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ASIAN PGPR CONGRESS

FOR SUSTAINABLE AGRICULTURE

21-24 JUNE 2009

Abstracts

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Contents

Preface

Rhizosphere biology is approaching a century of investigations wherein growth-promoting rhizobacteria (PGPR) such as *Rhizobium*, *Pseudomonas*, *Azatobacter*, *Frankia* and mycorrhizal fungi have attracted special attention for their beneficial activities. Considering the priorities of food security and enhancing the productivity, profitability and sustainable rural livelihoods at farm level, developing new order of farm inputs has become imperative. In this perspective, bio-inputs either directly in the form of microbes or their by-products are gaining tremendous momentum. Asian countries have a rich microbial biodiversity. Harnessing this biodiversity to identify agriculturally important microorganisms and deploy them as bio-inoculants could help in providing low-cost and environmentally safe technologies to the farmers especially those who cannot afford expensive technologies.

Considering these needs of Asian nations, 10 thematic technical sessions have been planned. In these 10 sessions, detailed deliberations through exchange of International as well as Asian experiences would lead to a better understanding of interaction between climate processes and biological diversity and thereby forming important research topics for addressing the issues in overall food security. A bouquet of lead lectures, invited papers and posters provides a platform for pioneers as well as youngsters for a thread-bare discussion. The core scientific committee and agricultural scientists of international repute have identified lead as well as invited speakers.

The Congress has received tremendous support from governmental and non-governmental agencies such as ICRISAT, ICAR, DST, DBT and many private companies who have already pledged their support to 'green technologies'.

Acharya N.G. Ranga Agricultural University has readily agreed to host this mega event and under the leadership of Hon'ble Vice Chancellor Dr. P. Raghava Reddy, all care has been taken for the smooth steering of the Congress. The Director of Research, ANGRAU, Dean Agriculture, Director of Extension and other senior officials of the ANGRAU have significantly provided their might in organizing this congress.

We are sure, all the delegates will have a fruitful stay in Hyderabad and get the best out of this maiden effort. We hope that this abstract book will be useful as a reference manual for the participants as well as other PGPR researchers of the Globe.

S. Desai
M.S. Reddy
Y.R. Sarma
V. Krishna Rao
B. Chenchu Reddy
K.R.K. Reddy

Invited Lectures

Inaugural speech by Dr. J. W. Kloepper

Good morning. It's a great pleasure for me to greet all of you here attending the 1st Asian PGPR congress for sustainable agriculture. Some of you in attendance here were present at the International PGPR workshop in Calicut in 2003. However, for the majority of you, this is, likely your 1st International congress centered on the theme of PGPR. Therefore, I would like to explain briefly the significance of this area. The concept of PGPR encompasses bacteria that function as biofungicides and biofertilizers. Worldwide R & D with PGPR has continually grown since the 1970s when the term PGPR was first introduced. Research with PGPR ranges from discovery of new strains and confirmation in field studies to basic molecular characterization of the strains. Hence, the study of PGPR is one area of science where both basic and applied research is essential to reach our goal of implementing the science in everyday life. And regarding implementation, every year, the use of PGPR in agriculture worldwide is increasing. As you will see during this congress, there are different models for extending the theories of PGPR to farmers depending on the social, political and regulatory policies of each country. As PGPR use was, we learned more about their current opportunities and challenges. Opportunities include alternating applications of PGPR biofungicides with chemical fungicides to manage fungicide resistance and to reduce the number of fungicide treatments per year. PGPR biofertilizers are showing promise in integrated nutrient management strategies with a goal of reducing run-off of unused fertilizers and the environmental damage that results. Throughout the world, there is a growing number of so called dead zones in oceans and seas that result from run-off of agricultural fertilizers into rivers and ultimately oceans. I very much believe that the goal of reducing fertilizer use will be to the 21st century what (while) reducing fertilizer use was to the 20th century. I am very much pleased that Dr. M. S. Reddy and the other organizers of this congress have developed a PGPR meeting specifically aimed at Asia. While the core underlying science of plant microbial interactions is global, applications in agriculture are somewhat region specific. For example, here in North America, we have no agriculture system similar to plantation crops. Hence, logically, the opportunities and challenges for using PGPR in a plantation crop system need to be addressed in the Asian region. Also, Asia has been a leader in studies of PGPR as biofertilizer which is I mentioned as a growing area of interest worldwide. I would specially like to welcome all the students and young investigators to this congress. Every year, the study of PGPR is enriched by a new crop of investigators who launch their careers working on PGPR. We all need to encourage the students and new investigators to persevere in this critically important field of science. Finally, allow me to say that I am very impressed with the organization of this congress. The entire organizing, planning and funding teams have done a simply outstanding job. I wish you all a very successful congress.

Thank You

(J. W. Kloepper)

Scope and Potential of First Asian PGPR Congress for Sustainable Agriculture

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Distinguished guests, ladies and gentlemen, it is indeed an honour for us to be here with you as a speaker in presence of the Sri Raghuveera Reddy garu, Hon'ble Minister for Agriculture, Agriculture Technology Mission, Horticulture, Sericulture, R.S.A.D., Hon'ble Vice Chancellor and host, Dr. Raghava Reddy and other distinguished guests, Asian PGPR board members and many other scientists and entrepreneurs who have come to participate in this Congress.

It is our very proud privilege in welcoming all our distinguished dignitaries, speakers, delegates, members of the press and media. The idea of having the First Asian PGPR Congress in Hyderabad was brought-out by Dr. Y. R. Sarma, when he visited me in Auburn, USA, 7 months ago. Then we have discussed in length and agreed to have an alternative workshops or Congresses other than the International Workshops. Because, not many who are interested in PGPR research could attend every International Conferences due to budget constraints, this plan started to organize this Congress in Hyderabad. Dr. Raghava Reddy, Vice Chancellor of ANGARU kindly agreed to host the Congress.

What is PPGR? Why Asian PGPR? Let us explain briefly about PGPR and its importance. Plant growth promoting rhizobacteria (PGPR) are root associated bacteria representing many different genera and species that colonize the rhizosphere, rhizoplane and improve plant growth when artificially introduced onto seeds, seedpieces, roots, or into soil. PGPR improve plant growth by one or more mechanisms: direct stimulation of plant growth; enhancement of nutrient uptake; suppression of plant pathogens; and/or induction of resistance in plant hosts against pathogens.

The first PGPR Workshop was held in Canada in 1987 and since then the workshop has been held every three years at locations around the world: Switzerland (1990), Australia (1994), Japan (1997), Argentina (2000), India (2003) and The Netherlands (2006). The 8th International PGPR Workshop was held very recently in the USA (2009). In 2003, PGPR workshop held in India has received considerable importance and there were more than 300 delegates. Since then, the PGPR research has increased exponentially and then resulted in start of various companies for production of PGPR related products in India.

Asian PGPR Congress for Sustainable Agriculture aims to assemble all the professionals who want to gain and share their knowledge on PGPR under one roof to present their views on the themes, Status of PGPR research, PGPR applications in crops, Biofertilizers and PGPR in integrated nutrient management, Mechanisms, signaling, plant responses, bioactive metabolites, Plant pathogen - PGPR interactions, Farmers – academia - industry interaction, Biogeography, genomics, bioinformatics, Rhizosphere interactions, climate change and new technologies, Round table discussion on research – industry - policy interfacing, and Commercialization, regulatory issues, trade barriers in PGPR, Human resource development and transfer of technology.

Today, many economically important agricultural, horticultural and ornamental crop plants are attacked by various soil borne and foliar diseases, resulting in billions of dollars in crop losses. Currently, the most widely used disease management strategy is the use of chemical fungicides. But, the use of these fungicides encountered problems, such as development of resistance by pathogen to fungicides and rapid degradation of the chemicals. Other factors leading to increased interest in alternatives include the increasing cost of soil fumigation, lack of suitable replacements for methyl bromide and public concerns over exposure to fungicides. Both the agriculture and agri-food sector are now being expected to move toward environmentally sustainable development, while maintaining productivity. These concerns and expectations have led to renewed interest on the use of "biologically based pest management strategies".

One approach to such biologically based strategies is the use of naturally occurring and environmentally safe products such as PGPR.

It has long been known that many microorganisms in the soil root ecosystem are attracted by nutrients exuded by plant roots. This soil-root ecozone is called rhizosphere. Many microorganisms from the rhizosphere can influence plant growth and plant health positively, and are therefore often referred to them as PGPR. The beneficial effect of these bacteria has been variously attributed to their ability to produce various compounds including phytohormones, organic acids and siderophores, fixation of atmospheric nitrogen, phosphate solubilization, antibiotics that suppress deleterious rhizobacteria or to some other unidentified mechanisms.

India is the largest democracy on the planet and perhaps the smartest because of the scientists in the government. India has a unique opportunity to lead the way the application of PGPR innovation towards social and economic development to continue commitment and funding for scientific research.

Worldwide, PGPR technology is being considered as the latest pursuit for expertise in knowledge intensive sectors. Today, the global agriculture biotech industry was valued at US$ 45 billion and is expected to grow at 25% annually. Indian biotechnology industry is currently valued at US$ 2.5 billion. Much of the credit for growth of the Indian Ag biotechnology industry goes to the government that created a separate department for biotechnology under the Ministry of Science and Technology. Our state governments are also equal contributors towards making India an emerging hub of Ag biotechnology. Today, we have the benefit of having both Central and State Governments partnering with us for this congress. India inherently has all the strengths, an excellent network of research laboratories, rich biodiversity, well-developed seed industries and most importantly highly skilled and trained pool of scientific manpower. The success in this sector, however, depends on a number of enabling factors like facilitating venture capital funding, technology absorption and strengthening of links between the industry, academic and government institutions. I am confident that by working together we can overcome the obstacles and seize the opportunities in the PGPR technologies in the new millennium. I, therefore, take this opportunity to call upon all stakeholders from all over Asian countries to join hands and make the world a much better place to live. Come; let us see the future of PGPR through this Congress.

The green revolution of agriculture brought an enormous increase in food production. It not only made the world self sufficient in food but also gave the world her scientists and farmers, immense amount of self-respect and the spirit-world can do it. Though the green revolution did increase food production, the productivity levels have remained low and increase was achieved at a cost of intensive use of water, fertilizer and other inputs which have caused problems of soil salinization, ground water pollution, nutrient imbalances, emergence of new pest and diseases and environmental degradation. To feed the ever increasing population globally and in Asia more and more food has now to be produced from less and less land, water and other natural resources with the environmental protection. It is, therefore, apparent that we have to do things differently and doing more of what we did yesterday would not take us forward. With the advent of PGPR technology and its use in crops, could we achieve higher productivity, better quality, improved nutrition, improved storage properties, increased pests and disease resistance and achieve higher prices for farmers in the global market place.

PGPR technology would appear to me have the potential of eradicating rural poverty and fuelling Asia's GDP growth. Exploiting our knowledge for PGPR technology could we make Asia the global center of bioresearch?

The creation of biotechnologies, bio-businesses, bio-technopreneurs, bio-farmers, bio-students and bio-billionaires is the theme of "ASIAN PGPR CONGRESS FOR SUSTAINABLE AGRICULTURE". India has a well-established PGPR based bioindustrial base than anywhere else in my opinion, where products are being made by using conventional technologies. Presently, out of the total production of PGPR products, more than 70% of the products are produced based on the local capabilities and skills. It is estimated that with the proactive role of the government this capability will rise in time and the Indian PGPR industry would show its impact in the global scenario. For PGPR business, entrepreneurship is very important. Since PGPR technology cuts across all the disciplines of science, the future of PGPR

industry is really exciting with various advances taking place in India and in other Asian countries such as China and South Korea.

The PGPR industry is just coming out of its infancy. Its potential is being tested, realized and used. The public awareness and acceptance of PGPR will accelerate the process. Currently these are being supplemented by private individual entrepreneurs for developing PGPR products for local needs as well as for the export market. Technologies are flowing into the country due to the changed economic scenario. Very soon we can become global players in PGPR technology. To me this is a very special and a spectacular for me to come to our mother land particularly Hyderabad, Andhra Pradesh to speak to you about PGPR technology.

The first point I want to make is that many people think what is PGPR? I would say, Asian people's lives in villages and PGPR is not just a game of few elites but touching the lives of Asian people and is something that PGPR technology can do, whether it is for food security, nutritional security, health security, environmental security and I would say even livelihood security because the potential that this technology has to create jobs, is unbelievable.

I am indeed very happy to be amongst the participants of this Congress which is being inaugurated by our Agricultural Minister Dr. N. Raghuveera Reddy. I am also very happy to see the galaxy of scientists who have come here to participate in this Congress on the subject of PGPR. I am also pleased that eminent PGPR scientists, leaders of public and private R&D agencies and those of industry are participating in this Congress to exchange their views on current and future scope of PGPR based business opportunities. My own rough calculations show that PGPR technology can add profitable products both for national consumption and international export. India is training and has trained large number of graduates at Masters level in various branches of biotechnology. Thus, India will remain a source of young and talented manpower in PGPR technology and its production areas. I suggest that the vital players including those present here should plan a multipronged approach to promote PGPR technology enterprises suited to our milieu. I agree with the view of the organizers of the conference that new millennium will be millennium of PGPR knowledge.

Ladies and gentlemen I, therefore, propose a close interaction and a close synergy between our Asian countries in PGPR. All of us should now come together and should form the basis of future scientific research as well as industrial development. At the end, let me end conclude by reminding our industry friends that the responsibility is no doubt to raise and strengthen economy that they should keep before them the face of the poor, malnourished child or an underprivileged population. Their basic minimal needs must be met and in this task industry would also benefit when we have a large healthy population as the main workforce. Asia can lead provided we follow the path of sustainable agriculture. The 21st century will belong to Asia with its vast diverse knowledge base, the precious biodiversity and our rich traditions of humility and complete dedication to our responsibilities and wonderful human beings.

I am encouraged by India's commitment to explore PGPR technologies, but we all need to do more and invest more if we are going to break free from our dependence on chemical fungicides. I hope I have been able to impart some of the great enthusiasm I feel about the future through the use of PGPR. We need a massive collective global effort dedicated to funding new research in PGPR's. It's no secret that I have been often frustrated throughout my career by the slow pace of research. My success only happened because I was very often a great personnel and professional cost to go against the brain and question authority. I was willing to take risk because I believe that settling for the status quo was not going to benefit me, my lab or the broader field of science or society. I encourage all of you here to faster the spirit in your colleagues and yourselves as you now enable Asia to become a world leader in the application of PGPR technology to the betterment of our agriculture.

Now, in conclusion I am glad to note that this Congress is going to deliberate on some important issues related to PGPR technology. I am hoping that the outcome of this Congress will provide a new impetus to the commercial application of PGPR technology for the sustainable agriculture. Also, this Congress could suggest a framework to the Asian world a policy by giving an integrated focus to the PGPR research and development, production and marketing.

My best wishes to all of you.

L1. PGPRs in crop production systems

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Abstract

The rationale for our research is that there is a great need for environment-friendly microbial technologies (PGPR) for sustainable agriculture. World agriculture is plagued by two main constraints. The first is the depletion of nutrient supply in the agricultural soils and consequently, the sizable gap between realizable and actual yields in various crops. The second main constraint is biotic stresses. Our research dealt with modifying the crop rhizosphere environments using PGPR technologies in a systems approach for improving and sustaining the nutrient supply for enhanced health and yield. Our network partnership (USA, India, South Korea, Argentina, China etc.) in the world has therefore rightly identified the use of microbial inoculants to provide holistic health and sustainable crop yields. Each partner in the global network has made substantial contribution~~s~~ to PGPR research. Sustainable agriculture in the world, particularly in Asia is highly dependent on the use of chemical fungicides, pesticides, herbicides and fertilizers. Repeated use of these chemicals are causing severe concerns from the health and environmental point of view. In view of these, the development of PGPR based technologies now viewed not only as a valuable eco-friendly alternative to chemicals but also for sustainable agriculture. However, the adoption of PGPR technologies by farmers in the world is still ~~in~~ at its infancy. Knowledgeable sources say that only about 5000 villages and about one lakh farmers have reaped the benefits from the use of PGPR in India. While already threatened by the unforeseen drought spells, crops suffer the frequent outbreaks of pests that lead to total crop failures every where. Because of such crop failures, the resource poor farmers can not afford expensive crop protection chemical fungicides, and therefore remain poor. Development and propagation of low-cost technologies would certainly help in the improving profitability and livelihoods of small and marginal farmers. In this study, we will present some successful strategies achieved through collaborative efforts for commercialization of PGPR technologies in various crop systems for sustainable agriculture. Also, some of the most important factors for commercialization of PGPR such as formulation, fermentation, shelf-life, packaging, storage, delivery system, compatibility, consistency of performance, and mode of action, toxicology, registration and pricing will be discussed.

L2. Eco-safe PGPRs for sustainable production of major crops for second green revolution in Gujarat – An overview

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Abstract

A brief account on plant growth promoting rhizobacteria (PGPR) research carried out in last two decades at Anand Agricultural University for sustainable production of major food and cash crops for second green revolution is highlighted. Systematic research on Biofertilizer was initiated in 1979 at Anand with major thrusts to identify and isolate efficient PGPR inoculants suitable for cultivable crops of different agro-climatic zones of Gujarat state. A number of agriculturally important microorganisms were isolated, screened and recommended viz**.** *Azolla, Azotobacter, Azopsirillum, Acetobacter, Rhizobium,* BGA, *Bacillus* etc which are effectively used as biofertilizers in majority of crops to augment N, P or both to reduce the cost of cultivation, simultaneously preserving agro-ecosystem and to reduce environment pollution caused by chemical fertilizers during manufacturing as well as in wide use. Our research efforts culminated in 36 state recommendations for farming community to ultimately provide a low cost technology for marginal and small farmers to reduce their dependence on chemical fertilizers. It also includes new vistas on native PGPR liquid formulations preparation with proving their multiple utility as bio-control agent *in vitro*. Anubhav Liquid Biofertilizers launched by university are currently popularized in central and north Gujarat under lab to land efforts through wide demonstrations.

L3. Isolation and characterization of PSIRB as biofertilizer and biopesticide in improving the plant health of tomato

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Abstract

Twenty one isolates of phosphate solubilizing-indole acetic acid producing rhizobacteria (PSIRB), 20 isolates of phosphate solubilizing rhizobacteria (PSRB) and 42 isolates of indole acetic acid producing rhizobacteria (IRB) were isolated from 49 rhizospheric soil samples of tomato collected from tomato growing regions of Karnataka. A combined method of Pikovskaya's and Bric's was developed to isolate PSRIB, PSRB, and IRB's. The selected isolates were further analyzed for their ability to solubilize calcium phytate. Based on the root colonization assay and ability of bacterial isolates to increase the seed germination and seedling vigor under laboratory conditions 5 isolates from each group were selected for further studies. Under greenhouse conditions, all the selected rhizobacteria isolates significantly increased seed quality variables and total phosphorus content of 30 day-old-seedlings. Isolate PSIRB1 and IRB36 significantly reduced the Fusarium wilt incidence over other isolates of same and other group, and the control. On the basis of results from laboratory and greenhouse studies, one bacterial isolate from each group was selected for plant growth and yield analysis studies. Isolate PSIRB2 showed increased plant height, fresh weight, number of fruits per plant and average

weight of fruit over PSRB9, IRB36 and control. Studies on the nature of resistance offered by these bacterial isolates following split-root technique revealed that the isolates PSIRB2 and PSRB9 had the ability to induce systemic resistance, but isolate IRB36 protect the tomato seedlings only through direct antagonism.

L4. Implications of rhizobacteria associated with the vegetation of coastal sand dunes on plant growth

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Abstract

Coastal sand dunes is a nutrient limited ecosystem, however there are certain plants growing on the dunes which have developed specialized mechanisms to cope with the adverse conditions prevailing in this ecosystem. Sand dune plants or psammophytes as they are called are naturally adapted to stress conditions and thus survive in experiencing salt spray, sand burial, low moisture content, high light intensity, wind exposure, soil salinity and nutrient deficiency(C, N, and P & K). Further, the rhizosphere is considered as the most intense ecological habitat in soil in which microbial communities are in direct contact with plant roots. As with other plants, we envisaged that the microbial community in rhizosphere of the plants growing on sand dunes may support the growth of these psammophytes directly or indirectly. Production of biologically active metabolites, particularly the plant growth regulators by rhizosphere bacteria, is considered one of the most important mechanisms of action through which the rhizosphere bacteria affect plant growth. With this in view, the study was undertaken to understand the potentials of the rhizosphere bacteria associated with sand dune vegetation. It was interesting to note that root system of the sand dune plants harbours distinct, diverse community of metabolically active soil microbiota that carry out biochemical transformations and produce significant metabolites.. Some of the important metabolites were siderophores, which sequester iron, HCN, IAA and enzymes such as phosphatases and ACC deaminase. The isolates also produced enzymes degrading plant molecules and hence potential for being developed as bioinoculants. The details of the work will be presented.

L5. Plant Growth Promoting Rhizobacteria (PGPRs) used as bioinoculants for increasing productivity and disease management of MAPs

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Abstract

The crops infected by plant pathogens need immediate protection through the use of chemical pesticides to maintain the productivity in our modern agriculture system but the selective and highly effective chemicals pesticides are not a long-term solution to the crop, human and animal health. Their intensive and indiscriminate use posed many serious problems including development of resistant strains of the pathogen; build up of harmful residues in the edible plants, non-target side effect of beneficial micro flora and environmental pollution etc. To avoid such problems, attentions have been diverted towards the use of PGPRs as bioinoculants for improving

yield and the management of pests and diseases. PGPRs as bioinoculants have a distinct possibility for the future and can be successfully exploited in modern agriculture without affecting our precious ecosystem. They have been applied to various agricultural and environmental problems with considerable success in recent years but very little work has been carried out on the uses of PGPRs as bioinoculant on medicinal and aromatic plants. In this presentation, we would present our work on the use of PGPRs as bioinoculants to enhance productivity and disease management of some medicinal and aromatic plants. They are effective only when they are presented with suitable and optimum conditions. All the PGPRs strains of *Bacillus subtilis*, *Pseudomonas flourescens,* and *Streptomyces* sp used in the present studies were isolated from indigenous sources. Prior to their application, their activities for growth promotion and antagonism against the plant pathogens of medicinal and aromatic plants (MAPS) were tested *in vitro.* The efficacy of different PGPRs strains have been evaluated by experimentation as follows: i) Use of *Bacillus subtilis* (B1), *Psuedomonas fluorescens* (psf1) and *Streptomyces* sp. (A1) either alone or in combinations of four different AM fungi viz. *Glomus aggregatum*, *G. fasciculatum*, *G. intraradices*, and *G. mosseae* as potential bioinoculant for their synergistic effect on the productivity of geranium over non-mycorrhizal control plants .ii) Use of *Bacillus subtilis* (B1), *Pseudomonas flourescens* (psf1) alone and in combination with IBA or Calliterpinone, a phyllocladane diterpenoids isolated from *Callicarpa heterophylla* showing remarkable growth promotion activity on monocotyledonous and dicotyledonous plants (Singh et al, 2004) on safed musli (*Chlorophytum borivillianum* L., Liliaceae) under glasshouse conditions, iii) Use of *Trichoderma harzianum, Bacillus subtilis* and *Glomus intraradices* for the control of the root rot and wilt disease of pyrethrum under glasshouse conditions The inoculum of the test bioinoculants was raised on different substrates and applied at the time of planting in the form of different doses. iv) Isolation and partial purification of antifungal compounds produced by *B. subtilis* (B1) and *Streptomyces sp.* (A1). The strain B1 of *B. subtilis* and A1 of *Streptomyces* sp. were grown on potato dextrose/nutrient broth for 21 and 5 days, respectively and antifungal compounds were isolated by modified method of Araujo *et al.* 2005 and Mukherjee and Chandra, 1974, respectively. Among 102 isolates, 6 isolates were identified as plant growth-promoting rhizobacteria, (PGPR's). They were designated as SGS2, B6, 2A, 2B. UPS1 and UPS2. Based on morphological characters and biochemical tests (Following Bergey´s manual of systemic Bacteriology viz. Gram staining, inodol production, MRVP, Citrate utilization, glucose, oxidase test, starch hydrolysis test, TSI test sucrose test, etc) four isolates (SGS2, 2A, UPS1and UPS2) were identified as *Bacillus spp.,* while two isolates (B6 and 2B) were identified as *Pseudomonas* sp., respectively. All the isolates were found active against the phytopathogenic fungi and cause inhibition in dual culture. The strain B1of *B. subtilis* showed maximum inhibitory effect against *Alternaria solani (*32mm*)* but least effect against *F. solani* (29 mm). The isolate UPS2 exhibited maximum inhibition against *Rhizoctonia solani* (37mm), A. *alternata* (36 mm), *Sclerotinia sclerotiorum (*35mm*)*,while the *Fusarium oxysporum* was poorly inhibited by this isolate (31 mm).The isolate SGS2 exhibited maximum inhibition against *Sclerotinia sclerotiorum* (40mm) and *Colletotrichum acutatum* (37 mm), while the *Fusarium oxysporum* was poorly inhibited by this isolate (28 mm). The isolates UPS1 2A and 2B were most effective against *Alternaria solani*. Thus, each of the above isolates was distinguished from one another by antagonistic activity against phytopathogenic fungi.The 3-day-old culture filtrate of strain B1 of *B. subtilis* and strains UPS1 and SGS2 of *Bacillus* sp. was tested against spore germination inhibition of phytopathogenic fungi of MAPs The strain B1 of *B. subtilis* and strains UPS1 and SGS2 inhibited cent per cent spore germination of *Alternaria alternata,* while their dilution by 20% inhibited 60%, 59% and 53% spore germination. Growth promotion activity by different isolates of PGPRs was evaluated on *Zea mays.* Our results showed that treatments with different strains increased the seedling vigor emergence, root growth; shoot growth and total biomass of the plant. The mycorrhizal treatment increased the growth and total biomass invariably over non-mycorrhizal control plants. In alone treatment, best result was obtained in *G. mosseae* treatment

where 380.9g and 335.3g fresh herb yield per pot was recorded over 217.3g and 180.3g in control in the year 2005-06 and 2006-07 respectively. There was an increase of 75.3% and 85.9% in biomass production over control. The next best response in herb yield of geranium was obtained in *G. fasciculatum* treatment, which increased the herb yield by 55.3% and 66.8% in 2005 and 2006, respectively. *G. intraradices* has very little effect. The plants inoculated with *Bacillus subtilis* alone also yielded 287.8g and 252.3g fresh herb, which was 32.4% and 39.9% more over uninoculated controls. However, *B. subtilis* in combination with *G. mosseae* produced highest herb yield i.e. 410.8g and 347.8g herbs/pot, with an increase of 89.4% and 92.9% over untreated controls. The plants treated with mycorrhiza and *B. subtilis* produced higher no. of branches with less L/s ratio The field experimental data were found in consistent with that of pot experiment, *G. mosseae* alone treatment increased 49.4% herb yield over non-mycorrhizal control while in combination with *B. subtilis* it increased 59.5% herb yield. The treatment of mycorrhiza and *B. subtilis* did not affect the essential oil content of the plant but the total oil yield was significantly increased due to the increase in the biomass production after treatment. Thus, it has been concluded that arbuscular mycorrhizal fungi with *B. subtilis* have synergistic effect on the growth and biomass yield of the plant. Results were recorded to be better than the IBA, a well-known plant growth hormone in identical conditions. Calliterpinone inoculated plants had 29.6% more fingers in comparison to control and 11.8% more fingers as compared with IBA treatments. Similarly, this treatment had 18.6% more fresh weight of fingers in comparison to control and 6.5% more as compared with IBA treatment. The synergistic effect of calliterpinone with the PGPRs used was also significant, as the mutual effect of these PGPRs was also found better than the alone inoculation. Among the different PGPRs used in the experiment, *P. fluorescens* demonstrated highest synergistic effect as this treatment exhibited 39% more yield than control. Simultaneously, this synergism yielded 20.4% more as compared with alone treatment of calliterpinone. Our results clearly demonstrated that biocontrol agents, *Trichoderma harzianum, Bacillus subtilis* and *Glomus intraradices* were as effective as the chemical fungicide, ridomil mancozeb which was completely able to manage root rot and wilt disease caused by *Rhizoctonia solani* AG-4 (Alam et al. 2006). The role of biocontrol agents was found much significant as these agents not only control the disease but they were also found to enhance the productivity. The antifungal compounds isolated from *B. subtilis* and *Streptomyces* sp. showed strong antagonistic activity in vitro testing. Two compounds from *B. subtilis* and 3 active fractions, SM-I, SM-II and SM-III from *Streptomyces* sp. were partially purified and tested for antagonistic activity by a special bioautographic agar overlay method. Each of the compounds was thermostable and significantly inhibited the growth of plant pathogenic fungi as well as spore germination at very low dilution 20µg/ml. The present strains of *B. subtilis*, *P. fluorescens* and *Streptomyces* were highly effective in increasing the productivity on the test plant and each one of them showed synergism with mycorrhizal fungi and growth promoting compounds. *Streptomyces* sp. strain A1 is highly antagonist to wide range of plant pathogenic fungi infecting medicinal and aromatic plants. Two US patents have been granted on *B. subtilis* B1 strain and *Streptomyces* sp. A1 strain for their activity.

L6. Integrated disease management in jute and allied fibre crops with pgpr based bioinoculants and bioregulators consortium

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Abstract

Field evaluation with co-inoculation of Plant growth promoting rhizobacteria *Pseudomonas fluorescens* Psfl1, *P. striata* Pst1 and *Azotobacter chrococcum* Azbc2 applied in consortium with *Trichoderma viride* JPT1, *Gliocladium virens* JPG1 and *Aspergillus niger* A26 strains were potential in disease control, biomass and fibre production in jute and mesta crops. Potentiality of talc and kaolin based Bioformulations of pgpr consortium compared to talc and fly-ash based fungal consortium (I:1) with IAA seed soaking and carbendazim seed dressing evaluated to be promising for integrated disease management, plant growth promotion and fibre production in jute and mesta crops. Biocontrol mechanism of pgpr and fungal antagonist involved production of chitinase, pectinase, cellulase and protease enzymes, HCN, volatiles, non-volatile antibiotic phenazine and phenolic derivatives, pyoverdine and pseudobactin types of siderophores, IAA and phosphorus solubilization. PGPR and fungal consortium formulate seed dressing @ 100g kg^{-1} seed and soil inoculants 1kg mixed with 5 kg soil-compost mixture soil drenching in 0.05 ha land reduced stem and root in jute by *Macrophomina phaseolina* maximum up to 55.8%. Carbendazim 2g with *Trichoderma* 10g kg^{-1} seed dressing followed by *Trichoderma* inoculants soil drench 15 DAS, and IAA 25-ppm seed soaking for 12 hours with carbendazim treatment and fungal and bacterial consortium soil drench achieved 24.7–45.3% disease control, 2.9-6.1% biomass increase and 11.9-19.7% fibre production. *Trichoderma* seed dressing achieved 32.2q h^{-1} fibre yield. *Trichoderma* + carbendazim, and fungal + bacterial consortium seed dressing yielded 29-31.3 q ha^{-1} jute fibre. Foot and stem rot disease in mesta by *Phytophthora parasitica* was controlled up to 35.9% with carbendazim and fungal + bacterial consortium seed dressing and soil drench. Biomass increased up to 26.3% with bacterial consortium, fungal + bacterial consortium seed dressing and soil drench. Fibre yield was highest 24.2 q h-1 (44% increase over control) with fungal, bacterial, fungal + bacterial consortium in farmers' fields. *T. viride* JPT1 and *P. fluorescens* Psfl1 strains appeared tolerant and compatible to carbendazim and IAA seed treatment. Studies indicated near isogenic PGPR strains consortium with biofertilizer and growth regulator effective beneficial traits for pathogen suppression, plant nutrient supply and growth promotion. Molecular characterization of functional genes and biopesticide from genetically improved PGPR may necessitate sustainable agriculture.

L7. Rhizobia as a bioinoculant

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Abstract

Rhizobia are gram negative, motile non sporulating rod shaped soil bacteria that fix nitrogen (diazotrophy) after becoming established inside root nodules of legumes (Fabaceae). Rhizobia are a paraphyletic group which fall into two classes of the proteobacteria—the alpha- and beta-

proteobacteria and most of them belong to the order rhizobiales but several rhizobia also occur in distinct bacterial orders of the proteobacteria. The present taxonomy of rhizobia comprises of 76 species found in 13 genera and most of these bacterial specices are in either *Rhizobium*, *Mesorhizobium, Ensifer* and *Bradyrhizbium* genera. The legume-*Rhizobium* symbiosis is a classic example of mutualism and especially important when nitrogen fertilizer is not used, as in organic rotation schemes and in some less-industrialized countries. From time immemorial rhizobia have been used as bioinoculants for increasing the yield of legume crops. In India, the first ever production and commercialization of rhizobium inoculants was started in the late 1960's when yellow seeded soybeen was introduced. In order to extend their use in other crops, inoculants were produced for pulses, groundnut and forage legumes like lucerne and berseem. Studies carried out with major leguminous crops under both pot and field conditions have shown that the nitrogen fixing potential of a rhizobium strain depends much upon its compatibility with the variety or genotype of the host. Field experiments conducted as part of different research projects have shown that the inoculation response of pulses with average increase in yield of 32% in pigeon pea and mungbean, 41% in chickpea, 49-50% in groundnut and lentil and 61% in soybean. Recently the research efforts are extended not only to the selection of efficient N fixing rhizobial strains but also to enhancing competitiveness, colonization, survivability under various abiotic stress conditions (salinity and drought) and other plant beneficial traits like P-solubilization, siderophore and phytohormones production. *Rhizobium* bioinoculants are available commercially in various formulations like carrier based, granular and liquid formulations but each has limited self-life and storage conditions. Even though, the production of *Rhizobium* bioinoculants is highest among the bioinoculants, their potential demand is ever increasing in this country with 35,730 Metric tons per annum at present and the continuous research efforts in mass production technology of *Rhizobium* bioinoculants will fulfill this production related limitations. Finally, the magic of conversion of atmospheric N_2 to plant protein by rhizobia not only increases production of pulses in rainfed fields of marginal farmers but also solves the protein malnutrition problems in this country.

L8. Phosphate solubilization mechanisms of Aspergillus tubingensis, a plant growth promoting fungus

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Abstract

Phenotypic mutants of *Aspergillus tubingensis* were obtained by UV irradiation and phosphate solubilization ability and the effects of carbon and nitrogen sources on P solubilization by these mutants were determined in this study. Among the different carbon sources, sucrose and glucose promoted higher P solubilization. Maximum P solubilization was achieved in presence of KNO_3 followed by $(NH_4)_2SO_4$. These mutants also showed maximum acid phosphatase and phytase activity. All the isolates secreted organic acids such as succinic, acetic and oxalic acid in presence of tricalcium phosphate. Hence, apart from acidification (or pH decrease), other mechanisms which may aid microbial P solubilization by *A. tubingensis* are acid phosphatase and phytase activity.

L9. Use of Bio-Fertilizer: A key to Sustainable Agriculture in India.

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Abstract

In the wake of Green Revolution, which brought in massive gains in agricultural output yet it did not translate into a model for sustainable agricultural growth. Excessive dependence on chemical fertilizers with major emphasis on N and P, excessive use of pesticides has led to fall in soil fertility, water contamination and unsustainable burden on the ecological system. Under this situation, bio-fertilizers offer great potential for not only improving soil fertility but also provide for efficient use of various recourses for increasing crop production on sustainable basis.The present work aims to study the extent of bio-fertilizers use in the different states of India and its impact on agricultural production. Secondary data has been collected from different reports and publications of CMIE, IFFCO, and FAI. Growth rates of different variables are estimated by the best-fitted trend line. For measuring regional disparity appropriate measure of dispersion is considered. The study shows, both State and Central Governments have been promoting the use of biofertilizers through various practices. The region wise study indicates the distribution of biofertilizers is more dispersed relative to chemical fertilizers. Even the growth rate of both production and consumption of biofertilizer in India is quite satisfactory, a very small percentage of estimated demand is justified with this production. There is no doubt that bio-fertilizers are the potential tools for sustainable agriculture not only in India but also around the world. As, the use of bio-fertilizer, till so far, is grossly inadequate in India, more emphasis on its production, consumption and also proper distribution need to be taken into consideration.

L10. Plant-Microbe Symbioses for better targets

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Abstract

The root-zone inhabiting microorganisms exert a significant effect upon the plant growth and health. The roots are associated with the symbiotic fungi to form the mycorrhizal association. The role of mycorrhizae as biocontrol deterrents to feeder root infection by pathogens is an important aspect of our under-standing of the overall ecological significance of mycorrhizae The occurrence of arbuscular mycorrhizal symbiosis improves the nutritional state of plants by enhancing mineral absorption through the extramatrical mycelium and AM fungal inoculated tomato plants were more resistant to soil borne pathogen. Biochemical and enzymatic changes in VA mycorrhizal inoculated tomato plants infected by *Fusarium oxysporum* was carried out. The enzymes responsible for defense response were enhanced by AM fungal inoculated plants than other treatments and the control. The tissue-cultured plantlets when transplanted into soil have very low survivability, because they cannot easily tolerate the environmental conditions resulting in stunting of growth. In AM fungal inoculated micropropagated plants of *Saccharum officinarum*, *Zea mays*, *Sorghum vulgare*, *Bacopa monnieri*, *Hybanthus enneaspermus*, *Azadirachta indica* and *Casuarina equisetifolia*, the root length, shoot length, dry weight and survivability rate were higher when compared with control. Higher levels of total sugar, free amino acids, total phenol,

protein and acid and alkaline phosphatase activity were estimated in AM fungal inoculated micropropagated plants. Highly reduced level of proline content was noticed in roots of AM fungal inoculated micropropagated plants indicating that AM fungal infection reduced the stress of the tissue cultured plants.

Mycorrhizal and actinorhizal technology has great potential for combating the current and future global problems of supplying food, fodder and fuel. The study on the effect of mycorrhizal (*Glomus fasciculatum* and *Pisolithus tinctorius*) and *Frankia* inoculation on *Casuarina equisetifolia* seedlings in laboratory, glasshouse and nursery conditions revealed that the triple inoculation is an ideal combination for enhanced growth and nodulation of *C. equisetifolia*.

The presence of *Rhizobium* and mycorrhizal infection help the plants to survive in neutral, acid and alkaline rhizosphere regions. The studies on the effect of AM fungus, *Glomus fasciculatum* and *Rhizobium* species on the tolerance of effluent treatment in *Prosopis juliflora* showed that root growth and dry matter content were higher in the dual inoculated *P. juliflora* plants than the individual inoculations, control and plants treated with effluent alone. Dual inoculated plants did not absorb much of Mn, Cr, Cd, Cu and Zn. Thus the mycorrhizal, frankial and rhizobial symbioses help the plants for better root growth and to achieve better targets of the plants.

The obligate symbiotic nature of AM fungi is a crucial factor in the mass multiplication of AMF spores in *vitro*. Since AM fungi have not been successfully sub-cultured *in vitro*, it has been difficult to obtain large amounts of inocula for seasonal and field application. Development of monoxenic culture system of host plants and AM fungi could be a valuable research tool to study their symbiotic association. Establishment of mycorrhizal association in root organ scultures with subsequent development of small round vegetative spores has been shown. A medium in combination of root exudate for axenic germination of *Scutellospora erythropa* and *S. nigra* in *vitro* conditions has been developed. Germination of AM fungal spores (*Gl. mosseae* and *Gig. gigantea*) *in vitro* condition by using root organ culture of *Sorghum vulgare* and *Saccharum officinarum* and establishment of *in vitro* root infection from infected roots of *S. officinarum* to *S. vulgare* have been carried out.

Selenium is an essential micronutrient for humans and animals. Recently it has been gained much importance for its anticancer activity. Plants have the ability to absorb and sequester selenium and to convert inorganic selenium to volatile forms of organic compounds. The potent cancer-causing compound, nitrosamine, is inhibited by garlic. Se-methyl-selenocystein is one of the main selenocompounds in Se-enriched garlic and Se has been identified as an important compound of glutathione peroxidase. A study was conducted to investigate the role of arbuscular mycorrhizal fungi in the uptake of selenium by garlic and anticancer activity of the Se enriched garlic A significant cancer protection in rats with treatment by selenium enriched (enrichment due to inoculation of AM fungi) garlic when compared to other treatments has been achieved. The findings pave the way for the importance of AM fungi in human healthcare.

The current classification and identification of AM fungi are based on the morphology and molecular techniques such as DNA Finger-printing, rDNA sequencing and cDNA synthesis techniques. Genetic variations can be identified and compared with other symbiotic species. AMF spores such as *Gigaspora margarita, Glomus mosseae, Gl. fasciculatum, Gl. leptoticum, Gig. gigantea, Scutellospora erythropa* etc. collected from various locations were cultured in glasshouse conditions. *Allium cepa* plants were used as trap plants. Infected roots as well as spores were collected and used for DNA isolation. AMF DNA was used as template for PCR. Small subunit rDNA primer sequences NS1 and NS21, the primers VAGLO, VAGIGA and VAACAU were used for PCR amplifications. The genetic variations of SS rDNA were analyzed by restriction analysis.

L11. Evaluation Of Nitrogen Fixing Microbes In Money Plant Rhizosphere

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Abstract

Money plants (*Scindapsus aureus*) are used as indoor plant because of the foliage and rapid growth in water and soil. The plants growing in water bottles are kept indoors, exposed to partial light and no additional nitrogen fertilizers were provided. Microbial nitrogen fixation is well known but there are no studies on nitrogen fixation in rhizosphere of money plant. Hence an attempt was made to identify and establish the biological nitrogen fixation in rhizosphere microbes of money plant. Total microbial count of root region and root free zones was analyzed. Nitrogen fixation ability of microbes in individual and combinations by acetylene reduction and antagonistic activity of Pseudomonas on selected bacteria and fungi were studied. More microbes were detected in root region as expected. *Klebsiella pneumonia* and *Pseudomonas sps* were predominant in the rhizosphere. Localization of Klebsiella in root zone and Pseudomonas in root free zone was observed. *Pseudomonas* showed inhibition on tested microorganisms on agar plate, except on *Klebsiella pneumonia*. Both *Klebsiella pneumonia* and *Pseudomonas sps* were able to grow in nitrogen free media but their growth rate was increased in the presence of money plant roots. Present study establishes symbiotic nitrogen fixation of *Klebsiella pneumonia* and *Pseudomonas spp* and suggests the selection of one antagonistic microbe with good/ optimize PGP activity along with a potent PGP activity microbe is the choice for potent biofertilizers.

L12. Deducing the mechanisms of biocontrol and PGPR activity by *Pseudomonas chlororaphis* PA23 - an ideal biocontrol agent for the tropics

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Abstract

Pseudomonas chlororaphis strain PA23 has shown excellent biocontrol of *Sclerotinia sclerotiorum* causing stem rot disease in canola (*Brassica napus* L.) in greenhouse plant assays and in field experiments. Similarly, it has been an effective biocontrol agent against several other pathogens in India and Sri Lanka . Strain PA23 produces the antibiotics pyrrolnitrin, phenazine 1-carboxylic acid, and 2-hydroxyphenazine, together with a number of other secreted products believed to contribute to biocontrol. PA23 also produces three organic volatiles (nonanal, benzothiozole, 2-ethyl, 1-hexanol) that are capable of completely inhibiting mycelial growth, and significantly reducing ascospore and sclerotia germination. Induction of higher activity of chitinase and β-1,3 glucanase was observed, when the bacterium was challenge inoculated with the pathogen. Western blot analysis confirmed the induction of a 34 kDa chitinase protein. Using transposon mutagenesis, we isolated a *phzE* mutant (PA23-63) that no longer produced phenazines but expressed over wild-type levels of pyrrolnitrin. In greenhouse studies, both the wild type and PA23-63 exhibited a similar ability to reduce the incidence of leaf infection, stem rot and disease severity in *S. sclerotiorum*-challenged canola. When the *prn* was knocked out, the mutant strain (PA23-1) could not inhibit Sclerotinia infection on canola plants compared to the

wild type strain PA23. However, when both *prn* and *phz* genes were knocked out (PA23-63-1) the infection was similar to the control (no bacterial inoculation) plants. These findings suggest that pyrrolnitrin, rather than phenazines, is the main antibiotic involved in PA23 biocontrol of *Sclerotinia sclerotiorum*. However, the phenazines are more useful in controlling other plant pathogens including *Phytophthora infestans*, the late blight pathogen of potato (*Solanum tuberosum*) and in forming biofilm. The PA23 also controls Rhizome rot of turmeric (*Curcuma longa* L) caused by *Fusarium solani* and other fungi. The plant growth promoting (PGPR) effect of PA23 on several greenhouse crops will be discussed at the conference.

L13. Biocontrol Potential of Siderophore Producing PGPR

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Abstract

Plant diseases caused by more than sixty pathogens causes severe global economic losses to agricultural crops (30% yield) amounting 416 Million US dollars. The dominantly used chemotherapy for controlling plant diseases has caused incalculable damage to the agroeco-system (1). Biocontrol through Siderophore based BCAs have merged as a sustainable approach for IPDM (2-4). Under iron stress conditions, *A. feacalis* and other PGPR produces siderophores, that chelates the available iron and prevents the iron nutrition of respective phytopathogen (3, 5). *Siderophore* production was carried in succinic acid broth [SM] at 28 $\pm$ 2 ^{o}C for 24 h. Siderophores were detected by CAS test and purified on amberlite XAD 4 (4). *In-vitro* antifungal activity was based on the principle of diffusion in which spore suspension [6 x 10^6 spores mL^{-1}]. Five wells each of about 10 mm in previously seeded with fungal culture and 25 µl each of culture broth [6x10^6 $cellml^{-1}$], were added with siderophore rich supernatant, XAD-4 purified siderophore, Bavistin and control and incubated at 29 ^{o}C for 48 h. Zone diameter of more than 8 mm was considered as growth inhibition and Minimum Fungicidal Concentration [MFC] was determined. Diffusion assay of previously seeded culture of *P. aeruginosa*, *A. vinelandii, R. meliotii* and *B. japonicum*, was performed with siderophoregenic *A feacalis*. Change in color of CAS agar (blue to orange red) and SM (colorless to golden yellow) indicated siderophore production. The yield of purified siderophores was 347 mgL^{-1}. Both cell free culture supernatant as well as siderophoregenic culture broth inhibited the growth of phytopathogenic fungi. The diameter of the zone of inhibition with culture broth, cell free supernatant, purified siderophores and bavistin is given in Table 1. Control preparation [free of any siderophore activity] did not inhibit the growth of any of the fungal spp. under study. Siderophore rich culture broth proved to be potent inhibitor of fungal pathogens than cell free culture supernatant and bavistin. MFC of culture broth was comparatively less than MFC of supernatant and bavistin. Culture broth, supernatant, and siderophores of *A. feacalis* did not inhibit the growth of any off the rhizobia under test and were therefore safe for all the useful soil rhizobia.

L14. Application of Bacillus-mediated induced systemic resistance against multiple plant pathogens and its mode of actions

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Abstract

Treatment of *Bacillus vallismortis* strain EXTN-1 showed a broad disease-controlling spectrum to the plant diseases caused by viral, bacterial, and fungal pathogens with plant growth promotion. When *Bacillus vallismortis* strain EXTN-1 was drenched to lettuce grown in hydroponic system, population of *Bacillus vallismortis* strain EXTN-1 was similar or increased in the rhizosphere, while the population was gradually decreased up to 10 fold in the hydroponic solution 4 weeks after treatment compared with initially treated population of the bacterium. Treatment of EXTN-1 increased oxidative burst in early stage of cucumber plants and induced the expression of resistance genes, PR-1a and PDF1.2 in wild type Arabidopsis plants. Mechanism involved in induced systemic resistance by EXTN-1 was revealed as simultaneous activation of SA and JA or ethylene metabolic pathways and pre-treatment of EXTN-1 reduced germination and appressorium formation of conidia of *Colletrotrichum orbiculare* on the leaf surface of cucumber plants with increased callus formation. Furthermore, treatment of EXTN-1 inhibited the bacterial wilt on tomato caused by *Ralstonia. solanacearum* for 4 weeks after treatment. Treatment of *Bacillus vallismortis* strain EXTN-1 showed the increased plant height in three varieties of barley and shorted the heading stage of two varieties compared with non-treated control. Taken all together with above results, *Bacillus vallismortis* strain EXTN-1 can be considered as a promising agent for practical application.

L15. Fungal endophytes of leaves and plant health management

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Abstract

Fungal endophytes infect living tissues of plants and survive in them for a short or prolonged period without producing any visible symptoms of their infection. Although endophytes have been reported from all major groups of plants and their technological potential as producers of novel bioactive compounds is being currently recognized, their interactions with their plant hosts and other organisms in the ecosystem have not been studied adequately. Since the definition of 'endophytes' is rather loose, it includes several different ecological groups of fungi exhibiting a variety of interactions with plants; such interactions have direct or indirect impacts on plant health. Studies from our lab indicate that foliar endophytes continue to survive in senesced leaves and switch to a saprobic mode from a mutualistic one and initiate litter degradation thus aiding in

nutrient recycling. Endophytes impose a cost on the host plant which should be significant considering the high density of infection shown by them. A few studies have shown that foliar endophytes can protect the host plant from insect pests and pathogenic fungi. *In Vitro* experiments from our lab also attest to the insecticidal and anti fungal properties of many fungal endophytes. Furthermore, the fact that some of phytopathogenic fungi survive as symptomless endophytes (latent pathogens) in host tissues raises several issues such as quarantine procedures and evolution of pathogenes. Our survey has shown that *Leptosphaerulina crassiasca,* the pepper spot pathogen of peanut exists as endophyte in host leaves in many districts of Tamilnadu state. Changes in the endophyte assemblages of host plant as a response to fungicide treatment as reported by our school or host susceptibility also have relevance to plant health. Finally, the wide host range of some endophyte species that are phytopathogens and the environmental cues that may orchestrate the oscillations between pathogens and endophytes have important implications in plant health management.

L16. PGPR mediated systemic resistance against tobacco mosaic virus in Tomato

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Abstract

Tomato (*Lycopersicon esculentum*) is one of the most popular and important commercial vegetable crops grown throughout the world. In Karnataka, it is grown in an area of 0.4 million ha with a production of 1.14 million tones (Anon., 2006). Tomato is affected by a number of viral diseases including tomato mosaic causing substantial losses in yields. The tomato mosaic virus has been reported to cause reduction in weight of tomato fruits up to 59.0 per cent with a mean disease incidence of 55.98 per cent (Cherian and Muniyapppa, 1998). In recent years, treatment with plant growth promoting rhizobacteria (PGPR) has been suggested as an alternative strategy for the control of viral diseases (Zehnder et al., 2000). These PGPR strains are known to reduce viral diseases in a number of crops through induced systemic resistance (ISR) which is associated with increased synthesis of defense enzymes (M'piga, et al., 1997). Department of Agricultural Microbiology, University of Agricultural Sciences (UAS), Dharwad has a large collection of PGPR isolates. Several of them controlled the early blight disease of tomato caused by *Alternaria solani* through induction of systemic resistance (Earnapalli, 2007) and promoted growth and yield of tomato as well. Hence, in this investigation, an attempt was made to determine if these isolates could also protect tomato against infection by TMV.Six selected PGPR isolates were inoculated following seed treatment and soil application method. In the soil application method, the lignite based inoculum was mixed with FYM/Compost @ 5 kg per acre and applied to soil. Seven days after transplanting, TMV was mechanically inoculated. The preparation and inoculation of TMV was done as per the proven method (Rao and Reddy, 1971). Per cent disease incidence was recorded at 15 days after inoculation (DAI) and 30 DAI (Rao et al., 1980). The total phenol content in leaves (Folin Cio-Calteau method), peroxidase (Mahadevan and Sridhar, 1986) and phenylalanine ammonia lyase activity (Ross Sederoff, 1982) were assayed. A perusal of results obtained indicates that all the isolates significantly reduced the disease under greenhouse conditions. The disease control ranged from 77.78 to 100 per cent. Application of *Pseudomonas* sp. B25 and fluorescent *Pseudomonas* sp. B36 resulted in complete protection against TMV. Although PGPR isolates were applied through seed and soil application methods, TMV on foliage was controlled, suggesting that the protection against TMV is due to

ISR activity by the isolates. TMV, being a viral disease, the mechanism of triggering defense molecules rather than any other mechanism of biocontrol holds promise. Induction of systemic resistance has been reported to play an important role in biocontrol of fungal diseases such as powdery mildew of tomato (Kloepper et al., 1992) and angular leaf spot of cotton (Gayathri and Bhaskaran, 2005) etc. PGPR have been known to bring about ISR by changing the physiological and biochemical reactions of the host leading to the synthesis of defense chemicals against the pathogen (Van Loon *et al.,* 1998). All the plants treated with PGPR strains showed multi-fold increase in phenol content, peroxidase and PALase activity. One of the major biological properties of phenolic compounds is their antimicrobial activity (Saini et al., 1988). They are also known to enhance the mechanical strength of the host cell wall.

In our study, the tomato plants treated with *Pseudomonas* B-25 showed the highest induction of peroxidase (13.80 ΔOD/g protein/min) accounting to 37.31 percent higher than the healthy control. Peroxidase is a key enzyme in the biosynthesis of lignin (Bruce and West, 1989) and plays a role in oxidation of hydroxyl-cinnamyl alcohols into free radical intermediates which take part in defense of plants. Increase in peroxidase activity has been correlated with resistance to viral diseases including sunflower necrosis virus in sunflower (Srinivasan et al., 2003). Inoculation of tomato plants with *Pseudomonas* B-25 resulted in the highest synthesis of phenylalanine ammonia lyase (0.270 change in cinnamic acid/min/g) (68.75% higher than the healthy control). Phenylalanine ammonia lyase (PALase) is known to play an important role in the biosynthesis of various defense chemicals in phenyl propanoid metabolism (Daayf et al., 1997). These chemicals have diverse functions in plants such as strengthening and repair of cell wall by deposition of lignin and suberin, antimicrobial activity and as signaling compounds. The increased biosynthesis of phenols, peroxidase and PALase might have reduced disease incidence and increased disease control in all the PGPR treated plants.

Thus, the present study has indicated *Pseudomonas* B25 as the most efficient PGPR isolate in controlling TMV in tomato by triggering defense molecules. However, the study needs to be corroborated with field experiments.

L17. Development of a synergistically performing bacterial consortium for sheath blight suppression in rice

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Abstract

Quorum sensing factors that could affect the synergistic performance of biocontrol agents (BCAs) were considered before developing a bacterial consortium, which has been used against sheath blight (ShB) disease of rice in this study. This work could be a novel approach for developing the plant growth promoting rhizobacteria consortia for the management of plant pathogens. From a total of 2204 rhizobacteria, three compatible antagonists (*Bacillus* sp. MML20662, *Bacillus* sp. MML21927 and *Pseudomonas* sp MML20706) were identified. Their antagonistic activity was not affected by the culture filtrates of other antagonists; culture filtrate of pathogen and rice root exudates and they were relatively tolerant to oxalic acid up to 150 mM concentration. They significantly reduced the viability and germination of sclerotia of *R. solani* and increased the seed germination and seedling growth in rice cv. IR50 *in vitro.* The BCAs liquid formulation treatment in field grown IR50 plants has reduced 55.3% ShB incidence and increased 36% grain and 46.8% straw yield. The careful selection of antagonistic rhizobacteria with multiple/diverse disease

control mechanisms for possible quorum sensing influenced synergistic performance has resulted in the assured ShB disease suppression and substantial yield increase.

L18. Bio-active secondary metabolites from PGPR and botanicals

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Abstract

ICRISAT has a large collection of bacteria, fungi and actinomycetes with agriculturally beneficial traits (PGPR- including antagonists of fungal pathogens and entomopathogens) isolated from various sources of composts, rhizosphere and rhizoplane samples, in addition to potent botanicals. Bioactive secondary metabolites of the potent PGPR and botanicals (also from bio-wash of 7 different herbal composts) responsible for entomopathogenic (against *Helicoverpa armigera* and *Spodoptera litura*) and antagonistic to five disease-causing fungi (*Fusarium oxysporum* f. Sp. *ciceri*, *F. udum*, *F. solani*, *Sclerotium rolfsi* and *Macrophomina phaseolina* were studied. Secondary metabolites of the potent PGPR strains and botanicals including bio-wash were purified by solvent partitioning; solid phase extraction, TLC and reversed-phase open column chromatography. Stages in purification were monitored by a live/dead assay employing neonates of *Helicoverpa* and *Spodoptera* or plant pathogenic fungi. Final purification will be done in HPLC and the purified active compound(s) will be identified by mass spectrometry and nuclear magnetic resonance studies. At least 1500 accessions of PGPR viz. 89 phosphate solublizers, 252 siderophore producers, 198 cellulose degraders, 490 nitrogen fixers, 350 antagonists, 101 entomopathogens and 20 fluorescent *Pseudomonads* have been isolated in addition to 17 botanicals capable of killing *Helicoverpa* and *Spodoptera*. Purification of the secondary metabolites from the above PGPR and botanicals are on and results will be discussed in presentation. Potent PGPR and botanicals capable of killing insect pests and inhibiting fungal pathogens are available. Purification of bioactive secondary metabolites from these biological options is on.

L19. Mechanisms of Plant Growth Promoting Rhizobacteria against Soil Borne Pathogens of Coleus and Ashwagandha

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Abstract

Seven efficient PGPR strains showing a very high inhibitory activity against species of *Fusarium, Ralstonia Meloidogyne,* the soil borne pathogens of coleus were used in the study. To elucidate their mechanisms of biocontrol, tests to detect siderophore, hydrogen cyanide production, fluorescein and pyocynin, volatile metabolites and antimicrobial antibiotics production by them were carried out. The results of siderophore production indicated that the PGPR strains, RB50,

RB31 and RB 43 showed a higher activity when compared to other strains as measured by zone of colouration of 28, 27 and 23 mm surrounding the colonies on dark blue CAS medium. Strains RB13 and RB50 were scored as strong HCN producers: RB01 and RB31 were scored as moderate and strains RB10 and RB43 were graded as weak whereas RB22 did not produce HCN as there was no colour development in the medium. The strain RB13 showed strong production of fluorescein and strains RB31 and RB50 showed strong production of pyocynin in the specific *Pseudomonas* agar medium. All the seven strains produced more than one metabolite, which appeared as dark blue spots under UV light (254 nm). The Rf values of the metabolites varied from 0.12 to 0.94. Higher concentration of volatile metabolites were produced in strains RB50, RB31 and RB1 which inhibited pathogen *Fusarium* to an extent of >80 per cent, *i.e.* 87.8, 86.7 and 82.2 per cent, respectively.

L20. Anti-termite and crop enhancing properties of a rhizobacterial consortium on tea in plantation under live wood eating termite infestation.

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Abstract

The attack of pest and diseases significantly affect the productivity and health of the tea plants. Live wood eating termites is serious threat to the plantation to maintain its productivity. Use of synthetic chemicals had a concern in the exporting scenario due to the residue problems. Use of rhizobacterial strains is a viable alternative to tackle this problem. This study deals with the effect of a bacterial consortium consist of three fluorescent *Pseudomonas* strains on the control of termite infestation besides crop enhancement in tea grown in plantation under severe live wood eating termites attack. Three bacterial strains shown plant growth promoting as well as disease suppressing properties in our earlier investigation on many crop plants including tea was selected for this study. A formulation of these three organisms was developed for the application. Foliar and ground application of the formulation (60 lit/ha) was applied initially for two times in a month at an interval of fifteen days and then at an interval of 30 days for a year. The application of the formulation resulted in a significant reduction (48.93%) in the termite infestation besides an enhanced crop yield (15%). It was also observed a 100% reduction of the termite attack in aerial parts of the tea bushes. The results confirmed the test PGPR consortium ability to control the live wood eating termite attack in tea plants besides an enhanced crop production. The findings will encourage the tea industry to utilize PGPR based bio-formulations for eco-friendly cultivation practices in tea for termite control and crop enhancement

L21. Cloning of genes involved in siderophore biosynthesis in *Pseudomonas mediterranea* G229-21T

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Abstract

Biological control of plant diseases in tobacco is a viable alternative to use of chemical fungicides. The present study deals with cloning of specific genes of the PGPR strain, G-229-21T involved in siderophore biosynthesis and also its biocontrol efficacy against tobacco black shank pathogen, *Phytophthora parasitica* var. *nicotianae*. Rhizosphere soil samples were collected from tobacco plants and *in-vitro* studies were carried out for determining the siderophore production of *P. mediterranea* isolate. The G-229-21T strain was identified as *P. mediterranea* based on morphological, biochemical and physiological characteristics, 16S rDNA sequence homology, phylogenetics and specific species molecular analysis. The siderophore production of the PGPR strain was determined by column chromatography and *in-vitro* studies indicated that the *P. mediterranea* isolate effectively inhibited the tobacco black shank pathogen up to 92% under low iron conditions. The G-229-21T strain was found sensitive to kanamycin and further a siderophore deletion mutant of the strain, G-229-21TA was obtained. Amplification of specific-fragments of the mutant G-229-21TA indicated that it is a mutant of G-229-21T. The *lux*A of the mutant was identical to that of Tn5-1063a at 100% level. DNA sequencing results indicated that Tn5-1063 was inserted into phosphoribosylformylglycinamidine synthase gene. It was identical to that of *P. fluorescens* Pf-5, complete genome at 91% level. With genomic DNA of G-229-21TA as template, amplification of whole gene of phosphoribosylformylglycinamidine synthase was done and a DNA sequence of 5891bp length was obtained and it was found to be identical to the phosphoribosylformylglycinamidine synthase of *P. fluorescens* Pf-5 at 89% level. No information on the promoter region of this gene could be obtained with TAIL-PCR by using Promoter 2.0 Prediction Server, Web Promoter Scan Service, BDGP Neural Network Promoter Prediction.

L22. Metabolomics approach to study the plant-PGPR interaction with bacterial strains isolated from chitin/chitosan rich soil

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Abstract

Interactions of plant growth promoting rhizobacteria (PGPR) with the host plant has been a topic of great interest in recent times. Study of the changes that occur both in the plant and bacterial system can provide valuable information regarding the involvement of different metabolites in plant-PGPR interaction. Since metabolomics offer a non-biased identification and quantification of all metabolites in biological system, we have initiated work to decipher the key metabolites in this interaction. Chitinolytic bacterial strains isolated from different soils rich in chitin/chitosan were tested for their PGPR activity. Seed bacterization with two bacterial strains identified as *Bacillus cereus* and *Paenibacillus elgii,* based on their morphological and biochemical characters

and confirmed by 16S rDNA sequence, resulted in significant increase in growth in terms of shoot height, root length, fresh and dry weight of plants. We have designed a simple gnotobiotic assay to study the metabolome profile of *B. cereus* and *P. elgii* on tobacco plant during the interaction through analysis of functional groups using Attenuated Total Reflection Infrared (ATR-IR) spectroscopy. Bacteria grown in presence of different root exudates showed difference in peaks which could be related to their growth promoting activity. The main difference detected was the presence of amide double peaks at around 1650cm^{-1} in the spectra of bacteria grown in media amended with tobacco root exudate. In absence of tobacco root exudates, there is the occurrence of one single band at that area instead of the characteristic double bonds of amide I and II.

L23. Abiotic stress tolerance in agriculturally important microorganisms

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Abstract

The efficacy of bioagents is affected by predisposing ecological factors, particularly temperature and habitat diversity, apart from host-plant interactions. In India, research on stress tolerance in natural enemies to abiotic factors such as temperature, drought, and pesticides and the mechanisms governing stress tolerance has not been carried out. D'souza-Ault et al (1993) have reported that acetylglutaminylglutamine amide and glycine betaine impart osmotic tolerance in *Pseudomonas aeruginosa*. At CRIDA efforts have been made to characterize strains of *Pseudomonas*, *Bacillus* and *Trichoderma* for their biocontrol ability, plant growth promotion coupled with tolerance to abiotic stresses such as High temperature, drought and salinity. Several strains of these agriculturally important microorganisms have been collected from stressed agro-ecosystems such as high temperature regions of Rajasthan, acidic soils of North-east, saline soils of Haryana and drought affected areas.
Pseudomonas, 25 *Bacillus,* 10 *Bradyrhizobium* and 10 *Azospirillum* isolates were isolated from rhizosphere soils of rainfed crops from arid and semi arid zones. Nine and 18 isolates of *Pseudomonas* promoted more than 50% growth over control of sorghum and pigeonpea seedlings, respectively. Similarly, four and five isolates of *Bacillus* promoted more than 50% growth over control of sorghum and pigeonpea seedlings, respectively. One isolate of *Pseudomonas viz.,* P22 (isolated from rhizosphere of sorghum production system of A.P) and GASRB4 and HASRB25 *Bacillus* isolated from rhizosphere of sorghum production system of A.P were found to be promising plant growth promoters of sorghum in pot culture by 60% over control. Out of 74 isolates of *Pseudomonas,* P17, P74, P75 possessed more than 2 PGPR traits . Of which P17 could promote growth of both sorghum and pigeonpea. Six isolates of *Pseudomonas* showed more than 50% P solubilization and also enhanced biomass of sorghum and pigeonpea seedlings in the range of 25-80%. Similarly, 1 isolate of *Bacillus* (GASRB13) showed 23% P solubilization and also enhanced biomass of sorghum and pigeonpea seedlings in the range of 25-50%. Selected strains of Pseudomonas and Bacillus possessed biocontrol ability against major pathogens viz. *Macrophomina phaseolina*, *Rhizoctonia solani*, *Fusarium ricini*, *Botrytis ricini*, and *Sclerotium rolfsii*. Amoung 18 strains of *Trichoderma* spp, *Trichoderma*KN could withstand –118 M pa osmotic pressure (created by amending the medium with 35% Poly ethylene glycol 6000) and showed 77% growth. Among all strains, *Trichoderma* 115 recorded the maximum tolerance with 27.06% growth @ 2 M Nacl followed by *T. viride* -071 with 24.7 growth. *Trichoderma* 391 shown highest tolerance with 5.6 x 10^7 CFU/g at 50^0 C followed by

Trichoderma -71 with 3 x 10^7 cfu/g. *T.viride KN* strain was highly effective against *P. oryzae* showing 84% inbibitionover control. *T. Viride* KN was highly effective against R.solanishowing 84% inhibition of growth over control. Similarly, strain CRIDA-3, 071 and 115 inhibited 90% growth of *P. oryzae*. Further work is in progress on functional characterization of abiotic stress tolerance in these microorganisms.

L24. Plant growth promotional and biocontrol potential of fluorescent pseudomonads from western ghat regions of Karnataka

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Abstract

Attempts were made to assess the biocontrol potential, production of plant growth promoting substance (IAA and GA) and phosphate solubilization ability of 30 fluorescent pseudomonads (FP) isolated from the soils of different forests in the Western Ghats of Uttara Kannada District, Karnataka. Results of the antagonistic effect of FP isolates on five fungal and three bacterial plant pathogens showed that, all the isolates are found to possess biocontrol ability to control one or the other pathogen tested. All the isolates showed inhibitory activity against *Alternaria carthami* and *Pyricularia oryzae,* 28 were inhibitory to *Fusarium oxysporum f.sp. carthami,* 23 to *Sclerotium rolfsii,* 15 to *Rhizoctonia bataticola,* 11 to *Rolastonia solanacearum,* 13 to *Xanthomonas compestris* and 8 to *Xanthomonas compestris pv punicae.* Besides biocontrol potential, all the isolates found to produce Indole 3-acetic acid (IAA) and Gibberlic acid (GA) in the range of 30 – 782 µg/L and 55 – 260 µg/L broth, respectively. Seventeen out of thirty FP isolates showed zone of P-solubilization and the percent Pi released from TCP was in the range of 16.20 - 57.93%. The study indicates that fluorescent *Pseudomonas* spp can be used as an alternative to agrochemicals for controlling plant diseases and increasing plant development.

L25. Climate Change, Related Stresses and Agriculturally Important Microorganisms

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Abstract

Climate change impacts on agriculture are being witnessed all over the world. Increased incidence of abiotic and biotic stresses has become major cause for stagnation of productivity in principal crops. A wide range of adaptation and mitigation strategies are required to cope with climate change impacts. Microorganisms could play a significant role in this task, if we can understand their unique properties of tolerance to extremities and their ubiquity, genetic diversity and develop methods for their successful deployment in agriculture production. Besides developing mechanisms for stress tolerance like production of exopolysaccharides, accumulation of osmoprotectants and induction of heat shock proteins etc, microorganisms can also impart some degree of tolerance to plants towards abiotic stresses like drought, chilling injury, salinity

metal toxicity and high temperature through their activities in the root zone. Use of these microorganisms *per se* can alleviate stress in agriculture thus opening a new and emerging application of microorganisms. These microorganisms also provide excellent models for understanding the stress tolerance mechanisms that can be subsequently engineered into crop plants.

L26. Diversity of PGPR associated with the saline coastal ecosystems and their beneficial roles in sustainable agriculture

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Abstract

In last few decades a large number of bacteria including species of *Pseudomonas*, *Azospirillum*, *Azotobacter*, *Klebsiella*, *Enterobacter*, *Alcaligens*, *Arthobacter*, *Burkholderia*, *Bacillus* and *Serratia* have been reported to enhance plant growth (Kloepper *et al*., 1999; Glick, 1995). With relatively short generation times and rapid growth under favorable conditions, microbial communities could be among the fastest components of an ecosystem to respond to changing environmental conditions (*Prosser et al*., 2007). The rhizobacterial communities are affected by different environmental stress *viz*., increasing CO_2 concentration, temperature, drought, salinity and agricultural practices which appear to determine community structure. In the last 150 years, the atmospheric CO_2 concentration has increased by approximately 33% due to human activity, and is predicted to continue to rise by 0.4% per year (Alley *et al*., 2007). There is considerable uncertainty about how rates of soil carbon (C) and nitrogen (N) cycling will change as CO_2 accumulates in the Earth's atmosphere. Any change in the amount and/or composition of plant material input into the soil in response to elevated CO_2 is therefore likely to affect soil microbial growth and metabolism of plant-derived substrates, and consequently C and N cycling in soils (Zak *et al*., 2000). Nitrogen plays an important role in the terrestrial ecosystem type and in ecosystem responses to climate change, with nitrogen controlling the feedback mechanisms of carbon sequestration (Lu *et al*., 2008). The changes in the frequency, relative abundance and richness of the functional genes nitrous oxide reductase (*nosZ*) and dinitrogenase reductase (*nifH*) with increasing CO_2 was investigated by Walker *et al*. (2009). Long-term experimental warming alters nitrogen-cycling communities but site factors remain the primary drivers of community structure in high arctic tundra soils (Jennifer *et al*., 2009). However studies on the rhizosphere microbiology especially describing the impact of the different environmental stress have been demonstrated. This paper presents the work carried out at the foundation as part of static research in understanding the rhizosphere microbes closely associated with saline coastal agriecosystem focusing on the mangrove ecosystem which serves as a bridge between the terrestrial and marine ecosystem, as increasing salinity is problem in the scenario of climate change. Our studies revealed that salinity caused a predominant selection of salt tolerant species of *Pseudomonas* spp. and *Azospirillum* spp. in the rhizosphere of different crops (Sunitha *et al*., 2001; Saleena *et al*., 2001). Although the mangrove ecosystem is rich in organic matter, by and large they are nutrient-deficient especially in nitrogen and phosphorus. Diversity of microbial communities inhabiting this unique swampy, saline, partially anaerobic environment is useful as it provides clue of the microorganism and their adaptability in such habitats (Semenov *et al*., 1999). Information is scarce with respect to the association of rhizobacteria with mangroves (Petra *et al*., 2004). Root exudates of higher plants serve as a food source for the microorganisms

living in this ecosystem. In addition, sediment and rhizosphere microorganisms are also the major biological components that contribute to the productivity of mangroves. Very little information is available about the microbial diversity, mechanisms and their interactions in the mangrove ecosystem. The work carried out at the M.S. Swaminathan Research Foundation has shown that the mangrove ecosystem is a most unexplored ecosystem which harbors potential microbes and there is a lot of scope for the identification of novel microbes with novel functions. In conclusion, this study for the first time demonstrates the occurrence of genetically diverse groups of antagonistic, diazotrophic red-pigmented Vibrios from different mangrove plants and suggests a new ecological role for Vibrios as heterotrophic plant associated rhizobacteria. This gains significance as the mangroves ecosystem is one of the crucial ecosystem which plays antiquity role during sea level rise as was demonstrated during tsunami. These beneficial saline tolerant microbes can be utilized in improving plant growth and yield in the coastal agriecoystem. However, the impact of climate change on the rhizosphere microbes still remains an unanswered question, due to the absence of substantial data. Therefore, the impact of the changing CO_2 level in the climate change regime on microbial diversity needs to be investigated, which will throw more light on diversity, ecology, physiology and functionality of the beneficial microorganisms.

L27. Management of rhizome rot of ginger using rhizosphere microbial communities

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Abstract

Ginger (*Zingiber officinale* Rosc.) belonging to the family Zingiberaceae is an important commercial crop grown for its aromatic rhizomes, which is used both as a spice and a medicine. A large portion of the ginger produced is consumed domestically as green ginger or dried ginger in culinary preparations. India is a major ginger producing and exporting country of the world, though it is also grown in China, Hawai, Japan, Pakistan, West Indies, Africa and Australia. During 2006-2007, the country produced 7,21,539 tonnes of the spice from an area of 1,29,014 ha and is grown mainly in Kerala, Meghalaya, Arunachal Pradesh, Mizoram, Sikkim, Nagaland and Orissa states together contributing 70 per cent to the country's total production. The cultivation of the crop is often hampered due to attack from a slew of rhizome diseases. Soft rot and yellows caused by species of *Pythium and Fusarium*, respectively, which are simultaneously predisposed by species of *Meloidogyne* and *Pratylenchus* gnaw away the roots of farmer's prosperity in different ginger growing areas. The disease intensities augmented through years due to inadequate knowledge on their nature, lack of quality planting material and improper management practices. Specific management practices targeting a particular pathogen i.e., *Pythium, Fusarium*, *Meloidogyne* and *Pratylenchus* often fail to minimize crop loss since a diverse group of fungal and nematode pathogens attack the crop in field and seed rhizomes during storage causing mixed infections. Being soil borne and the growing interest in producing organic rhizomes with little or no pesticide residue, chemical management is less preferred. Developing resistance varieties can be difficult in the absence of dominant genes and development of new races of the pathogen overcoming host resistance.

Biocontrol by use of plant growth promoting rhizobacteria (PGPR) represents a potentially attractive alternative disease management approach since PGPR are known for growth promotion and disease reduction in crops. Disease reduction by PGPR in colonization of plant roots occur directly, through competition for space, nutrients and ecological niches or production of

antimicrobial substances, and indirectly, through induction of systemic resistance (ISR). PGPR induce resistance in plants against fungal, bacterial and viral diseases, and insect and nematode pests. Despite these advantages, exploitation of PGPR appears to be very remote in rhizome rot management, even though the potential benefits of biocontrol agents (BCAs) like *Trichoderma* spp. have been partially demonstrated. Lack of information on disease threshold levels, reported inconsistent performance of a single BCA due to mixed infections and lack of technologies for commercialization could be the possible research gaps for the inadequate exploitation of PGPR to plan management strategies for rhizome rot of ginger.

Combined application of two or more biocontrol strains is likely to more closely mimic the natural situation and may, therefore, represent a more viable control strategy. Exploitation of native, efficient and stress tolerant multiple strain mixtures of rhizobacteria or rhizobacteria in combination with fungi like *Trichoderma* spp. capable of operating in ginger ecosystem could be therefore a viable approach to contain the diseases. Use of rhizobacteria in conjunction with fungicides as seed treatment may also be a valuable complementary strategy in disease management. An additional benefit of using such an integrated approach is to reduce residues on green ginger. Efficient biological control strategies can also be explored by exploitation of non-culturable organisms from the rhizosphere by metagenomics.

A careful evaluation and adaptation of these strategies under different cropping systems would highlight their importance in Integrated Disease Management package to be included in the package and practices of the crop.

L28. Biopesticide Registration: What is the Pathway for Public Sector Researchers?

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Abstract

The regulatory considerations in transitioning from a basic research project into a marketable product will be described including the registration process and requirements, networking to enhance data and waiver development, and information on funding and organizational infrastructure related to product development. This presentation is a primer for scientists involved in university and governmental research programs on how they can integrate regulatory research to satisfy regulatory requirements as a tandem to their research projects. Biopesticide research strategies and waiver construction are important considerations that can greatly assist in the process of bringing products to market.

L29. Commercialization strategies for PGPR products – Asian perspective

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Abstract

Asian countries have problems with handling nematodes and desertification along with many other environmental concerns. **3BioNet**'s advanced PGPR strains provided by our network and strong, thorough analysis of situation made possible to provide solution to those problems in our

previously tested soils around Korea and China. Furthermore, with the grown concern of environmental pollution, Asian countries are trying to avoid the use of chemical fertilizer and fungicides. With **3BioNet**'s network, we've been providing solutions to handle the situation and results exceeded our expectation. Based on our results, we have established following strategies to commercialize PGPR-based products:

3BioNet's commercialization strategy is based on providing consulting, CRO, and licensing. Throughout Asia, there are strong needs for environment-friendly microbe around the continent in recent years. Our consulting provides a thorough analysis of client's market, which to determine products, types (PGPR-based bio fertilizer, bio-pesticide or bio control), and establishing business strategies. Our CRO (Contract Research Organization), provides services in testing and conducting experiments on client's product as well as manufacturing (CMO) and sales (CSO) through **3BioNet** network, which gives an advantages to the clients of utilizing our ability of know-how, analysis and fastens product's commercialization.

Our licensing strategy is generic term of licensing-out and licensing-in. Through **3BioNet** network, we create a connection between organizations, whether it is a government or company or even institution. With this in place, our clients get benefits on R&D in aspects of saving time and cost. **3BioNet**'s licensing is not limited to the strains but natural products such as Neem, which the UN named as the 'tree of the 21st Century'.

L30. Skill enhancement in PGPR research and application for stake holders

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Abstract

Research activity on Plant Growth Promoting Rhizobacteria (PGPR) has become most sought after because of its potential. PGPR Research has picked up in all developed countries much faster because of its importance for increased crop growth, production and productivity. With increased demand for organic fruits and vegetables, PGPR products fit in very well for popularization of organic agriculture as an eco friendly technology. The reported higher yields by the PGPR product Bioyield by 200% in US is a clear indication of the potential of PGPRs. The pioneering research of Prof Joseph Kloepper and his group at University of Auburn, Alabama, US has given the leadership in this novel area of research. Inspite of rich microbial biodiversity that exists in tropical countries of Asia & South East Asia, the research efforts to tap this bio resource are far from satisfactory.

In India there are few research Groups, particularly at IARI, New Delhi, GB Plant University of Agriculture & Technology Pant Nagar, CAS, Botany of University of Madras, TNAU, Coimbatore, Central University & CRIDA, Hyderabad, IISR, Calicut which are very active as indicated by their research publications and product development . The International PGPR Workshop conducted at IISR, Calicut, India, with participation of several senior researchers during October 2003 did stimulate the activity of PGPR Research in India. The meeting enabled young active researchers to interact with leading scientific fraternity and has become a milestone in Indian PGPR research.

The enhanced research activity through funding by, Indian Council of Agriculture Research, (ICAR), Department of Biotechnology, Council of Scientific & Industrial Research (CSIR) led to the identification of potential PGPRs that had growth enhancement of target crops and also

disease suppressive potential. The fermentation technological facilities are in place. Some of the products are now in market. But there is a need for large scale field demonstrations to convince farming community about the potential of this ecofriendly technology. After India, the research activity in China and South Korea are highly impressive compared to other countries in Asia like, Sri Lanka, Pakistan, Indonesia, Malaysia, Singapore, Thailand, Cambodia, and Vietnam. But the opportunities in these countries are enormous for PGPR Research. Efforts are now being made recently in these countries to persue this activity.

Some of the reasons for the poor activity of research are lack of funding, infrastructure, lack of communications and opportunities scientific interaction.

The stake holders are the farmers and the companies involved in Bioproduct development, but face problems in registration and quality which need to be addressed.

In view of the above constraints, there is a need for grater funding for research and infrastructure development in Asia.. With the new launching of ASIAN PGPR, these lacunae can be over come to encourage PGPR research through networking of these research organizations to ensure a greater interaction that would enable to enhance crop productivity in these countries.

L31. Toward a Much-Needed Second Green Revolution

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Abstract

The basis of the Green Revolution of the 1960s and 1970s was Dr. Norman Borlaug's innovative plant breeding techniques that developed varieties of wheat and rice that responded well to chemical fertilizers, pesticides, and irrigation. The dramatic results that were witnessed in South Asia prompted investments in an international agricultural research network, coordinated by the Consultative Group for International Agricultural Research (CGIAR), buttressed with investments to strengthen national agricultural research systems in many countries. For the next two or three decades, except for parts of sub-Saharan Africa, food production increased faster than populations. Subsequently, large funding institutions, such as the World Bank, the U.S. Agency for International Development, and others, at least partly in response to certain pressure groups, began to back off in their support for the kinds of research that had sparked the Green Revolution. Increases in food production per capita began to taper off. Human hunger is spreading in many countries. The time is ripe for a second Green Revolution. The 2009 Asian PGPR Congress for Sustainable Agriculture is both timely and fortuitous. A reasonable objective for the Congress is to lay the groundwork, the foundations, for a Second Green Revolution. As a supplement to ongoing, innovative PGPR research, Dr. Hesser will describe a new non-toxic, humanly safe foliar spray developed by a firm in the USA that stimulates plant growth while causing the plants to resist harmful insects and diseases.

L32. Impact of Pesticides on Soil Micro Flora and on Plant Growth

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Abstract

The use of pesticides on agricultural crops causes environmental pollution and can affect the useful micro-organisms in soil. The effect of pesticides on microbial activities and population varied greatly with the type of pesticides. Insecticide, in general, have detrimental influence on the microbial and biochemical properties in soil while the fungicide results in more or less neutral effect. Herbicide on the contrary induces a beneficial influence on the microbial and biochemical properties in soil. A *Pseudomonas fluorescens* strain was resistant to some of the major Indian water pollutants, namely BHC [HCH], 2,4-D, mancozeb and phenols up to the levels occurring in the highly polluted regions. Moreover, the test strain seems to have a great potential for the detoxification of these pollutants. *Aspergillus niger,A. flavus and Trichoderma sp*. were common and dominant in the soils treated with pesticides i.e. malathion, 2,4-D and Sixer (carbendazim+mancozeb),. Sixer showed the maximum reduction in the number of fungal colonies. *Mucor sp.* could be isolated from Sixer-treated soil. *Mycelia sterilia* were lacking in Sixer-treated soil but was not affected by 2,4-D and malathion treatment. Heavy metal resistance and pesticide resistance properties were observed in *Azotobacter chroococcum* in different soil isolates whose concentrations ranged from 5-1000 micro g ml^{-1} and also to 2,4-D, aldrin and lindane whose concentrations ranged from 0-10000 ppm. Cyanobacterial species occur abundantly in rice fields of tropical and subtropical countries where agricultural technologies are involved in extensive use of pesticides for selective elimination of pests and weeds of rice crops. Cyanobacteria show high variations in their tolerance limits to the effect of different pesticides. The studies on different pesticides (propiconazole, profenofos, pretilachlor) on vermicomposting with *Eisenia foetida* for the adverse effects on soil enzyme activities (dehydrogenase [oxidoreductase], phosphatase [phosphoric monoester hydrolases], urease) and total microbial counts (TMC). revealed remarkable increase in enzyme activities and TMC in presence of earthworm. The study was designed to determine the persistence of chlorpyrifos (an organophosphate, Kurifast 40% EC) and fenpropathrin (pyrethroid, Dathrin 20% EC) pesticide alone and in combination with synthetic fertilizers viz., Urea, DAP [diammonium phosphate], SOP [potassium sulfate] and Foliar fertilizer Polydol with tap/hard water showed that Bacillus sp. was adversely affected by chlorpyrifos at 1000 ppm, but not by fenpropathrin. Klebsiella spp. population increased with the application of both pesticides. Quinalphos and 2,4-D enhanced both the percentage of infection and number of mycorrhizal propagules in both species. A direct correlation was observed between the extent of mycorrhizal infection and growth of the plants. Carbendazim inhibited VAM root colonization in agroforestry tree species particularly during the early growth stages. Application of 2,4-D_benefited soil fungi while the bacterial populations were depressed initially. 2,4-D does not persist in the paddy field beyond 30 days after spraying.2,4-D resulted in the greatest proliferation of bacteria, actinomycetes and fungi, and build-up of DTPA-extractable iron in the rhizosphere soil. Highest yield of rice was obtained from the treatment PSF 10 WP @ 100 g/ha. Pyrazosulfuron-ethyl proved stimulatory for both the beneficial organisms such as phosphate solubilizing bacteria and non-symbiotic N-fixing bacteria where as acetochlor showed negative response. Though availability of micronutrients did not follow any definite pattern of change with crop growth but higher availability was found in case of PSE 10 WP over acetochlor. Stomp, ripcord, tenekil, and sunfuran were highly toxic to soil microbes if all of the recommended concentrations reach the soil. The soil microbes were not affected by aplication of recommended level of mepra.

L33. Analysis of bacteria community during different growth and development stages of cotton rhizosphere soil

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Abstract

The rhizosphere constitutes a complex niche that may be exploited by a wide variety of bacteria. This study based on the extraction of cotton rhizosphere bacterial metogenome of high quality. The effect of developing cotton or invaded by the pathogenic fungus *Verticillium dahliae* roots on the presence and activity of bacterial populations in the rhizosphere was examined by using culture-independent methods, such as T-RFLP, 16S rDNA clone library and DGGE. In the extraction of soil metogenome DNA, we explored a method suitable for the extraction of plant rhizosphere soil bacterial metogenome under the premise of ensuring the integrity, yield and purity of metagenome. The results showed that bacterial community structure in rhizosphere of healthy and diseased cotton dynamic and changing after a growing season. Cotton rhizospheric bacterial community consists of *Proteobacteria*, *Firmicutes*, *Bacteroidetes* and *Acidobacterteria*. The diversity index of each sample was calculated by software Bio-Dap. 3h sample has the highest Shannon-Weaver diversity index (H′) and the the reciprocal of Simson's index of diversity (1/D), but 4y sample has the highest evenness (E). From squaring period to flowering and boll-forming period, the bacterial type were more abundant, which increased from 9 kinds in healthy squaring period to 15 kinds in healthy flowering and boll-forming period, but decreased to 9 kinds from flowering and boll-forming period to boll-opening period. The same rule was found in diseased samples. The primers 27F and 1492R were used to constructed six 16S rDNA clone libraries, namely, healthy cotton rhizosphere soil sample in squaring period, diseased cotton rhizosphere soil sample in squaring period, healthy cotton rhizosphere soil sample in flowering and boll-forming period, diseased cotton rhizosphere soil sample in flowering and boll-forming period, healthy cotton rhizosphere soil sample in boll-opening period and diseased cotton rhizosphere soil sample in boll-opening period. Subsequent sequence analysis revealed that, on the basis of the about 1500-bp sequence information, 79.2% has the highest similarity with uncultured bacteria. *Acidobacteria* and *Proteobacteria* are predominant. There are also 3%-8% of unclassified bacteria. According to the statistical analysis of this study, the predominant subgroups are the alpha, beta, gamma or delta subgroup and *Acidobacteria* in cotton rhizosphere soil. It is very interesting that epsilon *Proteobacteria* can not growth in cotton rhizosphere. Analysis of DGGE profiles by Quantity One, all of healthy samples were clustered one category in the level of 0.54 similarity, all of diseased samples were clustered another category in the level of 0.72 similarity, it showed that the cotton rhizosphere bacterial community composition was affected by the pathogens. The analysis of subclone showed that the brightest band in DGGE profiles matched with Alpha *proteobacterium*, this result was consistent with 16S rDNA clone libraries.The impact of invasion of pathogens on the cotton rhizosphere bacterial community was greater than root system activity in squaring period; root activity was the major influencing factors in flowering and boll-forming period, however, the impact of invasion of pathogens the cotton rhizosphere bacterial community was relatively smaller. To get biological control bacteria or beneficial gene for *Verticillium dahliae* Kleb., we could study diseased cotton rhizosphere soil sample in boll-opening period.DGGE had the highest resolution in the three ways. 16S rDNA clone library had the relative lower resolution and larger workload, but the most detailed sequence information can be obtained by this way. From the results of this study, the combination of DGGE and 16S rDNA

Poster session:
PGPR applications in Crops

P1.1. Evaluation of bacilli and fluorescent pseudomonads isolated from the rhizosphere and roots of *Theobroma cacao* L. for biological control of *Phytophthora palmivora*

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Abstract

Because of the high disease pressure and environmental concern biological control is a pertinent area of research for cocoa (*Theobroma cacao* L.) disease management. This study was conducted to evaluate the potential of bacilli and fluorescent pseudomonads as biological control agents. A total of 519 isolates were isolated from the rhizosphere and roots of cocoa trees in natural ecosystems of South India and evaluated for their ability to control *Phytophthora palmivora*, the black pod pathogen of cocoa, isolated from Vata, Kasaragod, under *in vitro* conditions on Carrot Dextrose Agar (CDA). Out of the 519 cocoa isolates (359 bacilli and 160 fluorescent pseudomonads), 95 isolates (44 rhizospheric bacilli, 45 endophytic bacilli and 6 rhizospheric fluorescent pseudomonads) were found to be antagonistic against *Phytophthora palmivora*. Among bacilli, four isolates, one from Pollachi (PSB 6) and three from Kasaragod (KGSB 5, KGSB 11 and KGSB 26) showed a maximum of 57% mycelial growth reduction of the test pathogen. One fluorescent pseudomonad isolate from cocoa rhizosphere from Kannipady area of Kasaragod (KGSF 26) and another from Kozhikode (KZSF 6), showed a maximum of 43% antagonism against *Phytophthora palmivora*. None of the fluorescent pseudomonads, isolated from the roots of cocoa showed antagonism against the black pod pathogen. According to previous studies with these isolates, it seems that the *in vitro* fungal inhibition caused by them may be due to the production of siderophores, or to HCN production or chitinases, or due to the production of antibiotics. The isolates showing higher antagonistic activity against the tested pathogens can be used in developing bio-control agents. And further field trials are necessary to confirm their effectiveness and potential in the field.

P1.2. Isolation and functional characterization of potential plant growth promoting fluorescent pseudomonads from the cocoa roots and rhizosphere

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Abstract

Cocoa (*Theobroma cacao* L.) is indigenous to the equatorial regions of the America, western slopes of the Andes and the American basin. In India, its cultivation is mainly concentrated in Kerala state and Dakshina Kannada district of Karnataka state. In recent years, fluorescent pseudomonads have emerged as a largest and potentially most promising group of plant growth promoting rhizobacteria (PGPR). In search of efficient PGPR strains with multiple activities, a total of 160 bacterial isolates belonging to fluorescent pseudomonads were isolated and purified from the rhizosphere soil and roots of cocoa. Strains were individually screened for *in vitro* production of IAA, ACC deaminase, HCN, siderophore, chitinases and antibiotics, ammonification, ability to grow on N-free media, solubilization of phosphate. Isolates selected on

the basis of *in vitro* screening for plant growth promoting traits were evaluated for elicitation of growth promotion of cowpea *in vitro* and *in vivo.* The results showed that 90% of the fluorescent pseudomonads produced siderophores. About 60% of 160 strains, showed the potential to utilize ACC, to solubilize phosphate, to produce IAA and ammonia. Less than 20% of isolates produced antibiotics, HCN and chitinase where as only 2% of the isolates could grow on N-free media. *In vitro* testing on soft agar indicated that 19 fluorescent pseudomonad isolates increased seedling length. *In vivo*, seven fluorescent pseudomonad isolates promoted seedling length, fresh weight and dry weight under greenhouse conditions. Results suggested that elicitation of growth promotion of cowpea seedlings by fluorescent pseudomonads was associated with production of plant growth regulators, particularly IAA. Selected isolates from this study can be used for developing potential plant growth promoting agents. Further studies are needed to investigate the role of these PGPR in improving the growth of the cocoa seedlings.

P1.3. *In vitro* antagonism studies of rhizospheric fluorescent pseudomonads of coconut against *Ganoderma* sp. and *Thielaviopsis paradoxa,* fungal pathogens of coconut

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Abstract

Ganoderma sp. and *Thielaviopsis paradoxa* are two soil borne fungal pathogens of coconut causing basal stem rot and stem bleeding diseases, respectively. We had isolated 156 fluorescent pseudomonads from rhizospheric soil of coconut from various locations in southern states of India such as Kerala (60 isolates), Karnataka (60 isolates), Tamil Nadu (11 isolates), Maharashtra (16 isolates) and Andhra Pradesh (9 isolates), with an aim to develop an efficient biocontrol agent against these pathogens. Antagonism of fluorescent pseudomonads towards *Ganoderma* sp. and *Thielaviopsis paradoxa* were tested in a dual-plate assay on King's B agar plates. 8% of the total fluorescent pseudomonads were antagonistic to *Ganoderma* sp. (inhibition ranging from 39% to 73%) and 16% of the isolates inhibited *Thielaviopsis paradoxa* in the range of 20%-78%. More number of antagonists were found in Tamil Nadu rhizosphere soil. About 27% of the Tamil Nadu isolates inhibited the growth of both pathogens, while it was lower among the isolates from Kerala (2% against *Ganoderma* sp. and 7% against *Thielaviopsis paradoxa*). 8 to 13% of the fluorescent pseudomonads from the other states showed significant inhibition towards *Ganoderma* sp. and 16 to 33% of the isolates inhibited *Thielaviopsis paradoxa* under *in vitro* conditions. The highest antagonism against *Ganoderma* sp. was found with KiF 17, a fluorescent pseudomonad from Kidu, Karnataka rhizosphere soil. It inhibited the growth of *Ganoderma* sp. by 73%. A maximum of 78% of growth inhibition was observed against *Thielaviopsis paradoxa* by the fluorescent pseudomonad KiF 21 from Kidu, Karnataka rhizosphere soil. 8% of the fluorescent pseudomonads significantly inhibited both pathogens tested. This study indicates the potential of indigenous fluorescent pseudomonads for biological control of coconut pathogens and further detailed studies are in progress.

P1.4. Screening of fluorescent pseudomonads from rhizosphere of coconut (*Cocos nucifera* L.) for plant growth promoting traits

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Abstract

Coconut (*Cocos nucifera* L.) is a very important crop in South and Eastern India, and occupies a position in the economy of the country. The coconut, a perennial horticultural crop, is grown either as sole crop (mono cropping) or in combination with compatible crops (mixed cropping). There is an immense possibility for increasing the agricultural production in coconut and intercrops through microbial manipulation of the soil. As the effect of PGPR on various crops have been demonstrated in a number of studies, this study was undertaken to isolate, screen and evaluate fluorescent pseudomonads from rhizosphere of coconut for various plant growth promoting traits. 156 fluorescent pseudomonads from rhizosphere soils of coconut growing in southern states of India were isolated, purified and characterized for various direct and indirect plant growth promoting traits. Out of the 156 isolates, more than 90% of the isolates exhibited phosphate solubilizing capability, siderophore production and ammonification. IAA production and ACC deaminase activity was noticed in 85% of the isolates. 5% isolates produced HCN, 2% isolates showed growth on N-free media and one fluorescent pseudomonad exhibited chitinolytic activity. Antibiotic production was detected in 10% of the fluorescent pseudomonads. 8% isolates showed antagonism against *Ganoderma* sp. and 16% isolates showed antagonism against *Thielaviopsis paradoxa*. All the isolates were assessed and scored in a scale of 1 to 3 based on their performance in above plant growth promoting traits. A total of 21 isolates, which scored more than 11 points, were further selected for seedling bioassay with paddy seeds under Environmental growth chamber conditions. Twelve isolates were found to be potent in paddy growth promotion which were then subjected to green house assay in un-sterile soil conditions. All the isolates tested were found to increase seedling length, fresh weight, and dry weight of paddy seedlings when compared to the uninoculated plants. The population of fluorescent pseudomonads was higher in the rhizosphere region of greenhouse-grown and inoculated paddy seedlings as compared to uninoculated plants. These studies highly commended the efficiency of the fluorescent pseudomonads isolated from coconut rhizosphere to be developed as bioinoculants.

P1.5. Effect of bacterization of finger millet grains with the PGPRs isolated from the rhizoplane of *Holostemma ada-kodien* Schultes. on its germination and seven days linear growth

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Abstract

Holostemma ada-kodien Schultes.(Asclepiadaceae), an endangered medicinal plant is a laticiferous, twining herb with tuberous roots. The roots are medicinally important and are used in more than 34 Ayurvedic preparations. It is included in the Red listed medicinal plants of South

India by FRLHT, due to the scarcity of the species in the natural habitats. So far there are no reports on PGPRs associated with this taxon. Five types of bacteria were isolated from the rhizoplane of *Holostemma ada-kodien* and were named RPHG1 (G- rods), RPHG2 (G+ rods), RPHG3 (G+ cocci), RPHG4 (G- rods) and RPHG5 (G+ rods). They were screened for phosphate solubilization, production of IAA, NH_3, and their growth promoting efficiency on finger millet was tested. The finger millet grains were treated with bacterial isolates, individually and also in different combinations and were germinated under *in vitro* conditions. The observations were recorded for one week. All the 5 bacterial isolates answered positively for production of IAA and NH_3 to varying degrees but only three showed phosphate solubilizing ability. RPHG5 alone showed growth promoting effect on the overall growth of the seedlings over the control whereas, RPHG3 showed an improvement only in the shoot growth. The mixture of these two isolates also showed an improvement only in the shoot growth. However, contradictory results were obtained with the rest of the three bacterial isolates. RPHG5 alone can be used to enhance the overall initial seedling growth of finger millet. The varied concentrations of IAA produced by the bacteria have probably played a role in regulating the root and shoot growth as, the effective concentration for shoot growth is generally inhibitory for the root growth. Though the isolates RPHG1, RPHG2 and RPHG4 reduced the seedling growth at this initial stage, investigation is going on to find out their possible positive effects on the later stages of plant growth as they have produced NH_3 and solubilized phosphate.

P1.6. Actinomycetes diversity in Turmeric (*Curcuma longa* L.) soils

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Abstract

An attempt was made to isolate actinomycetes from turmeric (*Curcuma longa* L.) soils collected from different districts of Tamil Nadu state for the production of bioactive secondary metabolites. The results showed that the population density of actinomycetes was found to be more in Erode (10.8 x10^3 cfu /gm soil dry wt) region followed by Salem (9.8) and lesser in Coimbatore (4.7) and Namakkal (4.3) regions. The population density was found to be interrelated to the soil nutrient status. All these isolates were purified, screened and characterized for their antifungal activity. Based on the morphological and biochemical parameters, all the isolates were identified as *Streptomyces* spp. Subsequently the strain (TPA-31) was tested against a rhizome rot pathogen (*Fusarium solani*) which revealed that the pathogen's growth was suppressed significantly under *in vitro* condition.

P1.7. Response of aerobic rice (*Oryza sativa* L.) to different isolates of *Bacillus megaterium*

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Abstract

The investigation was carried out to study the growth response of three varieties of aerobic rice to *Bacillus megaterium* isolated from soils of the ten different agroclimatic zones of Karnataka.The three aerobic rice varieties (MAS 26, MAS 946, MAS 109) were treated with ten different isolates of *Bacillus megaterium* under green house conditions. Observations on plant growth parameters like plant height, number of leaves, number of tillers, number of panicles, and biomass were recorded. Among the ten different zone isolates of *Bacillus megaterium*, zone 7 isolate performed best in improving plant growth, number of leaves,number of tillers and biomass when compared to un inoculated control and other treatments.

P1.8. Development of PGPR consortium for *catharanthus roseus* (l.) G. Don. Medicinal plant

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Abstract

In Tamil Nadu, the commercial cultivation of *C. roseus* is gaining momentum in the southern districts of Madurai, Tirunelveli `and Virudhunagar due to less input cost and wide adaptability in poor soils. With the aim of developing biofertilizer consortium technology, (i) relative occurrence of PGPR in the rhizosphere soils of *C. roseus* of different locations of Tamil Nadu, (ii) Isolation, purification, classification, screening of PGPR isolates and (iii) development of carrier based biofertilizer consortium for *C.roseus* were worked out. The relative occurrence of PGPR in the rhizosphere of soils of *C. roseus* collected from collected from twenty different locations of Tamil Nadu was enumerated. The isolates are further designated, characterized, screened for plant growth promoting traits. The best isolates (CAZS-4, CAZB-1, CPB-18 and CPF-14) inoculants as consortium in different carrier materials like lignite, vermiculite, pressmud and alginatebead with a cell load of $1x10^9$ cfu ml^{-1} i.e. $8.22x10^4$ for *Azospirillum*, $4.00x10^4$ for *Azotobacter*, $3.88x10^4$ for *Bacillus* and $3.92x10^4$ for *Pseudomonas.* The minimum population was recorded in N. Pudhur of Virudhunagar district. Among the twenty isolates of *Azospirillum*, CAZS-4 obtained from *C. roseus* recorded the maximum nitrogenase activity of 465.54 n moles of C_2H_4 recorded the maximum nitrogenase activity of 458.71 n moles of C_2H_4 mg^{-1} of protein hr^{-1} and cell nitrogen of 38.98 mg g^{-1} of cell weight followed by CAZB-18 and CAZB-5. All the PGPR isolates screened for phytohormones such as indole acetic acid and gibberellic acid. The *Azospirillum* isolates CAZS-4 produced the maximum amount of 85.3 µg of IAA 25 ml^{-1} of nitrogen free malate broth and 7.00 µg 25 ml^{-1} followed by other isolates of PGPR. The isolate CPB-18 recorded maximum solubilization of 30.2 mg of phosphorus, 84.46 n moles of p-nitrophenol min$^-$

^{1} mg^{-1} of cell protein of acid phosphatase activity. 2.9 of titrable acidic reduction of pH 4.0 followed by CPB-14 and CPB-4 isolates. Among the PGPR isolates, *Pseudomonas* isolates CPF-14 recorded the maximum siderophore production of 8.32 and 9.24 µg of catechol and salicylate types ml^{-1} which was followed by *Bacillus* and *Azospirillum* isolates. The surviving population per gram of alginate bead with PGPR consortium was 64.69 x 10^8 of *Azospirillum* 56.88 x 10^8 of *Azospirillum*, 49.88 x 10^8 of *Bacillus* and 64.66 x 10^8 of *Pseudomonas* in consortium inoculants and it was found to be the best carrier material and shelf life of 6 months was achieved followed by lignite, vermiculite and pressmud. Further, this PGPR consortium has been tested against *C. roseus* rosea and alba variety in both pot culture and field studies.

P1.9. A novel strain of *Bacillus circulans* isolated from apple rhizosphere showing plant growth promoting potential

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Abstract

Phosphate solubilizing microorganisms (PSM) play a significant role in making phosphorus available to plants. Studies on phosphate solubilizing activity of rhizobacteria associated with apple seedlings have not been conducted. Therefore, the present investigation deals with an *in vitro* study of phosphate solubilizing ability of apple rhizobacteria along with release of pathogen-suppressing metabolites. Rhizosphere soil bacterial strain of *Bacillus circulans* MTCC 8983 was isolated by standard microbiological techniques. Tri-calcium phosphate (TCP) solubilization and production of indole acetic acid (IAA), siderophore and antifungal antibiotic activity were assayed using universal analytical methods. Among a sub–sample of thirteen isolates, a highly efficient P- solubilizing strain was selected and presumptively identified as *Bacillus circulans* MTCC 8983.The strain solubilized a substantial amount of TCP (957.3 mg/l) in PVK broth and also exhibited the production of IAA (15.13 µg/ml), siderophore (49.49%) and per cent growth inhibition against *Dematophora necatrix* (46.57%). Phosphate solubilization of *Bacillus circulans* was inversely correlated with pH (r = -0.98) and positively correlated with growth (r = 0.98), siderophore production (r = 0.99), IAA (r = 0.78) and antifungal antibiotic activity against *D. necatrix* (r = 0.87). The ability of performing multifarious plant growth promoting activities in tandem suggested uniqueness of isolate MTCC 8983 and its potential use in developing a cost effective ecofriendly multifunctional biofertilizer for use in apple orchard.

P1.10. Studies on population of soil mycoflora in the paddy field of Dharmapuri District

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Abstract

Soil samples were collected from the paddy field of Dharmapuri District. The samples were collected in a random sampling method at 15cm depth and pooled together. The

pooled sample was taken as the representative soil sample. The population of fungi was studied using potato dextrose Agar medium (pH 6.7) by serial dilution technique. Totally 25 species of fungi were isolated and identified. The effect of physiochemical factors like temperature, moisture content, pH , organic carbon, organic matter, organic nitrogen and the population of fungi was correlated. Soil is inhabited by diverse array of microorganisms. Among them fungi plays an important role in the soil as potential antagonist, decomposer and pathogen. The results were discussed in detail.

P1.11. Plant growth promoting rhizobacteria potential for plant health and productivity

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Abstract

Microbial diversity of soil habitat not only supports the plant growth it also maintain soil health in various ways. Diversity and community structure in rhizosphere is however, influenced by both plant and soil types. Plants play an important role in selecting and enriching the types of bacteria by the constituents of their root exudates. Thus, the nature and concentration of constituents of exudates act as source of energy for the developing microbes in the rhizosphere. Several bacteria have the ability to live on root surfaces (rhizoplane) and few of them become more specialized and enter/penetrate inside the root tissues (endophytes) so as to direct access to organic compounds of plant cell. Besides, farmers/plant breeders use chemical approach by supplementing nutrients to manage the soil environment to improve crop yield. Efficiently growing such bacteria in the presence of chemical fertilizer may overcome the adverse effects of chemicals by substituting the beneficial impact on plant growth and development. Such bacteria are privileged not to face any type of competition as encountered in the rhizosphere or in soil. In between them, few are very important to plant and many are very deleterious. Bacteria associated with plants may directly promote plant growth by providing compounds that are synthesized by bacterium and provided to plant for growth promotion. These bacteria have been termed 'plant growth promoting rhizobacteria' or PGPR, which may directly facilitate the proliferation of plant growth by fixing atmospheric nitrogen, by producing siderophore that enable solubilize and sequester iron and provide to plants for growth promotion, solubilization of insoluble phosphates to release phosphorus, production of plant growth regulators that enhance plant growth and production of 1-aminocyclopropane-1-carboxylate (ACC) deaminase at various stages of development. The PGPR mediated 1-aminocyclopropane-1-carboxylate (ACC) deaminase hydrolyzes ACC, which is the immediate biosynthetic precursor of ethylene in plants and thereby lower the level of ethylene in a developing or stressed plant. The enzyme ACC deaminase has been found only in microorganisms and catalyses the hydrolysis of ACC to ammonia and -ketobutyrate. On the other hand, indirect plant growth-promotion occurs when PGPR promote growth by improving growth restricting conditions. This class of rhizobacteria that facilitates the plant growth is commonly referred as biocontrol agents, as they decrease/ neutralize the harmful effect of deleterious phytopathogens including plant parasitic nematodes and fungi. The biocontrol mechanisms include production of antibiotics and cell wall degrading enzyme, HCN, Siderophore, volatile and also through inducing systemic resistance against plant pathogens, and detoxification of virulence factors. However, in spite of enormous literature available on PGPR research in last few decade, their application and benefits for plants are still considered in initial

stages in the country. Inoculants have been used for over a century. However, research directed toward optimizing their impact is an ongoing activity. Formulation of bacterial inoculant is defined as preparation containing one or more beneficial bacterial strains (or species) in the form of consortium in an easy-to-use and economical carrier material, organic, inorganic, or synthesized from defined molecules. Most of the time, the plant growth promoting attributes of PGPR dominates over their rhizospheric competence while selecting the strains for formulation. Since associative interactions of plants and microorganisms must have come into existence as a result of co-evolution, the use of latter group as bioinoculants must be pre-adapted, so that it fits into a long-term sustainable agricultural system. Variations in the edaphic, abiotic and environmental conditions also restrict the application of PGRP formulations in different geographical locations. Formulation inadequacies are often the most common barriers to the commercialization of bio-inoculants. It is known that a microorganism may function optimally under laboratory conditions, but it is difficult to formulate that organism into an end-user affordable product that is consistently able to bring about equivalent results under field conditions. Also, one of the major concern is that the scientific information associated with the usage of inoculants are either not properly disseminated to the end users, or farmers don't follow the instructions due to lack of awareness and knowledge.

P1.12. Bioinoculants for Sustainable Agriculture

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Abstract

Human population is increasing day by day throughout the globe. The government needs more food to combat against hunger. Thus the demands the use of chemical fertilizers and other agrochemicals is increasing gradually. However, the cost of production of these chemical products is too high because it causes pressure on the fossil fuel reserves of the country unsustainable in the long-term and poses threats to environmental and human health. The continuous use of high levels of chemical fertilizers is adversely affecting the sustainability of agricultural production and causing environmental pollution. Application of inorganic fertilizers have greatly debilitated the physical and chemical properties of soil as well as drastically altered microbial diversity including microbial flora and fauna that play a vital role to sustain the fertility of soil. Sustainable agriculture refers to the use of a variety of prophecies, phenomena and products stressing on land reclamation and awareness towards hazards of pollution on health of ecosystem. This concept urges the utilization of diverse techniques as organic farming, biofertilizers, biocontrol agents/biopesticides, mixed/inter-cropping systems, etc. Bioinoculants are the viable form of cultures which are the most ecologically feasible and economically example of practical reproduction of lab experimentation for the help of farmers. Bioinoculants include biofrrtilizers, biopesticides and organic decomposers. Biofertilizers are live cells of beneficial microbial isolates that provide necessary nutrients (nitrogen, phosphorous, etc.), secrete growth promoting compounds and provide resistance to a variety of diseases that inhibit to enhanced yield and production. While biopesticides are live microbial isolates or their metabolic products that eradicate/kill known insects/pests of crops. One of the most popular and commercialized biopesticides is the products of *Bacillus thuringiensis* in the form of powder or in some other forms. The third component of bioinoculants are the organic decomposers that include certain fungal species, bacterial genera and actinomycetes that enhance the decomposition of

organic compounds locked up in complex organic materials and make it available as nutrients to the growing plants.

P1.13. Effect of bioinoculants on seedling vigour in tobacco (*Nicotiana tobaccum*) nurseries

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Abstract

Tobacco is an important commercial crop. The present study was undertaken to investigate the influence of nitrogen fixing bacterium *Azotobacter chroococcum*, growth promoting bacterium *Pseudomonas fluorescens* and phosphorus solubilising arbuscular mycorrhizal fungi on growth and nutrient uptake of seedlings in tobacco nursery. Selected cultures of *Azotobacter chrococcum,* were grown on Jensen's N_2 – free medium for 3 days. The cell suspension having 10^9 cells ml $^{-1}$ was used to inoculate the m^2 seedbed each 100 ml at the time of sowing. *Glomus intraradicus* was multiplied on maize plant roots under sterile conditions. Around 10 g soil including root bits containing 10-20 viable AMF propagules per gram soil was used as inoculum and spread as a thin layer one cm below soil surface on each seed bed. The seedlings were harvested for determining leaf area and total chlorophyll content and leaf nutrient content. Significant increase in the number of healthy transplantable seedlings was observed upon inoculation of tobacco nursery seed beds with various beneficial microorganisms more with AM fungi compared to that of nitrogen fixing bacteria.. Application of *Azotobacter, P. fluorescens* and AM fungi significantly improved plant height, leaf area, total chlorophyll and shoot weight at 60 days old tobacco seedlings with maximum enhancement in all the parameters under dual and triple inoculation. Nitrogen uptake was maximum in plants inoculated with nitrogen fixing bacterium. while phosphorus with AM fungus and,multiple inoculation effect was maximum on NPK. The consortia of nitrogen fixing bacteria (*Azotobacter chroococcum*, AM fungi (*Glomus intraradicus*) and *Pseudomonas fluorescens* could be successfully used in tobacco nurseries to produce healthy, vigorous and transplantable tobacco seedlings.

P1.14. Plant growth promoting activity through foliar spray of endophytes on Maize

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Abstract

Selection and screening for plant growth hormones production by efficient strains are important to optimize crop yield and improve the sustainability of the ecosystem. With an objective to screen nine isolates of *Azospirillum* and eight isolates of *Acetobacter* from the natural endophytic bacterial population for growth hormone production, a study was undertaken during 2007 to 2008 at Anand. Indole-3-acetic acid (IAA) was identified by TLC followed by HPLC. Foliar application of these isolates on maize enhanced total biomass as compared to check.

P1.15. Effect of different bioinoculants and agrochemicals on germination and biometric characters of Soybean

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Abstract

The effect of different bioinoculants and agrochemicals on germination and biometric characters of soybean were studied by pot culture method at 10,20 DAS. Evaluation of effect of bioinoculants on growth of soybean was carried out. Seeds were treated with different bioinoculants and agrochemicals (herbicides spray were taken at 1 DAS) and were sown in earthen pot of size 15 X 10 cm^2 containing soil and FYM mixture. The experiment was conducted in CRD with six treatments and three replications. The observations on different biometric characters were recorded at 10th and 20th days after sowing in pot culture method. The different bioinoculants and agrochemicals had significant effect on germination, shoot length, shoot biomass and root biomass. Seed inoculation with *Rhizobium* recorded maximum germination (82%), maximum shoot length 8.3cm (10DAS) and 11.3 cm (20DAS), maximum shoot fresh weight 0.490 g (10DAS) and 0.620 g(20 DAS), maximum shoot dry weight (0.051 g) (10DAS) and 0.060 g (20DAS), maximum root length 12.4 cm (10 DAS)and 16.3 cm (20DAS), Maximum root fresh weight 0.16 g (10DAS) and 0.023 g(20 DAS) maximum increase in vigor index 1702.4 (10 DAS) and 2278 g (20 DAS). Maximum root dry weight 0.014 g (10DAS) and 0.022 g(20 DAS) was observed in *Azotobacter* seed treatment. Germination shoot length, root length and vigour index were significantly influenced by *Azotobacter* and *Rhizobium*

P1.16. Effect of different bioinoculants and agrochemicals on germination and biometric characters of Jowar

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Abstract

The effect of different bioinoculants and agrochemicals on germination and biometric characters of soybean were studied by pot culture method at 10,20 DAS.Evaluation of effect of bioinoculants on growth of soybean was carried out. Seeds were treated with different bioinoculants and agrochemicals (herbicides spray were taken at 1 DAS) and were sown in earthen pot of size 15 X 10 cm^2 containing soil and FYM mixture. The experiment was conducted in CRD with six treatments and three replications. The observations on different biometric characters were recorded at 10th and 20th days after sowing in pot culture method. The different bioinoculants and agrochemicals had significant effect on germination, shoot length, shoot biomass and root biomass. Seed inoculation with *Azotobacter* recorded maximum germination (88%), maximum shoot length 6.42cm (10DAS) and 11.93 cm (20DAS), maximum shoot fresh weight 0.172 g (10DAS) and 0.2580 g(20 DAS), maximum shoot dry weight (0.0210 g) (10DAS) and 0.0313 g (20DAS), maximum root length 6.45 cm (10 DAS)and 11.95 cm (20DAS), Maximum root fresh weight 0.024 g (10DAS) and 0.0360 g(20 DAS) maximum increase in vigor index 1054.24 (10 DAS) and 2182.4 g (20 DAS). Maximum root dry weight 0.070 g (10DAS)

and 0.016 g(20 DAS) was observed in *Azotobacter* seed treatment. Germination shoot length, root length and vigour index were significantly influenced by *Azotobacter* and *Rhizobium*

P1.17. Effect of Different Bioinoculants on Vigour Index of Important Pulses and Oilseeds

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Abstract

Bioinoculants serve as cheapest, safe and alternative source of nutrients as compared to chemical fertilizers. Seed samples of important pulses and oilseeds were tested with some bioinoculants to study effect on vigour index. For the presents study the materials viz., *Acetobactor*, *Pseudomonas fluorescens*, *Azospirillum* and Pink pigmented facultative methylotrophs(PPFM) were used to assess their influence on vigour index of important pulses i.e. Pigeonpea, Greengram, Blackgram, Chickpea and oilseed crops i.e. Soybean, Safflower, Sunflower, Groundnut by roll towel paper and pot culture method. The vigour index can be calculated but using the formula Vigour index = Germination(%) × [Root length(cm) + Shoot length(cm)], formula given by Woodstock(1969). In case of pulses, seed vigour index was significantly influenced by the application of different bioinoculants. The inoculation of *Acetobactor* showed maximum vigour index. In case of oilseeds, PPFM showed maximum vigour index. *Pseudomonas fluorescens* and *Azospirillum* also influenced vigour index up to some extend. *Acetobactor* and PPFM increased the vigour index of pulses and oilseeds.

P1.18. Effect of *acetobactor* on root and shoot length of pomegranate (*punica granatum* l.)

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Abstract

Pomegranate occupies a prominent place in the horticultural wealth and economy of the country. For increasing productivity, use of chemical fertilizers are increased which results in hazardous effects on soil health. Microbial fertilizers improve the soil health. Some plant growth promoting microorganisms were assessed for growth of pomegranate. For the present study materials consists of viz., strains of Pink pigmented facultative methylotrophs (PPFM), *Acetobactor*, *Pseudomonas fluorescens, Trichoderma viride, Trichoderma harzianum* and growth hormone IBA were used for inoculation. The observations are recorded on Root and shoot lengths . Root and shoot lengths were measured at 30, 60 and 90 Days after planting. Among all bioagents and IBA, the maximum root length was recorded with *Acetobactor* at 30, 60 and 90 DAP and their values were 15.00, 31.33 and 51.33 cm respectively. Similarly, inoculation treatment with *Acetobactor* recorded significantly highest shoot length at 30, 60 and 90 DAP and their values were 20.58, 33.58 and 57.83 cm, respectively. The interaction effects due to variety and treatment indicated that the inoculations were significant in all the varieties. *Acetobactor* also proved most beneficial in enhancing fresh and dry weights of roots and shoots. Inoculation of *Acetobactor* resulted in significant increase in root length and shoot length of pomegranate.

P1.19. Integrated disease management in black pepper (*Piper nigrum* L.)nursery

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Abstract

Black Pepper (*Piper nigrum* L.) renowned as 'King of Spices' is one of the most important export oriented spice crops of India. It is propagating through rooted cuttings in nurseries. Every year heavy casualties do occur in pepper nurseries due to the incidence of diseases, especially the dreadful *Phytophthora* foot rot disease. The ability of *Trichoderma harzianum* and *T.viridae* in managing the *Phytophthora* foot rot in black pepper nurseries was tested in solarised and non solarised potting mixtures either alone or by incorporating with potassium phosphonate (0.2%) and Metalaxyl (0.1%) for two seasons. The black pepper variety used for the experiment was Panniyur 1. Incidence of *Phytophthora* rot in black pepper nurseries was minimum in plants received the treatments of solarisation of potting mixture for 30 days, *T.viridae* or *T.harzianum* and Potassium phosphonate. The results indicate the efficacy of integrated disease management of *Phytophthora* foot rot in black pepper nursery, which recorded 70% efficiency over control. Integrated disease management with bio control agents and fungicides in solarised soil is effective in managing *Phytophthora* rot of black pepper.

P1.20. Consortium of antagonistic bacteria improves growth in eggplant (*Solanum melongen*a L)

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Abstract

Six potential bacterial antagonists against *Ralstonia solanacearum* were tested for their growth promoting ability and survivability in eggplant. Talc formulation of the six individual isolates and 15 combinations were applied to soil and the growth parameters in eggplant were studied up to 70 days. Soil application of RBh42a, RBG4, EB69 as individual isolates; consortium of EB69+RP7, RBG4+ RBh42a, RBh42a+ ERG6 consistently increased the plant height up to 50 days of treatment. Among the treatments, EB69+ RP7 recorded maximum shoot length, root length was maximum (12.13 cm) in RBG4 treatment and maximum root biomass (41.5 g) was recorded in RBh42a treatment. Assessment of soil bacterial population indicated that maximum number of fluorescent bacteria (567x 10^4 CFU/g) was recorded in EB69+ ERG6 consortium. RBG4+ RBh42a, RBh42a+ ERG6 consortia recorded maximum (314 and 312x 10^4 CFU/g) non-fluorescent bacterial population. From this study it may be concluded that the above potential biocontrol agents with good growth promoting ability along with better rhizosphere competence could be used as promising PGPRs in disease management in eggplant.

P1.21. Growth promoting effect of PGPR in Khejri (*Prosopis cineraria*)

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Abstract

Khejri (*Prosopis cineraria*) is an important leguminous vegetable tree grown under Thar Desert of Rajasthan. Rootstocks are raised from wild species for vegetative propagation. However, the seeds germination and root stock growth are very slow and therefore native isolates of PGPR from desert soil were screened to identify suitable strains for plant. Out of various isolates tested for assessing the seeds germination and seedlings growth, isolate Kj-AB-1 induced whereas, isolate A-B-1 performed to induce more root growth (91.3 cm) followed by Kj-AB-1 (75.32 cm), SR-1 (68 cm) RB-28 (62 cm). Root length and number of leaves were significantly influenced by Pro-RR2 under hot arid conditions. In subsequent experiments, khejri seeds treated with PGPR isolates resulted significantly early and vigorous the rootstocks for successful propagation.

P1.22. Selection of Culturable PGPR from Maize Based Intercropping System

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Abstract

The main objective of this research was to determine PGPR diversity in maize based intercropping system and selection of suitable and efficient autochthonas PGPR on the basis of growth, hormone activities, nitrogenase activity and biocontrol activities and effects on seed germination. A total 48 rhizobacteria were isolated from different rhizotic zones of maize crop and maize based intercropping system on selective media (Table 2) from twelve different location of Bihar . Out of these twelve isolates each of *Azospirillum, Azotobacter*, *Pseudomonas* and PSB are represented as AZS_1 to AZS_{12}, AZT_1 to AZT_{12}, PSD_1 to PSD_{12} and PSB_1 to PSB_{12}, respectively. Root length of maize increased significantly. 4.33 to 7.48, 7.11, 8.805 and 5.904 cm due to inoculation of *Azospirillum* isolates AZS-7, AZS-6, AZS-10 and AZS-5 respectively. While shoot length increased significantly from 3.4 to 5.320 and 4.845 for AZS_5 and AZS_{12} respectively. Among all tested isolates of *Azospirillum* the highest value of root and shoot length recorded 7.48cm and 5.320cm due to isolates AZT-7 and AZT-5 respectively. The mean root length of maize increased significantly from 4.888 to 6.40 and 6.188 cm due to inoculation of *Azotobacter* isolates AZT-5 and AZT-11 respectively. Whereas shoot length increased from 3.4 to 5.566, 5.436, 5.243, 5.183 and 5.058cm due to isolates AZT_3, AZT_9, AZT_{12}, AZT_{10}, AZT_5 and AZT_4 respectively. Among all tested isolated *Azotobacter* the highest value of root and shoot length recorded 6.40 and 5.566 cm due to isolates AZT-5 and AZT-3. Among all tested isolates the highest value of root and shoot length recorded 4.339 and 4.851 cm respectively due to inoculation of *Pseudomonas* isolates PSD-10. Thus mean root and shoot length showed significant variation due to inoculation of *Azospirillum, Azotobacter and Pseudomonas* isolates, between 3.264 to 7.485, 3.416 to 5.323 and 4.266 to 6.40 cm for root while 3.40 to 5.566, 2.650 to 4.22 and 2.866 to 4.851 for shoot respectively. Bacteria are known to produced different

metabolites like GA, IAA and Cytolenin like substances that might be enhance root and shoot length (Tien *et al.*, 1979 and Minakshi *et al.*, 2005). Inoculation of *Azospirillum* isolates root & shoot length of maize was highest value was 7.48 and 5.320cm due to isolates AZT-7 and AZT-5 respectively. Inoculation of *Azotobacter* isolates root & shoot length of maize was highest value was 6.40 and 5.566 cm due to isolates AZT-5 and AZT-3. Inoculation of *Pseudomonas* isolates root & shoot length of maize was highest value was 4.221 and 4.851 cm due to isolates PSD-10.

P1.23. Isolation, identification, screening and evaluation of *Rhizobium sp*. from oilseed crops of Middle Gujarat

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Abstract

With an objective to find out natural population of *Rhizobium* species associated with important oil seed crops like soyabean and groundnut, samples were collected from Nawagam, Dahod and Devgadhbariya (PMs districts) as well as farmers' fields of Kapadwanj and Indore (M.P.). From collected plants *Rhizobium* nodulation status like poor, good and excellent was recorded. Eight (8) *Rhizobium* strains from soybean and one (1) from groundnut were isolated from nodules. These strains were further purified and grown on selective media with preliminary studies on cultural characteristics and finally maintained in laboratory at 5 ºC for further studies. Isolation efforts suggested that in Central and North Gujarat and well as adjoining area of M.P. state shows good natural population of *Rhizobium* in oil seed crops and may have different native species as some variation seen in size, shape and colony characteristics of native populations.

P1.24. Effect of various microbial inoculants on germination of bio-diesel crop *Jatropha curcas*

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Abstract

Jatropha is an emerging bio-fuel crop commonly grow in marginal, saline, acidic, alkaline soils and sloppy lands and without much care and irrigation. It also suits for dry-land farming and survive drought. It provides live hedge for farms to arrest the menace of stray cattle too. Due to its increasing importance as natural fuels cultivation, seed collection for bio-diesel processing also generates rural employment. More over Jetropha possess medicinal as well as other multiple uses. A feeler trail was conducted in micro plot, to study the efficacy of different biofertilizer strains for germination of Jatropha seeds. Seeds were treated with *Rhizobium*(T1), *Azotobacter chroococcum*(T2), *Bacillus coagulans*(T3) , *Azospirillum lipoferum*(T4), *A. chroococcum* + *B. coagulans*(T5), *B. coagulans* + *A. lipoferum(T6)* , *B. coagulans* + *Rhizobium(*T7*)*. Wherein *A. chroococcum* (ABA1) + *B. coagulans (* PBA16) treatment found to give highest germination 90% over untreated with subsequent better growth of plants. This is the first indicative results from Gujarat state on use of biofertilizer in Jatropha.

P1.25. Influence of different bio-inoculants alone and in various combinations on the productivity of *Aloe vera*

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Abstract

Aloe vera (L.) Burm. fil. (synonym *A. barbadensis* Miller) (Hindi – Ghikvaar), is a cactus-like plant with green, dagger-shaped leaves that are fleshy, tapering, spiny, marginated and filled with a clear viscous gel. It is present in the arid regions of India, and is believed to be effective in treating stomach ailments, gastrointestinal problems, skin diseases, constipation, radiation injury, for its anti-inflammatory effect, for wound healing and burns, as an anti-ulcer and diabetes. Currently, the plant is widely used in skin care, cosmetics and as nutraceuticals. In this presentation we study the effect of different arbuscular mycorrhizal (AM) fungi as well as *Bacillus subtilis* on the growth and biomass of *Aloe vera.* Four AM fungi viz. *Glomus aggregatum, G. fasciculatum, G. mosseae* and *G. intraradices* and *B. subtilis* were used alone as well as in different combinations in an unsterilised soil under glass house conditions. Results invariably showed that AM fungi as well as *B. subtilis* were capable of increasing biomass of leaves of *A. vera*. Maximum increase in fresh weight of leaves was exhibited by *G. aggregatum* treatment (55.3%) and followed by *G. intraradices* (41.0%). Although the combination of AM fungi increased the biomas but it was not as signigicant as made by alone treatment. *B. subtilis* alone also enhanced the biomass by 48.5%. G. aggregatum treatment also reduced the incidence of leaf spot disease caused by *Alternaria alternata* to the extent of >30-40%. Either AM fungi or *B. subtilis* alone or in combination could be promoted for enhanced productivity and reducing the incidence of leaf sopt disease on *A. vera.*

P1.26. Effect of Bioagent and Fungicidal Treatment for Enhancement of Seed Quality Parameter of Soybean (*Glycine max*. L. Merill)

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Abstract

The filed experiment was conducted on soybean JS-335 during monsoon (*kharif*) season of 2007-08 at breeder seed foundation programme, central farm of Marathwada Agriculture University; Parbhani. The experiment was laid out in randomized block design with three replication and seven different treatment cv JS-335 seed were introduced with three bioagent @ 0.6 %, Rhizobium; PSB @ 10^3 cells / seed and Thiram + Bavistin @ 0.2%. The use of bioagent, culture and fungicidal seed treatment significantly increased. The root length shoot length and vigor index at 90 DAS of crop over control .The germination percentage was recorded in the range of 82 to 92 % over control .The highest 100 seed weight was also recorded in rhizobium treatment (12.05g). Seed health percentage of seed borne fungus *Aspergillums fluvus* and *A Niger* were more as compare other fungus in unsterilized and sterilized .The use of *Rihzobium* up to 49 x 10

followed by PSB up to 235 x 10 cells/g soil. The yield confirmed that the inoculation with *Rhizobium* was very beneficial in increasing yield of soybean followed by PSB to the level of significant.

P1.27. Evaluation of *Bacillus* spp. from Rainfed Agro-Ecosystems for Plant Growth Promotion of Sorghum and Pigeonpea.

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Abstract

Plant growth promoting rhizobacteria(PGPR) are the beneficial bacteria associated with plant roots and results in increated plant growth (Kloepper, 1994 Glick, 1995), the direct mechanism of plant growth is by the secretion of phytohormones and Ammonia, indirect mechanism of plant growth is by the production of antimicrobial compounds that reduce the deleterious effects of phytopathogens, competition for nutrients and colonization sites. Among the PGPR, bacillus due to the spore formation can tolerate extreme heat and desiccation and hence could be the potential bio-inoculants in the stressed/rainfed ecosystem. *Sorghum vulgare* cv. CSV- 15 and pigeonpea cv. PRG-100 seeds were coated with talc formulated bio-inoculant containing 10^8 CFU.gm^{-1} and were sown in plastic pots filled sterile soil. Six replicates were maintained for each treatment. Un-inoculated seedlings served as control. After 40 days, root, shoot length, dry mass and Leaf area of the seedlings were recorded. In sorghum experiment **B87** enhanced shoot length (32%) & total dry plant mass (62.4%), **B36** enhanced root volume (135%), **B22** enhanced dry root mass (75.6%) & Root-shoot ratio (23.6%), **B73** enhanced shoot length(32%), dry shoot mass (55.4%) & leaf area (62.4%) and **B95** enhance shoot length (32%). Where as in pigeonpea experiment **B105** enhanced dry root mass (108%), dry shoot mass (89.7%), dry total plant mass (97.8%) & leaf area (110%), **B13** enhanced shoot length(31.3%) & Root shoot ratio(31.4%) and **B53** enhanced root length(78.4%). **B87** ranked first in sorghum experiment and **B105** ranked first in pigeonpea experiment by using **Z-scores** for ranking (z-scores as a way of understanding the contributions from various subsets of data to an overall test of trend.)

P1.28. Growth Response of corn during growing season by plant growth-promoting rhizobacteria

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Abstract:

The effect of PGPR strains on plant growth parameters during growing season were evaluated in a factorial experiment with two factors (*Azospirillum* an *Azotobacter* strains) and three replications. The bacterial strains were *Azospirillum lipoferum* s-21 and *Azotobacter chroococcum* s-5. *Azospirillum lipoferum* DSM 1691, *Azospirillum brasilense* DSM 1690 and *Azotobacter chroococcum* DSM 2286.Results of this study showed, at 45 days after inoculation (DAI), the differences observed between PGPR treatments compared to control. Inoculation of PGPR significantly enhanced leaf and shoot dry weight in 60 DAI. Results of this study show at final sampling date (120 DAI), PGPR can significantly increase grain weight. Grain weight produced by s-21 was, significantly higher than grain yields of other treatments. Results obtained

from this study showed inoculation of maize seeds with bacteria significantly increased the plant height and stem diameter, LAI and CGR.

P1.29. Investigation of Some Needed Local Factors of *Hordeum bulbosum* in East of Oshtorankuh

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Abstract

Investigation of some needed local factors of important species of rangelands such as the forage, the medicine, poisonous and the conservation are one of the most important to programmer and correct management of rangelands. *Hordeum bulbosum* is herb and perennial which propagate in most area in mountains and rangelands. Researches show that this species have height palatability and TDN (total digestible nutrient) which is considered by type of animals. This species is growth easy and speed and in early spring produce enough forage which can a source of rangelands for animal that caused using summer rangeland in deferred. In region under study dominant of this species have affected management of rangelands and annuals grass. In this study determined propagation of this species and then heterogeneous units and investigation of units. Factors such as weather, soil, hydrology, geology physiographic and its effects are investigation for propagation of *Hordeum bulbosum*. Also effect of changes of the height of the mountain is evaluation on density of this species. Number of 144 plots ($100 m^2$) in 9 restricted area for sampling were select. Results show that climate of region based on Amberege method is semi cold-dry and is suitable for propagation of this species. Most density of *Hordeum bulbosum* is 2200 to 2360 meter height and ensypti soils order in region are situation for most density of this species.

P1.30. Effect of soil fertility methods and sowing date on yield and some characteristics of *Carum copticum*.

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Abstract

Increasing soil organic matter content through the addition of organic amendments has proven to be a valuable practice for maintaining or restoring soil quality, especially in planting of medicinal plants. Organic agriculture relies greatly on building soil organic matter with compost typically replacing in organic fertilizers, biofertilizers and animal manure as the fertility source of choice. *Carum copticum* is a medicinal herb that its grains have too much uses. In order to understand the effects of sowing dates and soil fertility methods on seed yield and some traits of *Carum copticum,* an experiment was conducted at Torbat-e- Jam (a city in north east of Iran) in 2006. Experimental design

was split plot based on randomized complete block with 4 replications. Two planting dates (5 and 25 December) were as main plot. Six soil fertility methods (as sub plot) were: 50 t/ha animal manure, 50 kg/ha solid nitrogen, 25 t/ha animal manure, foliar application of micronutrients (pre-flowering), 100 kg/ha solid nitrogen and foliar application of micronutrients (post-flowering). Seed yield was affected by sowing date, significantly. Seed yield in the earlier sowing date (5 December) was greater than the other sowing date. The effect of soil fertility method on seed yield, harvest index, branch and umbels number per plant and plant height was significant. Animal manure (50 t/ha) treatment had the highest seed yield (244.3 g/m^2) and harvest index (0.256). The lowest seed yield (49.05 g/m^2) and harvest index (0.116) was related to post- flowering foliar application of micronutrients. In total, the result showed that the first sowing date with the use of 50 t/ha animal manure had the highest seed yield and HI.

Poster session:

Biofertilizers & PGPRs in

Integrated nutrient management

P2.1. Studies on nutrient use efficiency of bioinoculants and biocontrol agent interactions in *Casuarina equisetifolia* (Forst.) seedlings under tropical nursery condition

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Abstract

Casuarina equisetifolia is the only actinorhizal tree which is widely used in the tropics for fuel, as the wood is dense and has a high calorific value. Response of *Casuarina equisetifolia* seedlings treated the bioinoculants and biocontrol agents both individually as well as in combined under tropical nursery conditions for the period up to 180 DAT on CRBD. Combined inoculation seedlings showed substantial increase the biomass, nutrient content and use efficiency. The information on the effect of bioinoculants (AMF, *Frankia*, *Azospirillum*, PSB) and biocontrol agent (*Trichoderma*) on the growth and nutrient uptake and the interaction of these organisms in the rhizosphere of *C. equisetifolia* seedlings are lacking. To fill this lacuna the present study has been carried to assess the role of bioinoculants and biocontrol agent for improving the Nutrient use efficiency in tropical nursery experiments. *Casuarina equisetifolia* seedlings at 180 DAT (Table), combined inoculation had highest plant dry weight, which was average of 6.5 fold more than control at their respective harvests. Tissue nutrient of all microbes inoculated seedlings in T_7 treatment had highest tissue nutritional status among the treatments, which was followed by P maximum in PSB inoculated seedlings and K high in *Azospirillum* inoculated soil. Highest NPK use efficiency found in combined inoculation treatment of T_7 seedlings was 4.85, 4.24 and 4.95 fold respectively higher then uninoculated control at 180 DAT. In conclusion, *Casuarina* seedlings inoculated with AM fungi, *Frankia*, a symbiotic N-fixing actinomycete, associative symbionts of *Azospirillum*, PSB or their mixture showed substantial increase in seedling biomass, nutrient content and use efficiency under nursery conditions.

P2.2. Influence of Bio-Fertilizers and Sources of Nutrients on Upland Scented Rice

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Abstract

Rice enjoys a unique position in Indian economy contributing 45 per cent India's cereal production. field experiment was undertaken during kharif 2004. to workout the suitability of various organic ,inorganic sources in addition to Bio-fertilizers (PGPR) to increase the productivity of scented rice. The main plot treatments were inorganic nutrient levels i.e. control (No application of nutrient), 50 per cent of RDF (40:25:25 kg NPK/ha) 75 per cent of RDF (60:37.5:37.5 kg NPK/ha) and RDF (80:50:50 kg NPK/ha) sub plot treatments were organic nutrient sources i.e. control (No application of nutrients) FYM (10t/ha), Vermicompost (2.5 t/ha), Biofertilizer (*Azospirillum* + PSB @ 5 kg/ha), Green maundering (Glyricidia 10 t/ha) and Neem Cake (2.5 t/ha).Different inorganic nutrient levels have significantly influenced productivity as shown in Table -1. Treatment M3 recorded the highest grain yield (3163 kg/ha) ,straw yield(3749 kg/ha) and biological yield (6912 kg/ha) which was significantly higher than M0,M1

and M2. Similar results were recorded by Sarkar et. al. (1990).Application of RDF (80:50:50 NPK kg/ha) + Glyricidia green manuring @ 10 t/ha found beneficial as it has given 18% higher grain yield than RDF alone. Setty and Channabasavanna (1990) reported similar results (i.e. application of 100:75:75 NPK kg/ha + Glyricidia gave highest yields). Application of Bio-fertilizers (PGPR) was found effective and recorded the grain and straw yields of upland rice equal to application of 50 % RDF.

P2.3. Effect of integrated nutrient management on yield of soybean

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Abstract

Amrupani an organic formulation known to be having large population of PGPR claimed to be beneficial in improving soil microbial activity and soil fertility was tested on research basis, along with other organic and inorganic nutrients in different combinations for assessing their response to yield and yield attributes of soybean. The experiment was conducted in RBD with eleven treatments combination of inorganic, organic and biofertilizer and Amrutpani are T_1 RDF (30:75:00 kg NPK /ha), T_2 Amrutpani, T_3 75 % RDF, T_4 75 % RDF + 5t FYM/ ha, T_5 75 % RDF + Amrutpani,T_6 75 % RDF + Amrutpani + PSB, T_7 75 % RDF + Amrutpani + PSB + Rhizobium,T_8 5t FYM/ ha, T_9 5 t FYM/ ha + Amrutpani, T_{10} 5t FYM /ha + PSB, T_{11} 5t FYM /ha + Amrutpani + PSB + Rhizobium . In present investigation Amrutpani is prepared by taking 250 g Ghee + 15kg of cow dung + 10 lit of cow urine + 500 g of honey + 200 lit of water. The ingredients are thoroughly mixed together and allowed to ferment for one week, mixture so obtained is called as Amrutpani. The studies revealed that yield attributes viz.,number of pod/plant,weight of grain/plant , and yield/ha were maximum in 30:75:00 kg NPK/ha (RDF) followed by 75% RDF + 5 t FYM/ha, 75% RDF + Amrutpani + Rhizobium + PSB, 75% RDF + Amrutpani + PSB. The other treatments were inferior, Amrutpani known to be having good population of PGPR alone being the least effective. There was no advantage of addition of only Amrutpani to 75% RDF when compared with 75% RDF alone. However when Rhizobium and PSB were added to the 75% RDF + Amrutpani, these results were comparable with RDF indicating that Amrutpani may the growth of Rhizobium and PSB in rhizospere.

P2.4. Enhancement of mineral phosphate solubilisation (MPS) abilities of *Enterobacter asburiae* PSI3 by incorporation of *Pseudomonas putida* KT2440 gluconate dehydrogenase (*gad*) gene

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Abstract

Enterobacter asburiae PSI3 is a rhizobacteria of pigeon pea (*Cajanus cajan*) and solubilizes mineral phosphates by secretion of high levels of gluconic acid. *E. asburiae* PSI3 possesses phosphate starvation inducible, broad substrate glucose dehydrogenase enzyme. However, 2-ketogluconic acid is much stronger acid than gluconic acid. 2-ketogluconate is produced from gluconate by gluconate dehydrogenase (Gad) in fluorescent pseudomonads. Gad is encoded in *gad* operon consisting of three genes. The present study demonstrates the cloning of *P. putida* KT2440 *gad* operon in *E. asburiae* PSI3 and monitor its effect on MPS abilities. *gad* operon was amplified from *P. putida* KT2440 genomic DNA using specific primers. The PCR amplicon was cloned in broad host range vector pBBR1MCS2 and transformed into *E. asburiae* PSI3. MPS ability was monitored on 100mM Tris buffered rock phosphate agar plates and liquid medium. *E. asburiae* PSI3 transformants were selected on kanamycin resistance. Restriction digestion analysis confirmed the presence of recombinant *gad* plasmids. Transformants demonstrated 1.02 units/mg protein of Gad activity when grown on glucose as the carbon source. On 100 mM Tris pH 8.0 rock phosphate plates, the transformants showed acidification in the presence of 40mM glucose. In contrast, *E. asburiae* PSI3 plasmid control only showed at 75 mM glucose. In 100mM Tris pH 8.0 rock phosphate minimal medium, the *E. asburiae* PSI3 *gad* transformant acidified the medium upto pH 4.0 by 90 h whereas the control did not decrease the pH. Estimated P release in the medium was 1.5mM/L. Incorporation of *gad* gene has significantly enhanced the MPS ability of *E. asburiae* PSI3.

P2.5. Association of diazotrophic, phosphate and potash solubilizing *Roseateles terrai* and *Burkholderia gladioli* with sugarcane and their short-term inoculation effect on wetland rice

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Abstract

Large numbers of microbes are known to possess nitrogen-fixing capacity from atmosphere, dissolving soil minerals and releasing nutritional elements such as phosphate and potash from insoluble sources to the plants. In the present study, four isolates were obtained using Macronutrient Deficient (MD) medium. The microbes aimed for isolation were allowed to obtain N mainly from air and with traces of N from the medium constituents, P from Tri-Calcium Phosphate (TCP) and K from K-bound ore of Mica or Quartz. These isolates showed abilities on acetylene reduction, phosphate and potash solubilization along with IAA production. Study isolates formed two groups based on morphological, physiological and biochemical studies. 16s rDNA gene sequence analysis on one representative isolate from each group revealed the identity of the first group as *Roseateles terrai* with 99% sequence similarity while the second group as

Burkholderia gladioli with 100% sequence similarity. Short-term plant inoculation experiment with these isolates in pot-grown rice plants indicated their growth promotion abilities too.

P2.6. Transposon mutagenesis approach to dissect mechanisms of survival and rhizosphere colonization in fluorescent pseudomonads

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Abstract

Aggressive rhizosphere colonization and longer survival in dynamic soil environment were essential characteristics of PGPR for prolonged delivery of its beneficial activities to host crops. Iron was one micronutrient required for most forms of life. Pseudomonads have evolved efficient regulatory pathways for iron acquisition and depleting its availability to other rhizosphere residents as a means of its survival. In this study, we used Transposon mutagenesis for fluorescent pseudomonads to understand its genetic factors influencing iron acquisition and their role in root colonization. Transposon mutagenesis library of *Pseudomonas putida* (S11) was screened for their sensitivity to iron deprivation in minimal media agar plates with iron chelating agent. Of 3900 mutants screened, twenty mutants were sensitive to iron deprivation. Also five mutants found to be tolerant to iron starvation. The locus of transposon insertion in mutants was identified using genome walking PCR or rescue cloning or inverse PCR. Such mutants are now being functionally characterized for soil survival ability and rhizosphere colonization either alone or in combination with wild type *Pseudomonas* (S11). Understanding traits influencing iron uptake mechanisms in competitive rhizospheric and soil environment would identify role of genetic factors influencing root colonization of PGPR.

P2.7. Screening of chickpea root nodule bacterial strains to promote nodulation in chickpea

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Abstract

This investigation represents isolation of 18 chickpea Root Nodule Bacterial (RNB) strains from different areas of middle Gujarat, which used for screening of root nodulation as well as nitrogen fixation efficiency in comparison with four standard strains collected from IARI, Dharwad and Vadodara (GSFC). RNB isolates were confirmed as *Rhizobium* by using six different biochemical test *viz.* growth on selective medium (Yeast Extract Mannitol Antibiotics Agar, YEMAA), growth on Hoffers' alkaline broth, growth on lactose Agar medium, growth on YEM broth (pH 10.0, 11.0, 12.0), growth on Glucose peptone broth and H_2S production Test. The RNB strains were employed to test root nodulation and nitrogen fixation efficiency at field level with chickpea variety GG-2. The results revealed significant differences among RNB isolates. The RNB strain AR-9 was found superior for nodule number, nodule fresh and dry weight. While inoculation with

RNB strain An-3 was found superior for increasing shoot dry weight and seed yield of chickpea plants. Beside this 16s rDNA of RNB strains AR-9 was amplified by using universal primer, cloned, sequenced and BlastN analysis was carried for identification.

P2.8. Growth response and nutrient utilization of *Casuarina equisetifolia* seedlings inoculated with bioinoculants under tropical nursery conditions

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Abstract

We investigated the role of tetrapartitie associations between an arbuscular mycorrhizal (AM) fungus (*Glomus geosporum*), phosphate solubilizing bacteria (*Paenibacillus polymyxa*), *Frankia* and *Casuarina equisetifolia* on growth, nutrient acquisition, nutrient utilization and seedling quality of *C. equisetifolia*. Seedlings of *C. equisetifolia* were grown in an Alfisol soil was inoculated with *G. geosporum*, *P. polymyxa* and *Frankia* either individually or in combinations. Inoculation of bioinoculants stimulated seedling growth, the efficiency of nutrient uptake and improved seedling quality. Inoculation of *P. polymyxa* or *Frankia* increased the extent of AM colonization, which resulted in the accumulation of the nutrients. Seedlings inoculated with *Frankia*, G. geosporum had more, and heavier nodules compared to seedlings inoculated with *Frankia* alone. Dual inoculation of microbes was more effective than individual inoculations. The growth response of seedlings to inoculation involving all the microbes was greater than the response to either individual or dual inoculations. The results of this study showed that the tetrapartitie association could improve the growth, nutrient acquisition and seedling quality of *C. equisetifolia* under tropical nursery conditions.

P2.9. Reduction in dose of chemical fertilizers and growth enhancement of sesame (*Sesamum indicum* L.) with application of rhizospheric competent *Pseudomonas aeruginosa* LES4

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Abstract

P. aeruginosa LES4, an isolate of tomato rhizosphere was found to be positive for several plant growth promoting attributes like production of indole acetic acid, HCN and siderophore, solubilization of inorganic phosphate along with urease, chitinase and β-1-3-glucanase activity. In addition, it showed strong antagonistic effect against *Macrophomina phaseolina* and *Fusarium oxysporum*. *P. aeruginosa* LES4 caused halo cell formation and other morphological deformities in mycelia of *M. phaseolina* and *F. oxysporum*. Root colonization was studied with *Tn5* induced streptomycin resistant transconjugants of spontaneous tetracycline-resistant LES4 (designated $LES4^{tetra+strep+}$) after different durations. The strain was significantly rhizospheric competent, as its population increased by 17.44% in sesame rhizosphere was observed. Seed bacterization with the

strain LES4 resulted in significant increase in vegetative growth parameters and yield of sesame over the non bacterized seeds. However, application of LES4 with half dose of fertilizers resulted in growth equivalent to full dose treatment, without compromising with the growth and yield of sesame. Moreover, the oil yield increase by 33.3%, while protein yield increased by 47.5% with treatment of half dose of fertilizer along with LES4 bacterized seeds, as compared to full dose of fertilizers.

P2.10. Metabolic Diversity of Root Nodulating Soybean Rhizobia Isolated from Malwa Region of Central India

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Abstract

Soybean [*Glycine max* (L.) Merrill] is an important source of high-quality protein and oil and is the most quantitatively important grain legume in the world (220 Mt in 2006 [http://faostat.fao.org]). The root nodulating rhizobia of soybean have great importance because of its ability to fix nitrogen and possessing other growth promoting traits. In India soybean cultivation is being taken place in many ecological zones, hence there is likely possibility of occurrence of native rhizobia harboring soybean cultivars besides other exotically adapted strains. In this study, 27 rhizobial isolates and some representative reference strains were selected for biochemical and metabolic characterization. Of 27 isolates, 21 were recovered as fast growing isolates while rest were slow growing based on bromothymol blue (BTB) test. Unlike earlier belief that rhizobia have no ability to grow on glucose peptone agar medium but in this study, some isolates and some reference strains grew well on this medium. Similarly when all the isolates subjected to keto-lactose test, some of the isolates were found negative for the test. Based on C-utilization pattern (15 carbon sources) a remarkable metabolic diversity was observed among the rhizobial isolates. Such analysis suggests the occurrence of metabolically distinct types of rhizobia besides commonly known types (*B. japonicum, B.elkanii and S.fredii*) of soybean rhizobia.

P2.11. Effect of Biofertilizer on Yield and Quality of Sunflower (*Helianthus annus* L.)

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Abstract

Sunflower is mostly popular due to its special features like short duration, drought tolerance, photo and thermo insensitiveness, required low seed rate, high seed multiplication ratio (1:1000) higher water use efficiency and can be cultivated on any type of soil. It contains 20 % protein and 40-50% vegetable oil due its non cholesterol properties and cholesterol lowing factor (80-90% of total fatty acid) it is special recommended to patient of heart problem. Biological nitrogen fixation is the process causing free nitrogen gas to combine chemically with other elements or conservation of free nitrogen into different compound with the help of living and non living

agencies, the main sources of nitrogen for soil is nitrogenous fertilizer is very high and secondly the production one mole of ammonia by industries requires 163 kcal energy, while the production of one mole ammonia by biological nitrogen fixation requires 85 kcal energy with similarly, the industries process produced number of problem like air and water, soil pollutions which affect human health for encouraging the soil health more emphasis should be given on biological nitrogen fixation which is considered as an alternative source of nitrogen nutrition (Hegde D.M0., 2002). A field experiment was carried out during 2007 at Department farm, college of Agriculture, Latur. The experiment was laid out in randomized block design with eleven treatments replicated three times. The sunflower hybrid (PAC-336) was grown on 26-7-2007 by dibbling at 60x30 cm. plot size gross 4.8x 4.00 sq. m and net plot size 3.6 x 3.00 sq.m. eleven treatment were given with combination, NPK, *Azospirillum*, *Azatobacter* T_1- Control,T_2-(50 % N),T_3- (100 % N), T_4- (*Azospirillum* seed treatment), T_5-(*Azatobactor* seed treatment), T_6-(*Azospirillum* +*Azatobactor* seed treatment), T_7-(50 %N+*Azospirillum* seed treatment), T_8-(50 %N+*Azatobactor* seed treatment),T_9-(5 0%N+*Azospirillum* + *Azatobactor* seed treatment), T_{10}-(75%N+*Azospirillum Azatobactor* seed treatment), T_{11}-(100 % N+*Azospirillum* +*Azatobactor* seed treatment). Beneficial effects of different biofertilizer doses were observed. Application of 100% N + *Azospirillum* + *Azatobactor* was found beneficial in case of number of filled seeds ,number of unfilled seeds, test weight and was at par with *Azatobactor* and *Azospireillum* mixed seed treatment which are superior than other treatment. Similar result were reported by Sigh et. al. (2007). As the oil yield is the function of seed yield and oil content in seed .The maximum oil yield 545.15kg/ha was found with application of 100% N+B *Azospirillum* + *Azatobactor*. Other 100% N, 50% N and 75 % N along with *Azatobactor* and *Azospirillum* were found next best treatment. The result is in conformity with Kubsad *etal.* 2003, Nandhagopal *et al.* 2003, Pragati kumari *et al.* 2004, Ram *et.al.*1992,

P2.12. Isolation and Assessment of Zinc-Solubilizing *Bacillus* Isolates from *Nimar* Region of Central India

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Abstract

Quenching zinc requirement of soybean crop by use of microorganisms including bacilli as an inoculant is environmental friendly and sustainable approach. In this investigation, a total of 134 putative bacilli were isolated from soybean rhizosphere soils collected from 4 districts of Nimar region of Madhya Pradesh. These isolates along with standard cultures of *Bacillus* were subjected for screening to measure their zinc-solubilizing potential on tris-minimal medium supplemented with zinc oxide, zinc phosphate and zinc carbonate. Among 44% found positive for zinc solubilization, only 9 potential isolates were selected to measure actual potential of zinc solubilization. Isolates KHBD-6, KHBAR-1, BDSD-2-2C, KDMR-1-1, KHTH-4-1, KHBD-2-1A were found promising for solubilization of insoluble zinc salts.

P2.13. Phytase, Phosphatase activity and P- Nutrition of Soybean as Influenced by Inoculation of *Bacillus* isolates

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Abstract

A large proportion of total phosphorus in soils occurs as organic forms and mostly as complex organic esters (Richardson *et al*., 2005). The importance of organic-P as a source of plant available-P depends on its rate of solubilization and release as inorganic-P in soil solution. Inositol penta- and hexa- phosphates (phytates) and their derivatives account for a major component of organic-P. However, despite its abundance in most soils, the contribution of phytate to P nutrition is limited due to their low solubility, firm association with the solid phase and high stability. Several types of phosphatases and phytase may, thus, play a predominant role in the hydrolysis of organic-P compounds. In soils, the hydrolysis of organic-P is predominantly mediated by the activity of soil microorganisms, although plant roots also possess phosphatase and phytase activity. Some of the plant growth-promoting microorganisms (PGPM) strains of *Bacillus amyloliquefaciens, B. laevolacticus, B. subtilis,* and *Aspergillus Niger, Penicillium rubrum* are known to be active phytases producer (Idriss *et al*., 2002, Yadav and Tarafdar, 2003; Gulati *et al.,* 2007). The aim of the present study is to assess impact on soil phosphatase and phytase activity and their role in P nutrition of soybean as influenced by inoculation of *Bacillus* isolates recovered from soybean rhizosphere.

P2.14. Optimization of Phosphorus Requirement in Soybean-Safflower Cropping System on Vertisols

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Abstract

A long-term field experiment was conducted during 1997 to 2008 at research farm of AICRP on safflower, Marathwada Agricultural University, Parbhani. Soybean variety JS – 335 and safflower variety Sharda were grown every year during *Kharif* and *Rabi* seasons respectively. Different phosphorus management treatments were given to each crop. Application of 100% recommended phosphorus to soybean recorded significantly higher seed yield over 50% P and control, however, it was on par with 50% P + PSB, FYM 5t/ha and FYM + PSB. Application of 100% recommended P to safflower recorded significantly higher seed yield over control, however, it was on par with 50% P, 50% P + PSB, FYM 5t/ha and FYM + PSB. The treatment receiving 100% recommended P to both soybean and safflower recorded highest safflower equivalent yield. System gross returns, net returns and B:C ratio followed the similar trend.

P2.15. Co aggregation of microbes for efficient phosphorus solubilization

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Abstract

The commonly used bioinoculants i.e. *Azotobacter, Azospirillum, Bacillus, Pseudomonas* and *Trichoderma* were found to posses phosphorus solubilizing ability alone and in combinations with each other. *Pseudomonas* alone solubilized maximum phosphorus by forming 8.00 mm solubilizing zone on Pikovskaya's media followed by *Bacillus* (6.8 mm), Aztobacter + *Bacillus*+ *Pseudomonas* (6.5 mm), *Azotobacter* + *Bacillus* (5.7 mm) and *Azotobacter* + *Trichoderma* (5.3 mm). The temperature range of 25-30^{0}C and pH 7.0 was found most suited for all the tested parameters contributing phosphorus solubilization by the organisms. Maximum solubilizing zone, reduction in pH, phosphatase activity, available phosphorus and acidity of media i.e 8.0 mm, 4.1 from 7.0, 35.10 µmole/g/h, 135.42 ppm & 0.00738N respectively were observed due to *Pseudomonas* after 8 days of incubation followed by *Bacillus* at pH 7.0 and temperature of 25-30^{0}C.

P2.16. Phytate mineralization by native soil flora and diversity of phytate mineralizing rhizobacteria and their application for plant growth promotion

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Abstract

The predominant form of organic phosphorus in most soils is *myo*-inositol hexakisphosphate (IHP / phytates). Microbial mineralization of phytate by phytases is a key process for recycling phosphorus (P) in the biosphere. Since the roots of most plants cannot directly utilize phytate-P, IHP mineralizing microorganisms have been considered important in increasing plant growth when phytate is provided as the source of phosphate. Agricultural and non-agricultural bulk soil was amended with IHP and different parameters were measured. Phytate mineralizing bacteria were isolated from different plants' rhizosphere and their role in plant growth promotion was checked in synthetic medium. Phylogenetic relationship among the various phytate mineralizing rhizobacterial isolates was determined by Amplified rDNA Restriction Analysis (ARDRA). Natural soil microflora showed increased soil respiration upon IHP amendment to soil and showed increased Na-IHP mineralization. Phytate hydrolyzing rhizobacteria mainly represent genera of *Enterobacter*, *Pseudomonas* and *Bacillus*. Phytase producing rhizobacterial isolates showed increased plant growth promotion in synthetic medium provided IHP as a sole P source. Soil microbial activities were increased upon phytate amendment. Phylogeneticaly phytate mineralizing rhizobacterial population forms mainly three groups' *viz*. Enterobacteriaceae, Pseudomonadales and Firmicutes. Phytase producing isolates showed plant growth promotion with respect to increased P availability to plants.

P2.17. Effect of Inorganic Fertilizers and PGPR on the Growth of Rubber Seedlings (*Hevea Brasiliensis)* in Nursery

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Abstract

A nursery experiment was conducted to study the effect of inorganic fertilizers, plant growth hormone and PGPR on the growth of rubber seedlings in ground nursery at the Central Experiment Station, Chethackal of the Rubber Research Institute of India. The treatments comprised of inorganic fertilizers alone and in combination with plant growth hormone (Phytonol) and plant growth promoting rhizobacteria (PGPR). Preliminary results indicated significant difference between the treatments on the growth of rubber seedlings. Application of N and P@ 150 kg/ha as ammophos (20-20) in combination with PGPR or soluble form of N and P @ 250 kg/ha alone or in combination with plant growth hormone significantly improved the growth and percentage buddability of rubber seedlings in ground nursery. Highest nutrient uptake was noticed in the treatment having nitrogen and phosphorus @250 kg/ha as ammophos.

P2.18. Chracterizing an efficient phosphate solubilizer (*bacillus megatherium*) from rhizosphere soil of selective weed plants from dry farm of G.K.V.K. Main research station

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Abstract

The sequence of phosphorous solubilization and utilization by plants reveals the dominance of phosphate solubilizers and their diversity. A weed crop among the crop plants observed a better growth with minimum requirements. To utilize the novel luxuriant growth of weeds with neighboring crop plants, some weed plants were selected from agronomy research field of GKVK, UAS, Bangalore for the study of phosphate solubilization. The results showed that P-solubilizing bacterial population (identified as *Bacillus megatherium*) were more than the fungal population(*Aspergillus niger*). Among the weed rhizosphere soil samples, *Argimon mexicana* a thorny weed, had highest p-solubilizers(47.5%) followed by *Compania sp*(41.3%), *Lantana camera*(35.7%) and least from *Parthanium hysterothorus* (5.0%). The isolates were confirmed as *Bacillus megatherium* and five isolates (among 15 isolates) were more efficient p-solubilizers on both DCP and TCP compare to lab cultures. The molecular characterization of p-solubilizing bacterial isolates(PSBI)confirms the production of Organic acids, thus, the leachets(cell free extracts) showed pH of 4.70 from 7.00 on third day of incubation. HPLC analysis confirmed the dominant organic acid as Gluconic acid. The diversity among the weed plants for phosphate solubilization may reveal the identification of a novel phosphate solubilizer and will be used for developing microbial consortium for the crop plant. A bio-assay with tomato seedlings for screening efficient strain is in progress.

P2.19. Nitrogenase activity and plant growth promoting properties of *Asaia bogorensis*; an endophyte isolated from mango.

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Abstract

Isolation and characterization of *Asaia bogorensis* isolated from various plants and to study their plant growth promoting potential. *Asaia bogorensis* is one of the diazotrophic bacteria with endophytic characteristics and an object of intense research. Until quite recently, it was thought that *Asaia bogorensis* could only occur in plants that propagate vegetatively such as sugarcane, sweet potato, pineapple and banana. However, in present study it was also detected in plants propagated by seeds such as mango. This organism has high potential to fix nitrogen with contributions to the plant nitrogen metabolism. Other effects of *Asaia bogorensis* inoculation are associated with phytohormone production, phosphate solubilization and production of antimicrobial substances. The potential of this organism, to fix nitrogen was determined by the Acetylene Reduction Assay. Results showing its ability to fix nitrogen were encouraging. It could effectively solubilize phosphate. However, it has not demonstrated potassium and zinc solubilization. The bacterium was also investigated to establish the effect of phytohormones on plant growth produced by it. Thin-layer chromatography, high-pressure liquid chromatography and bioassay were used to separate and identify plant growth substances produced by the bacteria in liquid culture. *Asaia bogorensis* produced indole acetic acid and gibberellic acid both from tryptophan. Indole acetic acid production increased with increasing tryptophan concentrations from 20 to 120 μg/ml. Indole acetic acid concentration also increased with the age of the culture. Shaking favored the production of Indole acetic acid. It was more in a medium containing nitrogen. Very small amount of gibberellin was detected in the culture medium. Application of broth culture affected the morphology of maize (*Zea mays*) roots. The number of lateral roots was increased. They were covered with root hairs. Inoculation with *Asaia bogorensis* produced changes in root morphology of maize better than those produced by the combinations of indole acetic acid and gibberellin. The present study has shown that the use of nitrogen fixing *Asaia bogorensis* as a bioinoculum would support crop yields equivalent to or greater than yields supported by the recommended chemical nitrogen fertilizers. *Asaia bogorensis* used in the work reported here is a new strain, isolated from one of the varieties of *Mangifera indica* (mango). The occurrence of this bacterium as an endophyte in various gramineous and vegetatively propagated plants has been proven by many workers. However, we have detected it first time in plant propagated by seeds viz. mango. It recorded higher nitrogenase activity as compared to other isolates. The nitrogenase enzyme is directly responsible for the fixation of nitrogen in diazotrophic bacteria. It produced appreciable quantity of indole acetic acid. Roots of plants showed a striking growth response when maize seedlings were inoculated with this isolate. Root hairs as well as the number of roots were significantly increased.

P2.20. Screening of rhizospheric fluorescent pseudomonas for their antagonistic, and plant growth promoting activities and induced resistance in tomato

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Abstract

Plant growth promoting rhizobacteria (PGPR) are known to influence plant growth by various mechanisms. Pseudomonas spp. is common inhabitants of all types of rhizospheres and known for biocontrol and plant growth promoting activities. Hence, it has significance in agriculture to increase the production. Due to excess use of inorganic fertilizers and pesticides they are gradually loosing their growth promoting traits. Therefore it is essential to isolate the strain that has bio-antagonistic potentials as well as plant growth promoting activity. With this objective survey was conducted in IGP region (Uttaranchal and Uttar Pradesh) to collect rhizospheric soil from different cropping systems. A total of 84 *Pseudomonas fluorescence* (PF1-PF84) were isolated by using selective media (*King's* B). The fluorescent pseudomonads were selected on the basis of fluoresence under short wave length (254 nm) ultraviolet light. All these isolates were evaluated for their antagonistic potential against *Fusarium oxysporum* f. sp. *lycopercisi* using dual-culture method. Among these, 14 isolates showed more than 75% mycelial growth inhibitions in dual culture were selected for its growth promoting activities. Plant growth promotion may increase either by uptake of nutrients from soil or producing certain plant growth promoting substances like iron chelating compound, hydrogen cyanide, Ammonia etc. The results showed that 80% of selected strains were positive for HCN, 70% were positive for ammonia production and only 8 strains were able to chelate Iron. These isolates were also evaluated for production of fungal cell wall degrading enzymes. Results showed chitinase and protease production by two isolates and endoglucanase production from another five isolates. Genetic diversity of strains were analysed through 16S r DNA gene amplification and restriction pattern generated by AluI, HaeIII, and MboI. Genetically diverse isolates positive for hydrolytic enzymes and PGP substance production were selected for induction of systemic resistance in tomato plant under green house condition. Several biocontrol agents have been identified to induce systemic resistance (ISR) by activating the signal transduction system in genetically susceptible cultivars. The antagonists which control diseases by inducing resistance can be exploited for effective disease management by applying them before the disease outbreak. Studies were carried out for induced systemic resistance in tomato against tomato wilt caused by *Fusarium oxysporum f.* sp. *lycopercisi* in green house condition assay by using potential selected strains. Tomato seedlings were bacterized with potential pseudomonas isolates and non-bacterized served as control. The treated seedlings were planted in plastic pots inoculated with *F. oxysporum f.* sp. *Lycopersicum*, uninoculated also served as control. After challenge inoculation leaf and root were analysed at every 48 h up to 10 days for changing in peroxidase, super oxidase dismutase and polyphenol oxidase. Peroxidase isozyme analysis indicated that PF23 and PF 61 maximum peroxidase activity was observed on inoculation of PF23 followed PF61. The peroxidase activity initially started increasing after 24 hrs of inoculation and reached at maximum after 4-6 days of inoculation. However, in case of PF 61 after 4 days of inoculation and the maxima was obtained after 4 days of inoculation and subsequent decrease was observed thereafter. SOD activity was markedly induced by PF 61 and PF 75 to the pathogen. In the case of PF 75 and PF 23 polyphenol oxidase activity was observed significantly up to 6 days.

P2.21. Evaluation of Azotobacters with multiple PGPR traits for PGP in *Pongamia pinnata*, individually and in combination with AM fungi

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Abstract

Pongamia pinnata is an economically important Nitrogen Fixing Tree (NFT) species employed by forest department of India under various plantation programmes. Seedlings of these are grown under nursery level and healthy saplings are transplanted in field. Transplantation shock is the major problem encountered. To address this problem an attempt was made to tailor the nursery saplings with Arbuscular Mycorrhiza Fungi and Plant growth promoting (PGP) Azotobacter to withstand transplant shock. Nursery saplings were subjected to seed bacterization by Azotobacter (AZ-5) possessing multiple PGPR traits and AM (*G.fasciculatum*) (AM-1) infection spread at 1/4th of the experimental pot as a layer. Treatments contained both individually and dual inoculations. Each treatment was replicated thrice and means were compared with fishers LSD test. *Pongamia pinnata* saplings treated with a mixture of AZ-5 and AM-1 showed high mycorrhizal colonization (58.7%) and nitrogen content (2.06%) compared to individual inoculation (0.84% and 0.8% nitrogenforAZ-5 and AM-1 (35.2 %infection) respectively) after 6 months of sowing. Even the Phosphorus content in the plant increased significantly (1.32mg/g and 2.01 mg/g in AZ-5 and AZ-5+AM-1 respectively). All plants showed increased root and shoot dry mass compared to control without inoculation. Mycorrhiza in combination with PGP azotobacter (AZ-5) is found to be a promising treatment for making the Pongamia saplings grow better and withstand the transplant shock.

P2.22. Isolation, identification, screening and evaluation of Phosphate Solubilizing Microorganisms (PSMs) from different plants

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Abstract

It was attempted to isolate native phosphate solubilizing microorganisms with special emphasis to endophytic bacteria from different plants. Isolation of phosphate solubilizing microorganism was carried out on Nutrient and PKVK agar. Endophytic bacteria, *Bacillus* spp were isolated from *Cynodon dactylon* (Durva), *Pothos scandens* (Money plant), *Saccharum officinarum* (Sugarcane), *Musa paradica* (Banana) and *Eichhornia crassipes* (water hyacinth). Tri-calcium phosphate (TCP) solubilizing activity of the isolates was further confirmed on Sperber's solid medium which showed clear zone of solubilization. Further P solubilizing capacity was quantified by estimation of available P following Vanedomolybdate method in PKVK broth containing 0.25% TCP (50 µg / ml). The bacterial cultures showed available P ranging from 7.5 to 27.5 and 5.9 to 19.3 PPM on 5th and 10th day of inoculation respectively. *Cynodon dactylon* stem isolate was showed maximum P solubilizing activity. Thus, all native endophytic *Bacillus* isolates of various plants showed very good p solubilization indicating and have future scope to use as phosphatic biofertilizers.

P2.23. Efficacy testing of phosphate solubilizing fungi

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Abstract

Phosphorus is one of the major plant nutrients, second only to nitrogen in requirement. However, a greater part of soil phosphorus, approximately 95–99% is present in the form of insoluble phosphates and hence cannot be utilized by the plants. It has been reported that many soil fungi and bacteria can solubilize inorganic phosphates. Phosphate solubilizing microorganisms (PSMs) play an important role in supplementing phosphorus to the plants, allowing a sustainable use of phosphate fertilizers. Application of PSMs in the field has been reported to increase crop yield. Several mechanisms like lowering of pH by acid production, ion chelation and exchange reactions in the growth environment have been reported to play a role in phosphate solubilization by PSMs. Among PSMs, fungi perform better in acidic soil conditions. Species of *Aspergillus*, *Penicillium*, *Curvularia* and yeast have been widely reported solubilizing various forms of inorganic phosphates. Various beneficial fungal cultures viz. *Trichoderma*, *Paecilomyces*, *Beauveria* and *Metarhizium* have been revived by inoculating them in 250 ml Erlenmeyer flasks containing 50ml of sterile Potato Dextrose Broth (PDB). Tri-calcium phosphate (TCP) solubilizing activity of the isolates was checked on Sperber's agar medium, which showed clear zone of solubilization. Further 'P' solubilizing capacity was quantified by estimation of available 'P' following Vanedomolybdate method from Pikovskaya's broth supplemented with 0.25% TCP (50 µg / ml). The fungal cultures showed available 'P' ranging from 20-58 µg / ml on 3rd day of inoculation. The reduction of 'P' level on 5th day may be due to inhibitory effect of free 'P' in media as well as formation of organo 'P' compounds. Thus, beneficial fungal soil inoculants for biological control of pests and diseases also acting as PGPR for plant growth by means of their phosphate mobilizing activity.

P2.24. An Efficient Method for Qualitative Screening of Phosphate-Solubilizing Bacteria

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Abstract

An efficient protocol was developed for qualitative screening of phosphate-solubilizing bacteria, based upon visual observation. Our results indicate that, by using our formulation containing bromophenol blue, it is possible to quickly screen on a qualitative basis the phosphate-solubilizing bacteria. Qualitative analysis of the phosphate solubilized by various groups correlated well with grouping based upon quantitative analysis of bacteria isolated from soil, effect of carbon, nitrogen, salts, and phosphate solubilization-defective transposon mutants. However, unlike quantitative analysis methods that involve time-consuming biochemical procedures, the time for screening phosphate-solubilizing bacteria is significantly reduced by using our simple protocol. Therefore, it is envisaged that usage of this formulation based upon qualitative analysis will be salutary for the quick screening of phosphate-solubilizing bacteria. Our results indicate that the formulation can also be used as a quality control test for

expeditiously screening the commercial bioinoculant preparations, based on phosphate solubilizers.Mycorrhiza and zinc solubilizing bacterial inoculation to acid lime in sodic soils.

P2.25. Mycorrhiza and zinc solubilizing bacterial inoculation to acid lime in sodic soils

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Abstract

Soil pH greatly influences the solubility and availability of nutrients in the soil. In alkaline sodic soils, deficiency of phosphorus and zinc is widespread. The bioinoculants *viz*., mycorrhiza and zinc solubilizing bacteria (ZSB) could effectively be employed in this soil to enhance nutrient availability. Native efficient strains of ZSB were isolated and the mycorrhizal fungi were multiplied in the maize roots grown in sodic soil. Field experiment was laid out with six months old acid lime seedlings to know the effect of mycorrhiza, ZSB and their combination apart from an uninoculated control. The combined inoculation of mycorrhiza and ZSB resulted in a gradual increase in the growth of acid lime and microbial load in the rhizosphere. Combined application of ZSB and mycorrhiza enhanced the height of plants (141.2 cm) when compared to the individual inoculations and uninoculated control (122.7 cm) at 180 days after inoculation. Other biometric observations were also showed the same trend. The population studies revealed that the inoculated plots showed higher population of the respective organisms. Utilizing these bioinoculants *viz*., mycorrhiza and zinc solubilizing bacteria (ZSB) would certainly improve the phosphorus and zinc nutrition in the sodic soils.

P2.26. Exopolysaccharide producing *Rhizobium* sp as PGPR in groundnut and wheat

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Abstract

The term Plant growth promoting rhizobacteria (PGPR) refers to those bacteria, which directly or indirectly promote the plant growth by variety of mechanisms. In recent days along with nitrogen fixer large number of microorganisms are coming up as a potent PGPR. This includes *Enterobacter* spp, *Xanthomonas* spp, *Lactobacillus* spp, *Pseudomonas* spp *Leuconostoc* spp and *Auribasidium* spp etc that produce variety of exoplysaccharide (EPS) to maintain minimum moisture in their immediate environment, even after prolonged exposure to desiccation, since they possesses remarkably high moisture holding capacity. These PGPR are also known to play important role in the solubilization of minerals and therefore in the promotion of plant growth. Microbial polysaccharides have been commercialized in agriculture for the encapsulation of

somatic embryoids, which offer a greater feasibility for precise delivery of plant growth regulators, fungicides and pesticides. Isolation and partial characterization of *Rhizobium* sp. and its screening for EPS production was carried out by agar plate method. EPS production was studied in congo red yeast extract mannitol broth (CRYEMB) at shake flask level. The influence of carbon, nitrogen and phosphate, KCl, $MgSO_4$, $CaCl_2$ and $CaCO_3$ on the yield of EPS was studied by submerged process at shake flask level in CRYEMB. The bio-efficacious potential of *Rhizobium* sp was examined in wheat and groundnut seeds. The role of EPS producing bacteria as PGPR has not been explored fully and therefore needs to be investigated. Formation of mucoid colonies on **CRYEMA** and increase in the viscosity of CRYEMB indicated the EPS producing potential of *Rhizobium* sp. isolate produced copious amount of EPS in CRYEMB with dextrose as carbon source, ammonium sulfate as nitrogen $CaCO_3$ as mineral source. The EPS was readily extracted with 30% isopropanol and the yield of EPS obtained from optimized CRYEMB medium was 3.1 g/L, which was almost three folds more than the yield obtained with unoptimized media (1.1 g/L). Bacterization of seeds with isolate promoted groundnut and wheat seed germination in (10%), root length (73%) shoot length (51%) and root number of rootlets (51%) in both the seeds.

Poster session:

Mechanisms, signaling, plant responses, bioactive metabolites

P3.1. Effect of NADH insensitive *E. coli* citrate synthase on citric acid secretion of fluorescent pseudomonads

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Abstract

Fluorescent pseudomonads are efficient plant growth promoting rhizobacteria plant growth is mediated by their ability to secrete a variety of molecules either enhance plant growth or control plant pathogens. These fluorescent pseudomonads with mineral phosphate solubilizing (MPS) ability are postulated to be more effective. Citric acid is one of the strong organic acids with very good MPS ability. Natural fluorescent pseudomonads do not secrete citric acid. Citric acid biosynthesis is known to be governed by the citrate synthase activity. The citrate synthase of *Escherichia coli* is an example of a Type II citrate synthase, a hexamer that is subject to allosteric inhibition by NADH. In this report, we overexpressed NADH insensitive citrate synthase and monitored its effect on central metabolism when grown on glucose as the carbon source. NADH insensitive *E coli cs* Y145F and R163L were incorporated under *lac* promoter in broad host range vector, transformed in selected strains of fluorescent pseudomonads, tested for NADH inhibition, *cs* activity and citric acid secretion. *Pseudomonas fluorescens* ATCC 13525 and Pf01 strains containing NADH insensitive *E coli cs* Y145F and R163L demonstrated kanamycin resistance phenotype. Restriction digestion analysis of the plasmids isolated from these strains confirmed the transformants. Preliminary results demonstrate significant increase in citrate synthase activity. Fluorescent pseudomonads with NADH insensitive *E. coli* cs appears to be different from the transformants containing wild type enzyme.

P3.2. Beneficial traits of microbial isolates of organic liquid manures

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Abstract

Among indigenous technologies used by farmers of Karnataka, use of panchagavya, jeevamruth, beejamruth and bio-digester has gained importance. These organic liquid manures have been used since age old days by the farmers who claimed higher yield levels in several crops of Karnataka. Hence, an attempt was made to isolate and study beneficial microorganisms present in these organic liquid manures. Bacteria isolated from these liquid organic manures were capable of nitrogen fixation, p-solubilization, hormone production (IAA, GA) in addition to biological deterrence of soil borne pathogens and improvement in seed germination, seedling length and seed vigour in chickpea and wheat.

P3.3. IAA production by the isolates of *Psuedomonas spp.* from the Eastern Ghats of Tamil Nadu

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Abstract

A total of 12 *Pseudomonas* isolates were obtained from different rhizospheric soils in the Eastern Ghats (Kolli hills) and they were characterized as per standard methods. These isolates were further tested for the production of indole acetic acid (IAA) in Tryptophan medium. The *Pseudomonas* isolates such as KLP6, KLP9 and KLP10 produced high levels (31.0 to 43.2 µg/ml) of IAA while other isolates produced IAA in the range of 13.4 to 25.2µg/ml. Production of IAA was further confirmed by extraction of crude IAA from these isolates and subsequently subjected to TLC analysis. A specific spot from the extracted IAA preparation was found in corresponding with the standard spot of IAA with same Rf value.

P3.4. Quantitative assay for ACC deaminase producing isolates and their characterization for plant growth promoting potentials

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Abstract

The ACC deaminase has been widely reported in numerous microbial species of gram negative and gram positive bacteria, rhizobia, endophytes and fungi. In this present study 17 organisms were isolated and out of them eight different isolates ACC_1, ACC_2, ACC_3, ACC_4, ACC_5, ACC_6, ACC_7, & ACC_8 were found positive for ACC deaminase. Now these ACC deaminase producing PGPR were characterized for phoshphate solubilization, Siderophore production, IAA production, and for nitrogen accumulation. The Km value in this present study for ACC deaminase is found is 2.75 mM that is between the ranges of 1.5 to 17.5 mM. The ACC deaminase-producing PGPR lowers the ethylene concentration and prevents the inhibition of root elongation by ethylene by sequestering and cleaving plant-produced ACC. ACC deaminase-producing bacteria have been shown to be able to promote plant growth under various kinds of stress including salinity, drought, water logging, heavy metal and contaminations. PGPR containing ACC deaminase is present in most soils and offer promise as a bacterial inoculum for improvement of plant growth, particularly under unfavorable environmental conditions.

P3.5. Molecular characterization of *Bacillus megaterium* isolated from different agroclimatic zones of Karnataka

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Abstract

The investigation was carried out to study the molecular characterization of *Bacillus megaterium* isolated from soils of the ten different agroclimatic zones of Karnataka.The diversity of these isolates was characterized by randomly amplified polymorphic DNA (RAPD) marker. RAPD analysis revealed a total of 37 bands, out of which 34 bands were found to be polymorphic. The RAPD marker analysis clearly depicted that all the ten *Bacillus megaterium* isolates form two major clusters. Among the two major groups of isolates, from zone 4 and 3 form the first group while all others form the second group. The RAPD banding pattern of these isolates could easily distinguish the isolates of different zones. Variation in these isolates was also reflected on the growth and development of rice plants as mentioned above.

P3.6. *Synecechococcus elongatus* PCC 6301 phosphoenolpyruvate carboxylase gene overexpression improves the phosphate solubilizing abilities of wheat rhizosphere isolates of fluorescent pseudomonads

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Abstract

Fluorescent pseudomonads are efficient phosphate (P) solubilizing bacteria (PSB) predominantly secreting gluconic and 2-ketogluconic acids; the biosynthetic genes of which are often the genetic engineering targets for developing efficient PSBs. Many other mono and dicarboxylic acids are also implicated in P-solubilization. The present study reports genetic manipulation of anaplerotic node in central carbon metabolism by *Synechococcus elongatus* PCC 6301 *ppc* gene overexpression and its effects on P-solubilizing ability of *P. fluorescens* 13525 and wheat rhizosphere isolates of fluorescent pseudomonads P109, Fp315 and Fp585 with varying inherent P-solubilizing abilities. Di-calcium phosphate (DCP) and rock-phosphate solubilizing abilities of *ppc* transformants of fluorescent pseudomonads was respectively monitored on Pikovaskya's agar and 100mM Tris buffered minimal medium containing rock-phosphate as the sole P source. Incorporation of pAB3 plasmid expressing *S. elongatus* PCC 6301 *ppc* gene in *P. fluorescens* 13525, P109 and Fp585 enhanced their DCP solubilizing ability on both glucose and xylose as carbon sources, as compared to their respective controls. However, DCP solubilization of Fp315 *ppc* transformants was unaltered. On the other hand, Fp315 *ppc* transformant showed faster growth, media acidification and rock-phosphate solubilization as compared to its control; unlike Fp585 and P109 in which *ppc* ovrexpression did not alter growth and media acidification profiles. *ppc* overexpression could enhance the P-solubilizing ability of fluorescent pseudomonads probably by benefiting their growth. This strategy could be employed to overcome the adverse

effects on growth imposed due to P-limitation as well as due to plasmid-load while developing efficient genetically modified PSBs.

P3.7. Analysis of metabolite changes in *bacillus cereus* grown in presence of different root exudates

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Abstract

Plant growth promoting rhizobacteria (PGPR) is a widely studied group of rhizosphere microorganisms. However, metabolite changes in the bacterial partner during plant-PGPR interaction is yet to be explored. Cellular metabolic processes, including their alterations induced by various environmental factors, result in metabolite changes in microbial cells. The metabolome is the downstream product of gene expression and reflects the functional level of the cell more appropriately. Changes in the metabolome are expected to be more amplified in comparison to proteome or transcriptome changes. We have initiated work to analyze the key metabolites and their changes in PGPR when grown in minimal media amended with different root exudates. *Bacillus cereus* strain MTCC 430 showing growth enhancement in tobacco was selected for this study. Attenuated Total Internal Reflection-Infrared (ATR-IR) spectroscopic studies of this strain when grown in minimal media alone and in presence of tobacco root exudate showed difference in peaks denoting production of compounds differing in functional groups. *B. cereus* MTCC 430 did not promote growth of groundnut. ATR-IR spectra of *B. cereus* MTCC 430 grown in minimal media amended with or without groundnut root exudate showed no difference in the detectable functional groups. Thus, difference in spectra of bacteria when grown in different root exudates showed its specificity. Depending on the root exudate available, bacteria produced different metabolite(s), which could be related to growth promoting ability.

P3.8. Mercuric reductase (*merA*) gene isolated from plasmid bearing strains of *Escherichia coli*

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Abstract

Out of 30 *Escherichia coli* strains isolated from five different aquatic environments of India, 8 strains showed significantly high levels of tolerance to the inorganic form of mercury i.e mercuric chloride ($HgCl_2$). Among the isolates MYA8 strain from Yamuna river (Delhi) could tolerate the highest concentration of $HgCl_2$ i.e 48µg/ml and strain MAS12 from Safdarjung Hospital area (Delhi) tolerated the lowest concentration of $HgCl_2$ i.e 20µg/ml. All the 8 resistant strains revealed the presence of a plasmid of approximately 24kb size and transformation of the isolated plasmids into the mercury sensitive competent cells of *E. coli* DH5α rendered transformants

resistant to the same concentration of mercury as the wild type strains. The mercuric reducatse (*merA*) gene of 1695 bp was isolated from the resistant strains, it was noted that resistance to $HgCl_2$ was conferred by conversion of the toxic ionic form of mercury (Hg^{++}) to the non-toxic elemental form (Hg^0) by mercuric reductase gene.

P3.9. Molecular markers for population dynamics of cellulose degrading bacteria in Chickpea (*Cicer arietinum L.*) soils

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Abstract

Bacteria were isolated and screened for cellulase activities in chickpea (*Cicer arietinum L.*) soil of Patiala, Punjab. Three most efficient cellulose degraders identified using 16S rDNA, as *Serratia sp., Pseudomonas sp.* and *Serratia marcescens* showed cellulase activity of 3.83, 4.21 and 4.52 mM glucose ml^{-1} h^{-1} respectively. Enterobacteriaceae Repetitive Intergenic Consensus Polymerase Chain Reaction (ERIC-PCR) was performed to obtain fingerprint and showed clear genetic variability among all three isolates. The bacteria were mass cultured and re-inoculated in soils to study the population dynamics under chickpea (*Cicer arietinum L.*) cultivation. The role of introduced bacteria was studied towards sustainability of soil and organic carbon indicating good survival of 40.2, 34.4 and 56.8 % respectively. The highly positive correlation (R^2=0.857) among the cellulose degraders population and soil organic carbon was observed during the chickpea plot trails towards inoculated bacterial strains.

P3.10. Growth promotion in rice by an IAA producing rhizobacterium, *pseudomonas aeruginosa* MML2212

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Abstract

Rice (*Oryza sativa* Linn.) production, which helps to feed almost half the world, is under pressure due to various biotic and abiotic factors. Among which, the biotic stresses like diseases caused by pathogenic microorganisms can be suppressed by biological control thereby the grain yield of this staple food crop can be increased. A large numbers of rhizobacteria were isolated from rice rhizospheres, screened against the sheath blight (ShB) pathogen, *Rhizoctonia solani* and characterized. The selected strain was tested for its efficacy in reducing the ShB disease. Further, the strain was also characterized for its plant growth promotion activity. Among 671 fluorescent pseudomonads isolated from rice rhizosphere, *Pseudomonas aeruginosa* MML2212 was

identified as most efficient antagonist against *R. solani*. In addition to ShB disease suppression, *P. aeruginosa* also increased the plant growth and grain yield considerably both in greenhouse and field trials. It has been found that the antagonist produced IAA (48µg/ml) and its biocontrol ability was due to the production of phenazine-1-carboxamide (PCN). The purified PCN has also inhibited the *in vitro* growth of *Xanthomonas oryzae* pv. *oryzae,* the causal agent of bacterial leaf blight. The talc based formulation of the selected strain has increased 56.6% and 26.5% grain yield by the reduction of 82.6% and 76.4% of ShB disease incidence both in green house and field trials, respectively. Rice yield can be enhanced considerably by the use of *P. aeruginosa* MML2212, which exhibited plant growth promotion and disease control activities.

P3.11. *Bacillus licheniformis* MML2501 promotes growth and yield of groundnut by the production of Indole acetic acid

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Abstract

Groundnut (*Archis hypogaea* Linn.) is one of the most important sources of edible oil and vegetable protein. Pests and diseases challenge the groundnut cultivation all over the world. Several plant growth promoting rhizobacteria (PGPR) mainly belonging to the genera, *Bacillus, Pseudomonas* and *Rhizobium* were developed as successful biocontrol agents against this disease. Several rhizobacteria were isolated and screened for both plant growth promotion and biocontrol activity against *Macrophomina phaseolina*, the causal agent of root rot in groundnut. A selected efficient antagonist was characterized for its mechanisms to promote the plant growth and biological control of root rot using standard methodologies. The IAA production by selected strain, which was attributed for its plant growth promotion activity was optimized *in vitro*. The strain was also evaluated in greenhouse conditions. Among rhizobacteria isolated from groundnut rhizosphere, *Bacillus licheniformis* MML2501 was identified as the most efficient antagonist against *M. phaseolina*. At optimized culture conditions, the selected antagonist produced 23µg/ml of IAA. Importantly it did not solubilize phosphate. The biocontrol ability was due to the production of a novel thermostable azole compound and induction of disease resistance in groundnut. Application of talc-based formulation of *B. licheniformis* MML2501 to the groundnut plants has significantly enhanced the yield and growth attributes along with remarkable root rot disease reduction. *B. licheniformis* MML2501 promoted growth of groundnut by producing IAA and reduced root rot by the production of an azole compound. The groundnut pod yield was significantly enhanced by the application of this bacterium compared to control.

P3.12. Molecular characterization and screening of plant growth promoting rhizobacteria under drought stress

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Abstract

Rhizosphere is the largest ecosystem with enormous energy flux defined as the effect of the roots of the plants on the surrounding soil, in terms of higher microbial activity because of the organic matter released by the roots. A large number of microorganisms such as bacteria, which are abundant, coexist in the Rhizosphere promoting the plant growth. Several strains of *Pseudomonas* and *Bacillus* with plant growth promoting (PGP) characteristics were isolated from different arid and semiarid zones with different crop production systems of India. The isolates were screened for drought tolerance (-0.73MPa) and analyzed for their PGP activities under both normal and drought stress. The PCR amplification of conserved and variable regions of 16srRNA gene used for deeper insight into molecular characterization of distant plant growth promoting rhizobacteria (PGPR). A total of 277 isolates, 190 from Rhizosphere soil and 87 from bulk soils were isolated. 26 *Pseudomonas* and 15 *Bacillus* strains could grow at highest matric potential (-0.73MPa). *Pseudomonas* and *Bacillus* strains could produce IAA (between 13.1µg and 81.2µg mg^{-1} protein), gibberellins (between 13.3 µg and 385 µgGA mg^{-1}), Solubilize phosphate (between 30ppm and 60ppm), HCN, siderophore and ammonia were positive under normal conditions, where as production of IAA, GA, Phosphate solubilization, HCN and ammonia production were less under drought stress compared to normal conditions. Among *Pseudomonas* strains P45, P52, P53, P13, P14 and among *Bacillus* strains B17, B18, B19, B30, B44 could grow at highest matric potential (-0.73Mpa) having efficient PGP characters were chosen for *in vivo* green house experiments and proved to be very efficient in promoting a significant increase in root and shoot biomass of maize plant, increase in root adhering soil/root tissue ratio, chlorophyll content, relative water content and leaf water potential. Molecular characterization of the efficient PGP *Pseudomonas* and *Bacillus* was done using 16s rRNA gene sequence analysis. The isolation and identification of PGP *Pseudomonas* and Bacillus sp strains from arid and semiarid zones could alleviate drought stress effects in maize. The strains were identified as *Pseudomonas syringae*, *Pseudomonas putida Pseudomons monteilli, and Pseudomonas entomophila. Pseudomonas stutzeri, Bacillus amyloliquefaciens, Bacillus licheniformis, Bacillus thuringiensis, Paenibacillus flaviporus, Bacillus subtilis*.

P3.13. Isolation and molecular characterization of Antibiotic- DAPG (2, 4-diacetylphloroglucinol) from *pseudomonas fluorescens.*

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Abstract

Strains of fluorescent pseudomonad from soil have been shown to promote plant growth by inhibiting bacteria and fungi that are deleterious to plants. The production of antibiotic substances by some strains has been recognized as a major factor in suppressing root pathogens and the prime antibiotic one among these metabolite is 2,4-Diacetylphloroglucinol (DAPG) produced by *Pseudomonas fluorescens*. Experiment was carried out by isolating *Pseudomonas fluorescens*

from rhizosphere soil of different crop plants using king's-B medium. The results showed significant number of *Pseudomonas fluorescens in* capsicum (70.50.%) and chili(48.75%) soil rhizosphere. The production of DAPG from different strains of *P. fluorescens* isolates showed that isolates from chili rhizosphere produces high amount of DAPG (212.00 µg/l), least from soybean (0.71µg/l). when these results were compared with the standard culture, a significant 107% over the standard culture- PFB-8. An attempt was made to increase the production of DAPG by substituting different carbon sources such as glucose, sucrose, galactose, fructose and glycerol. It was observed that the production of DAPG was maximum in sucrose containing media while glucose as a carbon source produced least amount of DAPG. Dendrogram of RAPD data revealed that there were only two branches, one for the isolates and other for the standard culture. The antifungal assay with purified DAPG revealed that, DAPG inclined more as antifungal antibiotic showing inhibition zone with important plant pathogens like *Rhizoctonia solani*(15mm at 20ug con.) and *Sclerotium rolfsii, Aspergillus flavus, Aspergillus niger* (12mm at 20ug con.).

P3.14. Induction of systemic resistance in tomato (*Lycopsersicon esculentum* Mill.) by plant growth promoting rhizobacterial mixtures of *Bacillus* spp. for vascular wilt management

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Abstract

Tomato (*Lycopersicon esculentum* Mill) cultivation is often hampered by vascular wilt caused by *Fusarium oxysporum* f.sp *lycopersici* (FOL). Due to inconsistent field performance in application of single biocontrol agent, this study focused on the efficacy of an ideal plant growth promoting rhizobacteria (PGPR) mixture identified from *in vitro* interaction studies on induction of systemic resistance (ISR) in tomato for vascular wilt management. Antagonistic PGPR belonging to fluorescent pseduomonads and *Bacillus* spp effective against FOL were selected from dual culture assay and assessed for their *in vitro* interaction for antagonism. Designated strain mixtures were evaluated for plant growth promotion and biocontrol of vascular wilt of tomato in greenhouse by classical induced resistance challenge experiments and enzyme activity assays. In dual culture assay for antagonism, 5 *Bacillus* spp. and four fluorescent pseudomonads showed antagonism against the pathogen both in presence and absence of $FeCl_3$ indicating that the antagonism is not due to siderophores alone. The antagonistic isolates, in general, showed variation in production of plant growth promoting and biocontrol traits. Among various combinations of the bacterial strains, S2BC1+GIBC-Jamog and S2BC2+TEPF-Sungal were identified as the ideal combinations showing maximum antagonism. Seed bacterization with GIBC-Jamog and TEPF-Sungal recorded maximum vigour indices over control in paper towel and small pot experiments. In greenhouse, seed bacterization and soil application of S2BC1+GIBC-Jamog challenged inoculated with the pathogen recorded reduced disease incidence of 21.7% besides promoting plant growth. Root and leaf sample analysis revealed maximum induction of chitinases (2.8 and 3.9 units/ml, respectively) and β-1,3-glucanases (26.4 and 25.1 units/ml, respectively). In native gel activity assays, two unique chitinase isoforms were induced on treatment with the rhizobacterial mixtures. Bacterial strain mixture of GIBC-Jamog+S2BC1 with varying functional traits could be promoted for management of vascular wilt of tomato at the field level because of its ability to induce systemic resistance for disease control along with plant growth promotion.

P3.15. Phytate utilization ability of *Sinorhizobium meliloti* by heterologous overexpressing *E. coli* phytase (*appA*) and its growth promotion of maize

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Abstract

Organic phosphate constitutes about 20-50% of the total phosphate available in the soil and therefore, an potential source of P for plants. The principal group of organic P compounds is the inositol phosphates or phytates. P apart from various other physiological functions has also been shown to enhance the Nitogen fixing ability. Thus to impart the phosphate solubilising ability to rhizobium, *E. coli* Phytase gene was overexpressed in *Sinorhizobium meliloti* 1021 and growth promotion of maize was investigated. *appA* gene was amplified from *E. coli* and cloned under broad host range plasmid under the control of *lac* promoter, which is strong and constitutive in *Rhizobium*. AppA protein was detected in the periplasm of all transformants by western blot using rabbit anti-AppA antibody. Soluble P was determined using ascorbate method. Plants studies was done sterile M.S. synthetic medium. appA transformant had increased phytase activity by ~ 40-50 fold compared to control. Western blot showed the presence of expressed protein. *S. meliloti* harboring *appA* could drop the pH below 5.0; therefore, released P under unbuffered minimal media containing CaP or NaP as sole P source. *S. m* (pVA1) was able to release P from the NaP under sterile M.S. synthetic medium, which promoted maize plant growth. Plant parameters in case of *S. m* (pVA1) were found to be equivalent to the parameters of plants grown in presence of KH_2PO_4 (soluble Pi). Over expression of *E. coli appA* gene could render the phytate utilization and thus, growth promotion ability to *S. meliloti.*

P3.16. Field Evaluation of Bacterial Consortia to Alleviate Salt Stress for Growth and Yield of Wheat

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Abstract

In India about 10 million ha of arable land is salt affected. The high concentrations of salt in the soil have a detrimental effect on crops and microorganisms. Microorganisms have been implicated in alleviating the effects of abiotic stress by different mechanisms. They can alleviate salt stress by production of growth promoting substances. Bacterial exo-polysaccharides have been implicated in providing protection from environmental stresses and host defences. Yield losses of wheat in moderately saline areas average 65%. Thus an attempt was made to alleviate the effect of salt stress by inoculating wheat crop with rhizobacteria to improve its growth and yield in saline soils. Nine strains that performed well as single inoculant in the field were tested for compatibility with each other so as to develop the microbial consortium. Of the nine strains, isolate 13 was inhibitory to most of the other strains; isolates 8 and 47 were most sensitive, while 5, 8 and 18 were compatible with all isolates. Based on the results eight different consortia were prepared and field evaluated. Plants inoculated with microbial consortia showed significantly high proline accumulation as compared to uninoculated control. Concentrations of proline increased for all treatments from 60 to 90 DAS. Treatment T8 [a consortium of *Bacillus pumilus*

(isolate 121), *Bacillus aquimaris* (isolate 8) and *Bacillus sporothermodurans* (isolate 5)] showed maximum amount of proline at 60 DAS (2.53 µg mg^{-1}) and at 90 DAS (2.74µg mg^{-1}). Reducing sugars and total soluble sugars content for all treatments was higher at 60DAS as compared to 90 DAS. Again treatment T8 showed maximum amount of reducing sugar as well as total soluble sugars. The percent accumulation of N, P, K and Na decreased with the age of the plant and was more at 60 DAS as compared to 90 DAS. Treatment T8 (3.18% N) showed more nitrogen percent at 60 DAS as compared with control T9 (1.85% N). The % Na in the plant shoots also decreased from 60DAS to 90 DAS. Inoculation with microbial consortium did not have a significant influence on the accumulation of Na. Among all the treatments, T1 [a consortium of *B. pumilus* (isolate 121), *B. pumilus* (isolate 3) and *Bacillus cereus* (isolate 24)] showed slight reduction in Na content as compared to the control at 60 DAS. A differential response to microbial consortium inoculation was observed on the plant growth parameters both 60 and 90 DAS. Shoot length was significantly influenced due to inoculation of T1 as compared to control and other treatments. Dry biomass of shoot was significantly higher for treatment T7 [a consortium of *B. aquimaris* (isolate 8), *B. aquimaris* (isolate 44) and *B. pumilus* (isolate 3)] as compared to uninoculated control. Root dry weight was significantly influenced due to treatment T8 both at 60 and 90 DAS. The grain yield and biomass yield, in general, was significantly influenced due to inoculation of microbial consortium. Maximum grain yield of wheat was achieved in treatment T3 (3085 kg ha^{-1}) [a consortium of *B. pumilus* (isolate 121), *Pseudomonas mendocina* (isolate 40) and *Arthrobacter* sp. (isolate 18), closely followed by T8 (3057 kg ha^{-1}).

P3.17. Enhancement of chilling tolerance of inoculated wheat seedlings with cold tolerant plant growth promoting Pseudomonads from N.W. Himalayas

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Abstract

Cold stress leads to a series of molecular, biochemical, physiological and morphological changes that adversely affect plant growth and productivity. Epiphytic or endophytic plant growth promoting rhizobacteria (PGPR), enhance plant growth and yield while improving their tolerance/ resistance to environmental stress. In the present investigation cold tolerant plant growth promoting Pseudomonas strains were tested for their ability to enhance chilling tolerance in wheat (VL 804) seedlings. The effect of seed inoculation with twelve cold tolerant plant growth promoting *Pseudomonas* strains on wheat growth and physiological changes were examined in a greenhouse at 10±2°C. In order to determine the basis of growth promotion and chilling tolerance root, shoot length, dry biomass; chlorophyll, anthocynin, proline, starch and protein contents; physiological available iron, total phenolics, electrolyte leakage from leaves were determined using standard methologies. Bacterization with Pseudomonad*s* had significantly ($P > 0.05$) improved root length (27.9 to 70.5%), shoot length (4.7 to 26.1%), dry root biomass (1.69 to 3.19 fold increase), dry shoot biomass (1.27 to 1.66 fold) compared to that of nonbacterized control. Enhanced total chlorophyll, anthocynin, free proline, total phenolics, starch content; a decrease in Na^+/K^+ ratio and electrolyte leakage was also observed in bacterized wheat plants, which is critical to the plant's ability to tolerate stress conditions (cold stress). Moreover, relative to the noninoculated controls, bacterization wheat plants had significantly increased levels of proline, phenolics, protein, pigmentation and starch deposition. These increase correlated with the enhancement of cold tolerance of the wheat plants. In summary, cold tolerant Pseudomonads inoculation stimulates wheat plant growth and improves its ability to withstand cold stress.

P3.18. *In silico* characterization of heavy metal stress specific phytochelatin synthase(*pcs*) gene from heterelogous systems

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Abstract

Phytochelatin synthase (PCS) is responsible for the synthesis of heavy-metal-binding peptides (phytochelatins) from glutathione and related thiols. Heterologous expression of PCS has shown heavy-metal detoxification in various other systems. Initial first hand information about functional regulatory domains for enhanced *PCS* expression will provide a platform for mining genes responsible for heavy metal tolerance. The nucleotide and protein sequences of *PCS* genes from heterelogous source were assembled from databases and analysed using updated software. Analysis of promoter sequence, 3' and 5' UTRs analysis for free energy change, homology profiling was carried out through UNAFold and PLACE to propose for regulatory domains of PCS. High consensus region was revealed near N-terminal in *PCS* genes from various sources. This proves that the catalytic domain of PCS is nearby N-terminal and C-terminal might act as local sensor to different heavy metals. The promoter and UTRs analysis revealed that the *cis*-acting elements conferring heavy metal responsiveness are poorly characterized, and heavy metal specific responsive promoters have not yet been reported in higher plants. The 3' and 5'UTRs reveals very less percent similarity and seems specific for *PCS* expression. The ΔG° of the 5' UTRs when compared with expression of *AtPCS* especially revealed that *AtPCS2* is +0.14 whereas *AtPCS1* has -0.7 and it corroborates with expression profile of *AtPCS1* higher than *AtPCS2* as observed via AtGen Express under various abiotic stress profiles. The more $-\Delta G^{\circ}$ directs towards the lower energy requirement for faster unfolding and may act as enhancer responsible for higher *AtPCS1* gene expression. The *in silico* study revealed that the catalytic domain bearing specific *Cys* residues lies near N-terminal region. Plants don't have MRE like binding sequences as reported in prokaryotes and has specific UTRs as seen in *AtPCSs*. Hence, the transcriptional mode of regulation may be different from bacteria.

P3.19. Biological hardening of micro propagated banana *(Musa* spp*)* plantlets with rhizosphere and endophytic bacteria to manage *Banana bunchy top virus (*BBTV*).*

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Abstract

Banana bunchy top disease (BBTD) is one of the most destructive viral diseases of banana in India. As there is no effective control measure available to contain this disease, an attempt was made to use rhizosphere and endophytic bacterial strains in the tissue culture plantlets during their hardening and subsequent stages as microbial inoculation (Bio hardening) at Tamil Nadu

Agricultural University, Coimbatore, India during 2003-04. The experiment consisted of ten treatments involving microbial inoculations with three bacterial strains *viz., Pseudomonas fluorescens* strains Pf1, CHAO and *Bacillus subtilis* strain EPB22 in single or in combination. The tissue culture plantlets were challenged with viruliferous aphids to ensure transmission of BBTV to all the plants. Observations on BBTD incidence revealed that tissue culture plantlets treated with *Pseudomonas fluorescens* Pf1 + CHAO (rhizobacteria) + *Bacillus subtilis* EPB22 (endophyte) both foliar spray (1%) and soil drenching (1%) resulted in a lesser BBTD incidence. Analysis of the plants tissues for oxidative enzymes *viz*., PO, PPO, and PAL, pathogenesis – related (PR) proteins like β – 1 -3 glucanase and catalase and phenolic contents revealed that their activities were found to be higher with plants treated with CHAO strain in single or in combination with Pf1 and EPB 22 when challenged with viruliferous aphids. Thus bio-hardened plantlets with beneficial bacterial strains could reduce the damage caused by *banana bunchy top virus* through eliciting induced systemic resistance in the plant system.

P3.20. Molecular Characterization of native *Bacillus thuringiensis* isolated from tobacco and castor rhizosphere.

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Abstract

Bacillus thuringiensis (*Bt*) is a gram-positive, spore forming, soil bacterium. Strains of *B. thuringiensis* produce different insecticidal crystal proteins, which are encoded by *cry* genes and useful for control of insects. The present investigation was undertaken with the aim of characterizing three native *B. thuringiensis* cultures isolated from tobacco and castor rhizosphere including standard *B.t.k* HD-1 and *B.t.k* HD-73 to found genetic diversity. RAPD analysis with OPA series and OPD series primers revealed variable polymorphic loci for all the five isolates. When a dendogram of OPA and OPD series primers combined was constructed the isolates were divided into four clusters. One cluster was made by *B.t.k* HD-1 and Tob. isolate. CT-1, CT-2 and *B.t.k* HD-73 isolate was making completely a new cluster.

P3.21. Effect of High Temperature on *Pseudomonas putida* NBRI0987 Biofilm Formation and Expression of Stress Sigma Factor RpoS

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Abstract

Pseudomonas is an efficient plant growth–promoting rhizobacteria; however, among the limiting factors for its commercialization, tolerance for high temperature is the most critical one. After screening 2,500 *Pseudomonas* sp. strains, a high temperature tolerant–strain *Pseudomonas putida* NBRI0987 was isolated from the drought-exposed rhizosphere of chickpea (*Cicer arietinum* L. cv. Radhey), which was grown under rain-fed conditions. *P. putida* NBRI0987 tolerated a temperature of 40°C for ≤ 5 days. To the best of our knowledge, this is the first report of a

Pseudomonas sp. demonstrating survival estimated by counting viable cells under such a high temperature. *P. putida* NBRI0987 colony-forming unit (CFU)/ml on day 10 in both the absence and presence of $MgSO_4.7H_2O$ ($MgSO_4$) in combination with glycerol at 40°C were 0.0 and 1.7×10^{11}, respectively. $MgSO_4$ plus glycerol also enhanced the ability of *P. putida* NBRI0987 to tolerate high temperatures by inducing its ability to form biofilm. However, production of alginate was not critical for biofilm formation. The present study demonstrates over expression of stress sigma factor σ^S (RpoS) when *P. putida* NBRI0987 is grown under high-temperature stress at 40°C compared with 30°C. We present evidence, albeit indirect, that the adaptation of *P. putida* NBRI0987 to high temperatures is a complex multilevel regulatory process in which many different genes can be involved.

P3.22. Indole Acetic Acid production by Azospirillum strains

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Abstract

Azospirillum are potentially applicable as biofertilizer, owing to their ability to secrete phytohormones such as Indole -3-Acetic Acid (IAA), Gibberellin and Cytokinin like substance. This ability might be a factor in the close association of Azospirillum with root of many economically important cereal crops. Azospirillum spp. Affect not only the growth and development of plant, but also their health by production of vitamins played important role in colonization of VAM-fungi. Azospirillum strains were grown for 30 days in Okon medium (Okon et. a.l (1977) as modified by Lakshmi Kumar et. al. (1980) and Auxin (IAA) production, secreted by Azospirillum, was estimated in the medium by adopting the colorimetric method given by Stress and Vemis (1970) and improved by Knegt and Bruinsma (1973). Production of growth hormone IAA was studied by the Azispirillum strains (SP7a, RAU-1, ICM-101, SL-33, SPcd, IARI, AB-2, Azo-A-13N, ICM-104, ICM-107, ICM-102, ICM-105 and ICM-103) after the 30 days growth at pH 7.0 and 8.5. These Azospirillum strains were collected from different National and International resources. All the strains showed IAA production. The IAA production was maximum in SP7a (4.45ppm) whereas minimum was in ICM-107 (2.48ppm). IAA production was more at pH 7.0 pH than the pH 8.5 by all the strain.

P3.23. Evaluation of Fluorescent *Pseudomonas* spp. with Single and Multiple PGPR Traits for Plant Growth Promotion of Sorghum in Combination with AM fungi

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Abstract

Traits involved in plant growth promotion by bacteria are ambiguously decided as phytohormones, siderophores, HCN, proteases, chitinases, cellulases, ammonia, exopolysaccharide production and phosphate solubilization or antagonistic activity. An experiment was conducted in order to fulfill the ambiguity of the PGPR traits and their role in

plant growth promotion. A total of 75 fluorescent *Pseudomonas* strains were isolated from diverse soils of rainfed agro-ecosystems of the country. These strains were screened for plant growth promoting ability towards sorghum, biocontrol activity and PGPR traits. Among these 7 strains *viz,* P1, P10, P13, P18, P21, P28 and P38 were selected depending on their character of possessing single or multiple PGPR traits. These isolates individually and in combination with arbuscular mycorrhizal fungi (*Glomus fasciculatum* and *Glomus aggregatum*) were used for treating sorghum seeds. 25 days after sowing, plants were analysed for different plant growth promoting parameters and nutrient content. It was observed that strains in presence of mycorrhizae performed well compared to the strains devoid of mycorrhizae. Further, from the data it can be observed that possession of PGPR traits (single/multiple) and plant growth promotion in sorghum seedlings showed varied results. Strain P1 possessing GA3, EPS production and 'P' solubilization performed well compared to other strains having more number of PGPR traits. Strain P38 which was a volatile (HCN) producer but a good phosphate solubilizer did not perform well. The reason for which is not known. Strain P28 even though having multiple PGPR traits did not show the expected out come. These results varied when mycorrhizae was used in combination. P10 and P13 which were good in IAA, GA3, EPS, siderophore and 'P' solubilization performed well with mycorrhizae, with an overall increase in plant biomass, leaf area, total chlorophyll and mycorrhizal infection compared to other combinations. Here, strain P1 in combination with mycorrhizae did not show significant increase in plant growth compared to P10 and P13. Hence, mere possession of multiple PGPR traits does not confer fluorescent *Pseudomonas* strains as PGPR. Further studies have to be carried out in order to evaluate the other traits, which may be involved in plant growth promotion.

P3.24. Proteome analysis of rice responses to beneficial microbe, *Pseudomonas fluorescens* strain KH-1

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Abstract

Pseudomonas fluorescens strain KH-1 promote plant growth and induce resistance in rice plants against major pests and pathogens under *in-vitro* and *in-vivo* conditions. Presumed functions of the identified proteins through proteomic studies are related to antifungal activity, energy metabolism, photosynthesis, protein degradation and antioxidation. This strongly implies the role of *P. fluorescens* KH-1 in various pathways including energy metabolism and plant defense. In addition to the current efforts, further studies using transcriptomics and proteomics on rice-*Pseudomonas* interactions will allow to manipulate the PGPR based crop health and yield response in rice through genetic engineering.

Poster session:
Plant pathogen - PGPR interactions

P4.1. Eco-friendly approaches in the management of bacterial blight caused by *Xanthomonas oryzae* pv. *oryzae* of rice in Karnataka

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Abstract

A field experiment was undertaken to evaluate the bio-efficacy of *Pseudomonas flourescens* (talc based formulation) against bacterial blight disease of rice during *kharif* 2003-04 in vertisols under irrigated condition at Agricultural Research Station, Siruguppa, Karnataka. The experiment was laid out in Randomised Block Design with seven treatments (*viz*., Streptocycline + Copper sulphate, Streptomycine sulphate + Copper oxychloride, neem seed kernel extract, neem oil, water extract of fresh cow dung, root dip + spray of *Pseudomonas fluorescens* and untreated check) in three replications. The results of the experiment showed that all imposed treatments were significantly effective in managing bacterial blight disease and producing higher grain yield over untreated check. The bio-control agent *Pseudomonas fluorescens* (@ 2.0 g/lit) recorded least bacterial blight disease index (33.33%) and higher grain yield (4321 kg/ha) compared to neem formulations. However, chemical control with Streptocycline + Copper sulphate (@ 0.1 + 0.1 g/lit.) was found to be more effective (recorded 11.85% disease index and grain yield of 5072 kg/ha) than the bio-control agents. The use of bio-control agents would be an effective component in development of IPM strategy against bacterial blight in India.

P4.2. Supression of bacterial blight of anthurium_(*anthurium andreanum*) by a fluorescent pseudomonad

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Abstract

Anthurium commands a significant economic share in cut flower industry. Commercial operations on anthurium production were hindered to a great extent by the outbreaks of bacterial blight of anthurium caused by *Xanthomonas axonopodis* pv.*dieffenbachiae* (Xad). Objective of the present work is to study the biocontrol ability of a strain of *Pseudomonas fluorescens* against Xad and the mechanisms responsible for antagonism.Potent Xad isolates were collected from infected leaf samples and fluorescent Pseudomonads were isolated from rhizhosphere soil. The most vigorous isolate was selected for further studies after field experiment. In vitro screening was performed by dual plate assay on Potato sucrose agar medium. Field studies were performed under greenhouse conditions. Disease induction was performed using talc based formulations of the antagonist. Scoring was done, percentage of infection recorded one month after application of antagonist and disease index calculated. Ferric chloride test (Neilands, 1981) was performed to detect hydroxamate type of siderophores. Production of HCN was detected using picric acid (Guptha 2002).Among different isolates of Xad, xad 4 was the most virulent. *Pseudomonas fluorescens* Pf2, was the most efficient of all the isolates as indicated by the largest zone of inhibition (17mm). Disease index was lowest (5.3) after foliar application of Pf 2 on the disease induced anthurium plant. Isolate pf2 produced hydroxamate type of siderophore as indicated by

the appearance of a wine red colour upon addition of 2% ferric chloride solution to the culture supernatant. These siderophores bind iron and create an iron depleted environment where the pathogenic bacteria fail to survive. HCN production was detected in plated cultures of Pf2 where the colour of picric acid changed from yellow to brown. HCN disrupt electron transport inhibiting the energy supply of the cells. Pf2 isolate of *Pseudomonas fluorescens* proved to be an efficient biocontrol agent, inhibiting the causative organism of bacterial blight of anthurium.

P4.3. Biological suppression of charcoal stalk rot of maize by Trichoderma and phosphate solubilizing Pseudomonads

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Abstract

The charcoal stalk rot of maize caused by *Macrophomina phaseolina* (Tassi.) Goid has become one of the constraints for its cultivation. Chemical management of disease is often uneconomical, rather not feasible, since the pathogen is seed and soil borne. Field trials were laid out in charcoal stalk rot sick soil at Agricultural Research Station, Arabhavi during *rabi* 2007 in Randomized Block Design with 5 replications and 6 treatments using maize hybrid DMH-2. The treatments included were (T_1) : Seed treatment with *Trichoderma harzianum* Sk_1 @ 6 g/kg, (T_2) seed treatment with phosphate solubilizing bacteria (PSB) Acd-15 @ 25 g/kg, (T_3) Seed treatment with *Trichoderma harzianum* Sk_1 @ 6 g/kg and PSB Acd-15 @ 25 g/kg, (T_4): Seed treatment, with carbandazim @ 2 g/kg, (T_5) : Seed treatment with thiram @ 2 g/kg and (T_6): Untreated control. The seeds were treated with above treatment, air dried and then used for sowing. Untreated seeds served as check. The recommended dose of fertilizer i.e., 150 kg N, 75 kg P_2O_5, 37 kg K_2O per hectare along with 10 tonnes FYM per hectare was applied in the field. Sowing was done on 12th December, 2007 in the plot size of 4.5 x 5.0 m. The data on disease incidence and grain yield were recorded and statistically analysed. The data revealed that, all the treatments significantly decreased the disease incidence and increased the grain yield except T_5 i.e., Thiram seed treatment @ 2 g/kg which is on par with untreated control (Table 1). Among the treatment, T_3 i.e., seed treatment with *Trichoderma harzianum* Sk_1 @ 6 g/kg and PSB Acd-15 @ 25 g/kg recorded significantly lower disease incidence (9.64%) and highest grain yield (56.97 q/ha) as compared to check where in it recorded maximum disease incidence (27.31%) and lowest grain yield (45.95 q/ha). Performance of seed treatment with carbandazim @ 2 g/kg was the next best treatment. Seed treatment with *Trichoderma harzianum* @ 6 g/kg alone was equally effective and on par with seed treatment with carbandazim @ 2g/kg. The highest benefit cost ratio was obtained with T_3 (2.39:1) followed by T_1 (1.39:1). The present study revealed that, combined seed treatment with *Trichoderma harzianum*, Sk_1 @ 6 g/kg and PSB Acd-15 @ 25 g/kg found to be the best eco-friendly strategy for the management of charcoal stalk rot in maize. Anahosur and Patil (2001) found that the seed treatment with *Trichoderma harzianum* @ 4 g/kg and planting such seeds in soil amended with FYM was the best eco-friendly practice for the management of cowpea dry root disease. Pseudomonads are known phosphate solubilizers (PSB) and constitute a dominant population of the rhizosphere bacteria which may also used as bio-fungicide. PSB have been used as biofungicide to control many root rots, foliage and post harvest diseases (Tratch and Bettiol, 1997 and Girlanda *et al*., 2001). The present study inferred that, combined application of *Trichodrma harzianum* Sk_1 @ 6 g/kg and PSB Acd-15 @ 25 g/kg as seed inoculation and soil amended with FYM @ 10 t/ha and recommended dose of fertilizers proved beneficial in suppressing charcoal stalk rot incidence and enhanced grain yield. Thus it can be a potential

component of IPM. Since nature harbours a mixture of these antagonistic agents for natural biocontrol, combination or mixture of compatible organisms would be an added advantage over single species application. These bio-agents apart from their action against pathogens, are also good growth promoters which is an added advantage for sustainable agriculture.

P4.4. *Psuedomonas fluorescens* and *Trichoderma spp* as biocontrol agents for the management of soil-borne fungal pathogens

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Abstract

Psuedomonas fluorescens, a well known plant growth promoting rhizobacteria is also used as biocontrol agent against many foliar and soil- borne diseases. Biocontrol efficiency of two isolates of *Psuedomonas fluorescens* and five isolates of *Trichoderma spp* were tested against *Fusarium oxysporum, Rhizoctonia solani* and *Sclerotium rolfsii* in dual culture. Isolates of *P. fluorescens* performed equally better compared to *T. viride* isolates in inhibiting the pathogen growth. The efficiency of plant growth promoting rhizobacteria can be further improved by genetic manipulation.

P4.5. Role of endophytic bacteria in plant growth promotion and induction of systemic resistance

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Abstract

Five chickpea (*Cicer arietinum*) endophytic bacteria namely *Bacillus megaterium* (MTCC6533), *Bacillus* sp. (MTCC 6534), *Bacillus circulans* (MTCC 6535), *Erwinia herbicola* (MTCC 6720), and *Enterobacter agglomerans* (MTCC 6536) were tested for plant growth promotion and induction of systemic resistance in chickpea. Maximum phenol content 483.33 µg/g was noticed in *B. megaterium* treated and the lowest (246.67 µg/g) was in control. Highest PAL activity was observed on the fourth day in *Bacillus* sp. and *B. megaterium* treated leaves (120 to 123 nmol *trans*-cinnamic acid/min/g). Similarily ß-1,3-glucanase activities were significantly higher in all bacteria treated plants when compared to control. The highest activity of 2.79 U/g was noticed in *B. megaterium* treated and the lowest was in control (1.28 U/g). High ß-1,3-glucanase activity was also observed in *Bacillus* sp. and *P. fluorescens* treated plants. Growth and vigour was monitored in 45-day-old chickpea plants that were seed treated with the test bacteria and sown in plots that were already inoculated with *R. solani.* It was evident that plants responded positively to treatment with bacteria. Highest vigour index of 4091.47 was observed in *B. megaterium* treatment and the lowest of 2892.83 was seen in control plots. Fungicide treated also gave a high index of 4060.53. It was evident that endophytic bacteria isolated from healthy chickpea plants play a role in plant growth promotion and induction of systemic resistance.

P4.6. Enhancement of disease resistance against red rot in sugarcane by *Pseudomonas aeruginosa*

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Abstract

Ten different bacteria were isolated from phylloplane, rhizosphere and internal stalk tissues of healthy canes of red rot susceptible varieties were isolated. The efficacy of native bacterial isolates was studied *invitro*. Among the ten bacterial species, maximum inhibition in the mycelia growth of *C. falcatum* was recorded by the isolate *Pseudomonas aeruginosa.* Scanning electron microscope photographs revealed that severe lysis of C. *falcatum mycelium due to interaction with P. aeruginosa.* Field experiment was conducted using talc formulation of potential native isolate P. aeruginosa to determine the most effective method of application of biocontrol agent in reducing the red rot disease intensity. The biocontrol agent was applied as sett treatments, soil application, foliar spray and in combination. Among the treatments, soil application alone or soil application in combination with other treatments were found to be effective in reduction of per cent disease intensity and also spectacular improvement in qualitative and quantitative parameters which led to increased cane and sugar yield. Survival studies of P. aeruginosa in the soil at 60 DAP, 150 DAP and at the time of harvest revealed the population density of P. aeruginasa in the individual treatments was proportionate to the quantity of the biocontrol agent added to the soil.

P4.7. Plant growth promoting rhizobacteria mediated resistance against *Alternaria helianthi* in sunflower

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Abstract

Sunflower (*Helianthus annuus* L.), is one of the most important sources of vegetable oils. Alternaria blight, caused by the fungus *Alternaria helianthi* is a serious disease of sunflower in many parts of the world. Seven PGPR strains (*Bacillus pumilus* INR7, *B. pumilus* T4, *B. amyloliquefaciens* IN937a, *B. subtilis* IN937b, *B. subtilis* SE34, *B. subtilis* GB03 and *Brevibacillus brevis* IPC11) were multiplied and adjusted to a final density of 10^8 cfu/ml^{-1}. PGPR in a purified talc powder formulation were prepared by aseptically mixing 400 ml of the bacterial suspension, Sunflower seeds were mixed with the formulation at a rate of 15 g/kg of seed. For screening of PGPR strains for their potential to elicit systemic protection against *A. helianthi* under screen house, the 15-day-old seedlings were challenge-inoculated with *A. helianthi* inoculum as described earlier. Seedlings inoculated with buffer served as control. Alternaria blight disease incidence was recorded 14 and 28 days post-inoculation (dpi). Seed treatment with pure suspension of INR7 recorded a protection of 71% in comparison to control (92% disease incidence) and 64% protection with talc formulation in comparison to 92% disease incidence with control under greenhouse condition. The next best protection was offered by strain GBO3, which

offered a protection of 66% on seed treatment of fresh suspension. PGPR strains were effective in protecting sunflower plants against *A. helianthi* under greenhouse conditions by inducing resistance against the necrotrophic pathogen. Thus it is proposed that PGPR strains particularly INR7 could be potential inducer of resistance against the blight causing pathogen in sunflower.

P4.8. Evaluation of Rhizosphere Actinomycetes forAnti-*Rhizoctonia* Activity

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Abstract

A total of 131 actinomycetes isolated from the rhizosphere soil of 20 plants belonging to 15 families were screened *in vitro* for antifungal activity. One isolate (G2/86) out of the five potential antagonists was worked out in detail. The antagonist not only strongly inhibited *R. solani* mycelial growth and sclerotial germination but also exhibited broad spectrum activity. Interestingly *Trichoderma harzianum* a biocontrol agent is not affected by the antagonist, suggesting compatibility.

P4.9. PGPR mediated systemic resistance against tobacco mosaic virus in Tomato

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Abstract

Selected PGPR isolates which previously demonstrated induced systemic resistance in tomato against fungal foliar disease was evaluated for their ability to protect tomato from disease development of Tobacco Mosaic Virus (TMV). All of them controlled the disease ranging from 77.78 to 100 per cent when seed inoculated as well as soil applied. Out of these isolates, *Pseudomonas* B25 was the most promising isolate which controlled TMV disease completely under green house conditions. All the isolates induced systemic resistance in tomato plants. Plants inoculated with *Pseudomonas* sp.B-25 recorded the highest phenol content, peroxidase activity and PALase activity (44.82%, 37.31% and 68.75% higher than the healthy control respectively).

P4.10. Antagonistic effect of *Trichoderma spp*. against *Phytophthora*- the foot rot pathogen of black pepper (*Piper nigrumL.)*

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Abstract

Fungi belonging to the genus *Trichoderma spp* are the most promising biocontrol agent against a range of plant pathogens under a variety of environmental conditions (Chet, 1984). *Trichoderma spp*., which is an active myco parasite, has been considered as biocontrol agent of foliar diseases (Elad *et al;* 1993), and soil borne diseases (Papavizas, 1985). Isolation of Phytophthora spp and its pathogenecity tested and Trichoderma spp are isolated and identified. All isolates were able to inhibit the growth of pathogen on PDA plates *in vitro* with the percentage of inhibition of radial growth between 30-70%.It was observed that out of 10 *Trichoderma* isolates, $T_{3,}$ $T_{5,}$ $T_{6,}$ T_9 showed high antagonistic activity against *Phytophthora*.The isolates were regarded as promising antagonists when there was more than 60%inhibition of radial growth of the pathogen as a result of their activities. Of these T_5 showed greater percentage of inhibition of *Phytophthora(70%).* The cellulase activity was assayed by Dinitrosalicylic acid method and the total cellulase activity was about 150 µgl ml. The amount of β1, 4 - gluconase in T5 *Trichoderma* culture =150 µg/ml; Specific activity of β1, 4 - gluconase = Total enzyme/ Total protein = 150/ 58 = 2.586 units/m. Studies on the biological control of the foot rot disease on black pepper are mainly focused on identifying microorganisms from rhizosphere of black pepper that can effectively suppress foot rot disease. Among the fungal antagonists, species of *Trichoderma* are the most potential agent for biocontrol.

P4.11. Biocontrol potential of salinity tolerant *Pseudomonas aeruginosa* against *Macrophomina phaseolina* under saline stress conditions

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Abstract

Charcoal rot of *Macrophomina phaseolina* is an economically important disease of chickpea (*Cicer arietinum*). A large fraction of land in India as well as throughout the world comes under arid and semiarid region affected by saline soil is another important constraint. Secondary metabolites of fluorescent pseudomonads play key role in plant growth promotion (PGP) and suppression of various soil-borne plant pathogens however, very little knowledge is available about the *in situ* expression of these traits under saline stress conditions. A fluorescent pseudomonad strain TO3 was selected from the collection to evaluate its ability of biocontrol against *M. phaseolina*, and suppression of charcoal rot disease and PGP of chickpea under saline stress conditions. Strain TO3 was identified by Biolog analysis to be *Pseudomonas aeruginosa* with a similarity index of 0.603 and found to tolerate salinity level up to 1550 mM. The strain TO3 showed production of biocontrol metabolites upto 400 mM NaCl concentration and 76.19 % inhibition of *M. phaseolina in vitro* conditions. The strain showed PGP and suppression of charcoal rot disease of chickpea under both saline stressed (75 %; NaCl 100mM) and unstressed (72.73 %) *in vitro* (culture tube) conditions. The PAGE protein profile of normal and saline

stressed bacterial cells showed a number of induced and repressed proteins. *Pseudomonas aeruginosa* TO3 showed intrinsic ability to survive and biocontrol at salinity conditions makes this strain suitable for ecofriendly agriculture at both non-stressed and saline stressed regions.

P4.12. Characterization of antifungal metabolites of *Pseudomonas fluorescens* and their effect on mycelial growth of *Magnaporthe grisea* and *Rhizoctonia solani*

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Abstract

Fluorescent Pseudomonads have been successfully employed in controlling major fungal plant diseases due to their antifungal metabolites. The present study focuses on characterization of secondary metabolites produced by *Pseudomonas fluorescens* and their *in-vitro* antagonistic ability against rice blast caused by *Magnaporthe grisea* and sheath blight caused by *Rhizoctonia solani*. Among 20 strains of *P. fluorescens* isolated from rhizosphere of rice seedlings, one particular strain P.f 05 was highly effective in inhibiting mycelial growth of rice pathogens. To further characterize the production of antifungal metabolites by strain P.f.05, several growth media were used. Among the media tested, King's B medium at 120 rpm with pH of 7.0 and 40% of dissolved oxygen incubated at 28 C yielded maximum amount of secondary metabolites. Among them, four secondary metabolites were identified through thin layer chromatography with R_f values of 0.22, 0.35, 0.42 and 0.51. Of these four, one particular metabolite was found to inhibit the mycelial growth of two rice pathogens significantly higher compared to other three metabolites. Of interest, this metabolite was further characterized by HPLC, NMR and Mass Spectroscopy and identified as 2, 4-diacetyl-phloroglucinol (DAPG). The melting point of 2, 4 DAPG was between 143-175^{0}C. The infrared spectroscopy spectrum of 2, 4 DAPG showed carbonyl group at 1636 cm^{-1}, other functional groups at 1639 cm^{-1} and OH group at 3434 cm^{-1}. The molecular weight was estimated at M/z 210 by mass spectroscopy which agreed with the composition of $C_{10}H_{10}O_5$ for 2, 4 DAPG. These results offer a scope of identifying superior strains of *P. fluorescens* with high potential of antifungal metabolite production in rhizosphere of rice ecosystem for successful management of rice blast and sheath blight diseases.

P4.13. *In-vitro* antagonistic potential of *Pseudomonas fluorescens* isolates and their metabolites against rice sheath blight pathogen, *Rhizoctonia solani*

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Abstract

Sheath blight of rice caused by *Rhizoctonia solani* is an economically important disease affecting rice production. Eight *Pseudomonas fluorescens* strains were isolated from rhizosphere of rice seedlings collected from Andhra Pradesh and Tamilnadu. These strains were characterized with PCR based RAPD technique and tested for their *in-vitro* antagonistic activity against *R. solani*. Crude metabolites from one particular isolate of *P. fluorescens* (P. f 003) were extracted with

organic solvents such as ethyl acetate and petroleum ether and these were tested against *R. solani.* Commonly used fungicides in rice sheath blight disease management such as hexaconazole, carbendazim, copper oxy chloride and mancozeb at 150 ppm were screened against mycelial growth of *R. solani* using poisoned food technique. All the strains tested were exhibited antagonistic activity against *R. solani*. One isolate, P.f 003 gave 78% inhibition compared to control. All the fungicides and crude extracts of P.f.003 inhibited the mycelial growth of *R. solani*. Highest inhibition was recorded with hexaconazole and ethyl acetate crude metabolite extract. The results offer a scope for integrating *P. fluorescens* with chemical fungicides for control of sheath blight of rice.

P4.14. Siderophore-mediated antibiosis of rhizobacterial fluorescent *Pseudomonads* against rice fungal pathogens

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Abstract

Rice blast caused by *Magnaporthe grisea* and sheath blight caused by *Rhizoctonia solani* are the major diseases affecting the rice production. Application of beneficial bacteria as seed or seedling root dip to protect these diseases may be an alternative strategies to chemical control. In this study, fluorescent Pseudomonads isolated from rice seedlings were used to screen for their antagonistic ability and siderophore mediated antibiosis under *in-vitro* conditions against these pathogens. Among, 10 isolates, strain P.f 003 gave significantly higher inhibition of mycelial growth of *M. grisea* and *R. solani*. Strains of P.f 001, P.f 003, P.f 005 and P.f 007 produced siderophores when grown on Fe deficient and Fe fortified King's B medium. These strains again tested for their in-vitro antagonistic activity against *M. grisea* and *R. solani* on King's B media with or without $FeCl_3$. Our results showed that all these strains significantly reduced the growth of *M. grisea* and *R. solani* with $FeCl_3$ in the media compared to without $FeCl_3$. Strain P.f 003 activity was superior compared to other strains evaluated.

P4.15. Growth promotion and control of brown root rot of tea through rhizobacterial strains under the agro-climatic conditions of Barak Valley of Assam, India

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Abstract

Barak Valley of Assam annually produces 46096 thousand Kg of tea from 35781 hactares. Pest and diseases play a major role in the crop production of this region. Among this, brown root rot caused by *Fomes lamoensis* is au important fungal disease to this important cash crop. Little effort was made on the management of brown root rot through PGPR strain in Barak Valley,

hence the present study was undertaken to isolate the PGPR strain for control the brown root rot. Bacterial strains were isolated from the soil samples collected from different tea growing areas of Barak Valley and the isolates were screened for *in vitro* antagonism against *F. lamoensis*. The bio-control potential of the selected organisms was done under gnotobiotic and nursery conditions in soil infested with F. lamoensis. Among the 100 number of bacterial isolates obtained, three of them showed significant *jn vitro* antagonism against *F. lamoensis*. Vegetative dressing of the tea cuttings with individual strains enhanced the shoot height, root length, fresh and dry weights of the cuttings in pathogen infested soil in gnotobiotic and nursery condition over the non-treated cuttings. A reduction in the development of disease symptom was also recorded in the bacterized tea cuttings. The results suggest that these strains can be used for the growth promotion and control of brown root rot in tea plants.

P4.16. Two species consortia, *Sinorhizobium meliloti* and *Azotobacter chroococcum* control *Macrophomina phaseolina* causing root rot and enhance growth and yield of *Cajanus cajan* L.

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Abstract

Root nodulating *Sinorhizobium meliloti* MR4 and free-living nitrogen fixing *Azotobacter chroococcum* AZ2 were isolated from nodules and rhizosphere of *Mimosa pudica* respectively. The strain MR4 produces the siderophore. The strain AZ2 fixed nitrogen asymbiotically and inhibited *Macrophomina phaseolina* causing charcoal rot in *C. cajan*. Both strains MR4 and AZ2 showed the property of IAA production and phosphate solubilization individually as well as together when co-inoculated. Seeds bacterization enhanced germination, root and shoot weight, root and shoot length, number of nodules, grain yield per plant and total grain yield of *C. cajan*. Strains exhibit aggressive root colonization resulting into enhancement of overall plant growth parameters. Both the strains MR4 and AZ2 led to proto-cooperation as evidenced by synergism.

P4.17. Effect of *Gluconacetobactor* inoculation on root growth of Sorghum (*Sorghum bicolor* (L.) Moench)

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Abstract

There is an urgent need to increase the productivity of cereals without further area expansion. Diazotrophic association has great importance in sustaining the yields. Biological nitrogen fixation is an important alternative. Among the diazotrophs associated with sugarcane *Gluconacetobactor diazotrophicus* is newly discovered diazotroph. *Gluconacetobactor* grew well on LGI medium. Root length was recorded by measuring the length of root from collar region to the tip of the longest root. The root length of sorghum as influenced by inoculation of *Gluconacetobactor* and nitrogen application was also recorded on 30, 60 and 90 days after

sowing. Root length of sorghum was significantly increased due to the inoculation of *Gluconacetobactor* i.e. 20.80, 37.40 and 47.53 cm on 30, 60 and 90 DAS respectively. Root length also was significantly increased with the *Gluconacetobactor* inoculation and nitrogen application. The maximum root length i.e. 28.00 cm, 44.00 cm and 59.33 cm was obtained with the treatment of *Gluconacetobactor* inoculation + 50% N application on 30, 60 and 90 DAS, respectively. *Gluconacetobactor* inoculation have brought about significant increase in root length of sorghum and these benefits were more pronounced at lower levels of nitrogen.

P4.18. Evaluation of PPFM along with other bio-inoculants on yield of cotton (*Gossypium* spp.)

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Abstract

Biofertilizers and other growth promoting bioinoculants need to be exploited commercially. Nitrogen fixers, Phosphate solubilizers, Pink pigmented facultative methylotrophs (PPFM) and Silicate solubilizers assume an important place for promoting plant growth. *Azospirillum*, PSB, PPFM and SSB were used to assess their effects on cotton productivity. At 90 days after sowing average boll weight and boll number per plant were recorded. The number of bolls per plant and average weight of boll significantly increased with seed treatment of Azophosomet (*Azospirillum* + PSB + PPFM) and phyllosphere sprays of PPFM. The highest boll weight was obtained from the plots receiving 100 per cent recommended dose of fertilizers. Maximum number of bolls per plant were obtained from the plots inoculated with Azophosomet along with 75 per cent N, P and K2O and phyllosphere sprays of PPFM at 45, 60 and 90 days after sowing. *Azospirillum* + PSB + PPFM + SSB along with chemical fertilizers increased boll weight and number of bolls per plant of cotton.

P4.19. Study on Leaf spot Disease Incidence and it's Severity of Jatropha in Maharashtra state, India

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Abstract

Jatropha curcas L. is a multipurpose crop. Jatropha oil is a potential substitute for diesel. In general, the Jatropha is considered to be free from various diseases and pests. However, some diseases have been reported recently. The moderate incidence of leaf spot disease caused by *Alternaria alternata* was first time observed in Maharashtra i.e. in the Jatropha plantation at central farm, Marathwada Agricultural University, Parbhani in 2006. Incidence and severity of the leaf spot disease observed. The disease was observed from July to first fortnight of November. The disease incidence was maximum in the month of August and subsequently it decreased up to November. In general, the symptoms of leaf spot disease were developed in rainy

season. The simple correlation studies also revealed the significant and positive association of percent incidence with meteorological parameters like relative humidity (PM) (%). However, negative and significant association exhibited between percent incidence and maximum temperature (^{o}C). Similarly, maximum (56.78 percent) disease intensity (severity) was indicated during second fortnight of August. The percent disease intensity decreased with decrease in temperature and humidity. Increase in humidity and temperature increases the incidence of the disease.

P4.20. Exploitation of PGPR and fungal strains for the management of leaf blight disease in Noni

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Abstract

Noni (*Morinda citrifolia*) is a small, fruit-bearing, evergreen shrub or tree and is grown throughout the tropical countries for medicinal purpose. The leaf blight disease caused by *Alternaria alternata* (Fr.) Keissler is a major limiting factor in all Noni growing areas. Various strains of *Pseudomonas fluorescens, Bacillus subtilis* and *Trichoderma viride* were screened against the pathogen growth and the talc-based bioformulations of effective strains were developed. The bioformulations were tested individually and in combination against the incidence of leaf blight disease both under glasshouse and field conditions. Among the bacterial and fungal biocontrol strains evaluated for their efficacy in inhibiting the mycelial growth, *P. fluorescens* Pf1*, B. subtilis* EPC8 *and T. viride* Tv1 revealed the highest inhibition zone formation than the other bacterial and fungal strains tested and the control. In both glasshouse and field conditions, the mixture of Pf1+EPC8+TV1 effectively reduced the leaf blight incidence than the individual strain mixture. In addition, the strain mixture induced the higher amount of defense enzymes in Noni plants against *A. alternata.* The mixture of Pf1, EPC8 and TV1 was found to be effective in reducing the incidence of leaf blight of Noni in both glasshouse and field conditions.

P4.21. Inhibition of *Ralstonia solanacearum* by antagonistic bacteria: Mechanisms of antagonism

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Abstract

Potential antagonistic endophytic and rhizobacteria isolated from different crop plants were tested against *Ralstonia solanacearum,* causal agent of wilt in eggplant. The promising antagonists were studied for their mechanism of antagonism against the pathogen. Secondary metabolites produced by antagonistic bacteria and their potential in pathogen suppression were studied. 2, 4-diacetyl phloroglucinol (DAPG), pyrrolnitrin, pyocyanin were extracted and analyzed by TLC. Further, production of siderophores, HCN by the antagonistic bacteria was also studied. Results of the experiments indicated that more than one compound is produced/secreted by the antagonistic bacteria, which might be responsible for pathogen inhibition. Purified extract of DAPG from few

isolates inhibited the pathogen under *in vitro* conditions. Most of the promising isolates produced IAA and solubilized inorganic phosphorus in the medium, which might contribute in improved plant growth. From this study we may conclude that it may be possible to select a potential bio-agent against plant pathogen based on the nature of secondary metabolites produced and their inhibition efficiency.

P4.22. Scope of PGPR in Seed Health Management

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Abstract

Seed health management is essentially for successful and uniform germination of seeds, establishment of plants and to contain further spread of seed-borne diseases on the crop. The beneficial effect of PGPR for the management of soil-borne and foliar diseases has been well established in a number of cereal crops. Though the research on their role in seed health management is limited, a series of laboratory and nursery experiments using the PGPR strains indicated a positive impact on seed health management of arid vegetable and root stock seeds of arid fruit crops. Further studies indicated the specificity of PGPR strains on the nature of seeds. In general, the externally seed-borne mycofloa can be managed by any one or combination of different mode of actions exerted by PGPR during their proliferation. However, it is relatively challenging to manage most of the internally seed-borne pathogens. Therefore, the possible mechanisms involved in the induction of systemic resistance in seedlings by seed treatments, selection of effective PGPR strains and different approaches involved in development of delivery system with reference to seeds and health management will be discussed.

P4.23. Plant growth promoting endophytic bacterium mediated resistance against brown spot disease of Paddy

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Abstract

Plant growth-promoting rhizobacteria (PGPR) have the potential to be used as microbial inoculants to reduce disease incidence and severity and to increase crop yield. Some of the PGPR have been reported to be able to enter plant tissues and establish endophytic populations. Here, we demonstrate an approach to screen bacterial endophytes that have the capacity to promote the growth of paddy seedlings and protect plants against brown spot pathogen. In the present study, three endophytic bacteria were isolated from roots and stems of paddy. The bacteria were identified based on its biochemical characterization and by molecular analysis. The isolates were identified as *Bacillus subtilis* and *Pseudomonas fluorescens*. The isolated bacteria were tested for

growth promotion and induction of resistance against brown spot disease of paddy. Preliminary study showed that resistance induced by these bacteria against brown spot disease was systemic and significant under green house conditions. *Pseudomonas fluorescens* isolate EPf1, EPf2 and *Bacillus* isolate EBs1 offered protection of 63, 48 and 53 %, respectively, against the disease in comparison to the control under green house conditions. The same isolates also increased growth of paddy plants under green house condition. An increased level of defense-related enzymes, *viz*., phenylalanine ammonia lyase (PAL), peroxidase (POX) and polyphenol oxidase (PPO) were also recorded.

P4.24. Assessment of Pgpr Components in The Management of Frog Eye Leaf Spot Of Bidi Tobacco In India

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Abstract

In order to assess the role of PGPR components in the management of frog eye leaf spot, economics and quality parameters the present study was under taken at Agricultural Research Station, Nipani during 2006. Among PGPR components, application of *Trichoderma harzianum* @ 50g/plot and spray @ 2g/lit recorded 38.7 Percent Disease Index(PDI) followed by *Pseudomonas fluorescens* @ 50g/plot and spray @ 2g/lit (48.5 PDI).The Economic analysis revealed realization of maximum net return in Propiconazole@0.1%(Rs.28,880/- per ha followed by Carbendazim @0.05% (Rs.27,220/ha) and Hexaconazole @0.1% (Rs.26,520/ha). The Benefit: Cost ratio indicated maximum B: C ratio (1.49) in Carbendazim@0.05% followed by 1.48 in Propiconazole @0.1% and Hexaconazole@0.1% (1.41). Among PGPR components maximum net return (Rs.23,375) with B:C ratio of 1.14 in case of *Pseudomonas fluorescens* @ 50g/plot and spray @ 2g/lit.The quality parameters analysis such as Nicotine, Reducing sugars and Chlorides deduced optimum level of these parameters as governed by different treatments. Surprisingly highest Nicotine % was recorded in Parthenium treatment (4.06%).Thus, investigations brought a first line of research on use of PGPRs and botanicals in management of frog eye leaf spot of bidi tobacco under field conditions in India.

P4.25. Antifungal activity of PGPR against soil borne pathogen in cotton

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Abstract

The interaction of PGPR with soil borne pathogen in cotton was studies *in vitro*. Ten distinct PGPR were selected from rhizosphere and rhizoplane region of different cotton cultivars of Amravati division. The PGPR population from rhizosphere and rhizoplane of different cotton cultivars and from various locations ranged between $6.33x10^6$ to $14.66x10^6$ cfu and $4.66x10^6$ to $13x10^6$ cfu respectively.
Antifungal activity of PGPR was studied by inoculation of fungal pathogen in bacterial mass in plate by inhibition method. PGPR isolates significantly inhibit the mycelial growth of *Sclerotium rolfsii, Fusarium oxysporum, Rhizoctonia bataticola* and *Colletotrichum dematium.* Maximum

inhibition of mycelial growth was recorded by CoRb-9 (62.66%) in *Sclerotium rolfsii,* CoRb-8 (56.97%) in *Fusarium oxysporum,* CoRb-10 (55.16%) in *Rhizoctonia bataticola,* CoRb-9 (61.24%) in *Colletotrichum dematium,* while interaction among PGPR and *Trichoderma viride* has not recorded any detrimental effect on the growth of each other.

P4.26. Integrated Management of foot rot of black pepper

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Abstract

Phytophthora capcisi (L.) is one among the 43 species known to exist in this remarkable genus. *P capcisi (L.)* is the causative agent of foot rot of black pepper the most destructive diseases reported in black pepper. Mulching is a common practice in plantations as it enhances germination and growth of plants in terms of plant height, number of leaves, size of berries and ultimately yields. It also has effect in reducing weed growth, soil erosion, conserving moisture and improves soil physical properties. In this context an on farm testing conducted at farmer's field during 2007-08 at sirsi using various mulches to reduce the inoculum levels of *Phytophthora capcisi*. The results revealed that soil application of neem cake (1kg/vine) mixed with *Trichoderma harzianum(50gm/vine)along with karada, areca husk etc* and subsequent mulching with plastic sheet followed by one spray with Bordeaux mixture to the vines has reduced the incidence of foot rot to the tune of 8%. The general appearance of the vines in this treatment was with dark green, shiny leaves, professed root development under the mulch, fast decomposition of organic manure; build up of bio agents and precautious bearing was observed.. However, disease incidence was 32% in farmers practice i.e., mulching with dried grass/leaves/areca fronds and a spray with Bordeaux mixture to vines. The UN mulched vines has showed 38 % disease incidence. The yields are also high (9.56q/ac) in plastic mulched plots compared to non mulched plots (2.18). Hence, in high rain fall tracts farmers can take up plastic mulching as one of the components in integrated disease management to reduce the inoculum of foot rot pathogen .

P4.27. Potential of *Trichoderma* strains in altering the pH environment of substrate

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Abstract

Fungi and bacteria are known to produce acids and alkalies in the substrates resulting in alternating the pH environment of the medium .However very little information is available for *Trichoderma* related to it .In the present study 30 *Trichoderma* strains were evaluated for their potential to alter pH of the growth medium using potato dextrose broth . Most of the strains lowered the pH of the acidic medium and all of the alkaline medium in variable degrees, Among these strains IPRT 4 and IPRT 30 showed maximum decrease of > pH 4 followed by IPRT 12 and 31 , On the contrary strains IPRT 7,8,15,16,18,28 and 29 increased the pH of the acidic substrate .These potential *Trichoderma* strains can further be exploited for soil amelioration besides soil borne disease management.

P4.28. Plant Growth Promoting Rhizobacteria for the Management of Root-knot/wilt Complex of Coleus and Ashwagandha

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Abstract

Plant growth promoting rhizobacteria isolated from healthy rhizospheres of *Coleus forskohlii* and *Withania somnifera* were tested against root knot/wilt complex caused by soil borne pathogens belonging to species of *Fusarium*, *Ralstonia* and *Meloidogyne* which are the major constraints for their cultivation. A survey was conducted and native rhizobacteria were isolated from coleus and ashwagandha growing areas of Karnataka. Among the efficacious rhizobactera tested, bioformulations containing RB31 and RB50 were significantly superior in reducing root knot/wilt complex under field conditions.

P4.29. Nutritional factors affecting the bio-control traits of fluorescent pseudomonads in *Vigna radiata* rhizosphere

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Abstract

Production of antifungal metabolites is an essential trait of plant growth promoting fluorescent *Pseudomonas* strains. 2,4 Diacetylphluoroglucinol(DAPG), pyrrolnitrin, pyoluteorin and phenazine are the major antifungal metabolites. It has been reported that nutritional factors required for the production of various antifungal metabolites are different. So far, no study reported related to plant assay under the nutritional factors essential for the antifungal metabolite production. Root colonizing fluorescent *Pseudomonas* strains were isolated by enrichment technique and characterized by ITS primers and biochemical tests. 2,4 DAPG, pyrrolnitrin, phenazine and pyoluteorin were estimated by HPLC.Plant study was performed using Murashige Skoog medium. Fluorescent *Pseudomonas* strains G1, G2, G8 and C2 has shown higher DAPG production than model PGPR ,*Pseudomonas fluorescens* CHA0 (*Pf*CHA0).G2 showed 4.6 fold higher DAPG production than *Pf* CHA0.G35 and G26 has shown 6.6 and 5.37 fold higher pyrrolnitrin production than model strain. Previous reports suggest that sucrose induces DAPG production in only *Pf* F113.In this study sucrose stimulated DAPG production interestingly in strains G8 and G1.In other study *Pf* CHA0 has shown decline in DAPG production at 10 mM Pi level while G2 showed good production up to 17 mM. Strain G1 showed exceptionally good DAPG production up to 50 mM Pi. Various combinations of minerals and carbon sources were obtained using statistical software Design Expert 7 and plant study was performed. Combination of nutritional factors could be suggested for the better production of antifungal metabolite which will facilitate the targeted application of specific strains to plant rhizosphere/soil type suitable to their bio-control activity i.e. “prescription” control.

P4.30. Compatibility of antagonistic growth promoting rhizobacteria with agrochemicals used in Hevea brasiliensis cultivation.

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Abstract

Out of the 84 bacterial isolates from rhizosphere, non rhizosphere soil and root endophytes three were antagonistic to the major pathogens of Hevea brasiliensis, viz., Phytophthora meadii, Corynespora cassiicola, Corticium salmonicolor and Phellinus noxius . They produced antifungal volatile organic compounds, HCN and siderophores. They could solubilize phosphate and produce nitrogenase, indole acetic acid and ammonia. On inoculation, they improved the growth of rubber seedlings. They were compatible with fungicides and fertilizers when used at low doses.

P4.31. Antagonistic activity of endophytic bacteria against major leaf pathogens of *Hevea brasiliensis*

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Abstract

A total of 154 bacterial isolates collected from leaf, petiole, stem and root of three clones of *H. brasiliensis viz.*, RRII 105, GT 1 and RRIM 600, were screened for antagonistic activity *in vitro* against the leaf pathogens *Phytophthora meadi* and *Corynespora cassiicola.* Six efficient antagonists were selected. These isolates produced antipathogenic volatile compounds, siderophores and salicylic acid. Isolates were identified as *Bacillus* spp. by 16S rDNA sequencing. Colonization of bacterial endophytes in rubber seedlings were confirmed by ERIC-PCR. Rubber seedlings inoculated with a consortium of the selected endophytic bacteria showed induced systemic resistance (ISR) to *P.meadii* and *C.cassiicola.* Chitinase, Peroxidase and PAL activity increased in the treated plants up to 45 days.

P4.32. Biological control of *Fusarium oxysporum* f.sp. *vanillae*, the casual agent of stem rot of Vanilla *in vitro.*

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Abstract

An experiment was conducted to evaluate the efficacy of biocontrol agents in suppressing the growth of six isolates of *Fusarium oxysporum* f. sp. *vanillae* causing stem rot in Vanilla *in vitro* by employing dual culture technique. *Trichoderma harzianum, Pseudomonas fluorescens and Bacillus subtilis* were used as bio control agents. All the three bioagents showed strong antagonistic activities compared to check. *T. harzianum* showed highest inhibition of 90.5 per cent in isolate Fov-3 followed by other isolates. However, it was least in Fov-5 (74.11%).

While, in *P. fluorescens* inhibited Fov-5 up to 80 per cent followed by other isolates. The inhibition was least in Fov-2 (70.05%). *Bacillus subtilis* recorded highest per cent inhibition of Fov-6 (73.98%). It was least in Fov-5 (69.31%). Thus, *T. harzianum* found to be most efficient in reducing the growth of *F. oxysporum* f. sp. *vanillae* isolates *in vitro*.

P4.33. Efficacy of different biological agents in the management of pigeonpea cyst nematode (*Heterodera cajani*) in black gram

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Abstract

Pulses are generally grown in marginal soils, during kharif and rabi seasons. In fact, there has been stagnation in the production and productivity of pulses over the past two decades. There are several constraints for the production of pulses. Among these constraints, the cyst nematode *Heterodera cajani* is one of the major limiting factors in the production of pulses. Keeping these in view different bio-gents, plant product and a chemical was tried to manage the menace of pigeonpea cyst nematode in pot culture. It was found that, application of *Pseudomonas fluorescens* @ 10 g per kg as seed treatment was able to reduce the number of cysts and number of juveniles and increased the plant growth parameters and yield of blackgram.

P4.34. Management of root-knot and wilt complex in *Coleus forskohlii* caused by *Meloidogyne incognita* and *Fusarium chlamydosporum*

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Abstract

The investigation were carried out for the evaluation of plant product, bioagent and chemicals for the management of root-knot and wilt complex in *Coleus forskohlii.* Combined application of neem seed kernel powder at the rate of 5g/kg + *Paecilomyces lilacinus* + *Trichoderma viride* and *Pseudomans fluorescens* at the rate 10 g/kg of soil respectively increased plant growth parameters and reduced nematodes multiplication as compared to inoculated control.

P4.35. Integrated management of root-knot nematode with organic amendments and bioagents in FCV tobacco

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Abstract

Field experiment on the influence of organic amendments and bioagents in the management of root-knot nematode was conducted during the kharif season of 2008 at ZARS, Navile, and Shimoga. There were two organic amendments *viz,* rice hull ash at 100g/m² and vermicompost at 100g/m² and two bioagents *viz*., *Trichoderma viride* at 10g/m² (2 x 10^4 CFU) and *Pseudomonas fluorescens* 10g/m^2 (2 x 10^4 CFU) tried singly and in different combinations**.**

P4.36. Screening of rhizobacteria for antagonism against *Rhizoctonia solani* and growth promotion activity

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Abstract

Rhizoctonia solani is a soil inhabiting fungi, causing dry and wet root rot in wide range of crop plants. Being soil born pathogen, chemical control is expensive and often ineffective, disease management through biocontrol means offers an excellent opportunity. The rhizobacteria are able to manage these diseases as well as promote the plant growth. To isolate a potential biocontrol agent, survey was conducted in different vegetable growing areas of Eastern IGP region. Isolations were made using mycelia baiting technique to selectively isolate the bacteria that to be processing for biocontrol traits. A total 128 bacterium strains were isolate and evaluated for their biocontrol potential against *R. solani* through direct confrontation test and 33 bacteria inhibited the mycelia growth. These bacteria were also evaluated for production of hydrolytic enzymes, Sidrophore, HCN and various growth promoting traits viz. Ammonia, Indole acetic acid production (IAA) and Phosphate solubilisation. Out of 128 bacteria 12 were to be positive for Chitinase, 36 for Glucanase, 53 for Protease, 51 for cellulase. Out of these a number of isolates 14, 57, 63, 20 and 6 found positive for production of HCN, Sidrophore, Ammonia, IAA and Phosphate solubilisation respectively. The isolates having multiple traits for pathogen suppression and growth promoting were selected and further evaluated for disease suppuration and growth promotion under net house condition. The isolate (B-123) showed maximum reduction of *Rhizoctonia* infection in tomato plants and increased the total plant fresh weight (14.61%), plant dry weight (414.96%), root length (95.38%), shoot length (64.43%), root area (130.22%), Chlorophyll-A (55.77%), Chlorophyll -B (105.83%), total phenol (153.69%) over control.

P4.37. Biological control of charcoal rot of sorghum by using arbuscular mycorrhizal fungi

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Abstract

Sorghum *(Sorghum bicolor* L. Moench) is one of the major cereal crops of the world. Charcoal rot caused by the fungus *Macrophomina phaseolina* (Tassi) Goid, is a root and stalk rot disease of great destructive potential in most sorghum growing regions. The concept of biological control as a mechanism to reduce plant disease is gaining increasing importance in recent years because of environmental concerns over use of pesticides. Arbuscular-mycorrhizal fungus, *Glomus fasciculatum* (Thaxter, Sensu Gerd) Gerdemann & Trappe has been exploited in the present study for the control of charcoal rot of sorghum. The inoculation of mycorrhiza with charcoal rot fungus (dual inoculation) significantly restricted the progression of the pathogen in the root tissues of all the genotypes tested. Among all the genotypes studied, E.36-1 was found promising or charcoal resistance recording no disease incidence whereas the cultivars RS-29 and M.35-1 have showed moderate response to charcoal rot by recording lower counts of charcoal rot fungi and free from lodging symptom. On the contrary, the variety, CSV-8R with more than 90% of disease incidence and complete lodging symptom was categorized as highly susceptible to the disease. The inoculation of plants with arbuscular-mycorrhizal fungi will improve plant health by enhancing nutritional status and yield, and also by protecting their host plants against the pathogens either by physical or physiological process. It is difficult to generalize the interaction of pathogen-host-mycorrhiza, but effective mycorrhizal fungus can be used in controlling diseases effectively. It is therefore essential to know the specificity of arbuscular-mycorrhizal fungus-host-pathogen combination for beneficial purposes.

P4.38. *Bacillus subtilis* RP24: A potent biocontrol agent for *Fusarium udum* causing pigeonpea wilt

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Abstract

Biocontrol properties of Bacillus subtilis RP24 against Fusarium udum, causal agent of pigeonpea wilt were tested in vivo under sterile conditions. Inoculated bacteria could efficiently colonize the pigeonpea rhizosphere as indicated by the population size (3.6×10^5 cfu/g soil) after three months at the time of harvesting. Upto 77.56% reduction in disease intensity of pigeonpea wilt was observed due to seed bacterization of pigeonpea with B. subtilis RP24. The effect of inoculation was observed in terms of better shoot and root biomass (fresh and dry). The inoculated plants could accumulate more phenols, reducing sugars and chlorophyll and also showed higher level of stress responsive enzymes like peroxidase and PALase as compared to uninoculated control plants and the plants treated with fungal pathogen alone. Bacillus subtilis RP24 could efficiently control pigeonpea wilt caused by fungal pathogen Fusarium udum, probably due to increased stress response in the inoculated plants. Further testing in unsterile soils and field conditions is required.

P4.39. Study on the efficiency of PGPR on Zea mays.L in increasing the plant growth promotion and control on the seedling blight disease caused by *Fusarium* spp.

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Abstract

Two strains from rhizosphere soil of plant Zea mays were isolated and studied for plant growth promotion and induced systemic resistance(ISR) against seedling blight disease caused by *Fusarium spp*. Seeds were sown in soil along with the pathogen. After 8 hours the bacteria screened for plant growth promotion and induced systemic resistance (ISR) were inoculated at 10^{-9} dilution. The inoculated samples showed plant growth promotion as well as induced systemic resistance (ISR). Seed germinated after four days (normal time taken for germination 6-7 days) and showed ISR against the pathogen inoculated. he plants have shown significant one-fold increase of root and shoot length.

P4.40. Biological control of FCV tobacco damping-off using talc based formulations of antagonists

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Abstract

The effect of Talc based formulations of *Trichoderma viride* and *Pseudomonas fluorescens* on damping-off and growth of FCV tobacco and population of *Pythium aphanidermatum* were studied under pot culture conditions. Application of *T.viride* and *P.flourescens* either individually or in combination highly reduced the pre and post emergence damping-off and increased the seedling height, number of leaves and length of leaf of tobacco seedlings. Significant reduction of *P. aphanidermatum* was also recorded in bio-agents applied pots compared to the population recorded in pots drenched with copper oxychloride.

P4.41. Bio-management of root-knot nematode, *Meloidogyne incognita* in jasmine (*Jasminum sambac* L.)

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Abstract

Studies on the effects of application of organic amendments such as neem cake, vermicompost, pungam cake and castor cake @ 500 g/plant each; bio-agents formulations such as the plant

growth promoting rhizobacterium *Pseudomonas fluorescens*, the antagonistic fungus *Trichoderma viride,* the egg parasitic fungi *Paecilomyces lilacinus* @ 10 g/plant each and nematicides such as carbofuran and phorate @ 10g/plant each for the management of root-knot nematode, *Meloidogyne incognita* infecting jasmine, *Jasminum sampac*, was conducted under glasshouse conditions. Results revealed that all the treatments significantly reduced *M. incognita* in soil, number of adult females of *M. incognita* per g of root, number of eggs per g of root and reproduction factor. Application of organic amendments and bio-agents also had positive influence on growth parameters such as plant height, shoot weight and root weight. The introduced bio-agents as soil application were re-isolated from jasmine roots. *Pseudomonas fluorescens* was found significantly superior among all the treatments increased the flower yield by 36.6% and reduced nematode infestation in terms of mean number of juveniles per 100 g soil (69.7 %), mean number of adult females per g of root (70.1%), mean number of eggs/ g root (87.2%) with least gall index (2.6) and reproductive factor (5.44). It was followed by carbofuran, phorate, *Paecilomyces lilacinus* and neem cake. Application of *T. viride* was the least effective treatment.

P4.42. Management of major diseases of wheat through induced systemic resistance (ISR) using PGPR / PGPR - like organisms

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Abstract

Wheat (*Triticum aestivum*, *T. durum*) suffers from various diseases and pests. In India, the major diseases and pests of wheat are: rusts (yellow, brown and black), Karnal bunt, powdery mildew, foliar blights, head scab, foliar aphid, root aphid and termites. Wheat environment in India is relatively free from pesticides in comparison to other crops since, bare minimum levels of pesticides are used in wheat. It is due to the reason that major stress in wheat is on host resistance, especially for rusts. However, to achieve higher production targets, management of diseases and pests for which, host resistance is not well developed, is highly desirable. Integrated Pest Management (IPM) is the new key word in wheat that targets the crop health problems through biocontrol, tillage options and judicious usage of chemical pesticides. Also, these days, emphasis is being laid on non-chemical or alternative means of crop health management, especially in organic production of food grains, keeping in view the environmental and health factors. Hence, studies were conducted for the management of wheat diseases (Karnal bunt, powdery mildew and head scab) using PGPR and PGPR-like organisms that induce systemic resistance in the plant, and help in reducing the usage of chemicals. Studies conducted over three crop seasons on management of Karnal bunt disease (c. o. *Tilletia indica* Mitra) showed that *Pseudomonas fluorescens, Trichoderma viride* and *T. harzianum,* when used as seed dresser alone or in combination resulted in significant reduction in Karnal bunt disease incidence as compared to the untreated control. The infection of KB was created through artificially inoculated conditions to avoid any escapes. In case of powdery mildew, the disease initiation, disease progress and the terminal disease severity were reduced by seed treatment with *T. viride, Gliocladium virens and P. fluorescens* under both low and high fertility levels. Similar observations were recorded in case of head scab (c. o. *Fusarium graminearum*) wherein disease severity (per cent spikelet infection) was reduced significantly in two varieties of wheat, namely, WH 542 and UP 2338, through the systemic resistance induced by *T. viride*, *P. fluorescens, T. harzianum* and *T. virens* when applied as seed dressers. These studies have shown that the induced systemic resistance acquired by seed treatment with PGPR / PGPR- like organisms can help in reducing the disease incidence and

severity, though the insect pest damage was not influenced by these organisms. For disease management, a combination of reduced levels of chemical fungicides and these organisms can lead to effective disease management. These can very well fit into the IPM modules wherein the usage of chemical pesticides can be reduced or omitted, depending upon the situation.

P4.43. Characterization of some plant growth promoting rhizobacteria in relation to biotic stress management with enhanced growth and production of jute & allied fibre crops

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Abstract

Plant growth promoting rhizobacteria colonize in the root zone and enhance seed emergence, plant growth, biomass and yield. *Pseudomonads, Bacilli, Acetobacter, Azotobacter, Azospirillum, Burkholderia* and *Enterobacter* mainly constitute PGPR. 10-20% yield increase by PGPR in several crops has been documented. Efficacy of selected PGPRs evaluated as biocontrol agent in the management of stem and root rot disease complex of jute (*Corchorus olitorius* L. and *C. capsularis* L.) caused by *Macrophomina phasdeolina,* foot and stem rot of mesta (*Hibiscus sabdariffa* L.) by *Phytophthora parasitica* and vascular wilt in sunnhemp (*Crotalaria juncea* L.) (c.o. *Fusarium udum* f.sp. *crotalariae*) in field conditions. *Pseudomonads* and *Azotobacter* emerged as promising Bioinoculants for disease control and enhanced fibre yield in jute and allied fibre crops. Exotrophic and endophytic rhizobacteria colonize on and around the root surface of crop plants forming an endorhizosphere and protect from root infecting pathogen. Rhizobacteria colonizing roots of bast fibre plants are antagonistic to the seed and soil borne pathogens of fungal and bacterial origin. Fungicide and plant growth regulator tolerant PGPR in consortium suppressed disease, stimulated growth and enhanced fibre yield of jute, mesta and sunnhemp in field conditions. Bio-chemical characterization of PGPR strains for HCN, volatile and non volatile antibiotics, hydrolytic enzymes, siderophores and IAA production, and Phosphorus solubilization revealed antagonistic properties on jute, mesta and sunnhemp pathogens. Field evaluation trials conducted to determine efficacy of PGPRs alone and with bioregulators for disease suppression and plant growth promotion in these fibre crops to select potential biocontrol agent. Cellulase and catalase enzymes produced in *Pseudomonas fluorescence, P. striata*, *Bacillus* and *Azotobacter* between 51.1–38.7 IU ml^{-1} min^{-1} with highest β-1, 4-endoglucanase activity in Psfl1. Volatiles of Psfl-1 inhibited sclerotia formation by pathogens up to 58.0%. Non-volatile component phenazine and peptide antibiotic inhibited *Macrophomina. Pseudomonas* and *Azotobacter* isolates produced hydroxamate, catecholate and mixed type siderophores. Psfl-1 produced Maximum amount. *Rhizobium japonicum* + *Pseudomonas fluorescens* + *P. striata* consortium with carbendazim seed dressing and soil drench 15 DAS reduced root and stem rot diseases in jute by 20-61.8%, increased biomass 7.5-12.7% and fibre production 37-39.9%. Foot and stem rot of mesta declined by 55.6% with bacterial and fungal consortium seed dressing + quizalofop ethyl sprays. Bacterial consortium controlled sunnhemp wilt up to 37.6%, increased nodulation by 41.6%, plant biomass 58.1%, and fibre yield 51.5%. Fungicide and herbicide tolerant *Pseudomonas*, *Rhizobium* and *Trichoderma* strains enhanced biocontrol efficiency, plant growth and rhizosphere competence in the fibre crops. Molecular characterization of PGPRs is essential for identification and selection of efficacious

biopesticide formulation to combat want of appropriate integrated disease management system (AIDMS). Information and Communication Technology (ICT) tools can help accelerating such system of sustainable agriculture to the farmer level.

P4.44. Beneficial traits of PGPR mediated disease management and growth promotion in jute and sunnhemp with bioformulation of activated and wild biocontrol agents

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Abstract

In modern day agriculture, chemical fertilizer and pesticide has been indispensable with increasing demand for higher yield potential. Cost of production of jute and allied fibres as well has been skyrocketed with abundant use of chemicals. Over doses of fertilizer deteriorate micro-ecological balance in soil environment and spread soil borne diseases. Indiscriminate use of pesticides poses threat to resurgence and appearance of pesticide resistant strains of pathogens, lysis of beneficial organisms and pollution. Selection of safer pesticide to combat pest and disease out breaks averting non-target effects on soil, plant and human health becoming expensive but essential. Natural control through conservation and manipulation of bioagents is by far more important in the niche of biodiversity. In this borderline, plant growth promoting rhizobacteria (PGPR) present immense potential and promise as effective substitute.

P4.45. Biological control and Plant Growth Promotion by *Bacillus* strains from Milk

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Abstract

Six-hundred bacterial strains from human milk and milk from Sahiwal cows, Holstein Friesian cows, and buffaloes were screened for their ability to suppress phytopathogenic fungi under in vitro conditions. A consortium of 3 strains, viz., *Bacillus lentimorbus* B-30486 (B-30486), *B. subtilis* B-30487 (B-30487), and *B. lentimorbus* B-30488 (B-30488), isolated from Sahiwal cow milk resulted in better biological control and plant-growth promotion than single-strain treatments. For commercial-scale production of a bioinoculant, the solid-state fermentation of sugarcane agro-industrial residues, i.e., molasses,press mud, and spent wash, using the consortium of B-30486,B-30487, and B-30488, resulted in a value-added product, useful for enhancing plant growth. The application of the consortium to sugarcane fields infested with *Fusarium moniliforme* and *Colletotrichum falcatum* resulted in a reduction of mortality and significantly higher (P=0.05) plant height, number of tillers, and cane girth when compared with

the control. Furthermore, under field conditions, the treatment of sugarcane with the consortium resulted in significantly (P=0.05) greater plant growth compared with nonbacterized plants. Accordingly, this is the first report on the effective use of bacteria isolated from milk for biological control and enhancing plant growth under field conditions. Furthermore, a solid-state fermentation technology was developed that facilitates the economic utilization of agro-industrial residues for environmental conservation and improving plant and soil health.

P4.46. Growth Promotory and antipathogenic activity of Bradyrhizobium japonicum

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Abstract

Bradyrhizorium japonicumm inoculation not only enhances the plant growth, nodulation, nitrogen fixation, nutrient uptake and yield of soybean but also known to produce bacteriocins called rhizobactins and iron-chelaling compound ruch as siderophores (Rossium et. al., 1994) which have potential to reduce severity of seed and root decay disease (Blum et. al., 1991). Antipathogenic activity was determined by dipping sterilized round paper disc (4 mm dia) in B. japonicum inoculum and placing them on petri plates containing pathogen inoculum on modified Rhizobia-fungi dedium and by checking the inhibition zone after incubation. To study the growths promotory and antipathogenic activity a pot experiment was conducted with B. japonicum strains SB-12. Fusarium oxysporium sp lini and their interaction in triplicate using completely Random sided Design. B. japonicum strain inhibited the growth of pathogen and Fusaricum oxysporium, Rhizoctomia solani, strain SB-120 inhibited the growth of Microphomine phaseoli and strain TAL-95 inhibited the growth of Fusarium oxysporium invitro whereas none of the B. japonicum strains were able to inhibited the growth of pathogen Sclerotium rolfsii Inoculation of B. japonicum significantly increased seed emergence root and shoot length & their dry weight, nodule number and their dry weight, N, P, Zn, Fe, & Mn uptake, yield parameters in soybean. The inoculation by pathogen F. oxysporium alone reduced the above parameters whereas the ill effect of pathogen was reduced significantly by counoculation with B. japonicum SB-12 and F.oxysporium sp lini. in soybean and improved plant growth and nutrient uptake as compared to pathogen inoculation and control treatment.

P4.47. Biological control of soil-borne diseases of groundnut and pigeonpea by plant growth promoting rhizobacteria (PGPR)

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Abstract

Management of soil-borne diseases is a difficult task due to the complex nature of the soil system and the longevity of plant pathogens in the soil. Application of chemical pesticides is neither effective nor it is safe to the soil environment as it affects the non-target organisms as well. Biological control of plant pathogens has become an important eco-friendly alternative as it exploits microorganisms from their natural habitat. Rhizosphere being the site of plant pathogen and biocontrol agent interaction, the rhizosphere of groundnut and pigeonpea is explored for the

potential plant growth promoting rhizobacteria to test their ability against some of the important soil-borne diseases.
Several isolates of Plant growth promoting rhizobacteria (PGPR) isolated from rhizosphere soils of groundnut and pigeonpea were screened against wilt pathogen of pigeon pea, *Fusarium udum*, crown rot and stem rot pathogens of groundnut *Aspergillus niger* and *Sclerotium rolfsii* respectively *in vitro* employing dual culture technique. Two isolates of *Pseudomonas aeruginosa* (PA1 and PA2) exhibited effective antagonism against *A. niger* and *S. rolfsii* while a single isolate of *P. fluorescens* inhibited *F. udum*. Seed treatment of these PGPR isolates controlled the soil-borne diseases effectively in pot and field experiments. *Fusarium* wilt of pigeonpea was controlled by 32.4% by *P. fluorescens*. Crown rot of groundnut caused by A. niger was effectively managed by P.aeruginosa with 65% control. Stem rot caused by S. rolfsii was controlled by 76% showing maximum control among all the biocontrol agents. Biocontrol agents as a seed treatment proved to be efficient over soil application.

P4.48. Biological control of pigeonpea wilt by *pseudomonas fluorescens* and *trichoderma viride*

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Abstract

Plant growth promoting rhizobacteria, *Pseudomonas fluorescens* and *Trichoderma viride*, isolated from pigeonpea rhizosphere and were selected from in vitro screening against *Fusarium udum*. Effect of biocontrol agents as an individual and combination treatments against wilt disease and on plant growth of pigeonpea was studied in pot and field experiments. Combination treatment proved effective in disease control and growth improvement in pot experiments. Single treatment of *P. flourescens* performed better in the field. Biocontrol agents in the absence of wilt pathogen significantly improved plant growth.

P4.49. Biological Control of Crown Rot and Stem Rot Diseases af Groundnut by *Pseudomonas Aeruginosa*

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Abstract

Several isolates of plant growth promoting rhizobacteria (PGPR) isolated from rhozosphere soils of groundnut were screened against crown rot and stem rot pathogens of groundnut *Aspergillus niger* and *Sclerotium rolfsii* in vitro. *Pseudomonas aeruginosa* exhibited effective antagonism against *A. niger* followed by *S. rolfsii* . Siderophore plug assay method was found to be more effective with 65 mm and 36mm inhibition zones against *A. niger* and *S. rolfsii* respectively . Pot and field experiments showed significant reduction in disease control and increase in plant growth and biomass.

P4.50. Biocontrol potential of plant growth promoting rhizobacteria and fungi on sunflower collar rot (*Sclerotium rolfsii)* incidence.

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Abstract

Sunflower (*Helianthus annus* L.) is an important and efficient oilseed crop of the country with high quality edible oil and wider adaptability. The present study was carried out to screen the potential isolates of *Trichoderma* sp. and bacteria on sclerotium sunflower collar rot and plant growth promotion. Pot culture study was conducted to know the bio efficiency of selected strains of *Trichoderma* spp. and bacterial spp. against *S. rolfsii* in reducing disease incidence and promoting growth of sunflower in green house.Based on dual culture antagonism 9 *Trichoderma* isolates *Trichoderma* viride(TV2), *Trichoderma viride* (TV3), *Trichoderma viride* (TV5), *Trichoderma harzianum* (Th10), *Trichoderma viride(*TvN13), *Trichoderma harzianum* (TS12), *Trichoderma* sp (T12), *Trichoderma viride* (T33) and *Trichoderma* sp (TS4) and 3 bacterial isolates (*Bacillus subtilis*, *Pseudomonas fluorescens*, *B. megaterium*) were identified as potential. Screening of microbial isolates for phosphate solubilization and mycolytic enzyme production revealed variations among different groups of organisms. All 10 fungi and 3 bacteria were found to be tricalcium phosphate solubilizers (TCP) in the liquid culture (Table 1). The P content released into the medium from TCP was 120.7µg P $mL^{-1}$by *Trichoderma viride* N13. It was followed by *P. flourescens* 1 (116.0 µg P mL^{-1}) solubilized 80% of that solubilized by the reference strain *Aspergillus niger* (149.7 µg P mL^{-1}). *P. fluorescens* 1 was able to solubilize phosphate effectively compared to other bacterial strains. It is clearly evident from results obtained that the use of above potential bioagents were found effective in control of collar rot disease as well as in plant growth promotion.

P4.51. Studies on soil borne fungal –phytoparasitic nematode complex associated with groundnut with special emphasis on biological control

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Abstract

A preliminary survey on incidence of soil borne fungal pathogen-phytoparasitic nematode complex associated with groundnut was conducted in Warangal and Mahaboobnagar districts of Andhra Pradesh,India during Kharif 2008 under ANGRAU-Auburn University (USA) Collaborative Project to assess the incidence of disease complex and detection of soil borne fungi and phytoparasitic nematodes associated with diseased plants. A total of 14 and 10 groundnut samples (soil and root) were collected from farmers fields of Warangal and Mahaboobnagar districts respectively and the percentage incidence showing symptoms of dead plants /wilting varied from 4-10 per cent. The diseased groundnut root samples were analysed for the detection of soil borne fungi on Potato dextrose Agar Medium. The fungi viz., *Aspergillus niger*, *Penicillium* spp, *Rhizopus* sp., *Choanephora sp.* were detected from the samples collected from

Warangal and Mahaboobnagar districts. Similarly, fungi viz., *Trichoderma* sp, , *Rhizopus* sp, *Aspergillus niger.* were detected from the samples collected from Anantapur district. Collar rot pathogen (*Aspergillus niger*) was found to be predominant and was detected in most of the diseased samples collected from farmer's fields. The soil and root samples were also analysed for the detection of phytoparasitic nematodes associated with diseased plants following decanting and sieving and Baermann funnel technique. and there were no plant parasitic nematodes neither in soil nor in root samples except in one of the samples collected from Mahaboobnagar district with root knot galls @ 20 /root and 4 juveniles / 5 g root. The *Trichoderma* isolate(identified and designated as *T.viride* ANGRAU-1,detected from root samples was tested against the predominant fungal pathogen *Aspergillus niger in vitro* following dual culture technique. The fungal antagonist was found to be effective in inhibiting the pathogen by 47 %.

P4.52. Development of consortium of a PGPR - Pseudomonas fluorescens and its bio-efficacy against disease complex in carrot

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Abstract

Single bio-agent cannot be very effective in the management of nematode induced disease complex. Further the bio-pesticide formulations containing single bio-gent cannot be active in different soil types, agro-climatic regions and on all the crops. Hence efforts were made to develop consortium a few strains of *Pseudomonas fluorescens.*Initially efforts made to investigate the compatibility of selected strains *P. fluorescens in vitro* and *in vivo*. On the basis of the results a consortium of three strains of *P. fluorescens* was developed. Further, evaluated its bio-efficacy against disease complex in carrot. Disease complex in carrot (*Daucus carota.* L) is caused by the *Erwinia caratavora* and *Meloidogyne incognita.* Initially efforts were made to investigate the interaction of *M. incognita* with *Erwinia caratavora* in inducing the disease complex. Treatment of carrot seeds with consortium of *P. fluorescens* (3 strains) at the rate of 10 g /kg and subsequent application of consortium formulation at the rate of 10 g/ sq.meter, significantly reduced *M. incognita* in **carrot** roots by 79%. These treatments also reduced the incidence of *Erwinia caratavora* significantly. Observed 24% increase in the yield of crop. Cost benefit ratio (calculated for the additional cost of the bio-pesticides and additional returns accrued by the application of the bio-pesticide) was 1 : 4.5. The data on compatibility of the strains, rhizospheric competency and suppression of nematode induced Erwinia soft will be deliberated during the Congress.

P4.53. Antagonistic potential and molecular characterization of *Trichoderma harzianum* isolates against *Sclerotium rolfsii* infecting tobacco

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Abstract

Ten isolates of *Trichoderma harzianum* isolated from rhizosphere of tobacco and other crops were evaluated for their genetic diversity and antagonistic potential against *Sclerotium rolfsii*, a fungal pathogen causing collar rot in tobacco. In dual culture, isolates WG1, WG3, GT1 and DH were more aggressive in inhibiting the mycelial growth of the pathogen. The isolate WG1 showed a maximum production of HCN which reflected in the maximum inhibition of *S. rolfsii* growth by volatile compounds. Production potential of hydrogen cyanide, indole acetic acid and siderophore varied among the isolates. Siderophore production was not observed in isolate KP. The level of polymorphism detected with different primers ranged from 70 to 100%. Out of 249 amplified fragments, 216 (86.74%) were polymorphic. The primers OPP11, OPAB1, OPL4, PL5 and OPL6 were highly polymorphic (100%). Based on RAPD profiles, the pair-wise similarity coefficients among isolates ranged from 0.46 to 0.85 with an average of 0.65. The minimum genetic similarity was observed between the isolates KP and BK (46%) whereas, the highest (85%) was between isolates GT1 and GT2. Clustering analysis by unweighted pair group method on arithmetic averages (UPGMA) grouped the isolates into two major clusters. The clustering pattern of the isolates was based on host and region with the exception of isolate KP. There was no correlation between the RAPD pattern and the antagonistic potential of the *T. harzianum* isolates.

P4.54. *In-vitro* efficacy of various rhizobacterial isolates against *Rhizoctonia solani*, the causal agent of rice sheath blight disease

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Abstract

Sheath blight of rice caused by *Rhizoctonia solani* is an economically significant disease causing severe yield losses. Biological control of the disease using plant growth promoting rhizobacteria (PGPR) is a potential alternative to the presently available chemical control methods. The present study focuses on screening of 70 rhizobacterial isolates of *Bacillus*, *Brevibacillus*, *Paenibacillus* and *Arthrobacter* spp for antagonistic activity against mycelial growth, sclerotial germination and sheath blight lesion development on leaf blades under *in-vitro* conditions. Dual culture studies revealed that the mycelial growth of *R. solani* was inhibited up to 83% by these PGPR and 10 strains were found to exhibit antagonism of over 70%. Superior strains were within the following species: *Bacillus subtilis*, *B. mycoides, B. vallismortis, B. sphaericus* and *P. macerans*. Two strains of *B. subtilis* and one strain of *P. macerans* and *P. polymyxa* completely inhibited the

sclerotial germination of test pathogen *in-vitro*. The hyphal reduction of germinated slcerotia by other bacterial strains was up to 42%. Inhibition studies on sheath blight lesion development by PGPR on detached leaves revealed that 56 strains were effective with disease severities in the range of 2.9% to 97% as against control with 100% severity. Maximum inhibition of lesion development was noticed with two strains of *B. subtilis* and one strain of *B. atrophaeus* with disease severities of 2.9%, 39% and 32% respectively. Two *B. subtilis* strains that were effective in inhibiting mycelial growth, sclerotial germination of *R. solani* and also on lesion development were further selected for greenhouse and field studies on plant growth promotion and sheath blight disease management.

P4.55. Cellulolytic Bacteria Perspectivte for using in protectof Agricultural Cultures from Phytopathogenic Fungi

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Abstract

From rhizosphere cultural plants, from various natural substrates containing cellulose in Kazakhstan cellulolytic bacteria have been isolated and selected. Among these bacteria are selecting strains with higher antagonistic activity to fungi, which cause diseases causing diseases of agricultural plants such as grain crops, cucumbers, potato, beet and others. Cellulose is degradated by many groups of microorganisms, but the basic role in degradation of cellulose belongs to fungi and bacteria. Fungi have more powerful fermentative systems for destruction of cellulose, but cellulolytic bacteria are characterized by a high growth rate and a high degree of population stability. In a course of evolution there has been competition between these by two groups of microorganisms for the source of carbon and energy - cellulose. And as a result of this competition bacterium have developed substances capable of suppress growth and development of fungi

Poster session:
Biogeography, Genomics, bioinformatics

P5.1. Isolation and characterization of Plant growth-promoting Rhizobacteria from Western Ghat Forest soil, India

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Abstract

About 380 rhizobacterial strains isolated from the root-free soil, rhizosphere and rhizoplane of Western Ghat forest. Of the 380 bacteria, 87 strains were able to solubilize phosphate on plates and solubilize tricalcium phosphate in (NBRIP) broth medium. From this collection, a screening to identify those strains showing plant growth promotion attributes and biocontrol activities, as well as salt, pH tolerance was performed. Thirty rhizobacterial isolates were evaluated for their morphological, physiological characteristics, P-solubilization, Indole acetic acid (IAA) and siderophores production. Results showed most of the strains are tolerant to high salt (NaCl, w/v) and pH. Strains displaying plant growth promotion attributes and biocontrol features were selected for further characterization. The development in root system shows a growth downwards in the agar-gel column when the rhizobacterium has a potential ability to colonize roots. This can be visualizing, by transparency, bacterial growth (turbid or milky zone) along and around roots. Scanning electron microscopy evaluated that the colonization of potential isolates was consistently distributed on the surface of roots. The initial characterization and screening of rhizobacteria has helped in selection of potential isolates as superior strains for use as bioinoculants.

P5.2. Characterization of Indigenous PGPR Strains Isolated from the Soils of Himachal Pradesh

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Abstract

Soil is a dynamic, living matrix that is an essential part of the terrestrial ecosystem. It is a critical resource not only for agricultural production and food security but also towards maintenance of most life processes. The functions of soil biota are central to decomposition processes and nutrient cycling. Indiscriminate use of chemical fertilizers has polluted the environment and is causing deterioration of soil health. In this context Plant Growth Promoting Rhizobacteria (PGPR) have gained worldwide importance and acceptance as the potential tools for sustainable agriculture and the trend for the future. PGPR are heterogeneous group of bacteria that can be found in the rhizosphere, root surface and in association with roots, which can improve a plant growth directly or indirectly. Since the Himachal Pradesh has acidic soils, so the exotic isolates generally perform poorly under the local agro-climatic conditions. Keeping in view the above facts, 24 efficient P-solubilizers, 18 efficient *Azotobacter* and 20 efficient *Azospirillum* were isolated from various medicinal (*Aloe barbadensis* and *Bacopa monnieri*) and crop plants (*Triticum aestivum, Zea mays* and *Solanum tuberosum*). These P-solubilizers and Nitrogen fixers were analyzed for PGPR traits like Indole acetic acid (IAA), Ammonia production, Antifungal activity and HCN production. The most efficient P- solubilzer, *Azotobacter* and *Azospirillum* produced 15.91 µg/ml, 17.45 µg/ml and 19.27 µg/ml of IAA, respectively. All these isolates

were also found positive for ammonia production. The most efficient isolates were subjected to molecular characterization by Enterobacterial Repetitive Intergenic Consensus PCR (ERIC-PCR). The results of these findings will be discussed.

P5.3. Role of endophytes in inducing systemic resistance against leaf blight disease of amaranth

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Abstract

Leaf blight of amaranth caused by *Rhizoctonia solani* Kuhn is the most devastating disease in amaranth. Popular fungicides like Mancozeb can lessen the severity of the disease but residues may have negative environmental consequences. Hence, in an attempt to find ways of using a plant's own defense mechanisms, the present study was carried out to evaluate the efficacy of endophytic microorganisms in inducing enzymes related to induced systemic resistance. Such enzymes include peroxidase (PO), poly phenol oxidase (PPO) and phenyl alanine ammonia lyase (PAL). A total of 46 bacterial and 17 fungal endophytes were isolated and screened against *R. solani* under *in vitro* conditions using a dual culture method. Standard cultures of *Pseudomonas fluorescens* (KAU), *P. fluorescens* (TNAU), *Trichoderma viride* (KAU) and *T. harzianum* (IISR) were also used for comparison. Among the endophytes screened, only six bacteria and one fungus showed antagonistic activity against *R. solani*. A pot culture experiment was carried out in order to evaluate the performance of effective antagonistic endophytes in inducing enzymes related to systemic resistance. Their effects were compared with the standard fungal and bacterial bio control agents. The bacterial endophytes EB-22 (*Pseudomonas spp.*) and EB-20 (*Bacillus spp.*) were found most efficient in inducing the production of PPO and PO, whereas the endophytic fungus EF-2 (*T. harzianum*), endophytic bacteria EB-4 (*Bacillus spp.*) and all standard biocontrol agents induced high PAL production.

P5.4. Bioefficacy of endophytes in the management of leaf blight disease of amaranth

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Abstract

Amaranth leaf blight caused by *Rhizoctonia solani* Kuhn is a major production constraint in amaranth cultivation. The pathogen infects more than 90% of plants in the field and causes considerable economic loss owing to reduced marketability of the produce. Even though chemical control with mancozeb is a promising management tool, the fungicide poses certain problems when residue remains on crops. In an effort to find alternatives to chemicals, the present study was carried out in Kerala in 2006-2007 to evaluate the efficacy of endophytes in the management

of leaf blight disease of amaranth. The methodology involved the isolation of endophytes from amaranth, *in vitro* evaluation of isolated endophytes against *R. solani*, container evaluation of selected endophytes against the leaf blight pathogen in comparison with a recommended chemical (Mancozeb at 0.2%), and standard fungal (*Trichoderma harzianum* and *T. viride*) and bacterial (*P. fluorescens*) bioagents. A total of 63 (43 bacterial and 17 fungal) endophytes were isolated and evaluated against *R. solani* in dual culture studies. The results revealed that six endophytic bacteria (isolates EB-4, EB-20, EB-22, EB-38, EB-43 and EB-45) and one endophytic fungus (isolate EF-2) were antagonistic against the pathogen. In the container experiment, isolates EB-22 and EB-43 were found to be efficient in reducing leaf blight severity.

P5.5 Amaranth endophytes and their role in plant growth promotion

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Abstract

Amaranth is a highly nutritious and inexpensive leafy vegetable available in the tropics. Plant growth, which determines the yield of this leafy vegetable, was evaluated in this study on the effects of endophytes. A total of 46 bacterial and 17 fungal endophytes were isolated from amaranth plants collected from different fields. The isolated endophytes were screened against the leaf blight pathogen *R. solani*, which causes a foliar blight of amaranth and is the most devastating disease of this crop. Six bacterial endophyte isolates (EB-4, EB-20, EB-22, EB-38, EB-43 and EB-45) and one fungal endophyte (isolate EF-2) were found to be efficient in inhibiting the growth of *R. solani in vitro*. A pot culture experiment was conducted with these antagonistic endophytes to determine their ability for plant growth promotion. Their effects were compared with standard fungal (*Trichoderma harzianum* from IISR and *T. viride* from KAU) and bacterial biocontrol agents (*P. fluorescens* from TNAU and *P. fluorescens* from KAU) and one fungicide, mancozeb. In a greenhouse study, shoot length, root length, number of leaves, leaf area, fresh weight and dry weights of roots and shoots were recorded, and significant differences were found among the treatments. As a whole, the isolates EB-20, EB-43 and EB-45 were found to be the most efficient in improving biometrics of amaranth, and were similar in effect to the standard biocontrol agents *P. fluorescens* (KAU) and *T. harzianum* (IISR).

P5.6. Bioinformatic Studies on the Diversity of *Rhizobium*, a growth promoting rhizobacteria (PGPR)

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Abstract

Traditionally the name rhizobia portrays root and stem nodulating bacteria that live in N_2 fixing symbiosis mainly with leguminous plants. Rhizobial ecology studies have shown that they can change their life styles in adaptation to the highly contrasting environments they can inhabit and the rhizobial symbionts exhibit a large diversity. The diversity of rhizobia can be assessed by an array of methods that include 16S rDNA sequencing also. The sequence details of the Rhizobial isolates from root and stem nodules of *Sesbania rostrata* grown in ecologically different conditions viz., wet and dry were elucidated using molecular techniques and analysed using bioinformatics tools to throw light on the bacterial diversity.

P5.7 Plant Growth Promotional Activities of PCP Degrading Bacteria

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Abstract

Pentachlorophenol (PCP) is used as a pesticide and as a leather and wood preservative as well. It is present in tannery effluents and also formed unintentionally in effluents of paper and pulp industries. Microbes and plants are among the most important biological agents that remove and degrade waste materials to enable their recycling in the environment. Rhizosphere interaction between plants and microbial communities, including PGPB, benefits both organisms. The bacteria receive nutrients from root exudates and the plants get enhanced nutrients. In the present investigation, from the rhizosphere soil of PCP tolerant plants, as many as twenty seven PCP tolerant rhizobacteria and nineteen endophytic bacteria were isolated. These isolates were evaluated *in vitro* for plant growth promoting activities such as P- solubilization, IAA production, HCN production and Antibiosis. It was interesting to note that six rhizosphere isolates (ASOY2, ASOY8, ASAFF2, AGRN3, AMAZ1 and AMAZ2) exhibited all the four characters. Incidentally, the isolate AMAZ2 degraded PCP completely in 30 days. Similarly, five endophytic isolates [SAF(root)3, SAF(root)4, Sun(root)1, GRN(root)4 and , SOY(leaf)2] exhibited all the four characters and GRN(root) 4 was the efficient degrader (94.12 per cent in 20 days). The results, thus, indicated that AMAZ2 and GRN (root) 4 have both PGPR and bioremediating properties.

P5.8. Mineral phosphate solubilisation ability of *Rhizobium* species overexpressing heterologous phosphoenol pyruvate carboxylase (*ppc*) or citrate synthase (*cs*) genes on different sugars

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Abstract

Rhizobia are known to significantly contribute nitrogen to legumes by fixing nitrogen by forming nodules. Efficiency of nodule formation and function of nodules including nitrogen fixation is known to be governed by the abundance available P. Although soils are rich in organic and inorganic phosphates, they are deficient in available P. Release of P from soils as well as mineral phosphates is mediated by the nature and amount of organic acids. Citric acid is a very strong acid for P solubilization; therefore it is postulated that *Rhizobium* secreting citric acid would be a good P solubilizer. Oxaloacetate and acetyl CoA are condensed by citrate synthase to form citric acid. It is postulated that oxaloacetate levels and citrate synthase activity limit the biosynthesis of citric acid. Phosphoenolpyruvate carboxylase (*ppc*) and citrate synthase (*cs*) genes were transferred independently in *R. leguminosarum* and *R. meliloti*. 50mM Tris pH 8.0 minimal medium was used with rock phosphate as the sole P source. Growth, pH and Pi of the transgenic strains were monitored when grown on glucose, fructose and sucrose at 50mM concentration. *R. leguminosarum cs* transformants acidified the medium upto pH 4.0 with 50mM sucrose compared to *R. meliloti* transformants which acidified the medium up to pH 4.4. Significant pH drop and Pi release also observed when fructose and glucose (50mM) were used as a carbon source in the order sucrose , fructose followed by glucose. Compared to *ppc, cs* overexpression leads to more media acidification. Overexpression of *cs* in *R. meliloti* and *R. leguminosarum* has significantly altered Pi levels in the buffered medium.

P5.9. Utilization of rhizobacterial strains for decontamination and crop enhancement in tea plantations contaminated with oil and oily sludge

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Abstract

Assam is one of the states in India having high oil reserves. Exploration of oil and related activities generate oil and oily sludge, which pollutes the environment, mainly the soil fertility of the tea gardens in the vicinity. Utilization of rhizobacterial strains for oil and oily sludge decontamination besides crop enhancement is a eco-friendly and cost effective strategy to solve this issue. Bacterial strains isolated from the rhizosphere of tea plants, mainly growing in oil and oily sludge contaminated soils were screened for their ability to degrade oil and oily sludge, growth promotion and *in vitro* antagonism against *Fomes lamoensis* and *Ustulina zonata* causing brown root rot and charcoal stump rot in tea, respectively. Among the 200 number of bacterial isolates tested, 45 were shown oil degrading ability. Fifteen exhibited antagonism against *F. lamoensis*. However, only one of them showed antagonism against *U. zonata.* Five strains shown the best results were tested singly and in combination for growth promotion in tea and French

bean under nursery condition in soil amended with oil and oily sludge. The results confirmed that all the strains were able to degrade the oil and oily sludge in individual treatment. However, only three of them gave simultaneous growth promotion. The combination treatments gave enhanced percentage of oil degradation and growth promotion than the individual treatments. The findings indicate the use these strains in crop enhancement and oil and oily sludge decontamination of tea plantation contaminated with the same in an eco-friendly manner.

P5.10. Effect of Agrochemicals on PGPR

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Abstract

Use of agrochemicals are increased which result into hazardous effect on soil health. To reduce use of agrochemicals microbial inoculants are major alternative as microbial fertilizers, which maintain soil fertility and soil health. Taking into account the agrochemicals and bioinoculants, the present investigation is an attempt to see the effect of different agrochemicals and bioinoculant on the soil microorganisms including PGPR population in soybean crop. After application of agrochemicals at 1,30,60 DAS and at the time of harvest in treated plots the total number of Fungi, bacteria, Actinomycetes, Pseudomonas, nitrogen fixing bacteria i.e. *Azotobacter* and *Rhizobium* were counted. The number of colony forming units (*cfu*) in the selective media were determined by means of serial dilution technique and the pour plate method (Salle,1973). Analyses were performed in three replicates. The results with regard to bacterial population in soybean field were significantly influenced by bioioculant *viz. Azotobacter* and *Rhizobium.* The bacterial population was inhibited by herbicide Alachlor and fungicides Thiram and Mancozeb. After 30 days of spraying of chemicals the bacterial population was restored. With regard to *Azotobacter* and *Rhizobium* population the bioinoculants were significantly influenced the population in soybean field. The herbicides and fungicides were significantly decreased bioinoculant population, maximum inhibition was observed in mancozeb treated plot at 30 DAS. The results with regards to *Pseudomonas*, Actinomycetes and fungi population were influenced bybioinoculant *viz. Azotobacter*, *Rhizobium* in soybean field. While population were inhibited by Alachlor, Thiram and Mancozeb in soybean field. The *Pseudomonas*, Actinomycetes and fungi population were restored after 30 days of spraying. The bioinoculant *viz. Azotobacter, Rhizobium* has positive effect on yield of soybean crop. The bioinoculant i.e. *Azotobacter, Rhizobium* significantly influenced the soil microorganism population. The herbicides (Atrazine and Alachlor) and fungicides (Sulphur, Thiram, Mancozeb) effects on soil microorganism were temporary i.e. about 30 days. At the time of harvest of crop all microorganisms were recovered population.

P5.11. *Rhizobium undicola*, a novel endophyte of rice cultivated in India and its role in plant growth promotion

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Abstract

This paper deals with the isolation and characterization of a naturally occurring rice endophyte, *Rhizobium undicola* that promotes rice plant growth under laboratory conditions. Rice root samples were collected from 40 different locations of Eastern Uttar Pradesh where rice is under cultivation for more than two hundred years. Bacteria from these samples were isolated after surface sterilizing the root pieces of these samples by growing them in three types of media; yeast extract-mannitol, Luria-Bertani and BAz media. Out of these 40 samples, twelve isolates were capable of nodulating cowpea (*Vigna unguiculata* L.) and common bean (*Phaseolus vulgaris* L.) plants used as "trap plant". Based on ARDA and 16S rDNA sequence analysis, one of these (RREM36) was identified as *Rhizobium unidicola* showing 98% similarity in addition to few other isolates belonging to *Rhizobium leguminosarum phaseoli* and *Burkholderia cepacia* complex. *R unidcola* RREM36 was capable of producing plant growth promotion effects when tested on rice (*Oryza sativa* L.) plants. Possible mechanisms involved in plant growth promotion were the production of phytoharmone (IAA), phosphate solubilzation activity and nitrogen fixing ability under endophytic conditions.

P5.12. Characterization and Evaluation of Plant Growth Promoting Bacteria Isolated from Soils Rich in Chitin

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Abstract

Plant growth promoting rhizobacteria (PGPR) colonize the rhizosphere of many plant species and confer beneficial effects either by increasing the plant growth or by reducing susceptibility to diseases caused by fungi, bacteria, viruses and nematodes. Rhizosphere/rhizoplane region of the plant is often exploited for isolation of PGPR strains, which are found to be effective in plant growth promotion. But in present study, we have used different soils rich in chitin/chitosan for isolation of plant growth promoting bacteria. Using conventional methods, more than 50 bacterial strains were isolated and most of them were found to be chitinolytic. Two bacterial strains, showing larger zone of clearance on chitin-containing plates and also exhibiting antifungal activity against *Sclerotium rolfsii* and *Botrytis cinerea*, were selected and tested for their PGPR activity in groundnut with and without chitosan. Growth promotion ability was also tested in tobacco plant under gnotobiotic condition using a simple set up designed by us. Bacterial isolates were identified as *Bacillus licheniformis* and *Paenibacillus elgii* based on their morphological and biochemical characters and further confirmed by 16S rDNA complete sequences. Seed bacterization with the strains, alone or in combination with chitosan, resulted in significant increase in growth in terms of shoot height, root length, fresh and dry weight of plants. Different growth parameters observed under green house condition were also found to be increased under

gnotobiotic condition in *P. elgii* treated plants as compared to control. Soils rich in chitin could be considered as a good source for isolation of plant growth promoting bacteria. *B. licheniformis and P. elgii*, alone or in combination of both, could be used for enhancing growth of groundnut.

P5.13. Antagonistic potential and molecular characterization of *Trichoderma harzianum* isolates against *Sclerotium rolfsii* infecting tobacco

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Abstract

Ten isolates of *Trichoderma harzianum* isolated from rhizosphere of tobacco and other crops were evaluated for their genetic diversity and antagonistic potential against *Sclerotium rolfsii*, a fungal pathogen causing collar rot in tobacco. In dual culture, isolates WG1, WG3, GT1 and DH were more aggressive in inhibiting the mycelial growth of the pathogen. The isolate WG1 showed a maximum production of HCN, which reflected, in the maximum inhibition of *S. rolfsii* growth by volatile compounds. Production potential of hydrogen cyanide, indole acetic acid and siderophore varied among the isolates. Siderophore production was not observed in isolate KP. The level of polymorphism detected with different primers ranged from 70 to 100%. Out of 249 amplified fragments, 216 (86.74%) were polymorphic. The primers OPP11, OPAB1, OPL4, PL5 and OPL6 were highly polymorphic (100%). Based on RAPD profiles, the pair-wise similarity coefficients among isolates ranged from 0.46 to 0.85 with an average of 0.65. The minimum genetic similarity was observed between the isolates KP and BK (46%) whereas, the highest (85%) was between isolates GT1 and GT2. Clustering analysis by unweighted pair group method on arithmetic averages (UPGMA) grouped the isolates into two major clusters. The clustering pattern of the isolates was based on host and region with the exception of isolate KP. There was no correlation between the RAPD pattern and the antagonistic potential of the *T. harzianum* isolates.

P5.14. Sensitivity of PGPR to Agrochemcials

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Abstract

The studies were conducted to estimate the effects of different pesticides on beneficial PGPR. The pesticides, which we are used in plant protection practices, have been tested for their toxicity. Sensitivity of PGPR isolates to different pesticides viz. Carbaryl, Carbendazim, Copper oxychloride, Thiram, Vitavax and Paushamycin was tested turbidometrically at 620 nm. The pesticide were tried at recommended dose and bacterial cell growth was measured in terms of absorbance which was recorded at 24,48 and 72 hr. PGPR was found to be sensitive to Carbaryl 50 WP @ 0.3 % (CoRb-1,12.07%), Vitavax @ 0.25 % (CoRb-8 ,20.43 %),Thiram @ 0.3 %(CoRb-3 ,44.67 %),carbendazim (CoRb-1,0.11 %),Copper oxychloride @ 0.3 % (CoRb-6, 0.25 %). Antibiotic Paushamycin @ 250 ppm showed maximum inhibition of growth of PGPR isolates.Maximum suppression in growth was observed in CoRb-2 (48.20%) at 72 hr.

P5.15. Collection of *Aspergillus Niger* aggregates and evaluation of their plant growth promoting efficiency on tomato

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Abstract

A pot study was conducted to evaluate effectiveness of some selected soil isolates of *Aspergillus Niger* aggregates. Two hundred thirty six soil samples for isolation of *A. niger* aggregates were collected from 32 different crop fields of 40 districts in Uttar Pradesh. The fungus was isolated using dilution plate method and pure cultured on potato dextrose agar. Soil isolates of the fungus (236 nos.) were characterized for production of ammonia, hydrogen cyanide, hydrogen sulphide, indole acetic acid, siderophore, phosphate solubilization and heavy metal (Ni, Cd, Cr) biosorption *in-vitro*. Sixteen soil isolates of *A. niger* aggregates viz, AnC2, AnR3, AAn1, BAn4, BasAn5, GaAn1, BudAn3, JaAn2, LAn3, MeAn4, SkNAn3, SkNAn5, VAn4, BuAn3, ANAn1 and ANAn4 were selected on the basis of above *in-vitro* performance to examine their plant growth promoting effects on tomato, *Lycopersicon esculantum* cv. SGS UPAS 00021X in a pot culture test. Earthen pots (25 cm diameter) were filled with 4 kg sterilized soil-compost mixture. The isolates were applied as soil treatment (1g/kg soil) and bare root dip (10 g in 1000 ml water) treatment before transplanting of 3 week old seedlings of tomato. The isolate SkNAn5 was found the most effective in promoting the dry matter production (39%) and yield (42%) in comparison to the control. Chlorophyll, carotenoids and salicylic acid contents of the shoot increased by 33, 24 and 37%, respectively over control. The tomato fruits collected from plants grown in *A. niger* SkNAn5 treated soil contained 44% greater lycopene. The study has demonstrated growth promoting effect of the isolate SKNAn5 to a level that warrants its commercial exploitation.

P5.16. Effect of Agrochemicals on Microflora in Rhizosphere Soil of Soybean

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Abstract

Soil is a dynamic living system and consist of a variety of microflora viz., bacteria, actinomycetes, fungi etc. Modern Agriculture is really associated with the use of different agricultural chemicals. Different classes of pesticides like fungicides, herbicides and insecticides are used in managing different groups of pests to maximize crop production and to meet the demands for higher supplies of food. Total *Rhizobium , Azatobactor pseudomonas* counts generally decreased during the 1 DAS but recovered after 30 DAS. Among the doses tried, application of higher doses of Agrochemicals resulted in lesser *Rhizobium , Azatobactor* and *Psuedomonas* population as compared to lower dose applied at 1DAS. However the microbial population restored by 60 DAS of application of Agrochemicals as the toxic effects of these chemicals was nullified due to degradation in soil.

P5.17. Isolation & characterization of Plant Growth Promoting Rhizobacteria (PGPR) from Groundnut and Cotton Rhizospheres of Saurasharta Region

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Abstract

Plant growth promoting rhizobacteria (PGPR) are known to influence plant growth by various direct or indirect mechanisms. In search of efficient PGPR strains with multiple activities, a total of 25 rhizospheric soil samples were collected from different cultivated crop area of Groundnut & Cotton plants of Saurasharta region. Soil analysis is carried out & total viable bacterial population and total gram negative population in rhizospheric soil were determined. Total 45 Pseudomonas, 30 Bacillus & 45 actinomycetes were screened on King's-B and King's-A, N-agar & Actinomycetes agar respectively. Identification & biochemical characterization is currently undergoing for selected isolates. These isolates were screened in vitro for their plant growth promoting traits like production of indole acetic acid (IAA), hydrogen cyanide (HCN), siderophore production, phosphate solubilization & anti-fungal and anti-bacterial activity. More than 70% fluorescent Pseudomonas produced IAA and solubilization of phosphate was commonly detected in 40% and none of them hydrolyzed chitin. Siderophore production and antifungal activity were exhibited by 25 % isolates. HCN production was more common trait of Pseudomonas (80%). On the basis of multiple plant growth promoting activities, four bacterial isolates were evaluated for their quantitative IAA production, siderophore production, phosphate solubilization, and broad-spectrum (active against two test fungi) antifungal activity and antibacterial activity. Isolates exhibited broad-spectrum antifungal activity against *Aspergillus Spp.* and *Sclarocium Rolfsi* and antibacterial activity against gram-positive bacilli & cocci. Further evaluation of the isolates exhibiting multiple plant growth promoting Rhizobacteria (PGPR) and Biocontrol of fungal infection on soil-plant system is needed to uncover their efficacy as effective PGPR.

P5.18. Copper tolerant rhizobacteria from the industrial belt "Golden corridor of Gujarat" for plant growth promotion in metal polluted soils

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Abstract

Copper at excess concentrations affects plant parameters, microbial biomass, nitrification, ammonification, nitrogen fixation, and also causes community shift in rhizobacterial population. Reduction of plant growth in metal polluted soils is often associated with iron deficiency, ethylene stress, and limited phosphate availability. To cope with these deficiencies, inoculation of efficient Cu tolerant rhizobacteria with multiple PGPR traits can promote the plant growth at elevated concentrations of Cu. Cu-IC_{50} was determined by conventional plating method. Hydroponics was employed for isolation of Cu tolerant rhizobactreia. Isolates were screened for PGPR properties and Cu tolerance. Amplified Ribosomal Dna Restriction Analysis (ARDRA) was used for genetic diversity. *in vitro* plant growth assay (Hydroponics). Cu-IC_{50} value was

found to be higher for Amal khadi soil sample indicating high Cu contamination. By hydroponics a total of 40 Cu tolerant rhizobacteria have been isolated from different polluted sites in the industrial belt. Among these, 14 isolates showed good PGPR traits like IAA production, siderophore production, and phosphate solubilisation. Cu tolerance of the isolates was in the range of 1-2.0 mM. In an *in vitro* plant growth assay, isolates AKHP2, P31,P36 showed enhanced growth of mung bean (*Vigna radiata*) plants in absence and presence of Cu (15µM) by increasing the plant parameters like root length, number of lateral roots and biomass. Pot inoculation studies with efficient Cu tolerant rhizobaceria for plant growth in Cu supplemented conditions will be shown. Among the polluted sites in the industrial area of Gujarat, Amal khadi found to be highly polluted by Cu. Cu tolerant rhizobacteria P31, P36, AKHP2 showed pronounced effect on growth of mung bean plants under Cu stress in *in vitro* conditions.

P5.19. Diazotrophic bacterial diversity and activity in semi-arid agricultural and pristine soils of Mahi river basin, Western India

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Abstract

Diazotrophic bacterial diversity and activity is critical to the maintenance of good soil health. These bacteria influence aboveground ecosystems by contributing to plant nutrition, plant health and soil structure formation. However potential effect of environmental factors and anthropogenic activities, on the diversity and activity of diazotrophs is poorly understood. In the present investigation diazotrophic bacterial diversity and activity in agricultural and pristine soils were compared. Triplicate composite samples from agricultural and pristine soils of same sedimentary origin were collected. Polyphasic approach involving cultural and culture independent methods were employed. Diazotrophs were enumerated and abundant isolates were characterized by Amplified ribosomal DNA restriction analysis (ARDRA) and 16S rRNA gene sequencing. Denaturing gradient gel electrophoresis (DGGE) for community dynamics will be done. Comparatively high amount of diazotrophs with more phenotypic diversity were noticed in a soil under agriculture practice. ARDRA pattern revealed that comparatively high diversity were noticed in agricultural soil than pristine soil. 16S rRNA sequencing of selected isolates shown that most of the agricultural soil isolates are represented under phyla *Proteobacteria, Actinobacteria* and *Firmicutes,* where as in pristine soil, most of them are representative of *Firmicute*s. Based on ARDRA pattern and sequence analysis, it can be inferred that comparatively high diversity of nitrogen fixers are noticed in agricultural soil than pristine soil.

P5.20. Isolation of Chitinolytic bacteria from different Agroclimatic regions of India and Characterization of their PGPR activity, potential in Antifungal Biocontrol

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Abstract

A total 138 bacteria, 54 *Bacillus* sp (B1-B54) and 84 *Pseudomonas fluorescence* (PF1-PF84) were obtained from soil samples collected from the different agro-ecological zones namely North Eastern India (Kaziranga National biodiversity Park and Tea estates of Assam), Sundarban mangrove forests (W.B.), IGP regions (Uttranchal and Uttar Pradesh) for isolation of these bacteria soil samples were analysed by using different selective and semi-selective media *viz:* King's B medium for *Pseudomonas fluorescence* and Methylene Red-Nutrient agar medium for *Bacillus* sp., respectively. For the screening of chitinase producers colloidal chitin agar was maintained as a qualitative analysis, out of these 54 *Bacillus* sp (B1-B54) and 84 *Pseudomonas fluorescence* (PF1-PF84) only 7 isolates were designated from *Bacillus sp*. viz., B-14, 19,39,42,44,50, 51 and 8 isolates from Pseudomonas *fluorescence* viz., PF-1, 3,16,19,24,26,29,48. All these selected isolates showing zones of clearance against the creamy background were regarded as chitinase producing and selected chtinolytic bacteria chosen for further studies. *In vitro* screening of the chitinolytic bacterial isolates for its PGPR chacterization viz., ammonia, siderophore, IAA and HCN production activities were carried out, antagonistic property against *Fusarium oxysproum f.sp.ciceri, Rizoctonia solani* through culture filtrate method respectively. By using these isolates Quantitive estimation of chitinase was also reported by DNS method for potential chitinase producers. Out of the 15-chitinolytic bacteria 7 *Bacillus sp*. and 8 *Pseudomonas fluorescence.* 9 bacteria were found to produce IAA. Isolate B-14 showed the maximum production of IAA both in the presence (1010µg mg^{-1} protein) and absence of tryptophan (784 µg mg^{-1} proteins). All the strains showed positive results for the production of HCN and Ammonia productions; however, B-14 and PF-16, 24 exhibited significantly higher phosphate solubilisation activities in Pikovaskaya's media.60% of the strains were positive in siderophore production. To study the antifungal activity most of the chitinolytic bacterial crude extract was exhibit maximum growth of inhibition against *Fusarium oxysproum f.sp.ciceri* (60-80%), B-14 isolate showed up to 80% of growth inhibition. In the case of *Rizoctonia solani* only few isolates viz., B-14, B-44, PF-16 were showed inhibition of 50-70% respectively. Continued analysis was done for Quantitive estimation of chitinase. One strain of *Bacillus* (SB-14) has produced high amount of chitinase (2.231 IU/ml) using DNS method. This isolate was identified as *Bacillus fusiformis* on the basis of 16 S r -DNA partial sequencing. Further evalution of the isolates exhibiting multiple growth promoting (PGP) traits on soil-plant system is needed to uncover their efficacy as effective PGPR.

P5.21. Accessing actinomycetes from herbal vermicomposts and their evaluation for PGP traits

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Abstract

Role of actinomycetes in plant growth promotion and biocontrol are getting new insights as better alternative for sustainable agriculture production over agro-chemicals. Selection of novel, active actinomycetes can be done by examining microbial rich natural sources like composts and organic amended agriculture soils. Twenty-nine different herbal plants foliage with properties to help manage insect-pests was used to prepare vermicompost in 12-inch diameter plastic pots. Isolated actinomycetes were studied for plant growth promoting traits, biocontrol traits on different media. All these were also screened for anti fungal activity against plant fungal pathogens by using dual culture method. 136 Actinomycetes were isolated, purified and stored in mineral oil for further use. 100 isolates (73%) were recorded as siderophore producers, 51 isolates (37%) were chitinase producers, 72 isolates (53%) were protease producers, and none of the 136 isolates were able to solubilize rock phosphate and tri calcium phosphate. In dual culture conditions 72 isolates (52%) suppressed *Macrophomina phaseolina,* 26 isolates (19%) suppressed *Fusarium oxysporum f. sp. Ciceri*. Composts prepared using widely available herbs can be rich in actinomycetes with agriculturally beneficial traits such as siderophore production, chitinase production, and suppression of disease causing fungi. Some of these isolates were present in large numbers (105 per g compost). Regular and liberal use of composts prepared from these botanicals would highly likely enhance soil health.

P5.22. Stress-Tolerant and Rhizosphere-Competent Plant Growth-Promoting *Acinetobacter rhizosphaerae* Strain BIHB 723 from the Cold Deserts of the Trans-Himalayas

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Abstract

Plant growth promoting rhizobacteria offer an environment friendly means to increasing productivity and sustainability in agriculture. The performance of microorganisms is often limited by the stressful environment which affects their establishment, multiplication and spread through the soil. A phosphate-solubilizing bacterial strain BIHB 723 was identified based on phenotypic characteristics, carbon-source utilization pattern, fatty acid methyl esters analysis and 16S rDNA gene sequence and screened for multiple plant growth promoting attributes, organic acid production, stress tolerance, rhizosphere competence and plant growth promoting activity. The bacterial strain BIHB 723 identified as *Acinetobacter rhizosphaerae* exhibited inorganic and organic phosphate solubilization, IAA production, ACC-deaminase activity, ammonia generation

and siderophore production. HPLC analysis of the culture filtrates during solubilization of tricalcium phosphate, Mussoorie rock phosphate, Udaipur rock phosphate and North Carolina rock phosphate revealed that type and quantity of organic acids produced differed with the nature of phosphate substrate. The presence of indole-pyruvic acid, indole-acetamide, indole-3-lactic acid, indole-3-acetic acid, indole-3-acetaldehyde and indole-acetonitrile in the culture filtrate suggested the synthesis of indole-3-acetic acid *via* two different biosynthetic pathways. The strain also exhibited stress tolerance against temperature, alkalinity, salinity, calcium salts and desiccation as it could grow at 15, 30 and 45°C, pH range of 7-12, 2.5 and 5% NaCl, $CaSO_4$ and $CaCO_3$, and 2.5% $CaCl_2$ and 50% PEG 6000. A significant increase was recorded in growth of the inoculated pea, chickpea, maize and barley under controlled conditions. Field testing in pea also showed significant increment in plant growth and yield. The rifampicin mutant of the bacterial strain effectively colonized the pea rhizosphere without adversely affecting the resident microbial populations. Multifarious plant growth promoting activities, stress tolerance and high rhizosphere competence suggest potential for application of *A. rhizosphaerae* strain BIHB 723 as a bioinoculant for sustainable agriculture.

P5.23. Selection of Widespread Genotypes of Pea Root-Nodulating Bacteria with Plant Growth Promoting Activity from the Cold Deserts of the Indian trans-Himalayas

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Abstract

The bacteria capable of eliciting nitrogen-fixing nodules in leguminous plants, collectively known as rhizobia, belong to at least 15 genera and 50 species. Symbiosis between leguminous plants and rhizobia is of considerable agricultural importance. These nitrogen-fixing bacteria, directly or indirectly stimulate plant growth, have been targeted as the potential plant growth promoting rhizobacteria. Pea root-nodulating bacteria were isolated on Yeast extract Mannitol agar from the root nodules of pea collected from different locations of the cold deserts in Lahaul and Spiti district in the Indian trans-Himalayas. The isolates were screened for plant growth promoting attributes of phosphate solubilization, production of IAA-like auxins and siderophore, and root nodulation. Selected isolates were tested for quantitative estimation of inorganic phosphate solubilization, production of IAA-like auxins, ACC deaminase activity and productivity improvement in pea. Variability in the 16S rDNA of isolates was explored by ARDRA and 16S rDNA sequence of representative strains of rDNA types was elucidated. Twenty-four potential isolates were selected out of 120 on the basis of different plant growth promoting attributes. All isolates were positive for the solubilization of tri-calcium phosphate, production of IAA-like auxins and siderophore, and ACC deaminase activity. Fourteen isolates exhibited significant increase in the yield under micro plot evaluation. Genetic diversity of the root-nodulating bacteria using ARDRA placed the bacterial isolates into 21 rDNA types. Sequence analysis of 16S rDNA of the 19 representative strains showed identity with *Rhizobium leguminosarum*, one strain with *Rhizobium giardinii* H 152 and one strain with *Rhizobium etli* CIAT 652.

Work has led to the selection of the most widespread rDNA type with multiple plant growth promoting attributes as a candidate strain for broad-spectrum application as a microbial inoculant.

P5.24. Plant growth promotion by *Pseudomonas lurida* (MTCC 9245) a psychrotolerant bacterium from the Uttarakhand Himalayas

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Abstract

Pseudomonas lurida is a rhizospheric fluorescent pseudomonad that was first reported from Germany in 2007. Little is known about the occurrence, diversity of this bacterium outside the European continent and its utility in agriculture. A fluorescent rhizospheric bacterium was isolated from a high altitude grass rhizosphere (2500 amsl, Pithoragarh district of Uttarakhand), on nutrient agar at 4ºC. The identity of the isolate was determined by biochemical characterization and sequencing of the 16S rRNA (1430 bp). The plant growth promotion traits of the bacterium *viz.,* P solubilization, and IAA and siderophore production were determined under *in vitro* conditions. Its ability to influence plant growth was determined by a pot culture study with wheat seedlings (cv. VL 804) at 19°C under controlled conditions. The bacterium was identified as *P.lurida,* since it shared 100% identity with sequences of *Pseudomonas lurida* available in the NCBI database. It grew and expressed all plant growth promotion traits at 4, 15 and 30ºC. Seed bacterization with the isolate significantly improved the root length (51.3%), shoot length (11%) and dry biomass (50%) of 30 day old wheat seedlings, over the uninoculated control. *P.lurida* is a novel plant growth promoting bacterium, which can positively influence the growth of wheat seedlings. Its utility as an inoculant for winter season crops requires further validation under field conditions.

P5.25. Influence of cultivation practices on phenotypic and genotypic diversity of antagonistic rhizobacteria isolated from soybean (*Glycine max* L.)

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Abstract

The goal of this study was to study the effect of traditional and modern cultivation practices on the abundance and diversity of total population of culturable rhizobacteria which antagonized the soil borne pathogen *Sclerotinia sclerotiorum*. In addition to soil and plant type, cultivation practices are known to influence the community structure of bacteria associated with the roots of plants. Samples of rhizospheric soil were taken at different stages of plant growth (seedling, nodulation, maturation, harvesting and post harvesting stage). Traditional practice of cultivation involved the application of organic manure/vermi-compost while modern system of cultivation was based on the use of commercially available inorganic chemical fertilizer as nutrient supplement. Following *in vitro* antagonistic screening, the potential antagonists were studied for phenotypic and genotypic diversity. A total of 6,787 bacterial isolates which represented 420

bacterial morphotypes, were obtained from the rhizosphere and rhizoplane/endorhizosphere of soybean at different stages of growth. Among these, 83 strains showed considerable antifungal activity against the fungal pathogen following *in vitro* dual plate assay. 58 strains from traditional system while only 11 strains of modern system among the total antagonists exhibited protease activity while none of the antagonists was found positive for chitinase production. Cellulase and pectin degradation potential was observed for only 43 antagonists of which 36 strains were those obtained from traditionally grown crop and 7 were from modern cultivation practice. Siderophore production was reported for 49 antagonists. Likewise, a major proportion of these antagonists was recovered from traditionally grown crop and only 9 strains from modern system could account for this property. Samples obtained from traditionally cultivated crop exhibited a great deal of phonetic. This study is supported through Acharya PC Ray Fellowship to BNJ from MP Council of science & Technology and functional diversity than crop samples cultivated following modern practice. Significant variations were observed both in the abundance and diversity of antagonists obtained separately following traditional and modern cultivation practices. Traditional system employing vermicompost was found to support more abundant and diverse population of antagonistic rhizobacteria in soybean cropping.

P5.26. Isolation, characterization and efficacy testing of *Acetobacter* and *Azospirillum* isolates on maize (*Zea mays L.)*

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Abstract

Endophytic bacteria *viz. Acetobacter* and *Azospirillum* residing within living plant tissues without substantially harming plants have found a large number of applications in today's agriculture such as nutrient cycling, tolerance to biotic and abiotic stress as well as promotion of plant growth. In present study, endophytic bacteria mainly belonging to genera *Acetobacter* and *Azospirillum* were isolated from surface sterilized plant parts of species *Cynodon dactylon* (Durva), *Pothos scandens* (Money plant), *Ipomea batata* (Sweet potato), *Saccharum officinarum* (Sugarcane) *cv.* CO.LK-8001 and CO.-84135, *Musa paradica* (Banana) and *Zea mays* (maize) *cv.* GM-6 by using LGIP and NFB selective media, respectively. All the isolates can colonize maize endophytically under laboratory conditions, where in isolate A-5 found best. *In vitro* nitrogen fixation rates of all the isolates ranged from 4.0 to 36.3 mg N fixed / gm of sugar consumed. All the isolates were also capable of solubilizing tri calcium phosphate in Pikovskaya's broth and the rates. Seed and soil inoculation of all the isolates significantly influenced growth of maize *cv.* Narmada moti in pot experiment during Kharif 2008 and yield of maize *cv.* Narmada moti in field experiment. Among all isolates, A-10 was found superior over all other isolates. However, seed inoculation was giving better results than soil inoculation.

P5.27. Isolation and Characterization of Chitinolytic Rhizobacteria for the Management of Fusarium Wilt in Tomato

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Abstract

Vascular wilt caused by *Fusarium oxysporum* f. sp. *lycopersici* is an important disease of tomato (*Lycopersicon esculentum* Mill.), which causes great loss, depending upon the cultivar and the environmental conditions. Currently many harmful chemical fungicides are in use, biological control of Fusarium wilt using chitinolytic rhizobacteria can offer a potential alternative to chemical fungicide. Chitinase producing rhizobacteria (CRB) were isolated from rhizospheric soil collected from tomato growing regions of Karnataka. Chitinase was purified (Ammonium sulfate precipitation, DEAE-Cellulose ion-exchange chromatography and sepahdex G-100 gel filtration.) and characterized from effective strain and was used to manage the Fusarium wilt under greenhouse conditions. Sixty three CRB isolates were isolated from 57 rhizospheric soils. Thirteen CRB isolates were selected based on their ability to produce chitinase, root colonization, to increase the seed quality parameters under laboratory conditions and reduce Fusarium wilt incidence under greenhouse conditions. Isolate CRB20 significantly reduce the Fusarium wilt incidence and purified chitinase from CRB20 was 40 KDa, estimated by a sodium dodecyl sulfate polyacrylamide gel electrophorosis, and was confirmed by active staining with calcofluor white MR2. Chitinase was optimally active at pH of 4.5 and at 30°C. The enzyme was stable for pH 3.5 to 7.0, and up to 40°C. Among the metals and inhibitors that were tested, the Hg^{+} and Hg^{2+} completely inhibited the enzyme activity. The chitinase activity was high on colloidal chitin, glycol chitin and chitooligosaccharide. Under greenhouse conditions, significantly enhanced control of Fusarium wilt was recorded in seedlings grown from seeds pretreated with CRB20 followed by chitin application with respect to CRB20, chitinase and chitin alone.

P5.28. Survival of the rhizosphere-competent biocontrol strain *Pseudomonas fluorescens* NBRI2650 in the soil and phytosphere

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Abstract

Pseudomonas fluorescens NBRI2650 was isolated after screening 360 bacterial strains from the rhizosphere of chickpea (*Cicer arietinum* L.) grown in fungal-disease-suppressive field soil. The strain was selected because of its high rhizosphere competence and ability to inhibit the growth of *Fusarium oxysporum* f.sp. *ciceri, Rhizoctonia bataticola*, and *Pythium* sp. under in vitro conditions. Survival and colonization of NBRI2650 in the phytosphere of chickpea, cotton (*Gossypium hirsutum* L.), cucumber (*Cucumis sativus* L.), and tomato (*Lycopersicon seculentum* Mill.) were monitored using a chromosomally located rifampicin-marked mutant *P. fluorescens* NBRI2650R. The strain showed variable ability to invade and survive in the phytosphere of different plants. Chickpea was used as a tester plant for further work, as it was not invaded by NBRI2650R. The interaction between NBRI2650R and *F. oxysporum* f.sp. *ciceri* was studied by both light microscopy and scanning electron microscopy. The lysis of the fungal cell wall by

NBRI2650R was clearly demonstrated. Treatment of the chickpea seeds with NBRI2650R in prerelease experiments in the greenhouse using disease-conducive field soils from Jhansi and Kanpur resulted in increased plant growth and did not result in any perturbation of the indigenous microbial community that inhabited the rhizosphere of chickpea compared with nonbacterized seeds. Direct fermentation of diluted NBRI2650R on vermiculite without the need of expensive fermentors offers a reliable process for manufacturing bacterial inoculants in developing countries. Under field conditions, the horizontal and vertical movement of NBRI2650R was restricted to 30 and 60 cm, respectively, and the strain could not survive in the field during the 7 months before the chickpea could be planted for next cropping season. Field trials conducted at Jhansi, Kanpur, and Pantnagar resulted in higher grain yield increase in the bacteriatreated seed compared with the nonbacterized control. Seed and furrow treatment of the two chickpeas ('Radhey' and 'H-208') at Pantnagar resulted in significantly (P = 0.05) greater seedling mortality in nonbacterized seedlings compared with bacterized ones. The seed dry weight and yield for each variety were also significantly higher in bacterized seedlings than in nonbacterized ones. The population of NBRI2650R persisted throughout the growing season of chickpea in the range of 5.4–6.4 log10 CFU/g root.

P5.29. Preliminary screening of PGPR isolates from rhizosphere soils of indigenous rice plant *(Oryza sativa)* of Manipur

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Abstract

PGPR have shown great promise in agriculture promoting plant growth and disease suppression. Recently, the term PGPB has encompassed both direct growth promoting and biocontrol PGPR groups. Intensive research on PGPB is underway worldwide for developing biofertilizers and Biocontrol Agents (BCAs) as better alternatives to the chemical fertilizers and pesticides, as the latter harm the environment and human health. However, most PGPBs don't realize their commercial potential due to inconsistent performance in the field conditions. In this context, isolation and screening of efficient native strains suited to local conditions is of prime importance. Manipur (Indo-Burma Hotspot) holds promise for the search of such microbial agents. 0.1ml aliquots of serially diluted rice rhizospheric soil suspensions (Black & sandy soil, local rice cultivar *Thesa*, Chadong, Ukhrul, Manipur) with or without heat treatment (80^0C, 15 min) was spread plated on King's B (KB) medium (no heat treatment) and Nutrient Agar (NA) medium(heat treatment) and incubated at 28^0 C. 14 morphologically distinct KB and 10 NA isolates were subcultured to obtain pure culture and the pure cultures were preserved for further studies (agar slants, 4^oC). Important rice fungal pathogens (*Curvularia oryzae*, MTCC 2605 and *Fusarium oxysporum*, MTCC 284) were chosen as indicator strains for preliminary biocontrol screening by **dual culture method**. Potential biocontrol strains were streaked in circular patterns on PDA plates and a filter paper disc(6mm diameter) dipped in the fungal culture broth was placed at the centre and incubated at appropriate temperatures (*C. oryzae*, 28^oC, 5-7 days and *F. oxysporum*, 24^oC, 5-7 days, under moist conditions). Plates with fungal discs without the bacterial isolates were kept as controls. The radii of the fungal colony towards and away from the bacterial colony were measured. Out of 14 bacterial isolates (CHDR 1-14), isolated on KB medium, 7 isolates (CHDR 3, 4, 5, 7, 8, 9 and 12) inhibited *Curvularia oryzae* and 4 isolates (CHDR 3,4,10 and 12) inhibited *Fusarium oxysporum*. Out of 10 NA isolates (CHDHR 1-10),

CHDHR 5 and CHDHR 9 were antagonistic against *Curvularia oryzae*. None of the NA isolates (putative *Bacillus* strains) inhibited *Fusarium oxysporum*. Our results from survey of just a single site in Manipur shows promise. In particular, CHDR 12 showed inhibition against the mycelial growth even after 15 days of incubation, when other bacterial isolates were overgrown by the mycelia. Some other PGPR isolates also showed significant activities. Further studies on these sites and extending it to further sites may lead to development of promising BCAs for rice, which is a major crop in Manipur. The detailed results of this preliminary survey of PGPR bacteria in Manipur will be presented in this paper.

P5.30. Preliminary characterization of PGPR strains isolated from rhizospheric soils of Manipur.

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Abstract

Plant Growth Promoting Rhizobacteria (PGPR) have shown great promise in agriculture. PGPR strains are studied worldwide for developing biofertilizers and biocontrol Agents (BCAs) as better alternatives to the chemical agents. Towards the development of BCAs for rice, we have been surveying rice rhizospheres in Manipur. In this context, native PGPR isolates from a rice rhizosphere were subjected to detailed bioactivity screening and phenotypic characterizations were performed for the promising isolates. Towards this objective of developing bioinoculants for agricultural crops especially rice, we screened indigenous rice rhizospheric isolates for biocontrol activities against selected rice pathogens. 4 promising strains CHDR 4, CHDR 12, CHDHR 5 and CHDHR 9 were obtained from a sample in Chadong Village of Ukhrul District, Manipur. Antagonistic activity was assayed by the **dual culture method**. Amongst several Kings B isolates, CHDR 4 and CHDR 12 showed the highest activities. **CHDR 12** showed inhibition of 69% and 25% and **CHDR 4** 30% and 47% respectively against *Curvularia oryzae* and *Fusarium oxysporum*. 2 out of several NA isolates (CHDHR strains) exhibited potent antagonistic potential. **CHDHR 5** and **CHDHR 9** exhibited 53% and 50% inhibition respectively against *Curvularia oryzae* but none of them were antagonistic against *Fusarium oxysporum.* Detailed results of the bioactivity screening of these potential biocontrol PGPR strains and their phenotypic characterization will be presented in this paper.

P5.31. Rational Utilization of Water Resources for Sustainable Agriculture in India

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Abstract

The word Sustainable agriculture refers to the ability of a farm to produce food indefinitely, without causing severe or irreversible damage to ecosystem health. This is a special kind of agriculture along with farming technique, which makes maximum utilization of the environment

without causing any form of harm to it. The outputs from this Sustainable Agriculture are devoid of any types of inorganic chemicals such as pesticides and insecticides. This farming technique uses the organic way of farming. All these factors produce the products in a more environment friendly manner and are thus healthier for the consumers to consume. More mouths mean more water for drinking; greater population densities require more water for sanitation; while industrialization has raised the thirst for water from manufacturing and commercial sectors. Environmental flows to replenish depleted water resources are being utilized in a number of developed countries, and in some developing countries. The resulting total of these demands is far greater pressure on water resources and water users. Food and agriculture are the largest consumers of water, requiring one hundred times more than we use for personal needs. Up to 70 % of the water we take from rivers and groundwater goes into irrigation, about 10% is used in domestic applications and 20% in industry. Currently, about 3600 km3 of freshwater are withdrawn for human use. Of these, roughly half is really consumed as a result of evaporation, incorporation into crops and transpiration from crops. The other half recharges groundwater or surface flows or is lost in unproductive evaporation. Up to 90% of the water withdrawn for domestic use is returned to rivers and aquifers as wastewater and industries typically consume only about 5% of the water they withdraw.

P5.32. Culturable endophytic bacterial community in root interior of moso bamboo (*Phyllostachys edulis)* plants

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Abstract

Bamboos are one of the most important forest resources on earth and have some special biological characteristics: a member of *Poaceae* but most of them are woody plant, fast growing, and few of diseases or pests. Moso bamboo (*Phyllostachys edulis*) is the most important bamboo species in China, where it covers about 30,000 km^2. Until now, little is known about the endophytic bacteria and the effects of their association with moso bamboo plants. The culturable endophytic bacterial community in root interior of moso bamboo (*Phyllostachys edulis*) plants was investigated by amplified ribosomal DNA restriction analysis (ARDRA) and 16S rDNA sequencing. The cultivable endophytic bacteria recovered from fresh roots were 1.95×10^6 (KB) and 1.68×10^6 (LB) colony-forming units per gram fresh weight (cfu/g fw). A total of 66 bacterial strains with different colony characteristics were isolated. Among 66 isolates, 18 OTUs (Operational Taxonomic Units) were identified based on the similarity of the ARDRA banding profiles. Sequence analysis revealed diverse phyla of culturable endophytic bacteria in moso bamboo roots, which consisted of the various subclasses of Proteobacteria: Alphaproteobacteria (71.2%), Betaproteobacteria (1.52%) and Gammaproteobacteria (7.58%). Other isolates belonged to Bacteroidetes (9.09%), Actinobacteria (7.58%), and Firmicutes (3.03%). The majority of root endophytic bacteria were Alphaproteobacteria, the most dominant genera was *Rhizobium*. Several potential novel bacterial genera and species were found. The results show that the population diversity of culturable endophytic bacteria was abundant in roots of moso bamboo plants.

Poster session:
Commercialization, Regulatory issues, Trade barriers in PGPR, Human resource development and Transfer of technology

P6.1. Commercialization strategies for PGPR products

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Abstract

Globally, decline in productivity of soil and crops are witnessed on account of continuous cultivation, soil-degradation and unbalanced applications of fertilizers. PGPR play an important role to increase the productivity by providing the required balance. However, PGPR products face number of challenges towards commercialization and regulatory approvals. The commercialization of PGPR based bio-products and formulations can be carried out by effective establishment and standardization of sequential steps, such as - bio screening, formulation development, field applications, manufacturing, storage stability and toxicity. Though PGPR have been referred, identified and mentioned as environmental friendly for sustainable agriculture, the regulatory authorities in various countries continue to treat these products similar to single molecule based chemical pesticide products; without waivers. This necessitates large investment in physio-chemical, toxicological, bio-efficacy and environmental data generation through GLP laboratory studies. However, the functional properties with respect to PGPR are mostly dependent upon multiple active bio-molecules resulting in; better plant health, vigor and productivity. Hence, there is a need to re-look at regulatory framework and policies; to exploit the said potential for productivity improvements in agriculture. Product development and commercialization of PGPR in Agriculture requires integrated management as it involves several functional agencies such as farmers, researchers, process technologists, regulators, certification and inspection agencies, formulators, and experts in international marketing.

P6.2. Development of commercial formulations of certain PGPR bacteria and fungi

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Abstract

A fly ash based immobilizing material was invented to prepare commercial formulations of *Bacillus subtilis*, *Pseudomonas fluorescens*, *Trichoderma harzianum* and *T. virens*. The mass culture or stock culture of the PGPR fungi and bacteria was prepared on sawdust-soil-5% molasses material mixed in the ratio of 15:5:1. The immobilization of the PGPRs was done on a mixture of fly ash, soil (loam) and 5% molasses (15:3:1) plus 10 mg chloramphenicol/kg material for *T. harzianum* and *T. virens* or 45 mg novobiocin, 44.9 mg penicillin and 75 mg cycloheximide/kg formulation for *B. subtilis* and *P. fluorescens*. Fifteen parts carrier (fly ash) and one part stock culture of the PGPRs was used to prepare the formulation for *B. subtilils* and *P. fluorescen*s. The formulation was packed in polypacks of varying size. The shelf life test of the four formulations was tested at five temperature regimes i.e., 5°C, 10°C, 15°C, 25°C and ambient for six months (Feb-July). The PGPR fungi and bacteria remained viable in the formulation during storage and also multiplied, evidenced by a greater CFU load. During storage at ambient temperature, the CFU count of *T. harzianum* and T. virens increased significantly in comparison

to other temperatures, next was 25°C. Greatest CFU load/g formulation of *T. virens* (10^9) and *T. harzianum* (10^{10}) was recorded during 4 to 16 weeks. Beyond 16 week the CFU count tended to decrease but it remained greater than the prestore count. The CFU count of *P. chlamydosporia* in the formulation reached a peak (3-4 x 10^9) at 10th or 12th week at 25°C or ambient temperature. The CFU count of PGPRs in the formulation was greater during 16-24 weeks and reached a peak of 1-3 x 10^{14} (*P. fluorescens*) and 4-6 x 10^{12} (*B. subtilis*) at 19 - 20th week at 25°C or ambient temperature. Production cost of the formulation has been estimated as Rs 25/Kg soil.

P6.3. Efficacy of talc based formulation of *Pseudomonas fluorescens* for the management of foliar blight of wheat and sheath blight of rice

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Abstract

Talc based formulations of selected isolate of *Pseudomonas fluorescens* (Pf2) were developed singly and mixed with a compatible isolate of *Trichoderma harzianum* (Th38) to observe its efficacy against foliar blight of wheat (var. HD 2329 and PBW 502) as well as sheath blight of rice (var. PAU 201 and PR 116). The observations pertaining disease incidence, intensity and plant growth were recorded thrice during crop season. The combined formulation of Pf2 and Th38 was most effective to reduce the foliar blight in wheat as well as the sheath blight in rice. The treatment also gave maximum plant growth in terms of root; shoot lengths and dry contents per plant in both wheat and rice.

P6.4. Synergistic action of plant growth promoting rhizobacteria and biopolymer seed priming effectively stimulates immunity against pearl millet downy mildew disease

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Abstract

Application of beneficial microorganisms particularity plant growth promoting rhizobacteria to seeds that promote plant growth and plant health is well established. The application of beneficial microorganisms to seeds during priming enhances the efficiency of PGPR seed treatment. Plant based gum exudates are excellent biopolymers which contain plant growth regulating hormones with enormous therapeutical potential without any side effects. Previously we have showed that PGPR strain *Bacillus pumilus* INR-7 effectively induces resistance against pearl millet downy mildew disease. Also we have reported that certain plant based gums derived from *Accacia arabica*, *Moringa oleifera, Carica papaya*, and *Azadirachta indica* also enhance the efficacy of metalaxyl for controlling pearl millet downy mildew disease. In this study we report here that the synergistic application of biopolymer gum coating followed by PGPR coating to pearl millet seeds effectively induces resistance against pearl millet downy mildew disease. Biopolymer coating enhanced the efficacy of both PGPR and also the chemical metalaxyl significantly under

both greenhouse and field conditions. Biopolymer coating along with PGPR coating significantly improved pearl millet seed quality, growth parameters of pearl millet, and downy mildew disease resistance to *Sclerospora graminicola* in comparison to seed treatment with biopolymers or PGPR alone. *Acaccia arabica* and *Azadirachta indica* gum as biopolymers alone and also along with *Bacillus pumilus* INR 7 showed higher seed germination of 95 %. Seed priming with biopolymers alone recorded varied disease protection levels when compared to control. *A. arabica* and *A. indica* gums along with *Bacillus pumilus* INR-7 was best by offering significant disease protection of 79 % in addition to significant growth enhancement. Advantage of synergistic action of priming with biopolymers, PGPR and their combination in comparison to chemical controls is discussed.

P6.5. Understanding Environment Management Practices

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Abstract

Historically, development strategies ignored the effect of economic activity on environment. Few decades ago also have been marked by intensification spreading of pollution. Evidence of environmental changes world-wide indicates that humankind cannot continue its development path at the expense of nature. Realizing that there are so many negative impacts of unstable environment , people are starting to be aware on the importance of preserving it. They are now demanding for better quality of living. Thus, the implementation of sustainable development is very important to, meet such requirement. The Indian industry is showing pleasant signs of a shift that is more towards voluntary initiative, complementing the Command and Control regime, thus integrating environmental protection and pollution control with the business philosophy. The positive response received by the multi sectoral environmental performance evaluation/rating and public disclosure program from the Indian industry proved that it is a step forward in improving the environmental compliance performance of companies and encouraging proactive approaches. The developing world countries have experimented with the idea of implementing the ratings and public disclosure as a complementary mechanism to pollution control to strengthen the existing command and control regime and have succeeded to a fair extent. Maintaining a balance between economic growth and a healthy environment is a major challenge facing developing countries such as India. To meet this challenge India will need highly effective and efficient regulatory institutions to monitor, regulate and control pollution, especially from industry, which is a significant contributor to the overall pollution load. The current regulatory system- has inherent limitations of structure and resources to effectively control industrial pollution. According to R.Daniel (1992), if growth, which implies an increase in size is a quantitative phenomenon, development, which implies a realization and enhancement of potentialities, is a qualitative phenomenon. Recently, rapid industrialization, urbanization and other technological developments have exploited the available resources to a larger extent. This has caused serious scarcity of important natural resources. It has contaminated air, water and soil quality, and therefore has interfered with the basic needs of society. The public knowledge of environmental performance has important implications for companies sensitive about their reputation. Social and market pressure could generate strong incentives to comply with environmental regulations. A detailed accounting of multi-dimensional analysis of process and pollution data divides industrial firms' environmental performance into five symmetric color-coded rating categories, from best to worst- GOLD,GREEN,BLUE,RED and BLACK. Internationally, Environmental Performance

Rating and Public Disclosure Project has been of immense potential to reduce pollution load on the environment. This evaluation offers simple benchmarking of companies, both within the sector as well as across the sectors. The unsustainable lifestyle leading to unsustainable consumption of natural resources damaging ecosystem essential for sustainable agriculture, have resulted in humankind reaching the crossroad in relation to its future. The ultimate goal of The National Policy on the Environment is to attain sustainable development, which embodies the pillars of economic development, social development and environmental protection. Since all the pillars are integrated, sustainable development cannot be achieved if one of the pillars were compromised. The prime objective of implementing an Environmental Management Practice (EMS) is to improve the organization's environmental performance continuously. There are a lot of benefits will be gained from successful EMS implementation which include reduced cost in pollution prevention activities, compliance with regulatory requirements and better organizational image among others. The goal of ISO 14000 is to prevent pollution at the source and to achieve continual improvement of the environmental performance of organization and built on the "Plan, Do, Check, Act" model. Installing the "Cleaner Production" inside firms will give advantages from two visible aspects, which are internal and external. Internal including the aspect of economic usefulness and the external is the environmental protection and preservation. An environmental programme is a set of specific objectives and measures for improving the environmental performance of a company. It must define the means, schedule and responsibility at each relevant function and level to achieve the objectives and targets. Environmental indicators are yardstick for sustainable development. It plays important role in national economy. The sustainable development should be free of environmental degradation and a balance between the demands of economic development and the need for protection of the environment should be attempted. The indicators should be simple, easy to interpret and be national in scope. The population growth of the twentieth century and the injudicious use of new technologies will place unprecedented burdens on food, energy and environmental needs in the new century. The new biotechnology appears to offer viable and technically feasible solutions to these problems, but the products and processes need to be monitored locally, regionally and internationally for hazards that may be as yet unknown. Although the new biotechnology offers food and environment security at the international level, like any new technology, it can be expected to affect international trade. Biotechnology is used to assess the state of ecological systems, transform pollutants into benign substances, generate biodegradable materials from renewable sources and develop environmentally safe manufacturing and disposal processes. The benefits of biotechnology are many and include providing resistance to crop pests, improve production and reduce use of toxic chemical pesticides, thereby making major improvements in food quality and environmental protection. Industrial processes where biotechnology can play a major role are agricultural processing, fertilizer, refinery and petrochemical, food, pharmaceutical, chemical, plastics, textile, paper, dyes, perfumery etc. Industrial and environmental biotechnology has unparalleled promise for the next phase of Sustainable Development. "To meet the needs of the 8.3 billion people projected to be on this planet in 2025, the genetic improvement of food crops must include both conventional technology and biotechnology" commented Dr. Norman Borlaug, the 1970 Nobel Peace Prize Laureate. Restoring the quality of the environment and safeguarding it from further degradation is another major task to be undertaken with the support of biotechnology and chemical engineers world over have a major responsibility to carry out this great mission. The advances in biotechnology could be utilized to provide future technologies for environmental clean up and sustainable development. Environmental pollution is a global problem and a growing concern, so there is a need to create mass awareness by educating common people about the devastating consequences of environmental pollution. A consolidated approach supported with technical personnel would certainly be able to meet the environmental challenges in the new millennium by utilizing the resources and opportunities available. The loss of biodiversity poses one of the greatest challenges to the world community and the conservation

of the biodiversity by bringing awareness through eco-education is imperative for sustainable utilization of plant wealth resources.

P6.6. Development of bacterial consortium to alleviate high temperature stress in sorghum seedlings

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Abstract

Soil acts as a habitat for diverse group of microorganisms. Rhizosphere region of the soil enriched by plant root exudates, attracts a variety of microorganisms. Under these conditions the microorganisms are positioned in a heterogeneous environment and a strong interaction prevails between the group of microorganisms colonizing the rhizosphere region and plant root. Mixed inoculants that interact synergistically act as consortium are currently being devised, which yield better results. The present study was conducted to investigate the effect of microbial consortium and individual bacterial strains viz, *Pseudomonas aeruginosa*, *Pseudomonad putida*, *Bacillus subtilis* and *Bacillus amyloliqueficans* on sorghum seedlings under elevated temperature stress. The bacterial strains were grown as individual or consortium and studied for growth profile, IAA, GA, HCN, Ammonia, Siderophore production and P-solubilization. The consortium and the individual strains were tested for their ability to alleviate high temperature stress (50^0C) effect in sorghum seedlings in sterile soil conditions. The PGPR activities increased in mixed cultures when compared to individual cultures. Through this study we have identified, the bacterial consortium enhanced the plant growth and survival under elevated temperature up to 18days compared to individual strains. The application of bacterial consortium influenced the seedling growth through production of total sugars, amino acids, proteins, proline, chlorophyll content, reduced membrane injury and expression of high molecular weight proteins under elevated temperature. We hypothesized that bacterial consortium influenced plant growth positively by a multitude of synergistic mechanisms under heat stress when compared to single strain inoculation.

P6.7. Evaluation of Vermicasts of *Eudrilus eugeniae* (Kinb.) as Carrier Material for Biofertilizers

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Abstract
Vermicasts are pellet like excretory product of earthworms, which contain available NPK and plant growth promoting substances. Traditionally, materials like lignite, charcoal and vermiculite are very widely used as carrier materials for biofertilizers in India. So far, no study is available on the utilization of vermicasts as carrier materials for biofertilizers. Vermicasts of *Eudrilus eugeniae* were prepared using biogas slurry. Lignite (control) and powdered vermicasts were mixed in various proportions (vermicompost : lignite), 0:1,1:1, 2:1, 3:1, 4:1, 5:1, 6:1 and 1:0. The cultures of *Azotobacter chroococcum* and *Rhizobium leguminosarum* were mass multiplied and mixed with carrier materials ($1x10^8$) and packed. The carrier material was subjected to the viability analysis once in a month for a period of ten months by using spread plate technique. The populations of $1x10^7$ viable cells of *A.chroococum* and *R.leguniosarum* were observed in the carrier material up to 10 months of storage period where as lignite carrier material showed $1x10^5$ viable cells. The viable cells of *A. chroococcum* were observed up to 4th, 6th and 9th months respectively in 0:1, 1:1 and 2:1 combination of vermicasts and lignite. Though the number of viable cells decreased towards the subsequent months, the carrier material mix with higher proportion of vermicasts (3:1, 4:1, 5:1, 6:1 and 1:0) sustained $1x10^7$ cells. It is evident from the present study that the vermicasts of *E. eugeniae* supports the survival of the biofertilizers and hence can be used as carrier material for biofertilizers.

P6.8. Optimization of culture medium supplemented with vermicompost extract for mass multiplication of *Azosprillum braziliense* (MTCC 4036)

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Abstract

Vermicompost is the stable fine granular, nutrient rich organic matter produced by the combined action of earthworms and microorganisms through the process of vermicomposting. Vermicompost has been widely used to improve crop growth, yield and soil fertility. Thus far no study is available on the use of vermicompost extract as media supplement for biofertilizers. Vermicompost for the study was produced from biogas slurry using the earthworm species, *Eudrilus eugeniae* for 30 days. Bromothymal Blue (BTB) broth was supplemented with different levels (0-100%) of vermicompost extract (1:2 w/v with distilled water) for the mass multiplication of *Azospirillum braziliense* which was procured from IMTECH, Chandigarh (MTCC 4036). Growth of *A.braziliense* was assessed at regular intervals by direct plate count method. The vermicompost extract at the rate of 90% supplementation with BTB showed vigorous growth of *A.braziliense* from second day ($55x10^7$ CFU/ml) to fifth day ($115x10^7$CFU/ml) of incubation, while in BTB the growth was found to be comparatively very low (day 2: $15x10^7$ CFU/ml; day 5: $40x10^7$CFU/ml). The population count in 90% vermicompost extract supplementation was significantly different from that of BTB ($p<0.001$). From 10% vermicompost extract supplementation up to 90% supplementation with BTB showed increasing

trend, but in 100% supplementation, the growth of *A.braziliense* was found to decrease (day 5: $100x10^7$ CFU/ml). However, the difference between the colony forming units (CFU) observed for 80, 90 and 100% vermicompost extract supplementation did not differ significantly. The supplementation of BTB broth with 80-90% vermicompost extract best supported the growth of *A.braziliense,* hence this combination can be used for mass multiplication.

P6.9. Plant growth promoting microbial consortial formulations (talc/liquid) mediated biological control of sunflower necrosis virus disease under natural field conditions

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Abstract

Sunflower necrosis virus disease (SNVD) is severely affecting sunflower cultivation in India with disease incidence up to 90%. Biological control is the best option for managing SNVD as no other effective methods are available. In the present study, powder and liquid formulations of *Bacillus licheniformis* MML2501 (*Bl*), *Streptomyces fradiae* MML1042 (*Sf*), *Pseudomonas aeruginosa* MML2212 (*Pa*) and *Bacillus* sp. MML2551 (*Bsp*) were developed individually and evaluated as three (*Bl* + *Pa* + *Bsp*) and four cultures (*Bl* + *Sf* + *Pa* + *Bsp*) consortia against natural SNVD in the farmers' field. These formulations as consortia remarkably enhanced the plant growth and reduced SNVD there by increasing the seed yield. SNVD reduction was estimated up to 51.4% and 40.9%, due to four cultures consortium of liquid and powder, respectively formulations compared to control. Further, it significantly increased the yield parameters than the other treatments. Liquid formulation of four cultures consortium registered an additional seed yield of 936 kg/ha with an additional income of Rs. 12168/ha whereas, talc formulation registered an additional seed yield 840 kg/ha with an additional income of Rs. 10920/ha compared to control. The results of field experiments clearly demonstrated that the both the four cultures consortium formulations consisting of *Bl* + *Sf* + *Pa* + *Bsp* could be used for the effective control of SNVD.

P6.10. Growth, shelf life And Bioefficacy Of Liquid Inoculants (PSB, *Azospirillum* spp And *Azotobacter* spp) Formulated With Polymeric Additives

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Abstract

The present study was conducted to evaluate the effect of five different additives viz., Poly vinyl pyrollidine (PVP), Poly vinyl alcohol (PVA), Poly ethylene glycol (PEG), Sodium alginate and Gum Arabic for their ability to support growth, shelf-life stability and bioefficacy of bioinoculants (*Bacillus megatherium var phosphaticum*, *Azospirilum brasilense* and *Azotobacter chrococcum*). The interaction between strains of bioinoculants and the additives in relation to cell survival varied with the concentration of additives. The cell population in media amended with

different additives was slightly less when compared with the growth on un-amended media. The shelf-life of liquid inoculant formulations depended on the strains, additives and storage temperature. Liquid inoculants formulated with 2% PVP promoted long-term survival of PSB, *Azospirillum*, and *Azotobacter* with 2.1 x 10^7, 3 x 10^8 and 2.1 x 10^7 respectively after 480 days of formulation when stored at 30^0C. PVP also provided better survival rate (10^5 cells/seed) after 48 hours of application to the seed surface followed by incubation at 30°C. The surviving population was 10^4-10^5 cells/seed in liquid inoculants formulated with gum Arabic and sodium alginate whereas with PEG and PVA additives, cell numbers fell to 10^2-10^3 cells/seed after 48 hours of inoculation. Formulated bioinoculants were tested for their ability to promote the growth of sorghum and maize under pot culture conditions. Consortia of PSB and *Azospirillum* spp (in liquid formulation) enhanced the growth positively by a multitude of synergistic mechanisms when compared to single inoculant application.

P6.11. Evaluation of commercially available PGPR for control of rice sheath blight caused by *Rhizoctonia solani*

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Abstract

Sheath blight disease of rice caused by *Rhizoctonia solani* is a major production constraint in all rice producing areas of the world. The annual losses due to sheath blight are estimated to be 25 % under optimum conditions of disease development. Disease management is currently focused on extensive use of fungicides which has created concerns about environmental pollution, pathogen resistance and escalating costs. Field trials were conducted during rainy seasons of 2005 and 2006 in randomized block design with three replications to assess the commercially available bio-pesticide products for their effect on sheath blight. Products evaluated were Achook (Azadirachtin), Biotos (Plant activator), Tricure (Azadirachtin), Ecomonas (*Pseudomonas fluorescens*) and Bavistin (Carbendazim) in 2005 and Biofer (Plant extract), Biotos, Defender (Plant extract), Ecomonas, Florezen P (*P. fluorescens*), Trichozen (*Trichoderma viride*) and Bavistin in 2006. Products were applied three times as foliar sprays after appearance of first symptoms initially and repeated at 10 days interval. The disease severity was measured by adopting Highest Relative Lesion Height (HRLH) at 90 days after transplanting. The chemical (Bavistin) reduce disease severity 52% and 50% compared to the control. Corresponding reductions in disease severity with the bio-pesticides ranged from 22% to 48% in 2005 and from 15% to 31% in 2006. Specifically with PGPR, the disease reductions ranged from 14% to 38% compared to the control in both the years. Grain yields were assessed at 120 days after transplanting and significantly increased grain yields (3,901 and 1,938 kg/ha) over control (2,690 and 1,550 kg/ha) were obtained with PGPR in 2005 and 2006 respectively. Our results showed that there is a scope for

effective management of sheath blight disease with the use of the currently available PGPR and other products that are available under the conditions evaluated.

P6.12. Challenges Faced By Rural Women as an Entrepreneur Business, A Case study of Sindh

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Abstract

The research investigates the challenges faced by rural women as an entrenueship business in Rural Sindh, and rural women is facing challenges in the SMEs business.Survey were conducted from Five districts, Khairpur, Sukkur, Shikarpur, Jacobabad, Kandhkot/Kashmore Districts, and 100 entrepreneur business women's in rural sindh by using simple random technique. Questionnaire was the basic tool to find out the major challenges of rural women as an entrepreneur business. It was revealed that there is great potential of rural women I doing the various entrepreneur business like in Kandhkot, Jacobabad, Rali, Ajrak and Sindhi caps they are very much unique and they were generating income from there families. It was further revealed that the rural women is less confident and their husbands were always given them hard time once they are exposing them selves to out side the boundaries of the house. The biggest challenges which they were facing they were doing all business in house, lack of marketing facilities, Karo Kari criminal activities and they were deprived from the basic rights. Key implication of current study is that how rural women is doing SMEs business in various locations of Rural sindh, and how we develop business opportunities for rural women and how we overcome marketing and other social issues related to SMEs business. This study contributes and explores the Rural Women challenges in SMEs business and how these critical unethical problems we can overcome like KARO KARI, and other various social issues growth.

P6.13. Strategies for Developing the SMEs business and Entrepreneur opportunities on SAFTA

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Abstract

The purpose of this research is to investigate the entrepreneur opportunities on South Asian Free Trade (SAFTA) and to design strategies that help SMEs business growth in South Asia. Research was conducted from 200 SMEs units by using structured questionnaire as tool for the measurement. The data were analysis by using SPSS-16.5 software. It was revealed that different stages of SMEs business required the strategic planning and it was observed that SMEs most of

the units are sick units in Pakistan because of lack of Planning strategies. The strategies however continuous strong growth is not necessarily one of the aims of an enterprise, then success has been measured in other ways. It was further revealed that develop the good relation with neighbor countries and export those products to South Asian countries. Key implication of current study is to viable sick units in SMEs business and these strategies can grow SMEs business on SAFTA. It also helps SMEs business owners to find the better opportunities by developing the successful implementation of different strategies in Growth and maturity of the business. This study contributes and explores the various SMEs business opportunities on SAFTA and how SMEs can contribute more in our economic growth.

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