ethanol from lignocellulose are capable of improved hydrolysis rates, yields, and product concentrations compared to separate hydrolysis and fermentation systems, because the continuous removal of the sugars by the yeasts reduces the end-product inhibition of the enzyme complex. During the past decades considerably large efforts have been made to optimize the production of lignocellulose derived fuel ethanol production in order to develop a process configuration which is economically feasible and competitive with gasoline. One of the process alternatives uses cellulase enzymes for the conversion of cellulose content of lignocellulosic biomass to fermentable glucose. The benefits of performing the enzymatic hydrolysis together with the fermentation, instead of in a separate step after the hydrolysis, are the reduced end-product inhibition of the enzymatic hydrolysis, and the reduced investment costs. The principal drawbacks, on the other hand, are the need to find favorable conditions (*e.g.* temperature and pH) for both the enzymatic hydrolysis and the fermentation and the difficulty to recycle the fermenting organism and the enzymes.

Abstract (4.25)

Impact of Bio-organisms on agricultural waste management

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The agricultural is the backbone of our country. It generating the largest quantities of agricultural solid wastes, which may be allowed to accumulate indiscriminately and constitute nuisance to environmental problems without effective means of management methods. The benefits of recycling of agricultural solid wastes include reduction of greenhouse gas emissions and use as fossil fuel for cooking and lighting purpose ,contributing significantly to the development of new green markets, creation of jobs, production of bio-energy and bio-conversion of agricultural solid wastes to animal feed . Recycling of solid waste managed by different bio-organisms with the help of different kinds of decomposition technologies like anaerobic decomposition, composting, vermicomposting and fermentation. These recycled solid waste may serve as raw materials for another useful products. Implementation of effective agricultural waste management can not only solve the air pollution problem but also provide better inputs to crop.

Keywords: Agricultural solid wastes, decomposition, fermentation, vermicompost

THEME - V





IPR, Patents and Commercialization aspects of PGPR and Allied Technology

Chairperson :-

Dr. D.K. Maheshwari

Convener :-

Dr. Meenu Saraf

Speakers:-

1. Dr. Tongmin Sa
2. Dr. Dweipayan Goswami
3. Prof. H.B. Singh
4. Dr. Shraddha Gang

Abstract (IL 5.1)

Urgent need for designing biofertilizers to cope with global warming

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Global climate change has been a serious concern in various fields. The rise in temperature or climate depression occurring in different parts of the world has alarmed many scientists. The sudden change in environmental factors adds up to various kinds of abiotic stresses. It has been estimated that 50% of yield loss has been related to these abiotic stress factors such as temperature variation, drought, salinity and ultraviolet radiation. Agricultural sectors are also responsible for contributing harmful emissions into the atmosphere such as volatile organic compounds, methane and nitrous oxides. These amalgamations of emissions have severe effect on air quality and contribute to global warming. Plants exposed to environmental stresses such as salinity and heat results in emissions of volatile organic compounds (VOCs) such as green leaf volatiles (GLV), mono- and sesquiterpenes, light weight oxygenated volatile organic compounds (LOC), geranyl-geranyldiphosphate pathway volatiles (GGDP), saturated aldehydes, and benzenoids. On the other hand, rice paddies are reported to be contributing to the global methane emission that has 30 times higher global warming potential compared to carbon dioxide. There have been proposed alternatives to reduce methane emissions from the rice paddies with intermittent flooding practices. However, intermittent flooding has been observed to enhance nitrous oxide emission which has much higher global warming potential and atmospheric lifetime compared to methane. Therefore, the use of potential bacterial inoculants which can reduce such emissions as well as promote plant growth under environmental stresses can be a sustainable and eco-friendly approach. Plant growth promoting bacteria with characteristic feature of producing ACC deaminase have the potential to reduce the volatile organic compound emissions under environmental stress conditions by regulating the ethylene emission pathway and successively enhance stress tolerance. The additive feature of bacterial endophytes which can oxidize methane by the action of methane monooxygenase can help in reducing the methane emissions from rice paddies and reduce the methane emissions. Hence, considering the recent global scenario shifting the paradigm towards designing biofertilizers that can be effective in reducing agriculture based emissions and also enhance plant growth might be the need of the hour for sustainable agricultural practices.

Keywords: Global warming, volatile organic compounds, methane, ACC deaminase, biofertilizer, ethylene.

Abstract (IL 5.2)

Prospects of computational studies in studying next level of plant-microbe interactions

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Microbes are known to produce plethora of secondary metabolites including phytohormones which are known to interact with plant. The metabolites of microbial origin that are known to interact with plant include various auxins like indole acetic acid (IAA) and Indole butyric acid, cytokines, Gibberellic acids, etc. But apart from these known compounds, microbes also produce variety of compounds whose structures are known (thanks to the rapidly growing advancements in analytical techniques) but are still to be screened and identified for their interactive properties with plants. These compound on identification has great potentials in modern agriculture advancements. This can be achieved effectively by making use of computational approach. Most of the research on the plant-microbe interaction is stereotypic and to break the stereotype one must expand the vision to look out of the box. Making use of computational tools, but for which there are databases of known plant proteins and their biochemical pathways that could be targeted using computational methods is one probable approach. Such studies are being carried out on set of human proteins to develop drugs, but to use similar approach for plants is not being actively applied. Computational tools such as molecular dynamics, pharmacophore modelling, molecular docking can develop our understanding of interactions between the proteins of plants biochemical pathways and variety of microbial metabolites. Along with interaction studies, such proteins can serve as the novel target for applying the concept of rational drug design in the arena of plant, for developing analogues of phytohormones which can be considered drug for the plant, and phytohormone receptors as the drug targets. The current talk will focus on the potentials of computational approach in better understand plant-microbe interactions.

Keywords: Microbial metabolites; Plant biochemical pathways; Plant protein targets; Computational approaches

Abstract (IL 5.3)

Current scenario of biopesticides in India: Regulatory requirements, commercialization and IPR issues

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Biopesticides (PGPR, biostimulants) based on living microbes and their bioactive compounds have been well researched , documented and promoted as replacements for synthetic pesticides for control of plant diseases and also for plant growth promotion. However, lack of efficacy, inconsistent field performance, low shelf life and strict regulatory requirements by CIBRC has generally relegated them to niche products. Significant increases in market penetration have been made, but biopesticides/biostimulants still only make up a small percentage agri-bio input products. Many plant associated microorganisms are known to suppress pathogenic microorganisms, synthesizing growth stimulating plant hormones and promoting plant growth and impart disease resistance.

While working with some important antagonistic microbes (*Trichoderma* spp.), *Bacillus subtilis, Bacillus lentimorbus* and *Pseudomonas* sp., we have documented the plant growth promotion and biocontrol ability of these organisms not only at laboratory level but also at field level as well as up to the extent of commercialization.

We have started promoting the usage of biopesticide formulations as a component of integrated farming practices with involving farmers of eastern Uttar Pradesh.

The research on biocontrol agents (BCAs) can be fruitful only when we commercialize and register the product based on superior strains. Biopesticide registration require data on technical and formulation related information such as biological characteristics, pathogenic contaminants, other microbial contaminants, bioefficacy, toxicity, container compatibility and self life etc. To achieve this, certain norms specified by Central Insecticides Board are to be followed. Thiry four microbes have been included in the schedule to the Insecticide Act 1968 for production of microbial based biopesticides. Till date, about 970 microbial based biopesticides products are registered with CIBRC (http://cibrc.nic.in/bpr.doc) under section 9(3B) and 9(3) of the Insecticides Act, 1968 Government of India).During the presentation emphasis will be given on delivery system of biopesticides, commercialization, regulatory hurdles and intellectual property rights related issues.





Abstract (IL 5.4)

Resurgence of microbial application for regenerative agriculture: A global perspective

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In recent years, the uneven distribution of rains, temperatures, unwanted and uncontrollable anthropogenic activities have added uncertainties to the agricultural sector in many countries. The negative impact of continuous excessive use of chemicals, imbalance of soil nutrients, metal pollution and biotic and abiotic stresses has ultimately led to deterioration of soil health and ecology with prolonged food supply crisis. A pressing need is to shift focus from in trend sustainable agriculture to regenerative agriculture that can affirmatively cure and preserve soil life and health. Regenerative agriculture practices hold potential to rejuvenate the topsoil layers and can improve plant health and yield. Microbes are the critical components of soil health. Research worldwide aims to find and exploit indigenous soil microbes, especially those residing at the root-soil interface that are beneficial to soil and plant health. They are believed to serve as an alternative to unsustainable application of chemicals in the field (e.g., nitrogen fertilizers, pesticides). Scientific understanding of the nature of such microbes- their lifestyle pattern, mode of plant beneficial mechanisms and mutual interactions with other biotic and abiotic soil entities to maintain good soil health is the key towards healthier agricultural practices. Globally, the awareness has increased that practicing regenerative farming requires a paradigm shift by the farmers. Much focus is now directed towards microbial reproduction including biofertilizers, bio stimulants and bio stabilizers. Investigating and adapting simple to sophisticated methods to achieve soil minerals and microbial balance for agricultural production is gaining momentum, both at academic and industrial level research.





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