7th ASIAN PGPR 2022

INTERNATIONAL CONFERENCE FOR SUSTAINABLE AGRICULTURE

Regenerating Agriculture Through Beneficial Microbes for Improving Crop Productivity and Safety

23 - 26 August 2022
Auditorium Rashdan Baba
Universiti Putra Malaysia

Organisers

Supported by

MINISTRY OF AGRICULTURE AND FOOD INDUSTRIES MALAYSIA

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CONTENTS

FOREWORD FROM
MINISTER OF AGRICULTURE AND FOOD INDUSTRIES

My warmest welcome to all speakers, participants and guests of the **7th Asian PGPR International Conference for Sustainable Agriculture 2022** and to the international participants, 'Selamat Datang' to Malaysia.

It is our utmost pleasure that the conference has attracted many locally and internationally distinguished speakers and participants, which will surely benefit everyone in attendance.

The COVID-19 pandemic has taken the world by surprise and two years after the onset of pandemic, the health, economic, and social disruptions caused by this global crisis continue to affect us. Therefore, proactive actions must be taken in maintaining continuous agricultural productivity and increased sustainability to ensure global food security for the future. In this regard, the roles of beneficial microbes in shaping the future of agriculture are crucial.

With the theme of '**Regenerating Agriculture Through Beneficial Microbes for Improving Crop Productivity and Safety',** this conference is very timely and in line with many global challenges we face today in the agriculture sector especially in areas of food security and safety.

I would like to congratulate the organizing committee, Asian PGPR Society, Malaysian PGPR Society and Faculty of Agriculture, Universiti Putra Malaysia and collaborators for their great efforts in organizing the 7th Asian PGPR International Conference for Sustainable Agriculture 2022 in Malaysia. I am also pleased to see the involvement of Department of Agriculture (DOA) and Malaysian Agricultural Research and Development Institute (MARDI) as collaborators for this conference.

I hope this conference will provide an excellent platform for sharing knowledge and experience among researchers, entrepreneurs, investors, policy makers, innovators and practitioners where more ideas will be transformed into agricultural innovations for the benefit of everyone.

Finally, I wish all participants a fruitful conference and please enjoy your stay in the great city of Kuala Lumpur while experiencing our rich cultures, historical places, tourist spots and local foods.

Thank you.

YB DATUK SERI DR. RONALD KIANDEE

Minister of Agriculture and Food Industries Malaysia

FOREWORD FROM

VICE CHANCELLOR UNIVERSITI PUTRA MALAYSIA

First and foremost, I would like to welcome all distinguished speakers, exuberant participants and honorable guests to the **7th Asian PGPR International Conference for Sustainable Agriculture 2022**. I wish 'Selamat Datang' to Malaysia and Universiti Putra Malaysia (UPM) to the international delegates. I hope you will have a memorable time here. Please take the opportunity to enjoy your stay and experience our Malaysian hospitality. My deepest appreciation goes to all collaborators both local and international as well as sponsors who have contributed tremendously for the success of this conference.

Universiti Putra Malaysia's vision is to become a university of international repute while its mission is to make meaningful contributions towards food security, nation building and universal human advancement through the exploration and dissemination of knowledge. As an agriculture pioneer in Malaysia, UPM is able to facilitate researchers to translate their agricultural research into nation building as well as sustainability in food production. Universiti Putra Malaysia and the Asian PGPR Society for Sustainable Agriculture, aim to encourage research, education and the dissemination of knowledge on the important role of plant growth promoting rhizobacteria (PGPR) in agriculture. Thus, the organisation of this conference provides an excellent platform for participants to obtain new knowledge and research advancement pertinent to sustainable agriculture in line with the conference theme "**REGENERATING AGRICULTURE THROUGH BENEFICIAL MICROBES FOR IMPROVING CROP PRODUCTIVITY AND SAFETY**".

Malaysia has always been a strong believer in close cooperation amongst regional counterparts as well as international partners in collaborative efforts to shape the future of agriculture in this region and I am happy to know that there are many international participants from various agriculture-based countries at this conference.

I wish all participants a productive deliberation and networking not only during this conference, but for a long time to come.

I would like to congratulate the Faculty of Agriculture, Universiti Putra Malaysia and the Malaysian PGPR Society on behalf of the Asian PGPR Society, for successfully organising this conference.

"**WITH KNOWLEDGE WE SERVE**"

YH. DATO' PROF. DR. MOHD ROSLAN SULAIMAN
Vice Chancellor
Universiti Putra Malaysia

MESSAGE FROM

FOUNDER & CHAIRMAN, ASIAN PGPR SOCIETY for SUSTAINABLE AGRICULTURE,

AUBURN UNIVERSITY, USA

Greetings!

On behalf of the world-wide group of Asian PGPR Society members engaged in research and development of PGPR and related products, I take great pride in welcoming all of the great scientists, academicians, young researchers, business delegates and students from all over the globe to attend the 7th Asian PGPR International Conference for Sustainable Agriculture with a theme of **"Regenerating Agriculture through Beneficial Microbes for Improving Crop Productivity and Safety"** to be held at Universiti Putra Malaysia, Serdang, Selangor on August 23-26, 2022. *I would like to express my appreciation* to YB Datuk Seri Dr. Ronald Kiandee, Minister of Agriculture and Food Industries, Government of Malaysia, YH Prof. Dr. Mohd Roslan Sulaiman, Vice Chancellor, Universiti Putra Malaysia, Dato' Dr. Mohamad Zabawi Abdul Ghani, Director General, MARDI, Dato' Zahimi Hassan, Director General, DOA and Prof. Mui-Yun Wong, local organizing chairman and their team of dedicated members to lead each of you to the 7th Asian PGPR International Conference for Sustainable Agriculture which is very critical for the global effort in development of PGPR and bio-innovative based technologies.

How do we feed a hungry world? With almost 10 billion mouths to feed by 2050 and agricultural production threatened by declining resources, global food security faces an immense challenge – how it can be addressed. This is exactly what our delegates at this conference will set out to do. It is also expected that favorable global trade policies will continue to create wealth around the world. The size of the global middle class is expected to triple, growing from approximately 1 billion people today to over 3.5 billion people by 2050. A higher global standard of living is driving up demand for food, resulting in record high global grain prices during recent years. Experts are projecting that by 2050, food production must increase by approximately 80-100% to meet demand. Doubling the world's food supply is the grand challenge for the next generation of agricultural scientists. Land constraints dictate that much of the increased production must come from existing agricultural lands. According to the FAO, past efforts to increase productivity has led to global degradation of farmland at an alarming rate. Future technology must lead to increased production in a sustainable manner.

Approximately 50% of the current world population is engaged in agriculture, and 30% of the world population is small holder farmers living on less than $2.00 per day. Farm size, productivity and poverty are strongly linked. The promise of technologies such as PGPR is that they could provide solutions that will increase the productivity and profits of small holder farmers around the world, thus increasing food supply and reducing poverty in a sustainable way. Globally, though PGPR research has picked up, there is a need to widen the scope and perspectives of its application to several agricultural crops. Especially, PGPR applications need to be projected as viable alternatives or supplements to chemical fertilizers. At this juncture, the functioning of the "**Asian PGPR Society for Sustainable Agriculture**" is critical. Though, Asian countries are competing and syndicating in PGPR research, a

consolidated plan to bring forth sustainable, scalable and economic solutions to control plant diseases, improve soil health and enhance Agro-ecosystem through the use of PGPR is essential.

Asian PGPR Society is instrumental in bringing researchers, academics and entrepreneurs on to a common platform for exchange of ideas, promoting public-private partnerships and promoting research integration among public and private agencies involved in PGPR research. As you all know, the combination of accelerating climate change and the growing world population continues to challenge agricultural production. Local, regional, and multi-national agricultural product companies are investing in basic research aimed at improving drought tolerance and nutrient uptake. The need of today's world is high output yield and enhanced production of the crop as well as fertility of soil in an eco-friendly manner. Hence, the research must be focused on the new concept of rhizo-engineering based on favorably partitioning of the exotic biomolecules, which create a unique setting for the interaction between plant and microbes. Future research in rhizosphere biology will rely on the development of molecular and biotechnological approaches to increase our knowledge of rhizosphere biology and to achieve an integrated management of soil microbial populations. Fresh alternatives should be explored for the use of bioinoculants for other high value crops such as vegetables, fruits, and flowers. Plant-associated bacteria are being tested for sources of new genes, sources of metabolites that affect plant gene transcription, and as potential inoculants for crops. Studies on PGPR fit very well with these goals, and for this reason, our research area is receiving renewed interest.

I strongly believe that the scientific innovations can reach farmers only with purposeful and effective partnerships. So, to all the participants in this conference, let me encourage you to share, learn, reach out and build personal relationships throughout this conference that can lead to a productive partnership. As agricultural scientists, the world is looking to us to provide solutions to food challenges that the world is facing. I look forward to the presentations and interactions with the scientists at this conference. Never have so many people been dependent upon so few farmers for food. We're the ones who will have to make the decisions in the future, and we have to start now.

Let me take this opportunity to express my sincere appreciation to all of our sponsors which include Auburn Ventures, Agri Life, Dhana Crop Science Ltd., Valagro, ICRISAT, Ag Bio Systems, Prathista Industries Ltd., Gujarat Eco Microbial Technologies Ltd., Sujay Biotech Pvt. Ltd., Pragati Group., Sri BioAesthetics, Varsha Bioscience and Technology India Pvt Ltd., Diversatech Fertilizer Sdn. Bhd., Malaysia Convention & Exhibition Bureau, Behn Meyer AgriCare (M) Sdn. Bhd., Peat Organic (M) Sdn. Bhd., Hj Mat Hj Jantan Sdn Bhd, All Cosmos Industries Sdn. Bhd. and My Edu Group Sdn. Bhd. as well as to all of you for coming to share and keep abreast of what is new in PGPR technologies.

I sincerely hope that this conference will deliberate and discuss all the different facets of this exciting topic and come up with recommendations that will lead to a better, healthier, merrier world.

God Bless Asian PGPR Society for Sustainable Agriculture.

Prof. M. S. Reddy
Founder & Chairman
Asian PGPR Society for Sustainable Agriculture
Auburn University, USA

MESSAGE FROM

CHAIRPERSON, LOCAL ORGANISING COMMITTEE

UNIVERSITI PUTRA MALAYSIA

Salam Sejahtera dan Salam Keluarga Malaysia,

Warm greetings, it is with great pleasure that I welcome all honoured guests, delegates, speakers and participants to the **7th Asian PGPR International Conference for Sustainable Agriculture** with the theme "**Regenerating Agriculture through Beneficial Microbes for Improving Crop Productivity and Safety".** We are pleased to announce that about 130 participants are participating in this conference coming from various countries including USA, Spain, the Netherland, Saudi Arabia, India, Pakistan, Bangladesh, Nepal, Vietnam, Indonesia, Taiwan, Korea, Australia, and of course, Malaysia as the host country. This will allow both academia and industry to have interactive access to emerging technologies and approaches globally with presentations, discussions and side events that will inspire new ideas and innovations in agriculture. The role of microbial technology in sustainable agriculture is crucial in achieving the United Nations' Sustainable Development Goals (SDGs), specifically SDG1 (No Poverty), SDG2 (Zero Hunger), SDG8 (Decent Work and Economic Growth), SDG13 (Climate Action) and SDG15 (Life on Land). A paradigm shift from the current agriculture intensification system to the next-generation crop production systems utilizing biologicals to enhance soil health and minimizing synthetic input of fertilizers and pesticides is a challenge but required in moving towards sustainable agriculture. Biologicals have the potential to be in the mainstream of agriculture, thus, contributing greatly to bioeconomy. This is the gap we hope to bridge through the networking in this conference.

On behalf of the organising committee, I would like to thank Datuk Seri Dr Ronald Kiandee, Minister of Agriculture and Food Industries for officiating the **7th Asian PGPR International Conference for Sustainable Agriculture**. My sincere appreciations also go to the lead speakers, chairman of sessions, oral and poster presenters and judges, participants, sponsors, exhibitors, advertisers and volunteers as well as our collaborators, who in every capacity had made this conference a success. Hope you enjoy the conference and your stay in Malaysia.

Thank you.

PROF. DR. WONG MUI YUN
Chairperson
Organizing Committee
7TH Asian PGPR International Conference for Sustainable Agriculture

MESSAGE FROM

DEAN, FACULTY OF AGRICULTURE

UNIVERSITI PUTRA MALAYSIA

It is an honour for me to welcome researchers, speakers, policymakers and all participants to the 7th Asian PGPR International Conference for Sustainable Agriculture 2022. It is a great pleasure to see this gathering after two and half years of movement control orders due to the pandemic. It is very important for all of us to have a gathering like this in order to share our findings, thoughts and ideas in ensuring the continuity of the knowledge expansion. Hopefully, this conference will tighten the connectivity among all scientists as to bridge science and technology especially in agriculture sector is one of the big challenges in this century.

This international event is intended to create an open space networking and exchange of information on research and technology, especially in the use of microbes in agriculture. Having the theme "Regenerating Agriculture Through Beneficial Microbes for Improving Crop Productivity and Safety", which aims to explore the application of beneficial microbes to improve the productivity of agriculture is important to ensure the sector is properly driven. Moreover, this symposium is held to encourage the exchange of knowledge and technology towards food safety and security. I believe that this event will create a forum for intellectual dialogue to discuss, deliberate and disseminate innovative ideas.

I would like to congratulate the organizing committee for the outstanding effort in making this conference a success. To all the international delegates, welcome to Malaysia. I wish all of you will have a pleasant stay.

Thank you.

ASSOC. PROF. DR. NUR AZURA ADAM
Dean
Faculty of Agriculture
Universiti Putra Malaysia

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Founder & Chairman, Asian PGPR Society for Sustainable Agriculture

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TECHNICAL PROGRAM

Day 1	23 August 2022
1500 - 1900	Arrival / Reception / Registration / Poster setup **Venue: Lobby, Office of the Deputy Vice Chancellor (Research and Innovation), Universiti Putra Malaysia**
Day 2	**24 August 2022**
Master of Ceremony:	**Dr. Jasmin Binti Arif Shah**
0800 - 0845	Arrival of Participants / Registration / Poster setup **Venue: Auditorium Rashdan Baba, Office of the Deputy Vice Chancellor (Research and Innovation), Universiti Putra Malaysia**
0845 - 0900	Arrival of Honourable Guests & Delegates
0900 - 0905	National Anthem (Negaraku) and Prayer Recital
0905 - 0910	Invitation by President, Malaysian PGPR Society & Chairperson, Local Organizing Committee, Prof. Dr. Wong Mui Yun
0910 - 0915	Greetings by Founder & Chairman, Asian PGPR Society for Sustainable Agriculture, Prof. M. S. Reddy
0915 - 0925	Welcome by Vice Chancellor, Universiti Putra Malaysia, YH. Dato' Prof. Dr. Mohd Roslan Sulaiman
0925 - 0935	Officiating Speech by Hon. Minister of Agriculture and Food Industries (MAFI), YB Datuk Seri Dr. Ronald Kiandee
0935 - 0950	Montage and Opening of Conference Souvenir
0950 - 1000	Token of Appreciation to Honourable Minister
1000 - 1015	Group photo for all participants

1015 - 1115	Coffee break, Exhibition and Poster Session Press Conference & Media Interaction
1115 - 1145	Keynote address by Director General, Department of Agriculture, Malaysia, YBhg. Dato' Zahimi Hassan
	End of Opening Ceremony

Oral Presentations (OP)

Session 1

Theme: Commercialisation and regulatory issues in PGP microbial products

Chairman of the session: Prof. Kadambot Siddique
Co-chairman: Dr. Ni Luh Suriani

Lead Presenter (LP)

Time slot	Paper Id	Presenter	Paper Title & Affiliation
1200 -1215	**LP1**	**Prof. Hesham A. El Enshasy**	**Techno-industrial large-scale production of nitrogen fixing inoculant for commercial use in agricultural crops** Hesham A. El Enshasy[1,2,3*], Charles Thin[4], Wei Chang[4], Wan Azha Wan Mustapha[4], Solleh Ramli[1], Daniel Joe Dailin[1,2], Roslinda Abd Malek[1], Nor Zalina Othman[1], Siti Zulaiha Hanapi[1] and Zaitul Iffa Rasid[1] [1]Institute of Bioproduct Development, Universiti Teknologi Malaysia (UTM), 81310 Skudai, Johor Bahru, Malaysia, [2]School of Chemical and Energy Engineering, Faculty of Engineering, Universiti Teknologi Malaysia (UTM), 81310 Skudai, Johor Bahru, Malaysia, [3]City of Scientific Research and Technology Applications (SRTA), New Burg Al Arab, 21934 Alexandria, Egypt & [4]Allcosmos Industries Sdn. Bhd., Pasir Gudang, Johor, Malaysia
1215-1230	**LP2**	**Dr. Srinivasan Ramasamy**	**Redesigning agro-ecologies with beneficial microbes for safe and sustainable vegetable production in Asia and Africa**

			Flagship Program Leader for Safe and Sustainable Value Chains World Vegetable Center, 60 Yi Ming Liao Shanhua, Tainan 74151, Taiwan

Oral Presentations (OP)

Time Slot	Paper Id	Presenter	Paper Title
1230 -1240	**OP1**	Dr. Ritu Mawar	**Developing a bio-kit of bio control agent for managing soil borne plant pathogens of Indian arid region** Ritu Mawar* and Tanu Mathur Division of plant improvement and pest management, ICAR-Central Arid Zone Research Institute, Jodhpur 342003, Rajasthan, India
1240 -1250	**OP2**	Dr. Tanzima Yeasmin	**Mycorrhizae for sustainable agriculture - Bangladesh perspective** Tanzima Yeasmin[1]* and M. S. Reddy[2] [1]Dept. of Biochemistry and Molecular Biology, University of Rajshahi, Rajshahi, Bangladesh [2]Founder & Chairman, Asian PGPR Society for Sustainable Agriculture, Consultant & Entrepreneur, Auburn University, Auburn, AL, USA
1250 -1300	**OP3**	Dr. Sarjiya Antonius	**Influence of soil conditioners with PGPR enrichment to support microbial diversity and shallot production** Sarjiya Antonius *, Agung Adi Nugroho, Tirta Kumala Dewi, Achirul Nditasari, Sri Purwaningsih and Dwi Agustiyani Biology Research Center for Applied Microbiology, National Research and Innovation Agency (BRIN), Jl Raya Jakarta-Bogor Km. 46 Cibinong, Bogor, 16911, Indonesia
1300 -1310	**OP4**	Dr. Jitendra Patel	**Global status and trends of microbial inoculants** Asiagreen Biocrops, Bardoli, Kani, Gujarat 394950, India

1310 -1320	**OP5**	Dr. Livleen Shukla	**Pusa Decomposer-microbial consortium for biomass degradation and enhancing crop productivity** Livleen Shukla*, Kannepalli Annapurna, Ritu Raj Gupta, Sandeep Kumar Singh, Satish Lande, Deeba Kamil, Rauf A. Parrey, Niveta Jain, Y. V. Singh and Indramani Mishra Division of Microbiology, ICAR-Indian Agricultural Research Institute, New Delhi-110012, India
1320 -1330	**OP6**	Dr. Tamanna Bhardwaj*	**Melatonin and plant growth-promoting rhizobacteria (PGPR) regulate cadmium toxicity in *Brassica juncea* L.** Tamanna Bhardwaj* and Renu Bhardwaj [1]Department of Botanical and Environmental Sciences, Guru Nanak Dev University, Amritsar, Punjab, India
1330 -1345	**Q & A Session**		
1345 – 1430	**Lunch, Exhibition & Poster Session**		

Session 2

Theme: PGP microbes for plant protection, soil amendments and biofertilizer

Chairman of the session: Dr. Sarjiya Antonius
Co-chairman: Dr. Yuvarani Naidu

Lead Presenter (LP)

Time slot	Paper Id	Presenter	Paper Title & Affiliation
1430 -1445	**LP3**	**Dr. M. Lakshmi Prasad**	**Plant endophytes – a new ray of hope for sustainable agriculture** Sujay Biotech Pvt. Ltd, Vijayawada, Andhra Pradesh, India

Oral Presenter (OP)

Time Slot	Paper Id	Presenter	Paper Title
1445 -1455	**OP7**	Dr. K. P. Chong	***Streptomyces sundarbansensis* a potential biological control agent against *Ganoderma boninense* of oil palm basal stem rot disease** K. P. Chong* and P. H. Lim Biotechnology Programme, Faculty of Science and Natural Resources, Universiti Malaysia Sabah, Jalan UMS, 88400, Kota Kinabalu, Sabah, Malaysia
1455 -1505	**OP8**	Dr. Ni Luh Suriani	**Efficacy of *Brevibacillus agri* with *Piper cannium* extract to suppress the blast disease and to increase the yield of Bali red rice** Ni Luh Suriani[1*], Dewa Ngurah Suprapta,[2] I Nyoman Suarsana[3], M.S. Reddy[4]and Yulmira Yanti[5] [1]Biology Study Program, Mathematics and Natural Sciences Faculty, Udayana University, Bali 80361, Indonesia, [2]Biopesticide Laboratory, Agriculture Faculty, Udayana University, 80232, Bali, Indonesia, [3]Faculty of veterinary medicine, Udayana University, 80232, Bali, Indonesia, [4]PGPR Society for Sustainable Agriculture & Auburn Ventures, Department of Plant Pathology and Entomology, Auburn University, Auburn, AL 36830, USA and [5]Department of Plant Pests and Diseases, Agriculture Faculty, Universitas Andalas, Padang, Indonesia
1505 -1515	**OP9**	Dr. Venkadasamy Govindasamy	**Impact of application of bio-inoculants on native soil-microbial diversity in the rhizosphere of soybean-wheat cropping system** Division of Microbiology, ICAR-Indian Agricultural Research Institute, New Delhi, India, 110012
1515 -1525	**OP10**	Dr. Samina Mehnaz	**Inoculation effect of *Pseudomonas* strains on growth of tomato plants under controlled climatic conditions** Samina Mehnaz* and Sana Hashmi

			School of Life Sciences, Forman Christian College (A Chartered University), Lahore 54600, Pakistan
1525- 1535	**OP11**	Dr. Dhuha Sulaiman Salim Al-Daghari	**Efficacy of antagonistic rhizobacterial isolates from biofumigated soil for control of damping-off of cucumber caused by *Pythium aphanidermatum*** Dhuha Sulaiman Salim Al-Daghari*, Abdullah Mohammed Al-Sadi and Rethinasamy Velazhahan Department of Plant Sciences, College of Agricultural and Marine Sciences, Sultan Qaboos University, P.O. Box 34, Al-Khoud, Muscat 123, Sultanate of Oman
1535 -1545	**OP12**	Dr. V. Devappa	**Genetic variation and molecular characterization of *Ceratocystis fimbriata,* causal agent of wilt in pomegranate and its management by bio-stimulants** Devappa, V.* and Navyashree, S. E. Dept. of Plant Pathology, College of Horticulture, Bengaluru, Karnataka, India
1545 -1555	**OP13**	Dr. Dinesh Singh	**Potentiality of phyllospheric growth-promoting and antagonistic bacteria for management of black rot disease of cauliflower incited by *Xanthomonas campestris* pv. *campestris*** Dinesh Singh and Neelam Geat Division of Plant Pathology, ICAR-Indian Agricultural Research Institute, New Delhi-110012
1555 -1605	**OP14**	Dr. S. M. Aminu	**The role of beneficial bacteria associated with *Pteris vittata* for arsenic tolerance and plant growth-promotion in contaminated soils** S. M. Aminu[1,2*], K. Z. Zarkasi[1], H. Haris[1] and H. G. Amir[1] [1]School of Biological Sciences, Universiti Sains Malaysia, Penang, Malaysia and [2]College of Science and Technology, Hussaini Adamu Federal Polytechnic Kazaure, Jigawa State, Nigeria

1605 -1615	**OP15**	Dr. L. S. H. Jeffrey	**Isolation of locally potential fluorescent Pseudomonads from Kuini (*Mangifera odorata*) planted soil for their potential as biofertilizer** L. S. H. Jeffrey* and M. Z. Nur Samahah Green Technology Program, Agrobiodiversity and Environment Research Canter, Malaysian Agricultural Research and Development Institute, Persiaran MARDI-UPM, 43400 Serdang, Selangor, Malaysia
1615 -1625	**OP16**	Mrs. M. Stella	**Efficacy of endophytic bio-stimulant for root growth enhancement in chili** M. Stella[1,2*], A. Asgar[2], S. Yasmeen[3] and S. Christina Vimala[2] [1]Fertilizer Technology Programme, Soil Science, Water & Fertilizer Research Centre, Malaysia, Agriculture Research & Development Institute (MARDI), Selangor, Malaysia, [2]School of Biosciences, Faculty of Science, The University of Nottingham Malaysia Campus, Semenyih, 43500 Selangor, D.E., Malaysia and [3]Laboratory of Plantation Science and Technology, Institute of Plantation Studies, Universiti Putra Malaysia 43400 Serdang, Selangor Malaysia
1625 -1640	**Coffee break, Exhibition & Poster Session**		
1640-1650	**OP17**	Dr. Kumari Sunita	**Impact of PGPR in Kalanamak rice under salinity conditions** Kumari Sunita* and Omisha Kannaojiya Plant Physiology and Biochemistry PGPR Lab, Department of Botany, DDU Gorakhpur University, Gorakhpur, India
1650 -1700	**OP18**	Waleed Al-Busaidi	**Efficacy of endophytic bacterial antagonists against tomato damping-off caused by Pythium aphanidermatum under greenhouse conditions** Waleed Al-Busaidi*, Rhonda Janke, Manar Al-Saidi, Rahil Al-Badi, Abdullah M. Al-Sadi Rethinasamy Velazhahan

			Department of Plant Sciences, College of Agricultural and Marine Sciences, Sultan Qaboos University, Al- Khoud 123, Sultanate of Oman
1700 -1710	**OP19**	Dr. Zahra Noviana	**Beneficial effect of plant growth-promoting rhizobacteria on growth of Cassava (*Manihot esculenta* Crantz) and to enhance fertility of Ultisol soils** Dwi Agustiyani, Zahra Noviana*, Agung Adi Nugroho, Tirta Kumala Dewi, Achirul Nditasari, Sri Purwaningsih and Sarjiya Antonius Biology Research Center for Applied Microbiology, National Research and Innovation Agency (BRIN), Raya Jakarta-Bogor Street Km. 46 Cibinong, Bogor, 16911. Indonesia
1710 -1730	**Q & A Session**		
2030-2230	**Welcome Dinner** **Venue: Mines Beach Resort Hotel, Seri Kembangan, Selangor** **Sponsors Messages**: Auburn Ventures, Dhana Crop Sciences Ltd, Agri Life, Valagro, ICRISAT, Prathista, Ag Bio, Varsha Bioscience, Sujay Biotech, Sri BioAesthetics, Gujarat Eco Microbial Technologies, Pragati Resorts, Bio WE		

-End of Day 2-

Day 3	**25 August 2022**

Session 3

Theme: General application of PGP microbes in agriculture, forestry and environment

Chairman of the session: Prof. Chong Khim Phin
Co-chairman: Dr. Zahra Noviana

Lead Presenter (LP)

Time slot	Paper Id	Presenter	Paper Title & Affiliation
0830 - 0845	**LP4**	**Prof. Dilantha Fernando**	**Artificial intelligence: a promising technique to design synthetic microbial communities for plant health** Dilantha Fernando and Liang Zhao Department of Plant Science, University of Manitoba, Winnipeg, MB, Canada
0845 - 0900	**LP5**	**Prof. K.H.M Siddique**	**Potential of microbial consortium in combination with rock mineral fertilizer on wheat and pasture production** K. H. M. Siddique[1,2*], L. K. Abbott[1,2], S. K. Assainar[2], B. S. Mickan[1,2], S. Tshewang[2], P. J. Storer[3], N. S. Bolan[1,2] and Z. M. Solaiman[1,2] [1]The UWA Institute of Agriculture, The University of Western Australia, Perth, WA 6009, Australia,[2]UWA School of Agriculture and Environment, The University of Western Australia, Perth, WA 6009, Australia and [3]Troforte Innovations Pty Ltd, Wangara, Perth, WA 6065, Australia

Oral Presentations (OP)

Time Slot	Paper Id	Presenter	Paper Title
0910 - 0920	**OP20**	Dr. Wisnu Adi Wicaksono	**Plant–microbe-virus-interactions as game-changers in the natural ecological restoration of the aral sea** Gabriele Berg[1,2,3*], Wisnu Adi Wicaksono[1] and Tomislav Cernava[1] [1]Institute of Environmental Biotechnology, Graz University of Technology, Petersgasse 12, 8010 Graz, Austria; [2]Leibniz-Institute for Agricultural Engineering Potsdam, Max-Eyth-Allee 100, 14469 Potsdam, Germany and [3]Institute for Biochemistry and Biology, University of Potsdam, Karl-Liebknecht-Str. 24/25, 14476 Potsdam, Germany

0920 - 0930	**OP21**	Dr. Kalpana Balakrishnan	**Efficacy of Nano 5G-P in onion production** Balakrishnan Kalpana[1*], Sruthi, N.,[2] Kalai Kalangiam, K.V.[2], Karthik Arumugam[2], Ponnusamy Ponmurugan[3], Sai Ram K.V.S. S[4], M. Anusha[4] and Reddy, M. S.[5] [1]Dept. of Biotechnology, K. S. Rangasamy College of Technology, Tiruchengode, Namakkal, Tamil Nadu, India, [2]Dept. of Nanoscience and Technology, K. S. Rangasamy College of Technology, Tiruchengode, Namakkal, Tamil Nadu, India, Dept. of Botany, Bharathiyar University, Coimbatore, Tamil Nadu, India, [4]Dept. of Field Crops Research, Prathista Industries Ltd., Chowtuppal, Telangana, India and 5Founder & Chairman, Asian PGPR Society for Sustainable Agriculture, Consultant & Entrepreneur, Auburn University, Auburn, AL, USA
0930 - 0940	**OP22**	Prof. Tualar Simarmata	**Rhizomicrobiome engineering through halotolerant PGPR and bioameliorant to alleviate salinity stress and enhance rice production in flood-prone area in Indonesia** Tualar Simarmata*, Roby Ibnu Syarifain, Debora, D.M. Ambarita, Fiqriah, H. Khumairah, Dyian Herdiantoro, Nadia Kamaludin, Betty N. Fitriatin and Mieke R. Setiawati Department of Soil Sciences and Land Resources Management, Faculty of Agriculture of Universitas Padjadjaran, Jatinangor 45363, West Java, Indonesia
0940 - 0950	**OP23**	Dr. Ganisan Krishnen	**PGPR-induced systemic resistance for management of blood disease of banana** Ganisan Krishnen[a]*, Nur Sulastri Jaffar[b], Salehudin Md. Radzuan[c], Sivanaswari Chalaparmal[b], Suhanna Ahmad[b], Mohd Ridzuan Mohd Daud[c], Nurul Faizah Mohd. Ridzuan[a], Md. Nurul Khalid Koyube[b], Adnan Ambiah[c], Muhammad Hanam Hamid[a],

			Badjie Xaebcourieyiean Ibadallah[a] and Muhammad Noor Azmie Abdul Jalil Hasan[a] [a]Soil, Water and Fertilizer Research Centre; MARDI Headquarters, 43400 Serdang, Selangor, Malaysia, [b]Horticulture Research Centre, MARDI Headquarters, 43400 Serdang, Selangor, Malaysia and [c]Sintok MARDI Station, 06050 Bukit Kayu Hitam, Kedah, Malaysia
0950 - 1000	**OP24**	Prof. Dr. N. K. Nghia	**Evaluation of potassium solubilizing bacteria on growth and yield of spinach (*Spinacia oleracea* L.) under greenhouse conditions** N. K. Nghia*, V. D. T. Vy and L. T. Xa Department of Soil Science, Faculty of Agriculture, Can Tho University, Can Tho City, Vietnam
1000 - 1015	**Coffee Break, Exhibition & Poster Session**		
1015 -1025	**OP25**	Dr. G. B. K Rao	**Immunity boosting through therapeutic traditional herbal foods and sustainable green technology** Chairman and Managing Director, Pragati Sudhaama, Shankarpally Mandal, Hyderabad – 501203, Telangana State, India
1025 - 1035	**OP26**	Mr. Jagadeesh Reddy	**Progress of natural farming for sustainable agriculture in Andhra Pradesh, India** Jagadeesh Reddy[1]* and M. S. Reddy[2] Progressive farmer, Danduvaripalli, Chittoor District, A. P., India and Asian PGPR Society for Sustainable Agriculture, Auburn University, USA
1035 -1045	**OP27**	Dr. S. R. Patil	**Effect of severity of pruning and integrated nutrient management with PGPR on growth and yield of custard apple cv. Balanagar**

			Department of Fruit Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.), India
1045 - 1055	**OP28**	Dr. S. A. Ashtaputre	**Green synthesised zinc, sulphur and silver nanoparticles and their efficacy against soybean rust caused by *Phakopsora pachyrhizi*** S. A. Ashtaputre*, Supriya, M. L. and Shamarao Jahagirdar Department of Plant Pathology, College of Agriculture, University of Agricultural Sciences, Dharwad- 580 005, Karnataka, India
1055 - 1105	**OP29**	Dr. Gadde Venkata Swarnalatha	**Synergistic effects of PGPR and microalgae for sustainable agriculture** Gadde Venkata Swarnalatha[a*] and M. S. Reddy[b] [a]Department of Biochemistry, Rayalaseema University, Kurnool, Andhra Pradesh, India and [b]Founder & Chairman, Asian PGPR Society for Sustainable Agriculture, Consultant & Entrepreneur, Auburn University, Auburn, AL, USA
1105 - 1115	**OP30**	Dr. Muhammad Arslan Khan	**Application of *Bacillus subtilis* in combination with plant defense activators for eco-friendly management of wheat stripe rust** Hamza Zaffar Siddiqui[1], Muhammad Ashfaq[1], Mudssar Ali[1], M. Arshad Baloch[2], M. Ishtiaq[1] and Muhammad Arslan Khan[1]* [1]Institute of Plant Protection, MNS University of Agriculture, Multan, Pakistan, 66000 and [2]Regional Agricultural Research Institute, Bahawalpur, Pakistan, 63100.
1115 - 1125	**OP31**	Dr. M. N. Normahnani	**Studies of arbuscular mycorrhiza fungi application in *Ganoderma* management in oil palm plantation** M. N. Normahnani*, A. R. Meor Badli Shah and A. Samsudin Sime Darby Plantation Technology Centre Sd Bhd, 1st Floor, Block B, UPM-MTDC Technology Centre III, Universiti Putra

			Malaysia, Lebuh Silikon 43400 Serdang, Selangor, Malaysia
1125 - 1135	**OP32**	Ms. Asharani Patel	**Leaf endophytic *Microbacterium testaceum* mediated suppression of blast disease in rice** Asharani Patel* and A. Kumar** Division of Plant Pathology, ICAR - Indian Agricultural Research Institute, New Delhi - 110012, India
1135 - 1200	**Q & A Session**		
1200 - 1330	**Lunch, Exhibition & Poster Session**		

Session 4

Theme: Biochemistry and biotechnology of PGP microbes

Chairman of the session: Prof. Dilantha Fernando
Co-chairman: Dr. Ganisan Krishnen

Lead Presenter (LP)

Time slot	Paper Id	Presenter	Paper Title & Affiliation
1330 -1345	**LP6**	**Prof. Corné M.J. Pieterse**	**Bi-directional communication along the microbiome-root-shoot axis** Corné M.J. Pieterse & Plant-Microbe Interactions Team Utrecht Plant-Microbe Interactions, Department of Biology, Utrecht University, the Netherlands

Oral Presenter (OP)

Time Slot	Paper Id	Presenter	Paper Title
1345 -1355	**OP33**	Dr. D. I. Walitang	**Proteome of ACC deaminase producing bacteria-mediated salt tolerance in rice (*Oryza sativa* L.)** D. I. Walitang[1,2], T. Sa[2]* [1]College of Agriculture, Fisheries and Forestry, Romblon State University, Romblon, Philippines and [2]Dept. of Environmental and Biological Chemistry, Chungbuk National University, Cheongju, South Korea
1355 -1405	**OP34**	Dr. Abhishek Mathur	**Nutrient enriched fermented biological nano-composite silica for enhancement of sustainable food** Abhishek Mathur[1*], Akshma Koul[1], K.V.S.S. Sairam[1], Anusha Manikonda[1] and M.S. Reddy[2] [1] Prathista Industries Limited, Telangana, India. [2] Founder & Chairman, Asian PGPR Society for Sustainable Agriculture, Consultant & Entrepreneur, Auburn University, Auburn, AL, USA.
1405 -1415	**OP35**	Dr. Arti Raval	**Green synthesis of metal nanoparticles: A way forward to sustainable agriculture** Raval, A. A.[1*], Prajapati, N. B.[1], Reddy, M. S.[2] Sayyed, R. Z.[3] [1]Department of Microbiology, Arts, Science and Commerce College, Kamrej Crossroads, Surat- 396445, India and [2]Asian PGPR Society for Sustainable Agriculture, Department of Entomology & Plant Pathology, Auburn University, Alabama, USA[3] Department of Microbiology, P.S.G.V.P. Mandal's, Arts, Science, and Commerce College, Shahada, Maharashtra 425409, India
1415 -1425	**OP36**	Dr. Yuvarani Naidu	**Importance of white-rot fungi in agriculture and biotechnology**

			Yuvarani Naidu*, Shamala Sundram and Mohd Hefni Rusli Malaysian Palm Oil Board, No. 6, Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia
1425 -1435	**OP37**	Dr. Amrutha V. Audipudi	**Nickel tolerance and biosorption potential of *Bacillus amyloliquefaciens* AVP7 isolated from chili (*Capsicum annum Linn*.) fields** Amrutha V. Audipudi [1]*, C.V.S. Bhaskar[1] and M.S. Reddy[2] [1]Department of Microbiology, Acharya Nagarjuna University, Guntur 222510, Andhra Pradesh, India and [2]Founder & Chairman, Asian PGPR Society for Sustainable Agriculture, Consultant & Entrepreneur, Auburn University, Auburn, AL, USA
1435 -1445	**OP38**	Prof. Dr. Chandra Kant Sharma	**Cultivation, phytochemical and antimicrobial production of *Cordyceps militaris*** Chandra Kant Sharma[1]*, Aanchal Gupta[2] and Monika Sharma[3] [1]*Faculty of Science, Kalinga University, Raipur, Chhattisgarh, India, [2]Faculty of Applied Sciences, Parul University, Vadodara, Gujarat, India and [3]Dept. of Bioscience and Biotechnology, Banasthali University, Rajasthan, India
1445 -1455	**Short Break**		
1455 -1505	**OP39**	Dr. Shamarao Jahagirdar	**Recent approaches in exploration of endophytes and green nanoparticles in management of soybean diseases and their productivity enhancement in India** Shamarao Jahagirdar[1]*, Kavanashree, K.[1], Brunda K. S.[1], Vivekanand K. Karagi[1], Kambrekar, D. N.[2], Krishnaraj, P.U.[3], Ashtaputre, S. A.[1] andGurudatt Hegde[1] [1]Department of Plant Pathology, UAS, Dharwad-580 005, [2]Department of Agricultural Entomology, [3]Department of Agricultural Microbiology and [3]AICRP on Soybean, University of Agricultural Sciences, Dharwad, India

1505 -1515	**OP40**	Dr. Nagaraja Suryadevara	**Performance of *Streptomyces* strains against turmeric rhizome rot disease caused by *Pythium aphanidermatum*** Muthusamy Nithya[1], Balasubramanian Mythili Gnanamangai[1], Ponnusamy Ponmurugan[2] and Nagaraja Suryadevara*[3] [1]Dept. of Biotechnology, K. S. Rangasamy College of Technology, Tiruchengode, Tamil Nadu, India, [2]Dept. of Botany, Bharathiar University, Coimbatore, Tamil Nadu, India and [3*]School of Biosciences, Faculty of Medicine, Bioscience & Nursing, MAHSA University, Malaysia
1515 -1525	**OP41**	Dr. Elsayed Fathi Abd_Allah	**Synergistic impact of endophytic *Bacillus subtilis* (Bera 71) and mycorrhizal fungi to induce acquired systemic resistance against *Phytophthora infestans* in potato** Abeer Hashem[1,2], Hesham A. El Enshasy[3,4,5], Khalid F. Almutairi[6] and Elsayed Fathi Abd_Allah[6*] [1]Botany and Microbiology Department, College of Science, King Saud University, P.O. Box. 2460 Riyadh 11451, Saudi Arabia, [2]Mycology and Plant Disease Survey Department, Plant Pathology Research Institute, ARC, Giza 12511, Egypt, [3]Institute of Bioproduct Development (IBD), Universiti Teknologi Malaysia (UTM), Skudai, Johor, Malaysia, [4]School of Chemical and Energy Engineering, Faculty of Engineering, Universiti Teknologi Malaysia, Skudai, Johor, Malaysia, [5]City of Scientific Research and Technology Application (SRTA), New Burg Al Arab, Alexandria, Egypt and [6]Plant Production Department, College of Food and Agricultural Sciences, King Saud University, P.O. Box. 2460 Riyadh 11451, Saudi Arabia
1525 -1535	**OP42**	Ms. Charishma, K.	**Comparative genomic and metabolome analysis of rice phyllospheric Pantoea species biosynthetic pathways for bioprospection in crop protection** *[1]Charishma, K., [1]Bhaskar Reddy, [2]Aditi Kundu, [3]Ramanathan Vairamani and **[1]Kumar, A.

			[1]Division of Plant Pathology, ICAR, Indian Agricultural Research Institute, New Delhi, 110012, India, [2]Division of Agrochemicals, ICAR, Indian Agricultural Research Institute, New Delhi, 110012, India and [3]Rallis India Pvt Ltd, Bengaluru, India
1535 -1545	**OP43**	Dr. Anita S. Patil	**Enhancement of biocontrol potential of selected chitinolytic producing Trichoderma species through U.V mutagenesis** Anita S. Patil*, Ashwin Lunge, Anagha Undirwade and Diksha Gawai Lab No. 106, Plant Secondary Metabolite Lab, Department of Biotechnology, Sant Gadge Baba Amravati University, Amravati 444602 (M.S), India
1545-1555	**OP44**	Dr. Pramod Kumar	**Influence of foliar application of nano-zinc and zinc solubilizing PGPR on production of strawberry** Pramod Kumar[1*], N.C. Sharma[1], Simran Saini[1], Divya Joshi[1], D.P. Sharma[1] and D. Balachandar[2] [1]Department of Fruit Science, DYSPUHF, Nauni, Solan, Himachal Pradesh, India and [2]Department of Agricultural Microbiology, TNAU, Coimbatore Tamil Nadu, India
1555-1605	**OP45**	Dr. Abdul Gafur	**Isolation and selection of dark septate endophytes from chilli, eggplant and mustard greens as biocontrol agents of *Eucalyptus* diseases** S. F. Yani[1], Dyo Liantiqomah[2], Bayo A. Siregar[2], D. Zul[1], Abdul Gafur[2*] and Budi Tjahjono[2] [1] Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Riau, Pekanbaru 28293, Indonesia and [2]Sinarmas Forestry Corporate Research and Development, Jalan Raya Minas – Perawang KM 26, Perawang, Riau 28772, Indonesia
1605 -1630	**Q & A Session**		

1630 -1650	**Coffee Break**
1650 -1710	**Oral and Poster Awards Presentation** **Closing Remarks**
2030-2230	**Gala Dinner & Closing Session** **Venue: The Everly Putrajaya Hotel, Putrajaya** • Awards Ceremony: Prof. M. S. Reddy & Prof. Mui-Yun Wong • Announcement of the venue - 8th Asian PGPR International Conference: Prof. M. S. Reddy • Venue Presentation: Dr. Srinivasan Ramaswamy, Taiwan • Entertainment - Local • Vote of thanks by Prof. Amrutha V. Audipudi

- End of Day 3 -

Day 4	**26 August 2022 - Tours**
0830 - 1700	Post Conference Tour Note: Delegates requested to register participation at the registration table or the conference website, https://www.pgpr.org.my/post-conference-tour/.

-End of Day 4-

Conference Abstracts

Lead (LP), Oral (OP) & Poster (P)

Session: 1

Theme: Commercialisation and regulatory issues in PGP microbial products

LP1

Techno-industrial large-scale production of nitrogen fixing inoculant for commercial use in agricultural crops

Hesham A. El Enshasy[1,2,3*], Charles Thin[4], Wei Chang[4], Wan Azha Wan Mustapha[4], Solleh Ramli[1], Daniel Joe Dailin[1,2], Roslinda Abd Malek[1], Nor Zalina Othman[1], Siti Zulaiha Hanapi[1] and Zaitul Iffa Rasid[1]

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Nitrogen is one of the most important nutrients that plants require for healthy growth. All plants depend on some outside source of nitrogen, but plants of the legume family can fix their own nitrogen. In other words, they can convert atmospheric nitrogen, which is unusable to all plants, into a form of nitrogen that plants can use. Nitrogen fixing bacteria are important microbial biofactories in rhizosphere ecosystem for sustainable agricultural crops. They play essential role to provide nitrogen to plant through atmospheric nitrogen fixation process and thus reduce the extensive uses of nitrogen fertilizers. This not only reduce the fertilization use, but also reduce the soil and water pollution due to extensive application of inorganic nitrogen to the soil. However, most research on Azotobacters were focused on their genetics, metabolic pathways, and polysaccharide production. Therefore, the objective of this study was to develop a semi-industrial cultivation strategy for high cell mass production of *A. vinelandii*. Batch cultures in 16-L stirred tank bioreactors with and without pH control yielded cell mass concentrations of 7.52 g L^{-1} and 15.86 g L^{-1}, respectively. A series of fed-batch cultivations was carried out to determine the factors limiting cell growth. A combination of a constant feeding strategy coupled with pH and dissolved oxygen control with additional pure oxygen supplementation was found to yield the highest cell mass concentration of 40.65 g L^{-1} in 16-L bioreactor cultivations. Cultivation in a 150-L stirred tank bioreactor showed that the oxygen is one of the most critical factors affecting cell mass production of the highly aerobic *A. vinelandii*. The decreased oxygen transfer rate limited cell growth but increased alginate production. The maximum

cell mass obtained was 28.35 g L^{-1} while the maximum alginate concentration was 18.60 g L^{-1}. Our results showed that commercial strains can be used to inoculate agricultural crops and enhance N fixation and yield.

LP2

Redesigning agro-ecologies with beneficial microbes for safe and sustainable vegetable production in Asia and Africa

Srinivasan Ramasamy

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Vegetables are important crops in the smallholder farming systems in Asia and Africa, since they generate more profits from unit area than in cereal production, besides providing more employment opportunities. Vegetables are cultivated in 42.44 million ha with an annual production of 0.88 billion tons in Asia, whereas they are cultivated only in an area of 10.22 million ha, with an annual production of 85.15 million tons in Africa. They also contribute to improving human health by providing micronutrients, especially vitamins, minerals and dietary fiber. Thus, they have the potential to alleviate poverty and malnutrition. However, the productivity of vegetables is only 8.33 t/ha in Africa, and 20.72 t/ha in Asia, which are far below North America (34.39 t/ha) and Europe (26.25 t/ha). Vegetable production in the tropics is severely constrained by pests and diseases, including invasive species, which have been exacerbated by climate change. They can lead to complete crop failures if timely control measures are not initiated. In order to thwart the losses due to pests and diseases, the farmers use chemical pesticides indiscriminately, which impacts human and environmental health adversely. Hence, it has become imperative to develop and scale out safe and sustainable pest management strategies in vegetable production, which can be achieved through the adoption of agro-ecological approaches. Agro-ecology is a way of redesigning food systems, with a goal of achieving ecological, economic, and social sustainability. Five levels of food system change have been proposed. The first three levels prescribe the steps to be taken on the farms for converting them from conventional agroecosystems, whereas the levels 4 and 5 focus on the broader food system and the societies in which they are embedded. The World Vegetable Center (WorldVeg) has been implementing projects, which contribute to the redesigning of agro-ecosystems with beneficial microbes in Asia and Africa. For instance, WorldVeg has developed and piloted integrated pest management (IPM) packages through farmer participatory approaches for tomato, yard-long bean and leafy brassicas. The IPM packages are composed of sequential application of bio-pesticides, which were on par with Farmers' practice (calendar-based pesticide application) in reducing the pest infestations, without compromising yield. Hence, the IPM packages provide sustainable solutions for managing key pests on vegetable crops in Asia and Africa, and selected results from these projects will be discussed.

OP1

Developing a bio-kit of bio control agent for managing soil borne plant pathogens of Indian arid region

Ritu Mawar* and Tanu Mathur

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Agricultural productivity is hampered by various biotic and abiotic stresses under varied crop ecosystems worldwide**.** Plant growth-promoting rhizobacteria (PGPR) have emerged as effective tools for holistic crop health management. Bacteria are the most abundant microorganisms in soil compared to fungi and other microbes. Among PGPR, Bacillus species have been well recognized for its effectiveness against biotic and abiotic stresses, since it is most common bacteria found to colonize plants easily. They have been reported as plant growth promoter, inducer of systemic resistance, and used for production of a wide range of antimicrobial compounds and competitors for growth factors with other phytopathogenic microorganisms through colonization. The prime aim of our studies is to focuses on niche areas in PGPR research with respect to Bacillus species, mechanism of action and their potential role in alleviation of biotic and abiotic stresses and growth promotion in crops and trees of Indian arid region. Efforts were made to isolate antagonistic bacterial isolates from rhizosphere soil of the arid region. Soil samples were collected and analyzed from different locations of arid and semi-arid regions of Rajasthan. Some of the Bacillus species were confirmed by dual cultural assay on potato dextrose agar and further selected as potential antagonists against soil borne plant pathogens of the hot arid region. Native strains of bio agents' viz., *Bacillus firmus* and *B. tequilensis* have been isolated from arid soils. *B. firmus* was found specific antagonist to *M. phaseolina and B. tequilensis* against *Ganoderma lucidum*. Bio-formulated products of these both the Bacillus species have been developed for the management of Macrophomina & Ganoderma. After a series of experimentations, a bio-kit of bio agents was developed in a bio-formulated product, which was able to maintain shelf life for a period of 180 day of both the bio-agents.

OP2

Mycorrhizae for sustainable agriculture - Bangladesh perspective

Tanzima Yeasmin[1]* and M. S. Reddy[2]

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Mycorrhizae are fungi that have a symbiotic relationship with the roots of many plants. The fungi which commonly form mycorrhizal relationships with plants are ubiquitous in the soil. Mycorrhizae help build soil aggregate structure to provides plant roots with a better and healthy environment and strong growth. Mycorrhizal fungi associated with plant roots increase the absorption of nutrients, particularly phosphorus, and thus enhance the growth of crop plants and trees. Up to 20% of a plant's fixed C is transferred to the mycorrhizal fungus in exchange for water and nutrients such as N and P. Phosphorus is the most well-known and studied nutrient linked to AM fungi. Since P is immobile in the soil, plants can greatly benefit from the hyphal network of the fungi to aid in P uptake. Now a days human society demands the production of high-quality food in a most sustainable way with least damage possible to the environment. Food production has been increased more than three times in Bangladesh due to high yielding crop varieties, agrochemicals, irrigation system and chemical fertilizers. However, the high input use has led to increased land degradation, pest resistance, loss of soil fertility, nutrient imbalance and depletion of soil organic matter. Symbiotic arbuscular mycorrhizal fungi (AMF) form a key component of the soil microbial populations. AMF form a mutualistic association with the host plant and exert a positive influence on its growth and nutrient uptake. AMF has showed growth enhancement of crop plants, and serves as an effective alternative to fertilizers for improved vigor, nutrient uptake, disease resistance and drought tolerance. Use of nature's own mycorrhizal biofertilizers through biotechnological applications appears to solve these problems. In sustainable, low-input cropping systems, the natural role of microorganisms in maintaining soil fertility and biocontrol of plant pathogens may be more important than in conventional agriculture where their significance has been downgraded by high inputs of agrochemicals. To achieve sustainable agriculture in Bangladesh, AMF could play an important role towards modern agriculture improvement. Production of AMF inoculum for large scale projects is now feasible but many basic questions related to persistence of these fungi in field situations, competition with other microorganisms, and particularly the most efficient fungi to use for particular hosts remain to be investigated.

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OP3

Influence of soil conditioners with PGPR enrichment to support microbial diversity and shallot production

Sarjiya Antonius *, Agung Adi Nugroho, Tirta Kumala Dewi, Achirul Nditasari, Sri Purwaningsih and Dwi Agustiyani

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Despite growing interest in utilizing microbial-based methods for improving crop growth, much work still remains in elucidating how beneficial plant-microbe associations are established, and what role soil amendments play in shaping these interactions. Here, we describe a set of experiments that test the effect of soil conditioners on the soil and shallot growth and its root bacterial microbiome. The bacterial communities of the soil, rhizosphere, and root from amendment treated and untreated fields were profiled across the shallot growing season using next generation sequencing approach. A series of studies have been carried out on the selection of formulations of organic materials as soil conditioners in polybags and mini shading net experimental garden. Three types of soil conditioners were used: 1) soil conditioner frass compost (SCF) consisted of black soldier larvae waste and garden waste; 2) soil conditioner compost (SCC) consisted of chicken manure, cane sugar processing waste, husk biochar, zeolites; 3) soil conditioner botanical garden compost (SCCBG) consisted of botanical garden leaf litter, spent mushroom, tofu waste, zeolite and biochar. These conditioners were prepared according to Government regulations. Our results showed that application of SCF and SCC soil conditioners in combination with PGPR enrichment showed increased shallot growth, yield and soil quality better than control. The next generation sequencing analysis of microbiome showed increased microbial diversity. In all sample types, bacterial community composition and relative abundance were significantly altered with amendment application. Importantly, time point effects on composition are more pronounced in the root and rhizosphere, suggesting an interaction between plant development and treatment effect. These findings demonstrate that application of a commercial microbial enriched soil conditioners can impact the bacterial community structure of both roots and the surrounding environment and consequently improved crops production.

OP4

Global status and trends of microbial inoculants

Jitendra Patel

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Sustainable agriculture is creating an importance nowadays because of its capability to fulfil agricultural needs which cannot be accomplished by conventional agriculture. The technology to be used should be eco-friendly as well to ensure safe and healthy agricultural products. Microbial inoculants are helpful to drive the stability and productivity of agroecosystems. The use of microbes in agriculture is very attractive for sustainable agriculture. Potential microbes have the capability to increase plant growth and reduce disease incidence to enhance crop yields. The major focus in the coming decades is the use of plant-associated beneficial microbial communities. Its market is estimated to rise dramatically in near future. Success of commercialization of microbial inoculants depends upon the efficacy of the product under commercial conditions. Microbial communities possess a huge sink of mechanisms by which they act as biofertilizers, bioprotectants, and biostimulants as well as combaters of biotic and abiotic stress conditions. Thus, utilizing plant-associated microbiomes will surely support sustainable agriculture thereby reducing the production costs and environmental pollution. The use of microbial inoculants is increasing day by day and therefore the awareness in farmers about their importance is increasing. This could be accomplished by publicity, field demonstrations, bio-village adoption and regular training programmes for commercial producers and farmers. The use of the plant growth promoting microbes in agriculture could support a decline in utilization of chemical fertilizers and to boost the crops productivity in an eco-friendly manner.

OP5

Pusa Decomposer- microbial consortium for biomass degradation and enhancing crop productivity

Livleen Shukla*, Kannepalli Annapurna, Ritu Raj Gupta, Sandeep Kumar Singh, Satish Lande, Deeba Kamil, Rauf A. Parrey, Niveta Jain, Y. V. Singh and Indramani Mishra

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India is the global prime producer of rice (*Oryza sativa*) accounting for about 20% of world rice production. In India 43.2 m ha of area is under rice cultivation. The main byproducts of rice are straw, rice husk and rice bran. Approximately, 760 million tons of rice straw is produced per year globally, which is 1.5 times greater than per ton of rice-grain production. The disposal of this surplus straw creates a major concern in all the rice growing areas. Moreover, since last two decades farmers prefer to burn this straw to clear the field for the timely sowing of wheat in northern and north-western parts of India. Open field-burning of straw release a large amount of pollutants including methane and fine/ inhalable particles, toxic gases such as carbon monoxide (CO), carcinogenic polycyclic aromatic hydrocarbons and volatile organic compounds (VOCs) which are responsible for various environmental pollution and human health hazards. Burning of rice straw emits 0.7- 4.1g of CH4 and 0.019- 0.057g of N2O per kg of dry rice straw and other gaseous pollutants such as SO2, NOx, HCl, and to some extent, dioxins and furans. We have developed an effective microbial solution *Pusa Decomposer (both in liquid and capsule form)* for accelerated decomposition of paddy straw. Results show 90-95% degradation of the straw in a short period of 20-25 days, with concomitant improvement in soil OC, N and P availability and 15% increase in crop yield. In our presentation we shall discuss how the technology has been validated at large scale of more than 4,00,000 lakh acres in the two states of Punjab and Haryana where maximum burning events take place after rice harvest.

OP6

Melatonin and plant growth-promoting rhizobacteria (PGPR) regulate cadmium toxicity in *Brassica juncea* L.

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Cadmium (Cd) metal bioaccumulation in *Brassica juncea* induces toxic reactive oxygen species (ROS) that disintegrates various metabolic activities. Due to altered redox homeostasis, oxidative stress is generated on account of generation of free radicals. Plant microbiome plays an important role in metal stress tolerance. Currently, the role of phytomelatonin (MEL) in lowering oxidative stress in plants is being studied. As direct antioxidant, it scavenges ROS, reactive nitrogen species (RNS) and malondialdehyde (MDA). Keeping this in view, the present work in *B. juncea* was undertaken to study the stress protective potential of PGPR and MEL. The seeds of B. juncea were treated with different concentrations of MEL and raised under *in vitro* conditions containing two different strains of heavy metal resistant *Pseudomonas fluorescens* and *P. putida* for 10 days. They were analyzed for growth, photosynthetic and oxidative stress characteristics. Our results showed a retarded growth due to Cd treatment was restored with phytomelatonin treatment and microbe supplementation. Similarly, the chlorophyll and carotenoid content were raised by 33%, 28%, respectively in plants with melatonin and microbes treatment. Fluorescence quenching in Photosystem II was analyzed with Pulse-amplitude modulated chlorophyll fluorometry (PAM). Drop in photochemical quenching (qP) in PSII was recovered maximum by combined treatment of melatonin and microbes (80.42%) in comparison to Cd stressed seedlings (39.4%). There was enhanced production of oxidative markers (MDA, $O_2^{\cdot -}$ and H_2O_2) under Cd stress. Whereas combination of MEL and microbes could control generation of these radicals by 31.1%, 62.8%, 69.6%, respectively. Histochemical studies substantially validated the quantitative studies and recuperated effects of MEL and microbes were well indicated. The antioxidant enzymes activity of Asada-Halliwell pathway was also studied, Superoxide Dismutase (SOD) showed maximum hike by 67.1%. Pre-treatment of melatonin and microbes improved contents of Ascorbic acid and Glutathione to 41% and 74.2%, respectively. Localization of glutathione also indicated positive effect of melatonin in plants. It could be concluded that co-application of MEL and PGPR may help in mitigating deleterious effects of Cd on growth, photosynthetic efficiency and antioxidative defense system.

Session: 2

Theme: PGP microbes for plant protection, soil amendments and biofertilizer

LP3

Plant endophytes – a new ray of hope for sustainable agriculture

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Intensive agriculture, which depends on unsustainable levels of agrochemical inputs, is environmentally harmful, and the expansion of these practices to meet future needs is not economically feasible. Other options should be considered to meet the global food security challenge. Endophytic microbes are present in nearly all the plant species known to date but how they enter and flourish inside a host plant and display multiple benefits like plant growth promotion (PGP), biodegradation, and stress alleviation are still unexplored. Until now, most of the research has been conducted assuming that the host–endophyte interaction is analogous to the PGP microbes, although, studies related to the mechanisms of their infection, colonization as well as conferring important traits to the plants are limited. Endophytic microorganisms were first discovered by the German botanist Johann Heinrich Friedrich Link in 1809. Endophytes are microbes that inhabit the internal parts of the plants as commensals. They enter the plants through seeds, leaves, stems, and roots of a plant without harming the host plant. Some of the endophytes reside in leaf nodules as endosymbionts in a specialized endosymbiont housing structure. Non-nodulated species harbour these endophytes in between mesophyll cells intercellularly. Endophytes promote plant growth by enhancing nutrient uptake. Some endophytes regulate plant hormones such as auxins, gibberellins, cytokinin's, and ethylene. Also, endophytes operate several signalling pathways mediated by ethylene, jasmonic acid, and salicylic acid, to protect host plants from plant pathogens by initiating induced systemic resistance (ISR). Our work is based on horticulture and irrigated crops of India. Some of the endophytes of our study included *Gluconacetobacter diazotrophicus*, Rhizobium, phosphate solubilizers and PGPR on various crops of Solanaceae, Malvaceae, Cucurbitaceae, Leguminaceae, and Gramineae, the interactions between endophytes and plants can promote plant health and play a significant role in low-input sustainable agriculture for both food and nonfood crops. This review will summarize part of the work being done on endophytic microbes, including their isolation, identification, diversity, distribution, and applications for sustainable agriculture.

OP7

Streptomyces sundarbansensis a potential biological control agent against *Ganoderma boninense* of oil palm basal stem rot disease

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In Southeast Asia, basal stem rot (BSR) disease has remained one of the major obstacles in oil palm cultivation. It is caused by the white-rot fungus, *Ganoderma boninense* which cuts down the oil palm yield in most production areas in Malaysia as well as Indonesia. The available control measures for BSR disease such as cultural practices and mechanical and chemical treatment has not proved satisfactory since Ganoderma has various resting stages. Alternative control measures to overcome the Ganoderma problem are focused with the use of biological control agents. *Streptomyces sundarbansensis* was isolated from soil samples collected from Crocker Range of Sabah and tested against *G. boninense* and found 80% inhibition of radial growth of the fungus. The interaction of *S. sundarbansensis* with *G. boninense* was observed under scanning electron microscopy. *G. boninense* was inhibited by anti-fungal metabolites produced by *S. sundarbansensis* and caused hyphae damage. Ethyl acetate extract of metabolites of *S. sundarbansensis* showed the significant inhibition to *G. boninense*. Minimum inhibitory concentration of the ethyl acetate extract was at 0.18 mg ml^{-1}. The extracts were then fractionated through solid phase extraction (SPE). SPE fractions (0.02 mg ml^{-1}) showed better inhibition to *G. boninense* compared to crude extracts with the same concentration. Antimicrobial compounds such as ribostamycin, benzylmalic acid, landomycin B and salinomycin were detected in these samples by Liquid chromatography-mass spectrometry. These metabolites may contribute to the antagonistic effect against *G. boninense*.

OP8

Efficacy of *Brevibacillus agri* with *Piper cannium* extract to suppress the blast disease and to increase the yield of Bali red rice

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Blast disease caused by fungal pathogen *Pyricularia oryzae*, *Nigrospora oryzae*, and others is the most severe disease of rice (*Oryza sativa* L). On an estimate it annually destroys rice, which can feed around sixty million people. Keeping in view of the importance of the disease, various management strategies like controlled use of nitrogen fertilizers, application of silica and flooding of paddy fields are the practices in use to reduce the rice blast since long time. All the rice blast disease management strategies employed so far have had limited success and rice blast has never been eliminated from rice fields. Hence, there is a need to look for the best remedy in terms of effectiveness, sustainability, and organic nature of the method. Hence, this study was aimed at determining the plant growth-promoting and fungicidal effects of a mixture of *Piper caninum* leaves extracts and *Brevibacillus agri*. Gas chromatography–mass spectrophotometry (GC-MS) analysis of *P. caninum* leaves extracts fermented by *B. agri* of these new compounds such as 2,3 butanadiol; tetradecanoic acid; Butanoic acid; ethyl ester; Benzenepropanal; 3-(1,1-dimethylethyl)-a-methyl; a-N-Normethadol. The mixture of these extracts reduced the intensity of blast disease, inhibited *N. oryzae*, and improved the growth, yield, and quality of Bali rice. All treatments comprising of different concentrations of a mixture of leaves extracts of *P. caninum* plus rhizobacteria exhibited biocontrol and bioefficacy. However, a 2% concentration of a mixture of these leaves extracts with Brevibacillus exhibited potent inhibition of growth of *N. oryzae*, a significant reduction in the intensity of blast disease, and a maximum increase in growth, yield, and quality of Bali rice. Following at the 15th week, the intensity of blast disease decreased from 75.66% to 17.86%. The mixture of leaves extract + PGPR also improved the height of the plant, the number of tillers, number of leaves, number of grains per panicle, number of heads per panicle, and the full-grain weight per clump. Applications of various concentrations of a mixture of leaves extracts + PGPR resulted in improvement in the potential yield of rice, however, the application of 2% extracts + PGPR gave the highest potential yield of 7.22 tha−1 compared to the low yields in the control and other treatments. The high grain yield observed with the treatment was caused by the low intensity of blast disease. This treatment also strengthened the stem, prevented the drooping of the plant, and improved the quality of rice grain.

OP9

Impact of application of bio-inoculants on native soil-microbial diversity in the rhizosphere of soybean-wheat cropping system

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Soil microbial communities are responsible for performing many critical ecosystem functions and can be important biological indicators of soil health of agricultural lands. Any chemical and biological interventions undertaken during crop production practices would have direct impact on soil microbial communities in terms of their diversity and ecological functions of the soils, such as nutrient cycling, crop production and crop protection. Hence, the present work aimed to assess and understand the impact of application of bio-inoculants on microbial diversity of rhizosphere soil in soybean and wheat through PLFA (Phospholipid fatty acids) and TRFLP (Terminal restriction fragment length polymorphism) analysis. The PLFA profile analysis of rhizosphere soil samples collected at two different crop growth stages of soybean and wheat, showed on increased total microbial biomass content from vegetative stages to flowering stages and significantly a higher biomass and differences in types of fatty acids observed with selected bio-inoculants treatments in both crops. In both crop rhizosphere, overall G+ve groups were more prevalent at both stages and with increased in G-ve bacterial groups towards flowering stages was observed. Results of TRFLP analysis showed significant differences found between bioinoculants treatments and uninoculated control treatment in both soybean and wheat rhizosphere soil with respect to T-RFs sizes, peak height, and peak area. In the soybean and wheat rhizosphere, T-RFs with different sizes and a significant difference in their relative abundance among the bioinoculant treatments was observed in the respective rhizosphere soil. Four unique T-RFs was found observed in the uninoculated control treatment as compared to other bioinoculants treatments in the soybean, while in wheat rhizosphere, the observed unique T-RFs was found in the uninoculated control and RDF-250gN/plot treatments as compared to other bioinoculant treatments. The results from both PLFA profiling and TRFLP analysis was demonstrated the transient effects of bioinoculant treatments on microbial community structures in the rhizosphere of soybean and wheat.

OP10

Inoculation effect of *Pseudomonas* strains on growth of tomato plants under controlled climatic conditions

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Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetables worldwide. As it is a relatively short duration crop and gives a high yield, it is economically attractive and the area under cultivation is increasing. However, the yield of tomato is still relatively lower in Pakistan as compared to other countries. To enhance tomato production, a great alternative to chemical fertilizers is the use of plant growth-promoting rhizobacteria (PGPR). Environmental protection and the need to enhance agricultural output have made research in new sustainable technologies necessary. In recent years, interest in soil microorganisms that can promote plant growth or help prevent the attack of soil-borne plant pathogens has increased. These beneficial bacteria are usually referred to as plant growth-promoting rhizobacteria or PGPRs. Many *Pseudomonas* strains are known to significantly promote the growth of various crops and plants, directly or indirectly. The aim of this study was to check the effect of nine *Pseudomonas* subspecies *aurantiaca* and *chlororaphis* strains, (GS1, GS3, GS4, GS6, GS7, PBSt2, RP4, FS2, ARS38), on the growth of tomato under controlled climatic conditions. Three inoculation methods such as seed soaking, root drench at the time of transplantation, and root soaking were used. Six-days-old seedlings were transferred to pots filled with autoclaved sand and fertilized with full-strength Hoagland's solution, and later, watered daily. Plants were harvested after 30 days of transplantation and growth parameters such as seedling length, dry and fresh weight of roots, shoots and root surface area were measured. The results showed that four out of nine strains i.e., PBST2, ARS38, GS7 and RP4 performed very well with all inoculation methods and significantly promoted the seedlings growth. Among inoculation methods, seed soaking proved to be the best method to increase the lengths and plant biomass compared to other methods. We conclude that four out of nine strains evaluated have potential to be used as biofertilizer for tomato as seed soak method.

OP11

Efficacy of antagonistic rhizobacterial isolates from biofumigated soil for control of damping-off of cucumber caused by *Pythium aphanidermatum*

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Damping-off diseases in bedding plant production are commonly encountered in the greenhouse and are primarily caused by the ubiquitous pathogen *Pythium aphanidermatum*. Soil biofumigation is commonly used for the management of soil-borne diseases of vegetable crops. Biofumigation could be achieved by incorporation of fresh plant materials from members of Brassicaceae family which could produce glucosinolates in the soil. The hydrolysis products of glucosinolates exerts antimicrobial activity. However, the biofumigants may affect non-target beneficial soil biota including microbial antagonists due to their broad-spectrum toxicity. In this study, biofumigation-tolerant native antagonistic rhizobacteria were isolated and their potential in the management of *Pythium aphanidermatum* induced damping-off of cucumber was evaluated. A total of 36 morphologically distinct rhizobacterial isolates were isolated from cabbage grown in biofumigated soil. Among them, four bacterial isolates were showed inhibitory activity against *P. aphanidermatum* in a dual-culture assay. Deformation and shrinkage of the mycelium due to diffusible antifungal compounds of these bacterial strains were witnessed through scanning electron microscopy. These bacterial isolates were identified as *Pseudomonas aeruginosa*, *P. indica*, *Serratia marcescens* and *P. brenneri* on the basis of 16S rRNA gene sequence /MALDI Biotyper analyses. *P. indica* when applied to soil alone or in combination with biofumigation treatment reduced the incidence of cucumber damping-off by 60% and 48%, respectively under greenhouse conditions. The results from this study suggest that *P. indica* may be considered as a potential candidate for biocontrol of damping-off of cucumber in biofumigated soil.

OP12

Genetic variation and molecular characterization of *Ceratocystis fimbriata,* causal agent of wilt in pomegranate and its management by bio-stimulants

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Pomegranate wilt disease caused by *Ceratocystis fimbriata* Ell. and Halst. is one of the most important diseases of pomegranate adversely affecting the crop cultivation in all major growing areas of Karnataka, India. The pathogen being soil borne, preventive measures need to be taken to manage the disease. Hence, the present *in vitro* studies were undertaken to test the efficacy of bio-stimulants against the Pomegranate wilt. The different indigenous Trichoderma isolates were collected from pomegranate orchards during the survey and evaluated their efficacy *in vitro* against the pathogen. Among the isolates tested, Trichoderma isolate 3 and Trichoderma isolate 8 showed maximum inhibition of mycelial growth (71.27%) followed by Trichoderma isolate 4 (68.67%) within five days of inoculation and completely inhibited the perithecium production as well it grew over the pathogen. The least growth inhibition of fungus was shown by Trichoderma isolate 1 (57.44%) and Trichoderma isolate 2 (57.44%). Fifteen isolates of *Ceratocystis fimbriata* collected from different locations of Karnataka were characterized using ITS gene technology. It produced an amplification size of 600-650 bp length which indicated that, all the isolates belong to genus *Ceratocystis* thus confirmed the identity of the pathogenic isolates. To test the genetic variability, isolates were analyzed using microsatellite markers. UPGMA dendrogram for genetic variation among the isolates showed that, all the isolates fell into two major clusters. Cluster one consists of isolate Cf-10. The cluster two was further divided into two sub-clusters. The sub-cluster one consists of isolate Cf-2. Sub-cluster two was again divided into five groups. First group includes isolate Cf-13, second group consist of isolate Cf-14, third group includes isolates *viz*., Cf-1, Cf-4, Cf-6, Cf-7, Cf-8 and Cf-9 and fourth includes Cf-5 and Cf-11 whereas, fifth group consists of Cf-3, Cf-12 and Cf-15. Dissimilarity coefficient was ranged from 0.00 to 0.20 among the isolates. Isolates *viz*., Cf-1, Cf-3, Cf-4, Cf-5 Cf-6, Cf-7, Cf-8, Cf-9, Cf-11, Cf-12 and Cf-15 were found highly similar to each other as their dissimilarity coefficient was zero and maximum dissimilarity index (0.20) was found between isolates Cf-10 with all other isolates and genetically distinct with each other.

OP13

Potentiality of phyllospheric growth-promoting and antagonistic bacteria for management of black rot disease of cauliflower incited by *Xanthomonas campestris* pv. *campestris*

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Black rot of cauliflower incited by *Xanthomonas campestris* pv. *campestris* is a devastating disease worldwide and caused losses up to 50% under favorable environmental conditions. All crucifer crops are susceptible to black rot, including cabbage, broccoli, cauliflower, brussels sprouts, Chinese cabbage, kale, radish, turnip, mustard, rutabaga, watercress, and arugula. Symptoms of black rot generally begin with yellowing at the leaf margin, which expands into the characteristic "V" shaped lesion. To manage black rot disease by using antibiotics and copper fungicide is an option but it is not considered a long-term solution due its non-judicious use, exposure risks health and environmental hazards and resistance development against the antibiotics. Biological control is an alternative approach to manage bacterial diseases using plant growth-promoting and antagonistic bacteria which is a safe and promising strategy. Phyllosphere is a habitat for different kinds of microorganisms. Recent developments in the advancements of molecular and computational tools, high-throughput screening procedures, and amalgamation of omics techniques have significantly enhanced the understanding of phyllosphere-associated microbial communities in relation to their structural, functional, and ecological properties. Microbiome has played an important role in sustaining crop growth and health management by regulating plant physiological processes under ever-changing environmental conditions. We studied the diversity of culturable and non-culturable bacteria of phyllosphere of black rot infected and non- infected leaves of cauliflower (*Brassica oleracea* var. *botrytis*) and various of bacterial population and their diversity was recorded in black rot infected and non-infected leaves of cauliflower. In present study, culturable bacteria were isolated from phyllosphere of black rot infected and non-infected leaves of cauliflower and characterized them using morphological, biochemical and molecular techniques (16S rRNA sequence analysis). Out of 46 isolates of were isolated from phyllosphere of cauliflower 63.04% were belong to Gram positive bacteria, 50% showed antagonistic ability against *X. campestris* pv. *campestris*, 78.26% isolates produced IAA, 58.70% produced HCN, 63.04% produced ammonia, 82.60% solubilized phosphate. However, 39.13% of phyllospheric bacteria showed ability to produce siderophores. Further, we have selected 10 isolates of phyllospheric bacteria having plant growth promoting ability and antagonistic ability among them, four isolates, CFLB-27, CFLB-24, CFLB-26 and CFLB-31 significantly reduced black rot incidence under glasshouse conditions. Thus, we concluded that phyllosphere is a good source for harbouring potential plant growth promoter and antagonists to control black rot disease of cauliflower.

OP14

The role of beneficial bacteria associated with *Pteris vittata* for arsenic tolerance and plant growth-promotion in contaminated soils

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Pteris vittata, also known as Chinese brake or ladder Fern, is native to China. *P. vittata* is a hyperaccumulator of arsenic. It has been praised for its potential to remediate soils contaminated with arsenic. Even though it has the beneficial quality of being a natural bioaccumulator, it is still considered an invasive plant and should be managed as such. In view of this, this study was conducted to determine the role of beneficial bacteria associated with the rhizosphere of *Pteris vittata* for arsenic tolerance and plant growth-promotion abilities. A total of eighty-two bacteria were isolated and screened for arsenic (As) tolerance and various plant growth promotion (PGP) traits. The production of PGP substances by all the isolates under the arsenic influence was further evaluated. Eight best bacterial isolates were selected based on their PGP abilities and minimum inhibitory concentration (MIC). The isolates were identified based on 16S rRNA as *Enterobacter chengduensis* (2P5), *E. sichuanensis* (3P8), *E.sichuanensis* (3P15). *E. sichuanensis* (3P19), *Bacillus paramycoides* (3P20), *E. sichuanensis* (5P7), *E. sichuanensis* (6P9) and *E. sichuanensis* (6P10). The screened isolates sustained PGP traits and tolerated high arsenic stress, particularly *E. sichuanensis* (3P19), *B. paramycoides* (3P20) and *E. sichuanensis* (5P7), had the overall best performance compared to other isolates. Hence, the strains are assumed to be the major contributing factors to the growth and survival of *P. vittata*, which were endemic in the previous tin mining sites, could provide a basis to be used as indigenous bacteria for plant growth-promotion and bioremediation in arsenic-contaminated soils.

OP15

Isolation of locally potential fluorescent Pseudomonads from Kuini (*Mangifera odorata*) planted soil for their potential as biofertilizer

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Pseudomonas sp. are known to be good plant growth-promoting rhizobacteria (PGPR). In this study, Pseudomonas sp. was isolated from soil planted with kuini (*Mangifera odorata*) by soil dilution method and growing onto King's B media. Among these isolates, five isolates of Pseudomonas sp. were purified and designated them as K24pf, K29pf, K32pf, K33pf and K37pf. All these isolates were tested for production of phytohormones and antimicrobial activity against *Ralstonia solanacearum*, *Erwinia caratovora, E. mallotivora* and *Colletotrichum gleosporioides*. Also, these were tested for seed germination of *Brassica chinensis* seeds under laboratory and pot assays. Our results showed that K29pf, among the five isolates produced marked amounts of indole-3-acetic acid and gibberellic acid. The isolate K29pf was also produced antimicrobial activities towards *R. solanacearum*, *E. caratovora, E. mallotivora* and *C. gleosporioides*. Seed germination test showed that isolate K29pf was able to promote approximately 90% growth of *B. chinensis* seeds. Our pot assays showed that K29pf was also increased *B. chinensis* root biomass significantly compared to all other treatments includes control.

OP16

Efficacy of endophytic bio-stimulant for root growth enhancement in chili

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The agricultural sector is facing concomitant challenges in enhancement of productivity to feed the growing population. The plant bio-stimulants are biologically derived fertilizer supplements that are used in crop production. In this category, the beneficial microbes are one of the competent and eco-friendly to revitalize soil health and to increase nutrient absorption by plant roots. However, the beneficial microorganisms could not be established their populations in the soil root ecosystem due to its poor colonization potential. Furthermore, the nutrient use efficiency of crop is mainly dependent on root growth and root architecture. In this study, the colonization potential of endophytic bacteria on chili seedlings was assessed. The bacteria were isolated from moringa roots and screened for beneficial traits such as phosphorus solubilization and production of indole acetic acid, siderophores and biofilm. The bacteria were tested in various combinations to determine the most potential microbial consortium that could increase the root length and root biomass. The root colonization efficiency was tested using Scanning Electron Microscope. Our results showed that the endophytic bacteria significantly increased root biomass and root length compared to untreated control. The architecture of root was clearly influenced by the endophytic bacteria and increased lateral roots, root hairs and diameter of primary root. The root colonization assay showed that the endophytic bacteria colonized the root tips of chili seedlings. Therefore, the endophytic bacteria could have a great potential to be developed as a bio-stimulant for enhanced nutrient absorption in chili plants. More studies are in progress for commercialization of this bacteria.

OP17

Impact of PGPR in Kalanamak rice under salinity conditions

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The growth and yield of plants are strongly influenced by abiotic stress such as drought, high salt content, and temperature change. Environmental stress is a major challenge in the world quest for sustainable food production since it reduces potential yields by as much as 70% in crop plants. Plants under salt stress can suffer from membrane destabilization and general nutrient imbalance. Salinity produces oxidative stress by the enhanced occurrence of reactive oxygen species. Salinity is one of the major abiotic stresses that limits agricultural productivity with significant crop loss worldwide. It adversely affects the plant by retarding its growth and development morphologically and biochemically. Excess of salt in soil, adversely affect plant growth, development, and its productivity when osmotic stress reduces water uptake by roots. Halo-tolerant plant growth promoting rhizobacteria (PGPR) are potential bioinoculants to enhance crop productivity in saline agriculture. Current work was aimed at studying individual or synergetic impact of salt tolerant PGPR on rice growth and yield under saline conditions. In this study we have evaluated different levels of NaCl concentrations such as 100 mM, 150 mM, 200 mM, 250 mM, 300 mM, and 400 mM with and without Pseudomonas Spp. Our results showed that salinity causes a gradual reduction in the morphology of the rice. But, however, PGPR enhanced the growth of kalanamak rice irrespective of salinity conditions. This study recommends PGPR for the salt tolerant as potential bioinoculants to augment their growth and yield through modulation of morpho-physiological and biochemical attributes under saline conditions.

OP18

Efficacy of endophytic bacterial antagonists against tomato damping-off caused by *Pythium aphanidermatum* under greenhouse conditions

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Tomato (*Solanum lycopersicum* L.), one of the most widely grown vegetables worldwide, is susceptible to damping-off and root rot caused by *Pythium aphanidermatum* (Edson) Fitzpatrick. Pythium damping-off has the potential to cause severe loss in greenhouse and field grown tomatoes. Species of Pythium are found in soils from all climates, and capable of surviving for long periods without a host. Infectious structures of Pythium species are motile, and therefore able to travel through irrigation water and runoff. Currently, no tomato varieties with resistance to damping-off are available. In addition, the agriculture industry is striving for sustainable and biological methods of control of plant pests and pathogens. Therefore, biological controls that are capable of simultaneously protecting plants from pathogens and pests are needed. Hence our object was to test the efficacy of endophytic bacterial antagonists against tomato damping-off caused by *P. aphanideramtum* under greenhouse conditions. For this purpose, we have isolated endophytic bacterial isolate and characterized as Chryseobacterium *gleum* strain B2. In this study, C. *gleum* isolate B2 was significantly reduced the damping-off incidence by 50% compared with Pythium infected control. In addition, *C. gleum* isolate B2 significantly inhibited vegetative growth of *P. aphanidermatum* by compared to the control under dual antibiotic assay. Our study demonstrated that isolate B2 produced 9-Octadecenoic acid (Z)-, methyl ester (6.04%), Butanoic acid, 3-methyl ethyl ester (5.81%), Octodrine (3.55%) and a variety of esters negatively influenced the mycelium growth *P. aphanidermatum*. Artificial inoculation B2 into peat-based growing media resulted in a significantly lower percentage of damping-off affected tomato seedlings compared with the infected control. Therefore, it was concluded that the isolate B2 could be used to control damping-off and root rot of tomato caused by *P. aphanidermatum.* Further field studies are in progress to test this isolate under field conditions.

OP19

Beneficial effect of plant growth-promoting rhizobacteria on growth of Cassava *(Manihot esculenta* Crantz) and to enhance fertility of Ultisol soils

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Ultisol and Alfisol are potential soil types in Indonesia, and they cover 25% of the total land area in Indonesia. Cassava (*Manihot esculenta* Crantz) is a drought-tolerant crop and is capable of growing in marginal soils. The application of synthetic fertilizers in improving soil nutrient has long been employed by conventional farmers. However, excessive application of these chemicals has led to accumulation of contaminants in agricultural soils and consequently, a significant damage on important crops have been recorded. To increase Casava production, it is very important to improve low-input technologies such as PGPR well adapted to the particular soil conditions. The objective of the present study was to investigate the effect of microbial consortia (LOB N) as biofertilizer on plant growth, yield and quality of Cassava. The LOB N consisted of 10 PGPR strains isolated from the roots of various tuber crops with multifarious plant growth promoting traits such as P and K solubilization, N-fixing, production of IAA, ACC deaminase, protease, siderophore, HCN, and catalase, Out of 10 bacterial strains, four strains were identified as Burkholderia Sp. two strains as Bacillus Sp., the other strains as Paenarthrobacter, Klebsiella, Kocuria, and Rhizobium. The experiment was conducted in ultisol soil at Cibinong, West Java, Indonesia. The Cassava var Mentega 2 was used. The LOB N treatment was compared with commercial liquid organic biofertilier (LOB C), Mix of LOB N + LOB C and control (without LOB). The results showed that application of LOB N increased the tuber weight, chlorophyll and Fe content in leaf and starch content in cassava tubers. The LOB N application increased tuber weight by about 40% compared to control. The amylopectin content in tubers increased by about 2.5%, in the LOB N treatment (30.9%) compared to the control (28.7%). The application of LOB N increased the population of P-solubilizing, N-fixing, IAA-producing and protease-producing bacteria compared to control. The activity of urease and PME-ase enzymes also increased in the soil treated with LOB N.

Session: 3

Theme: General application of PGP microbes in agriculture, forestry and environment

LP4

Artificial intelligence: a promising technique to design synthetic microbial communities for plant health

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A functionally diverse microbiota to plant health is a combination of microorganisms that are compatible with host genotype, environmental changes, and soil type. Traditional microbe selection methods mainly focus on a single strain screening under defined conditions or well-known taxa such as disease inhibition, phytohormone production, nitrogen fixation, and 1-aminocyclopropane-1-carboxylate (ACC) deaminase activity. Although these methods are broadly adopted and some cases are extensively investigated, this strategy is unable to fully capture essential interactions between microbe traits and their effectiveness in promoting plant health and growth. The functions of inoculant rely on a highly diverse and complex community which provide reciprocal interactions between microbes and their hosts. Thus, designed inoculants with the traditional methods frequently failed to establish a sustainable association with crop plants under field environments. Synthetic microbial communities (SynComs) are small consortia of microorganisms designed to mimic, on a simplified scale, the naturally observed microbiome, and could be a possible alternative solution to the limitations. The key microbiome can be integrated into SynComs. An important resource to select microbes containing desirable traits such as colonization efficiency and prevalence to design the best SynComs is the expanded reference genome in public databases. However, identifying plant beneficial microbes from the massive amount of data might be another challenge in designing SynComs. In this perspective, the artificial intelligence (AI) technique will be critical for screening beneficial microbes from large datasets. In biomedical science, AI has proved its effectiveness in discovering novel antibiotics. In plant science, unfortunately, few studies have employed this technique. Another challenge in the assessment of the designed SynComs to plant physiology involves quantification of the robustness of colonization and their ability in outcompeting under diverse environmental conditions and heterogeneity of fields. With the accumulated genomic and phenomic datasets across, AI technique will be very promising in abstracting the complex interactions among microbes, host and environment, and in making predictions for the outcome of SynComs with given microbe combination, plant host and environmental conditions. AI technique could take the PGPR field and its research to a new level.

LP5

Potential of microbial consortium in combination with rock mineral fertilizer on wheat and pasture production

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Fertiliser management practices alter soil microbial processes and nutrient cycling mediated by rhizosphere microbial communities. Therefore, it is crucial to design and implement schemes that encourage farmers to adopt environmentally friendly farming practices. An emerging technology incorporates the use of soil microbes in conjunction with slow-release fertiliser application. Microbial inoculation applied with fertiliser can stimulate the mineralisation of rock mineral fertilisers to release nutrients for plant growth. While increasing crop yield without concomitant increases in fertiliser application is appealing environmentally, there are many unknowns about these consortium microbial inoculants. When applied in various combinations, microbial inoculants that have defined functional specificity have emerged as a potential management option for enriching soil health and plant growth. Therefore, a series of experiments were conducted under glasshouse and field conditions to monitor a microbial inoculant's potential for crop production and soil health improvement. The rock mineral fertiliser with and without consortium microbial inoculation to seeds or fertilisers showed an increased wheat shoot and root growth and grain yield. For pastures, the response to microbial consortium inoculation, either alone or combined with rock mineral fertiliser, was species-dependent, and showed potential for use in pasture production. These combinations can positively influence pasture production in low-P soil by increasing root surface area and fine root length. Overall, the multiple species microbial inoculant had beneficial effects in terms of wheat and pasture yield comparable to commercial mineral and chemical fertilisers applied at the recommended levels for on-farm use in south-western Australia. However, despite being able to assess the abundance of microbial diversity in the rhizosphere soil environment, there is no universally adopted code of 'best practice' for inoculum selection and quality control. Therefore, the effectiveness and persistence of inoculated microbes remain unclear for application in cropping systems.

OP20

Plant–microbe-virus-interactions as game-changers in the natural ecological restoration of the aral sea

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The desiccation of the aral sea represents is one of the largest man-made environmental regional disasters requiring immense restoration efforts. Here, we investigated interactions between prokaryotic and viral communities in the rhizosphere of pioneer plants in the dried-out aral sea basin across a gradient of desiccation. We implemented state-of-the-art qPCR analyses, amplicon, shotgun metagenome sequencing and bioinformatic tools to obtain the first insights into the prokaryotic and viral community structure in the dried-up Aral Sea area, a model habitat for investigating natural ecological restoration. Along the desiccation gradient, we observed a significant shift in the rhizosphere microbiota, which was reflected by i) a decreasing archaea-bacteria ratio, ii) replacement of halophilic archaeal indicator taxa i.e., *Halobacteria* by bacteria i.e., *Actinomycetia* and *Alphaproteobacteria*, and iii) an adaptation of specific, potentially plant-beneficial biosynthetic pathways. Interestingly, targeted analyses highlighted that viral populations in this habitat are subjected to certain dynamics that are mainly driven by the gradient of desiccation and salinity as well as the prokaryotic populations that are present in it. Metabolic prediction of viral auxiliary metabolic genes (AMGs) suggests that viruses play a role in biogeochemical cycles, stress resilience, and competitiveness of their hosts. We highlight that intricate interaction among microorganisms and interactions within their environment can have a significant impact on ecosystem functioning. This study provides a broad overview to holistically cover the response of microbial communities to environmental changes during natural revegetation for the first time in more detail.

OP21

Efficacy of Nano 5G-P in onion production

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Sustainable crop production requires an alternative nutrient source. The use of nanotechnology may offer an unprecedented opportunity to develop nano fertilizers for higher absorption, and efficiency. Despite the importance of macronutrients in crop production, most nano fertilizer research has been conducted on metallic nutrients. The lack of phosphorus among macronutrients adversely impacts yields and crop quality in many countries as it is essential to plant growth, reproduction, and soil fertility. Onion is a staple crop in India and daily necessities for most people. Even though India is the second biggest producer of onions, still, it requires novel organic fertilizers to increase its yield and to promote soil health. The present work was aimed to determine the efficacy of nano 5G-P, a commercial product produced by the Prathista Industries Ltd, on growth and yield of onion. A field experiment was conducted from November to May during 2020-2021 at Mallapalaym field near K. S. Rangasamy College of Technology. There were five treatments, and each treatment was replicated three times and arranged in a randomized complete block design. The onion cv. Arka Kalyan dark red was used to test the efficacy of nano 5G-P. The treatments included were Nano 5G-P at a concentration of 1 ml/L, 3 ml/L and 5 ml/L at 30 and 45 days after planting (DAP) as T1, T2 and T3, respectively; T4: Cytozyme @ 2 ml/L at 30 and 45 DAP and T5: Control (water without any fertilizer). Treatments were applied as a foliar spray. During the experimentation, various parameters of growth and yield were collected and analysed by ANOVA at $P>0.05$. Our results showed that T1 significantly increased onion seedling height, number of leaves per seedling, bulb diameter, and bulb size index, compared to all other treatments. There was no significant difference between T2 and T3. There was no evidence of phytotoxicity with any of the dosages of nano 5G-P. The soil microbial populations did not differ significantly among all the treatments applied. We conclude that nano 5G-P could be used to enhance onion production.

OP22

Rhizomicrobiome engineering through halotolerant PGPR and bioameliorant to alleviate salinity stress and enhance rice production in flood-prone area in Indonesia

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Lowland rice cultivation along the coastal area of Indonesia is highly vulnerable to salinity stress due to sea level rise. High salinity causes a devastating effect on rice growth and often lead to a significant yield loss or harvest failure. Halotolerant plant growth-promoting rhizobacteria (H-PGPR) and ameliorant could play an important role to improve the nutrient uptake, rhizomicrobiome-plant-soils health, fertilizers use efficiency and crop productivity. In view of this, our studies were conducted to isolate the superior of H-PGPR strains, formulating them for screening to alleviate the salinity stress and to improve rice growth in saline ecosystem. The composite soils samples were taken from different saline soils of rice ecosystem and isolated H-PGPR and formulated as inoculant of halotolerant bioagent in form of powder. Organic ameliorant (compost, biochar, and humic acid) enriched with natural mineral (guano and dolomite) and beneficial microbe was used as bioameliorant. Through biological assays and biochemical tests, gibberellic acid, IAA, organic acids, high activity of nitrogenase and phosphatase were characterized. These H-PGPR were characterized and identified as Azotobacter sp, Azospirillum sp, *Acinetobacter sp, Bacillus sp, Pseudomonas stutzeri,* and *Klebsiella pneumoniae. Our results showed that these strains significantly* increased the rice growth. The application of H-PGPR inoculant was able to improve the seedling growth. The formulated halotolerant PGPR inoculant as bioagent and biameliorant combined with adapted or salt tolerant rice variety (Inpari 35, Inpari 43, Mendawak) were able to improve the biodiversity of beneficial microbes and improved the growth and yield of rice significantly. These results suggest that application of 1000-1500 g ha^{-1} of HT PGPR inoculant and 2–3-ton ha^{-1} of bioameliorant combined selected halotolerant rice varieties are the promising and effective adaptation strategy to increase the rice farming resilience and productivity in coastal areas prone to flood in Indonesia.

OP23

PGPR-induced systemic resistance for management of blood disease of banana

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Banana is an important fruit for local consumption and to export. In this direction, the government had given emphasis to increase its production. However, the production and export had been hampered by an invasive alien disease called as blood disease or bacterial wilt caused by bacterial pathogen *Ralstonia syzygii* sub sp. *celebesensis.* The disease had significantly affected banana production in Malaysia. Though various approaches including chemical and biological controls available, but none of them were successful in controlling this disease. One of the approaches that was not fully explored was the enhancement of plant resistance against the disease known as induced systemic resistance (ISR). The aim of this study was to evaluate PGPR induced ISR against blood disease. PGPR strains isolated from local soil were evaluated against blood disease on banana variety Berangan which is a fresh eating variety. The same concept was also evaluated on Tanduk variety, which is a cooking banana and Saba (Nipah) variety. The banana seedlings were treated with PGPR, and blood disease pathogen was artificially inoculated onto PGPR treated seedlings. Our results showed that PGPR treated seedlings provided ISR against the blood disease pathogen in all varieties evaluated compared to pathogen infested control. We conclude that PGPR-induced ISR could be an ideal approach to combat the blood disease of banana in Malaysia.

OP24

Evaluation of potassium solubilizing bacteria on growth and yield of spinach (*Spinacia oleracea* L.) under greenhouse conditions

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The aim of this study was to evaluate the effecacy of two strains of potassium solubilizing bacteria (PSB) on growth and yield of spinach (*Spinacia oleracea* L.) as well as some soil properties under greenhouse conditions. Spinach seeds were soaked in bacterial solution with a density of 10^8 cfu/mL for 24 h and grown for 45 days in the soil supplemented with one ton of rice straw/ha and 50% of the recommended potassium. Our results showed that inoculation of PSB strains as seed treatment increased the growth and yield of spinach by 45.3-80.0% compared to untreated control. The PSB treatments also increased the total K content in spinach biomass and exchangable K content in the soil, and reduced up to 50% of the amount of inorganic potassium needed. Thus, the two PSB strains, *Burkholderia vietnamiensis* L1.1 and *Staphylococcus hominis* T7.3, could be potential candidates for development as commercial microbial fertilizers for sustainable growth and yield of spinach and other vegetable crops. More studies are in progress.

OP25

Immunity boosting through therapeutic traditional herbal foods and sustainable green technology

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Consuming a balanced and varied diet is beneficial for health, especially when individuals feel stressed, scared, insecure, unequipped, or disempowered from maintaining their health during the COVID-19 pandemic. Nutrient deficiencies from inadequate intake of healthful foods can contribute to a weakened immune system and greater susceptibility to infection. Including herbs and spices in a balanced and diverse diet is one of the highlights of nutritious eating that supports health and immunity. Pragati emerged and envisaged in 1994 with healing gardens to eradicate hunger and pollution and to Create "Vyadi Rahita Samajam". Dr. G.B.K. Rao (Gaddipati Bala Koteswara Rao) is the Founder Chairman of Pragati Group and Chairman for expert committee on agriculture and food processing for Southern Region, Indian Chamber of Commerce located in Hyderabad, Telangana State, India. Recently, received CERTIFICATE MOMENTO from WORLD BOOK OF RECORDS, LONDON for identifying sacred, herbal, medicinal mother plants and preserving more than 650 varieties of medicinal flora and raised 40,00,000 of plants in Pragati Sudhaama. Though, I was born into an agricultural family in Repalle of Andhra Pradesh, India and trained as a mechanical engineer developed Pragati by converting a barren limestone quarry into a wonderful green belt with 2500 acres of land. This land was utilized to grow 4.5 million herbal medicinal aromatic mother plants according to rich Bharatiya Rishi Sanskrit (culture), and Vedic living. Accordingly, Vanamulikalu and cows are being treated as Prana Pradaatalu and Arogya Pradaatalu. Vruksho Rakshati Rakshitaha and Gow Samrakshana to protect the sacred herbal, medicinal and aromatic plants. We utilized our sacred heritage cows for threats of hunger and pollution into natural farming, along with, we practiced yoga, meditation, naturopathy and spa, gardening, and landscaping, with mosquito-free environment. Recently we have launched the Amrutha Ahaaram program to create awareness to the public, to avoid eating rice and wheat, and started recommending consuming millets, the food of the future. With this in mind, we developed the concept that "Food is the Medicine" for health, wealth, and happiness to every household in India and the world. Pragati is an icon for Bharatiya Sanskrit (culture) and Sampradayalu (traditions), GBK Rao's wife, Mrs. G V Kumari who is instrumental in financial management in support of Pragati's milestones. Our efforts were recognised by the United Nations. My presentation will discuss the immunity boosting through therapeutic traditional herbal foods and sustainable green technology.

OP26

Progress of natural farming for sustainable agriculture in Andhra Pradesh, India

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The goal of sustainable agriculture is to meet society's food and textile needs in the present without compromising the ability of future generations to meet their own needs. Practitioners of sustainable agriculture seek to integrate three main objectives into their work: a healthy environment, economic profitability, and social and economic equity. Natural Farming is an ecological farming approach with the avoidance of manufactured inputs and equipment, and related to fertility farming, agroecology, agroforestry, ecoagriculture and permaculture, but should be distinguished from biodynamic agriculture. The system works along with the natural biodiversity of each farmed area, encouraging the complexity of living organisms both plant and animal that shape each ecosystem to thrive along with food plants. My presentation is to demonstrate step-by-step on how to turn a farm into a completely natural, chemical-free farm that produces highly nutritional food. Understanding the healthier and beneficial alternatives to chemical fertilizers and other invasive substances on crops of important. There are key differences between natural and organic farming. Natural and organic are chemical or poison free farming methods. Both systems discourage farmers using chemical fertilizers, pesticides in their farming practices. In organic farming, organic fertilizers, and manures like compost, vermicompost, hybrid cow dung manure, etc. are used and added to farmlands from external sources. In natural farming, neither chemical nor organic fertilizers are added to the soil. In natural farming, decomposition of organic matter by PGPR and earthworms is encouraged right on the soil surface itself, which gradually adds nutrition in the soil over the period. Organic farming still requires basic Agro practices like plowing, mixing of manures, weeding, etc. to be performed. In natural farming there is no plowing, no fertilizers, and weed removal is manually done. Organic farming is still expensive due to the requirement of specific manures, and it has an ecological impact on surrounding environments; whereas, natural agriculture is an extremely low-cost farming method, completely based on local biodiversity. There are many working models of natural farming all over the world, the SPNF is the most popular model in India. Farming is always my major interest since childhood. Therefore, I joined the family farm with my father who was a chemical farmer. Having seen the deadly effects of pesticides and artificial fertilizers lately, I decided to become a natural farmer following natural farming methods. My strongest desire is to save the soil from these chemicals and pesticides. I am much more focusing on the production of Desi Variety Paddy Crops as it has more Nutritional Values. Over the years I have conducted many workshops all over India. This transformation has attracted the attention of various sections of people though social media platforms and people are very enthusiastic to come and visit my natural farm and to buy some quality naturally grown chemical free food. Now, many farmers around my village are practicing natural farming under my guidance and I stand as an inspiration to many farmers cooperative groups. My works were recognized by several Governments and Social Organizations and conferred me with several awards. I am indebted my mentor, Prof. M. S. Reddy, the Founder and Chairman of Asian PGPR Society for his continued mentorship and support in my day-to-day activities. Hence, I am dedicating my farm for R & D activities of Asian PGPR Society for Sustainable Agriculture.

OP27

Effect of severity of pruning and integrated nutrient management with PGPR on growth and yield of custard apple cv. Balanagar

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To study the effect of integrated nutrient management (INM) on growth, yield and quality of custard apple and also to find out the combined effect of pruning levels and INM on growth, yield and quality of custard apple was carried out. The experiment was laid out in a FRBD design with nine treatment combinations with three replications per treatment. The pruning intensities were 20 cm, 15 cm, control and three applications of INM: I_1 - 75% RDF (194 g : 94 g : 94 g NPK/plant) +100g AM +100 g Azotobacter +100 g PSB + 0.50 Kg neem cake at onset of monsoon, I_2 - Half N (97 g) + Full P, K (94 g : 94 g) + 100 g AM +100 g Azotobacter + 100 g PSB + 0.50 Kg neem cake, I^{st} Application at 1/4 N (48 g), II^{nd} Application and 1/4 N (48 g) and III^{rd} application, respectively, at one month interval. Our results showed that the application of pruning of 20 cm from tip showed the better performance in terms of plant height, number of shoots per branch, canopy of plant, leaf area, days to flowering, number of fruits per plant and yield. The stony fruit percentage, fruit quality, weight of fruit, fruit volume, fruit to pulp ratio, % pulp, % fruit set were enhanced. Also, the %, number of different grade fruit, total soluble solids, acidity %, T.S.S and acidity ratio, total sugar, reducing and non-reducing sugar have increased. In respect of all INM applications significantly enhanced all above parameters measured. Similarly, the combinations of pruning and INM also showed the better performance. In conclusion, quality fruit yield of custard apple pruned at 20 cm from the tip in the month of April along with the application of Half N (97 g) + Full P and K (94 g : 94 g)+100 g AM +100 g Azotobacter +100 g PSB + 0.50 Kg neem cake as I^{st} application in the month of June, 1/4 N (48 g) -II^{nd} application in the month of July and 1/4 N (48 g) - III^{rd} application in the Month of August proven to be the best.

OP28

Green synthesised zinc, sulphur and silver nanoparticles and their efficacy against soybean rust caused by *Phakopsora pachyrhizi*

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Soybean rust caused by *Phakopsora pachyrhizi* Syd. is one of the major diseases in soybean. The use of nanoparticles against soybean rust is a new trend. Hence, three nanoparticles *viz.,* chitosan-based zinc oxide (Ch-ZnONPs), pomegranate aril-based sulphur (PA-SNPs) and pomegranate aril-based silver (PA-SNPs) were synthesised and characterised by particle size analyser and scanning electron microscopy and evaluated under *in vitro* and glasshouse conditions against soybean rust. The maximum percent spore inhibition of 70.25, 74.70 and 86.68 over control was recorded in Ch-ZnONPs (1250 ppm), PA-SNPs (2000 ppm) and PA-AgNPs (500 ppm), respectively. The effective concentration of each nanoparticle under *in vitro* condition were evaluated in glasshouse along with their corresponding bulk materials. Among synthesised nanoparticles, the PA-AgNPs recorded lowest disease severity (6.67 PDI) at 250 ppm over untreated control (43.70 PDI) was found effective in reducing soybean rust under glasshouse condition. The synthesised nanoparticles have antifungal and antimicrobial activity resulted the lowest rust disease severity in soybean compared to the corresponding bulk materials and control.

OP29

Synergistic effects of PGPR and microalgae for sustainable agriculture

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The twenty-first century has been witnessing rapid rise in human population along with critical issues in global agroecosystems, leading to decreased productivity and degeneration of sustainable agroecosystem. In modern agriculture high amounts of chemical fertilizers have been used to obtain high product yields with increased cultivation efficiency in agriculture. However, the excessive use of chemical fertilizers frequently causes severe environmental damage, such as water, soil, air pollution, the loss of soil fertility and sustainability. Moreover, the excessive use of chemical fertilizers leads to soil acidification and hardening, which decrease root vigor with reduced respiration. Microalgae and plant growth-promoting bacteria (PGPR) have been researched as alternatives to chemical fertilizers for improving soil fertility without any negative effects. PGPR representing microbial groups and with ability of colonizing plant roots, influence plant-growth through various indirect and direct modes to promote its growth and/or protect it from diseases or damage due to insect attack. Thus, PGPR research has received renewed interest worldwide. Algae are a group of ubiquitous photosynthetic organisms comprising eukaryotic green algae and Gram-negative prokaryotic cyan bacteria, which have immense potential in modern agriculture through facilitating increased nutrient availability, maintaining the organic carbon and fertility of soil, and enhancing plant growth and crop yields. Combined synergistic effect of microalgae and PGPR possess high efficacious biofertilizer properties, through the increased production of phytohormones, amino acids, and carotenoids and their ability to inhibit plant pathogens. Inhibition of plant pathogens is also one of the interesting functions of these microalgae and PGPR together better than alone. It is now in practice the use of either algae or PGPR alone for betterment in agriculture. There is growing experimental evidence suggesting that a symbiotic relationship between microalgae and PGPR synergistically affects each other's physiological and metabolomic processes. Moreover, the co-culture/combination treatment of microalgae and bacteria is considered a promising approach in biotechnology for wastewater treatment and efficient biomass production, based on the advantage of their resulting synergistic effects. However, much remains unexplored regarding the microalgal–PGPR interactions for sustainable agricultural applications. This paper focuses overview of prospects and challenges of application of microalgae and PGPR in various areas of agriculture, including crop production, protection natural resource management for the environmentally compatible production of various agricultural crops.

OP30

Application of *Bacillus subtilis* in combination with plant defense activators for eco-friendly management of wheat stripe rust

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Stripe rust (SR) caused by *Puccinia striiformis* Westend. f. sp. *tritici* Erikss (*Pst*) is one of the most important and destructive disease of wheat worldwide. SR was mainly endemic to cooler regions, but since then, new aggressive strains have emerged, spread intercontinentally, and caused severe epidemics in warmer regions across the world. This is a disease that poses a threat to the world food security. At present, the preferred strategy for control of SR is the access to wheat cultivars with adequate levels of SR resistance. In Pakistan, SR appeared as epidemic and is causing huge losses to wheat production. However, wheat breeding programs are not sufficiently advanced to cope with the recently emerged *Pst* strains. Under this scenario, current research was carried out for safe, effective and sustainable management of stripe rust of wheat. The application of new formulation including bacterial strain, dextrose, chitosan, salicylic acid along with fungicide as a positive control were used as treatments. There were three replications for each treatment and were arranged in a randomized complete block design. Seven wheat varieties include Sehar, Galaxy, Abdul Sattar, Faisalabad, Johar, Td1 and Ujala were planted in research farm of MNS University of Agriculture, Multan, Pakistan during November 2019-20 and 2020-21 to determine their response toward *P. striiformis var. tritici.* The data regarding screening of wheat varieties, disease severity percentage, environmental factors i.e. minimum air temperature, maximum air temperature, relative humidity, wind speed, solar radiation, rainfall and yield was taken. The bacterial inoculum was multiplied in an autoclavable plastic trays by pouring nutrient agar (NA). Three days after inoculation the culture along with NA was blended by adding distilled water in a mixer for about 3 seconds and homogenized. The liquid formulation was kept at 4°C. The other ingredients in powder form were mixed prior to application and applied using self-propelled sprayer operating at a speed of 4.5 km/h and height of 40 cm using Teejet 9504 nozzle. The fungicide Tilt®, propiconazole, (T2) at the rate of 3 ml per 1500 ml water was used while the *Bacillus subtilis* (T1) was added at rate of 0.25 ml/ml water with 15 g of dextrose, 0.25 g of chitosan and 0.25 g of salicylic acid in 1500 ml water to make a fine suspension. Our results showed that T1 reduced the disease effectively up to (8.18%) followed by T2 (10.7%) as compared to T0 (23.8%). The correlation of environmental factors and disease severity showed highly significant with minimum air temperature and relative humidity while negatively non-significant with maximum air temperature. Wind speed, solar radiation and rainfall showed non-significant correlation with disease severity whereas after application of T1 and T2 minimum air temperature expressed significant correlation with disease severity of Sehar, Galaxy and Abdul Sattar while non-significant with Faisalabad, Johar, td1 and Ujala. Maximum air temperature, relative humidity, wind speed and solar radiation showed non-significant correlation with disease severity while rain fall was negatively non-significant. The maximum average yield was observed in Sehar as compared to all other varieties and control. The SR management strategy showed to be innovative, and its epidemiological results obtained will be helpful for better management of disease.

OP31

Studies of arbuscular mycorrhiza fungi application in *Ganoderma* management in oil palm plantation

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Oil palm is an important crop, but it remains to be vulnerable to basal stem rot disease caused by *Ganoderma boninense*, the most severe oil palm disease in Malaysia. The oil palm industry needs sustainable solutions to ensure future food systems remain productive. Therefore, it is crucial to discover a sustainable and eco-friendly management strategy for managing this major disease of oil palm. Arbuscular mycorrhiza fungi (AMF) are ubiquitous in the soil and are well known to play an essential role in plant growth, plant protection and soil amendments. Although, the success of AMF research in oil palm has been variable, this paper reports studies conducted with AMF application for *Ganoderma* management in oil palm plantations in Malaysia.

OP32

Leaf endophytic *Microbacterium testaceum* mediated suppression of blast disease in rice

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Microbacterium, a rice leaf endophytic and pigmented bacterial species displayed suppressive activity against rice blast disease. Our polyphasic taxonomic approaches along with phenotypic fingerprint, and transmission electron microscopy revealed the species identity of the antifungal isolate as *Microbacterium testaceum.* Besides, the endophytic Microbacterium displayed plant probiotic features such as mineral solubilization, hydrolytic enzyme and phytohormone production, as well as endophytism in rice. Endophytism of *M. testaceum* in rice seedling by a green fluorescence from gfp tagged Microbacterium. Antifungal activity testing of *M. testaceum* showed mycelial inhibition of *Magnaporthe oryzae* by volatilome. Chemical profiling of volatilome of *M. testaceum* indicated the abundance of several antimicrobial compounds. Upon seedling bacterization, *M. testaceum* not only triggered altered growth patterns of rice seedlings but also showed 80.0% reduction of blast severity over untreated plantlets. The qPCR based transcriptional analysis showed enhanced expression of defense genes such as *OsCERK*, *OsPAD4*, *OsNPR1*.3, and *OsFMO1*. *M. testaceum* mediated antifungal antibiosis, and host defense elicitation could be a potential alternative to fungicide-based blast management of rice in the future.

Session: 4

Theme: Biochemistry and biotechnology of PGP microbes

LP6

Bi-directional communication along the microbiome-root-shoot axis

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Plants nurture a large community of root-associated microbiota, which in turn provide them with essential services, such as enhanced nutrient uptake, growth promotion, and protection against pathogens. Our research is focused on understanding plant-beneficial functions encoded by the root microbiome and the role of plant genes and traits that recruit these functions. We demonstrated that upon foliar pathogen infection, plant roots recruit a consortium of synergistic microbes to their rhizosphere that in turn trigger induced systemic resistance (ISR). Using the Arabidopsis-*Pseudomonas simiae* WCS417 model, we identified the root-specific transcription factor MYB72 as a central regulator in the onset of ISR, which is effective against a broad spectrum of pathogens. Metabolomics of root exudates revealed that MYB72 controls the biosynthesis of iron-mobilizing coumarins, such as scopoletin, which are secreted in the rhizosphere where they aid in iron uptake. Scopoletin also has antimicrobial activity that inhibits growth of soil-borne fungal pathogens, but to which beneficial rhizobacteria such as WCS417 are insensitive. Microbiome analysis of coumarin-deficient Arabidopsis mutants revealed that coumarins function in rhizosphere community assembly, possibly to promote recruitment of ISR-stimulating rhizobacteria to the roots. Whole genome expression profiling of WCS417 exposed to root exudates of wild-type and coumarin-deficient mutants revealed that coumarins have strong effects on bacterial functions such as motility, which may steer the transition of the free-living phase to growth in biofilm on the root surface. Recent data show that rhizobacteria-induced coumarins can also be transported from the roots to the shoots, where they may serve as players in the onset of ISR in the leaves, highlighting coumarins as central players in bi-directional communication along the microbiome-root-shoot axis. Besides coumarins, also other chemical and structural root defense barriers emerged as players in shaping plant-microbiome interactions. Understanding their mechanistic basis will provides a firm knowledge basis for the development of future crops that maximize profitable functions from the root microbiome.

OP33

Proteome of ACC deaminase producing bacteria-mediated salt tolerance in rice (*Oryza sativa* L.)

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Characteristic proteins in plants revealed through proteomics analysis elucidate mechanisms of protein-based ACC deaminase producing bacteria-mediated salt tolerance. The current study evaluated changes in the proteome of rice (*Oryza sativa* L.) mediated by inoculation with an ACC deaminase producing bacteria under normal and salt stress conditions. Overall, salt stress caused significant reduction in chlorophyll a, b, and carotenoids but significant improvement in pigment contents were observed upon inoculation of *Methylobacterium oryzae* CBMB20 regardless of stress conditions. Proteomics analysis showed 41 and 35, 36 and 15, and 14 and 19 upregulated and downregulated differentially abundant proteins (DAPS) in non-inoculated salt-stressed plants, CBMB20 inoculated plants under normal, and CBMB20 inoculated plants under salt stress conditions, respectively. Under normal conditions, CBMB inoculation increased abundance of proteins related to plant growth and development. On the other hand, salt stress resulted in the decreased abundance of proteins related to photosynthesis and enhanced abundance related to ethylene emissions and programmed cell death. The effects of salt stress were countered by CBMB20 inoculation resulting in the increased abundance of antioxidant proteins, RuBisCo, and ribosomal proteins and decreased abundance of proteins related to ethylene biosynthesis. Rice is affected by salt stress in terms of photosynthesis and ethylene induced programmed cell death but ACC deaminase producing *Methylobacterium oryzae* CBMB20 attenuates salt-induced stress by improving photosynthesis, reactive oxygen species scavenging and modulating ethylene biosynthesis in plants.

OP34

Nutrient enriched fermented biological nano-composite silica for enhancement of sustainable food

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Nanotechnology is a key advanced technology enabling contribution, development, and sustainable impact on food, medicine, and agriculture sectors. Nanomaterials have potential to lead qualitative and quantitative production of healthier, safer, and high-quality functional foods. Silicon dioxide nanoparticles, also known as silica nanoparticles, are promising for biological applications owing to their excellent biocompatibility, low toxicity, thermal stability, and large-scale synthetic availability. The soil microbes are the suitable catalysts producing enzymes for the degradation of complex macromolecules into nano-molecules. Rapid and extreme climate changes needed new challenges for agricultural productivity. Increased biotic and abiotic stresses are threatening the agricultural productivity. Since silicon is the second most abundant element in the earth's crust, and is absorbed by plants as silicic acid. Most soils generally contain significant quantities of silica, but with continuous cropping, particularly with crops that accumulate significant quantities of silica, could reduce plant available levels of Si to the point. Hence the application of supplemental Si is required. There appears to be a need for Si amendments in temperate as well as tropical crop production systems. High Si uptake has been shown to improve drought resistance, increased resistance to fungi and other pathogens, and also increased plant growth rate and yield. Silica enables the plants to build up a physical mineral barrier lining the cell. This makes it difficult for biting and sucking bugs to damage the plants. Naturally this reduces the food intake, growth longevity, and fecundity and population growth of xylem feeding insects. It has been observed that plants accumulate Si around fungal infected sites. If the plant has sufficient Si level, it creates an active defense against fungal infections. In our studies, nano-silica composites were prepared with Si solubilizing beneficial bacteria and when tested were found useful to enhance agricultural productivity, resistance against insects and pests such as larvae, mites, thrips, and sucking. Also, found, these were stimulated the vegetative and reproductive growth of various crop plants. Hence, we project that this technology will be a boon for future growers.

OP35

Green synthesis of metal nanoparticles: a way forward to sustainable agriculture

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The agricultural sector is currently facing many global challenges, due to climate change and environmental pollution caused by pesticides and fertilizers, which will be exacerbated in the face of population growth and food shortages. Therefore, the need of the hour is to change traditional farming approaches and replace them with new technologies is essential. The application of nanotechnology offers considerable promise in alleviating these problems. The development of simple, economical and reliable method for the fabrication of nanoparticles has gained global attention. Biological approach of using microbials have emerged as an environmentally friendly, safe and viable alternatives to physical and chemical approaches. In the current study, synthesis of metal nanoparticles using cell free culture supernatants of bacteria isolated from agricultural soils are being reported. The silver nanoparticles (AgNPs) and copper nanoparticles (CuNPs) were characterized with UV-VIS spectroscopy and Scanning Electron Microscopy. The AgNPs which were produced from two bacterial isolates SNH8 and EH1 (Bacillus spp.) showed maximum absorbance at 420 nm on UV-VIS spectra. The CuNPs produced from WH1 and VH2 bacterial isolates showed maximum absorbance at 500 nm and 530 nm, respectively. The particle size of AgNPs was between 70-93 nm and CuNPs ranged between 56-84 nm. The SEM images revealed that the particles were spherical in shape. The influencing parameters such as pH, temperature and concentration of $AgNO_3$/$CuSO_4$ were evaluated. Temperature at 30°C, pH 7 and 1mM concentration of $AgNO_3$/ $CuSO_4$ were optimal for metal nanoparticle synthesis. The green fabricated AgNPs and CuNPs showed strong antimicrobial activity against plant pathogenic bacteria *Xanthomonas campestris, Agrobacterium tumifaeciens, Arthrobacter sp., Erwinia sp.,* and pathogenic fungi *Fusarium oxysporum, Pythium sp., Sclerotium rolfsii* and *Rhizoctonia solani.* Insecticidal, toxicity and mutagenicity studies of these nanoparticles will be further evaluated. The use of these nanoparticles as biological approaches could be used as newer developments which could revolutionize the agricultural farming in various agricultural sectors to achieve food security, improve crop production and reduce the use of pesticides and chemical fertilizers.

OP36

Importance of white-rot fungi in agriculture and biotechnology

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The growing concern over the pollution issues by the rapid industrialization has posed a fundamental problem forcing researchers around the globe to seek alternative eco-friendly technologies. To solve this problem, work has done to discover biotechnological applications such a biological process, which can detoxify wastes and is not damaging the environment. Examples of white-rot fungi that possess selective decay at least under certain conditions. White-rot fungi is widely used for various processes in agriculture and biotechnological applications. The application of white-rot fungi as biofertilizers is an emerging area that receives greater interest as it plays a key role in availing the nutrients to the plants by solubilizing soil minerals from insoluble to soluble form. The application of white-rot fungi as biofertilizers improves the plant growth and productivity through several traits includes stimulating the production of phytohormones, siderophores, and hydrolytic enzymes, thereby increasing the availability of various nutrients and protecting the plants against pathogens. The exploration of white-rot fungi or their enzymes for industrial purposes is known as white-rot fungal biotechnology which exploits renewable sources for sustainable agriculture. White-rot fungi or their enzymes play a significant role in the textile, pulp, and paper industries, as well as the food and feed industries. A large number of enzymes were purified from fungal cultures and characterized by their biochemical and catalytic properties. A variety of enzymes could be easily induced by manipulating the culture conditions of microbes, regardless of bacteria, fungi, or yeasts. Numerous studies have identified the role of this enzymatic machinery includes laccase, lignin peroxidase and manganese-dependent peroxidase enzymes in the transformation capacity of ligninolytic fungi towards a wide range of organic pollutants in contaminated soils. In this paper, we will discuss the ability of ligninolytic fungi, to convert, modify and utilize toxic pollutants to obtain energy (carbon source) and biomass production in the process.

OP37

Nickel tolerance and biosorption potential of *Bacillus amyloliquefaciens* AVP7 isolated from chili (*Capsicum annum Linn*.) fields

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Plant growth-promoting rhizobacteria (PGPR) are beneficial microorganisms that can be utilized to improve plant responses against biotic and abiotic stresses. Applications PGPR have appeared as a promising approach for the mitigation process of heavy metal tolerance. Bacillus is one of the most diversified bacterial genera broadly used as plant growth promoting agent and reported in the mitigation of heavy metal toxicity. The phytoremediation of nickel (Ni) using plant growth-promoting Rhizobacillus remains unexplored till now. *Bacillus amyloliquefaciens* AVP7 isolated from chili rhizosphere was screened for Ni tolerance *in vitro*. AVP7 could tolerate 1000 µg g^{-1} of Ni and observed that Chili plants have shown Ni stress tolerance in Ni amended soils up to a concentration of 100 µg g^{-1} in presence of AVP7. Chili plants treated with AVP7 showed higher PGP traits, Phosphate solubilization, Ammonia production, and IAA production at 100 µg g^{-1} of Ni than control plants without AVP7 inoculation. Analysis of biosorption potential of Ni in Chili plants inoculated by AVP7 strain was done using atomic absorption spectroscopy. The results showed that the maximum biosorption in root system compared to shoot. Besides, there was a reduction in the heavy metal content in the soil samples, which demonstrates a fair amount of heavy metal extraction and accumulation of Ni by the root system of AVP7 treated chili plants. This study demonstrates that the strain *B. amyloliquefaciens* AVP7 could be a potential isolate for bioremediation of Ni and could be useful in the phytoremediation of Ni contaminated soils in the future for sustainable agriculture. We conclude that the PGPR strain described in this study has great potential for use in the phytoremediation of heavy metals and for enhancing chili plant productivity under stress conditions, particularly those involving salinity and drought.

OP38

Cultivation, phytochemical and antimicrobial production of *Cordyceps militaris*

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The fungus, *Cordyceps militaris* (CM) originally used in Chinese and Tibetan medicines as well as known for its numerous medicinal properties. This study was planned for the cultivation of *C. militaris* and for evaluation of its production of phytochemical compounds. To evaluate for the bioactive compounds production, primary phytochemical screening was conducted. Our results showed that methanolic extract of Cordyceps contained phenols, alkaloids, flavonoids, tannins, coumarins, proteins, carbohydrates, and polysaccharides. The quantitative analysis of different concentrations of extract was analysed for total flavonoids and phenolic contents. The antioxidant activity was determined by using the DPPH (1,1-diphenyl-2-pycryl-hydrazyl) and hydrogen peroxide assays. $CM_{20\%Meth.}$ showed highest phenolic and flavonoid contents, respectively, with highest antioxidant activities. The evaluation of extract for antimicrobial activities against gram positive and gram-negative bacteria showed that aqueous and methanolic extract were more effective against *Bacillus subtilis* and *Escherichia coli* at different concentrations.

OP39

Recent approaches in exploration of endophytes and green nanoparticles in management pf soybean diseases and their productivity enhancement in India

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Endophytes and green nano particles have emerged as a new innovative and sustainable approach to manage the diseases, abiotic stresses and to promote plant growth. Thirty fungal endophytes were isolated from major soybean growing areas of northern Karnataka and Maharashtra. Out of which, eight effective fungal endophytes were obtained by *in vitro* screening against major soil-borne pathogens such as *Sclerotium rolfsii*, *Rhizoctonia bataticola* and *Fusarium oxysporum*. The fungal endophytes RF-BV-3 (46.46%), SF-DM-8 (49.15%) were effective against *S. rolfsii,* and the isolate SF-DM-8 (49.32%) was effective against *R. bataticola*. The effective bacterial endophytes against *F. oxysporum* were RB-HS-1 (41.99%), SB-BiJ-9 (40.07%), LB-BU-1 (54.20%) and LB-BV-2 (51.64%). Based on molecular characterization, the effective bacterial endophytes were identified as Acinetobacter Sp. (RB-HS-1), *Alcaligenes faecalis* (RB-KK-6), Stenotrophomonas Sp. (SB-BiJ-9), *Bacillus pumilus* (SB- DG-11 and LB-BiN-8), Paenalcaligenes Sp. (LB-BU-1), *B. cereus* (SB-BS-6) and *Brevibacillus* Sp. (LB-BV-2). *Neofusicoccum parvum* and *Daldinia eschscholzii* showed positive results for siderophore production and zinc solubilisation. *N. parvum, D. eschscholzii* and *Colletotrichum aenigma* showed positive results for HCN production. For chitinase production, only *N. parvum* was found to be positive. Green synthesized PAAgNF could be explored as a novel technology in managing *C. truncatum*. Characterization through PSA and SEM showed the range of particle size as 9.9 to 83.5 nm and shape as circular to irregular. Elemental confirmation was also performed by EDS. Among tested nano-formulations, PAAgNF was found effective in suppressing *C. truncatum* mycelium up to 82.75 percent under laboratory conditions. PAAgNF was also found best in managing anthracnose disease at 500 ppm as it could reduce disease up to 100 and 96.97 percent in JS 335 and DSb 21 variety which was on par with recommended fungicide. LC-MS analysis of PAAgNF showed major role of phenolic acids (hydroxy benzoic, protocatechuic, gallic, caffeic and ferulic) and flavonoids (naringenin and epicatechin) in antimicrobial activity. Entophytes and green synthesized PAAgNF could be explored as a novel technology in managing soybean diseases and productivity enhancement of soybean in India.

OP40

Performance of Streptomyces strains against turmeric rhizome rot disease caused by *Pythium aphanidermatum*

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Free-living bacteria that live in soil and has the ability to colonize the rhizosphere and mutually benefit the plant for its development to increase the yield are called plant growth-promoting bacteria (PGPR). PGPR are identified in wide group of microbes such as bacteria, fungi and actinomycetes. Actinomycetes are the least explored for the traits of PGPR in various plants. Among Actinomycetes, the Streptomyces accounts the highest population in the soil that colonize the rhizosphere with many beneficial impacts with their richness of producing secondary metabolites. Turmeric is a tropical herb which grows in different types of soil under rainfall and irrigated conditions. Turmeric is the golden spice of India. In world trade, India ranks first in both production as well as export. Turmeric cultivation is severely afflicted by various diseases. Amongst them rhizome rot caused by *Pythium aphanidermatum* is more prevalent fungal disease in turmeric and is a major threat to turmeric-cultivating areas of India. Its management has been exclusively based on the use of chemical fungicides. Although chemicals show promising results in controlling the disease, there are several major issues concerning pesticide residues, human health predicaments and environmental pollution. Therefore, an alternative for the management of rhizome rot disease is essential. Though, there are several reports on PGPR in turmeric to get the maximum rhizome yield potential, but no efforts have been made on *Streptomyces* spp against rhizome rot of turmeric. In view of this, the current study was aimed to isolate Streptomyces Spp. and evaluate against rhizome rot disease under field conditions. The experiments were conducted at Thondamuthur turmeric fields located near Coimbatore District of Tamil Nadu, India during 2015-2020. Turmeric CV. CO12 was selected for evaluation. There were five treatments includes T1: chemical treatment with Companion @ 100 ml/plant (0.05%), T2: strain of S. lydicus, T3: strain of *S. griseus,* T4: strain of *S. sannanensis* and T5: untreated. The treatments were arranged in a randomized complete block design with three replications per treatment. In each treatment there were 100 turmeric seedlings. The treatments were applied as in-furrow around the seedlings. The following parameters such as rhizome rot incidence, primary, secondary, tertiary finger rhizomes, final yield, curcumin, and oleoresin were evaluated at harvest. The data was analysed using ANOVA and separated by Newman Keuls test at P = 0.05 for treatment variation. Our results showed that T3 significantly suppressed rhizome rot and increased yield compared to all other treatments. The treatment T3 yielded at 43.8 t/ha with 1.52 productivity index followed by T2, T4 and T1. The treatment T3 also enhanced primary (2.8), secondary (3.4) and tertiary finger rhizomes (2.9) including the estimation of curcumin (5.2%) and oleoresin (5.9%) contents. Results of this study revealed that S. griseus appeared promising for commercialization, which can be used for plant growth promotion and management of turmeric rhizome rot disease.

OP41

Synergistic impact of endophytic *Bacillus subtilis* (Bera 71) and mycorrhizal fungi to induce acquired systemic resistance against *Phytophthora infestans* in potato

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The synergism between endophytes in relation to responses of plant metabolism is an important to upregulate the expression of disease associated genes with an effective acquired systemic resistance strategy against biotic stresses. However, little is known about the interactions between *Bacillus subtilis* (Bera 71) with arbuscular mycorrhizal fungi (AMF) and plant development under biotic stress caused by *Phytophthora infestans*. The current study focused on the synergistic interactions between (Bera 71) and AMF in potato (*Solanum tuberosum* L.) grown under biotic stress caused by *P. infestans*. The application of Bera 71 and AMF significantly enhanced phytohormones balance and consequently strengthen plant antioxidant defence system responsible for improvement of acquired resistance against adverse impact of *P. infestans*. The gene expression of antioxidant enzymes was also studied in potato. In conclusion, our results showed that the co-inoculation of endophytic bacteria and AMF contribute to a tripartite mutualistic symbiosis in potato under biotic stress caused by late blight disease caused by *P. infestans*. This approach could be used as a strategy for sustainable agriculture in the epidemic regions of potato cultivation areas.

OP42

Comparative genomic and metabolome analysis of rice phyllospheric *Pantoea* species biosynthetic pathways for bioprospection in crop protection

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Two epiphytic Pantoea isolates namely Os_Ep_PPA_1b isolated from adaxial and Os_Ep_VPA_9a isolated from abaxial rice leaf surface collected from Almora, Uttarakhand, India showed excellent antimicrobial activity against rice blast fungus, *Magnaporthe oryzae* and blight bacterium, *Xanthomonas oryzae* pv. *oryzae*. The polyphasic taxonomic investigation including metabolic fingerprinting by Biolog and 16S ribosomal RNA gene sequencing revealed their identity as *P. agglomerans* Os_Ep_PPA_1b and *P. deleyi* Os_Ep_VPA_9a, respectively. A total of 52 million and 48 million reads of the isolates generated by Illumina HiSeq sequencing (150 X 2bp chemistry) were *de novo* assembled into three and ten scaffolds showing the genome size of 4.44Mb and 4.57 Mb with GC content of 57.13%, and 57.72%, respectively. The gene finding by genome annotation revealed 4297 and 4389 CDS and 133 biosynthetic pathways. Comparative genome analysis of *P. agglomerans* PPA_1b revealed 88 % average nucleotide identity (ANI) with other *P. agglomerans* genomes; *P. deleyi* VPA_9a showed 99 % ANI with other *P. deleyi* genomes. Several pathways showing links in biosynthesis of polyketides (PKS) and nonribosomal peptides (NRPS) were observed. In particular, biosynthesis of polyketide sugar unit, siderophore group nonribosomal peptides, vancomycin group antibiotics, Type II polyketides, macrolides were recorded. Additionally, pathways involved in biosynthesis of secondary metabolites such as Novobiocin, Puromycin, Phenylpropanoids, and Terpenoids were also found. Further, metabolome profiling through UPLC-QToF-ESI-MS has revealed presence of antimicrobial metabolites such as Agglomerin A, Herbicolin A, Pantocin B, Methoxy phenazine, Dapdiamide in both the isolates. Interestingly, Pulicatin was identified only in *P. deleyi* VPA_9a isolate. These metabolite profiles indicate the potential of these isolates for crop disease management as microbial inoculants. The genome data coupled with the metabolome profiling would elucidate the antagonistic mechanism of epiphytic *P.* strains for microbe assisted crop protection in rice cultivation in the future.

OP43

Enhancement of biocontrol potential of selected chitinolytic producing *Trichoderma* species through U.V mutagenesis

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Chitinolytic enzyme producing Trichoderma species have long been recognized as biocontrol agents for controlling plant diseases caused by various phytopathogenic fungi. In this study three wild species of Trichoderma were isolated and were identified using standard techniques as *Trichoderma viride, T. flavofuscum* and *T. harzianum.* The UV mutation was induced in each isolated strain. The UV dose time, florescent colonies and morphological distinguish colonies were selected and checked for their enhanced chitinolytic activity against aflatoxigenic *Aspergillus flavus* and *A. parasiticus* using variable culture techniques and various detection methods. The pot experiment was conducted to evaluate the effect of Trichoderma wild strains and their respective mutants induced by U.V. metagenesis for control of *A. flavus* and *A. parasiticus* and on growth of *Cicer arietinum*. The treatment of cicer seeds with Trichoderma mutants resulted reduction of colonization of *A. flavus* and *A. parasiticus* compared to their wild type. The results showed that *T. viride* mutants showed 56.52- 71.01% inhibition against *A. flavus* and 60% against *A. parasiticus*, while *T. flavofuscum* showed 49.27 – 76.81% inhibition against *A. flavus* and 60% against *A. parasiticus. T. harzianum* and its mutants showed more antagonistic activity, (58.52 -71.01%) against A. *flavus* and 50.0-64% against *A. parasiticus.* The capacity of Trichoderma species to bioremediate aflatoxin was investigated using TLC, UV spectroscopy and HPLC analysis. The study concluded that the strains with increased chitinase activity and their biocontrol effectiveness could be easily produced by low-cost method for use in sustainable agriculture.

OP44

Influence of foliar application of nano-zinc and zinc solubilizing PGPR on production of strawberry

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The present investigation outlines the effect of foliar zinc (Zn) nano-fertilization vis-à-vis an analogue and Zn solubilizing bacteria (ZSB) on production of biofortified strawberry (*Fragaria × ananassa* Duch.) cv. Camarosa. The treatments comprised of four Zn sources *viz*., Zn_0 (no Zn), nZnO, ZnO, and $ZnSO_4$ and with and without ZSB inoculation. Each treatment was uniformly supplemented with recommended dose of NPK at 80:40:40 kg/ha. The treatments were arranged in a randomized complete block design and each treatment was replicated three times. The experiment was carried out between 2020-2021. During the experimentation, conjoint effects of nZnO and ZSB on physiological profiling, fruiting**,** rhizosphere microbiome and Zn persistence were measured. Our results showed that the beneficial effects of ZSB and Zn sources on flowering parameters, fruit set, yield, yield efficiency, enzyme activity and nutrient persistence at fruit set and maturity stage were significantly increased in all the treatments compared to control (no Zn application). The interactive effect of nZnO and ZSB resulted earliest flowering (within 54.5 days) after transplanting. Fruit set (1.15 folds) and yield (1.70 folds) were significantly increased compared to control. Also, a significant reduction in fruit phytic acid (PA) content along with reduced PA/P and PA/Zn ratio in fruit samples assayed. Microbial biomass of phosphorous solubilizing bacteria and Zn solubilizing bacteria was increased by 1.45 and 2.32 times, respectively, over control. The activity of Zn required enzymes *viz*., acid phosphatase (µg PNP g^{-1} h^{-1}) and dehydrogenases (µg TPF g^{-1} h^{-1}) were also significantly increased with corresponding values by nZnO with ZSB followed by $ZnSO_4$ with ZSB and ZnO with ZSB (80.15, 10.20). Our study showed that nano-Zn and ZSB inoculation increased foliar P and Zn content in strawberry at different fruit developmental stages.

OP45

Isolation and selection of dark septate endophytes from chilli, eggplant and mustard greens as biocontrol agents of *Eucalyptus* diseases

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Eucalyptus has been used as raw material for pulp and paper because it has fast-growing properties, good adaptability and high productivity. Monoculture crops with low vegetation diversities have the potential to cause disease epidemics caused by major pathogens such as *Cylindrocladium* sp. (leaf spot), *Ceratocystis* sp. (stem rot) and *Ganoderma philippii* (root rot). Thus, in addition to the control measures currently available, other methods need to be continuously developed. Dark septate endophyte (DSE) fungi have been considered as alternative biocontrol agents. This study was aimed to isolate and select DSE isolates from chilli, eggplant, and mustard greens as biocontrol agents of *Eucalyptus* pathogens of *Cylindrocladium* spp., *Ceratocystis* spp. and *Ganoderma* spp. Observation of DSE colonization in roots was conducted microscopically and DSE isolation was performed using corn meal agar. The DSE isolates obtained were tested for their ability to inhibit the pathogens. As many as twenty-five isolates of DSE fungi with the typical characteristics of septate and pigmented hyphae were obtained. These isolates were able to inhibit the development of pathogenic fungi with varying degrees of inhibition. The five best DSE isolates based on growth rate and their ability to inhibit fungal pathogens were T2.S8, T3.S3, T3.S1, T2.S6 and T4.S3. Biosafety tests in hemolysis and pathogenicity were carried out for the five best DSE isolates using the Analytical Hierarchy Process method. Blood agar and pathogenesis tests showed that they are not pathogenic to humans, animals and plants. Based on the macroscopic and microscopic characteristics, the DSE isolates were identified as *Curvularia* spp. These DSE isolates have the potential to be developed as alternative antagonists

List of Poster Presenters

Poster Presentation (P)

Paper Id	Presenter	Paper Title
P1	Aruna Lakshmi Komarraju, Sunitha. P., Venkateswara Rao. Y. and M. S. Reddy	Mitigation of transplantation shock in banana tissue culture plantlets with PGPR Email: prof.m.s.reddy@gmail.com
P2	Tongmin Sa and D. I. Walitang	ACC deaminase producing bacteria regulates ethylene emission for enhancing stress tolerance of rice (*Oryza sativa* L.) under heat and UV-B stress Email: tomsa@chungbuk.ac.kr
P3	M.Y. Wong and A. Wael	Efficacy of *Pseudomonas aeruginosa* and *Chryseobacterium proteolyticum* against *Phytophthora palmivora*, the causal agent of cocoa black pod disease in Malaysia Email: muiyun@upm.edu.my
P4	P.V. Ravi Kumar, P. Prasanth Kumar and K.S.R.K. Murthy	Studies on the performance and efficacy of Coropulse (a PGPR) on Soybean (Glycine max) under rainfed conditions during Kharif 2020 Email: pvrkumar@dhanacrops.com
P5	M. R. Kamelia Syuhada, M. J. Noraini and Aufa Ain	Evaluation of arbuscular mycorrhizal fungi, PGPR and rice husk biochar on soil properties and maize growth Email: j_noraini@upm.edu.my
P6	S. P. Chong, K. H. Phua-Choo, N. Bahari and M. Deraman	Optimization of seed coating with plant growth-promoting rhizobacteria Email: sawpeng@nm.gov.my
P7	I. Smirnova and A. Sadanov	Consortium of agronomically important microorganisms for soybean production in Kazakhstan Email: iesmirnova@mail.ru

P8	Ali Tan Kee Zuan, Buraq Musa Sadeq, Susilawati Kasim, Wong Mui Yun, Nur Maizatul Idayu Othman and Jawadyn Talib Alkooranee[4]	Development of formulation carrier for *Bacillus subtilis* to enhance shelf-life for commercial application Email: tkz@upm.edu.my
P9	Mariani	Utilization of antagonistic fungi from house-old organic waste for control of moler disease in shallots in west Nusa Tengara of Indones Email: marianiharamain@gmail.com
P10	M. Ashajyothi and A. Kumar	Transcriptional trade-off between plant growth and defense induced by endophyte *Pseudomonas putida* to elicit defense responses in rice against blast disease incited by *Magnaporthe oryzae* Email: kumar@iari.res.in
P11	M. R. Razean Haireen, R. Izlamira, M. Yaseer Suhaimi, W.U. Amyita, A. Fatin Nurliyana and M. Mazidah	Potential of commercial biocontrol agents against rhizome rot of ginger caused by *Pythium myriotylum* in Malaysia Email: aireenmr@mardi.gov.my
P12	M. Y. Talha, S. B. Chiu and H. G. Amir	Potential leguminous cover crop *Vigna marina* for soil improvement and crop productivity under high salinity conditions Email: talhayunus.07@gmail.com
P13	Nurul Atilia Shafienaz binti Hanifah	Insights into the molecular mechanisms related to auxin transport genes underlying PGPR-plant interaction Email: natilias@mardi.gov.my
P14	Sri Varshitha Kondamadugula, Sravani Ankati and K. R. K. Reddy	Rhizosphere microbiome engineering of chickpea for drought tolerance with a novel seed priming delivery system Email: srivarshitha2095@gmail.com
P15	Pavitra. H.T. and Ravindranath Hunje	Bio-pelleting of PGPR's for enhancement of seed yield and quality of green gram in India Email: ravihunje@gmail.com

P16	Sukmawati, I Made Adnyana, D. N. Suprapta, Meitini Proborini, N.L. Suriani and Hirjani	Role of Arbuscular mycorrhizal fungi and its population density on soybean grown in dryland of central Lombok, Indonesia Email: SukmawatiNW69@gmail.com
P17	S. S. Tan and M. N. Tasren	The progression of endophytes from seeds to the seedlings in oil palm Email: tanss@aarsb.com.my
P18	Susila Herlambang, Muammar Gomareuzzaman, Indriana Lestari, Danang Yudhiantoro and Ayu Utami	Influence of biochar and liquid sheep manure on plant growth Email: susilaherlambang@upnyk.ac.id
P19	E. Maharjan, D. Jain, M.Y. Wong, R. Adhikari and D. R. Joshi	Antagonistic activity of Bacillus spp. and botanical extracts against *Drosophila melanogaster* Email: mrjn.elina@gmail.com
P20	Abdul Majeed, H. T. Chandranath and P. Jones Nirmalnath	Effect of foliar nutrition and bio-inoculants on yield of black gram (*Vigna mungo* L.) under rainfed conditions Email: chandranathht@uasd.in
P21	Mariani and Sugiarta	Efficacy of liquid organic waste for control of Fusarium wilt in shallot Email: sugiartamimbar@gmail.com
P22	Siti Zainab, Mariani and Baharuddin	Efficacy of organic liquid waste on growth of shallots in west Nusa Tenggara Email: sitizainab83@gmail.com
P23	V. R. Kulkarni, S. A. Ashtaputre and Shamarao Jahagirdar	Association of causal agents inciting boll rot complex of cotton and its management Email: kulkanivr@uasd.in
P24	M. I. N. H. M. Sazali, F. R. Kundat and F. A. A. Zakry	Pathogenicity of *Trichoderma longibrachiatum* in red lettuce (*Lactuca sativa* L.) and the potential of rhizobacterial antagonists to manage the disease Email: zakryfitri@upm.edu.my

P25	M. F. A. Rahman, F. A. A. Zakry, F. R. Kundat, N. Saupi and S. Bokhari	Potential of rhizobacterial isolates in rooting enhancement of *Piper nigrum* L. stem cuttings Email: zakryfitri@upm.edu.my
P26	Juliana Ivanova, Venelin Hubenov, Lilyana Nacheva and Lyudmila Kabaivanova	Biogas production from lignocellulosic wastes integrated with microalgal cultivation for use in agriculture Email: juivanova@yahoo.com
P27	Lyudmila Kabaivanova, Lilyana Nacheva and Adriana Goushterova	Improvement of compost quality with microbes and vegetable waste for sustainable organic farming Email: lkabaivanova@yahoo.com
P28	Lilyana Nacheva, Lyudmila Kabaivanova, Nikolai Dinev and Adriana Goushterova	Evaluation of various types of composts in soil organic matter tor sustainable agriculture Email: lin1@abv.bg
P29	Ghina Fadhilah, Ayu Utami, Herwin Lukito and Susila Herlambang	Wastewater treatment from tofu industry with anaerobic PGPR's Email: ayu.utami@upnyk.ac.id
P30	M. H. Erneeza, Y. Mohd Termizi and Z. Dzarifah	Efficacy of Streptomyces sp. against rice bacterial leaf streak caused by *Xanthomonas oryzae* Email: erneeza@upm.edu.my
P31	H. Farah Farhanah, R. Nurul Farisa, A.N. Norzaimawati	Biocontrol potential of Plant Growth-Promoting Rhizobacteria against Anthracnose disease caused by *Colletotrichum gloeosporioides* Email: farahfarhanah@mardi.gov.my
P32	Mohd Zafrul Arif Radhi, Muhammad Naim Fadzli Abd Rani, Emmyrafedziawati Aida Kamal Rafedzi, Nor Syahidah Md Sam, Mohd Aziz Rashid, Ahmad Arif Ismail, Nurul Ain Ismail, Noor Shita Desa and Nor Hidayah Mohamad Dzani	Application of biostimulants in paddy production under field conditions Email: zafrul@mardi.gov.my

P33	Kamal Prasad & Mr. Ankush Shrivastava	Glycoprotein Producing AM Fungi, Lifestyle and Energetic Role in Global Sustainable Agriculture to Green Technology For Future Generation Email: kamal@absolutefoods.in
P34	Kuleshwar Prasad Sahu & A. Kumar	Phyllomicrobiome assisted suppression of blast disease in rice Email: kumar@iari.res.in
P35	Deenali K. Dhangar Dr. Farida & P. Minocheherhomji	Optimization of DNA isolation protocol from wheat rhizosphere soil for metagenomics applications Email: deenalidhangar123@gmail.com
P36	Uday. G., Gurudutt Hegde, Priyanka, K., and Patil, P.V.	Molecular characterization and management of wheat foot rot caused by *Sclerotium rolfsii* Email: udaireddy7095@gmail.com
P37	K. N. Pawar	Role of foliar application of bio-inoculants and nutrients on productivity of cotton Email: kasu_pawar@rediffmail.com
P38	Ili Bazilah Abd Razak, Nor Hidayah Bohari and Elya Masya Mohd Fishal	Ability of Endophytic Nitrogen Fixation Bacteria *Paenibacillus alvei* M3-12 to Reduce Inorganic Fertiliser's Usage in Oil Palm Seedlings through Different Application Techniques Email: bazilah.ar@fgvholdings.com
P39	H. Nor Ayshah Alia and T. K. Z. Ali	Influence of chemical fertilizer application on rhizosphere bacterial dynamics Email: ayshalia@mardi.gov.my
P40	Amalia Abdul Razak, Muhamad Aidilfitri b. Mohamad Roslan, Murni Halim, Nor'Aini Abdul Rahman	Indole acetic acid production by *Enterobater cloacae* 38 through fermentation of various carbon and nitrogen sources using response surface methodology Email: nor_aini@upm.edu.my
P41	Noor Azizah binti Musa	Influence of Rhizobium in Leguminous cover crops in oil palm plantation Email:noor.azizah.musa@simedarbyplantation.com

P42	Ajay Kumar Singh and Praharaju Laxminarayana	Innovative bioherbicide from discovery to application - industrial perspective Email: laxmi@agbio.co.in

POSTER ABSTRACTS

P1

Mitigation of transplantation shock in banana tissue culture plantlets with PGPR

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Micropropagation is a boon to horticulture, agriculture, forestry and eco-tourism. A major constraint to micropropagation is high mortality of the plantlets during or following the transfer from laboratory to nursery due to /their poor root system devoid of root hairs, malfunctioning of stomata, underdeveloped vasculature and reduced photosynthetic capacity. A rationale approach to reduce transplantation shock is to biotinize *in vitro* plants with PGPR to enhance their survival under abiotic and biotic stresses. Plant growth-promoting rhizobacteria (PGPR) are free-living bacteria having a beneficial effect on plants as they enhance emergence, colonize roots, and stimulate growth. In recent years, the concept of PGPR for promotion of plant growth is gaining worldwide acceptance. This study was aimed to assess the influence of PGPR consortium and Vesicular Arbuscular Mycorrhiza (VAM) on the growth and survival of banana plantlets under *in vit*ro conditions and to mitigate their transplantation stress. The PGPR consortium comprised of *Azotobacter chroococcum* AZO311, *Azospirilium lipoferum* AZS301, *Pseudomonas fluorescens* Ps006, Bacillus Spp. Bs40 and VAM comprised spores of Glomus Spp. and Gigaspora Spp. Formulated PGPR and VAM spores was mixed with sterilized coco-peat-soil and usedto evaluate tissue cultured banana transplants survival and growth. There were four treatments included T_1 - inoculation with PGPR consortium; T_2 - inoculation with VAM; T_3 - mixture of PGPR and VAM; T_4 – untreated control. The design of the experiment was randomized complete block with five replicates. Growth and survival of plantlets were monitored for 90 days under greenhouse conditions. PGPR colonization in the rhizosphere, photosynthetic pigments, nutrients, and protein were also evaluated. Our results showed that T1 and T2 significantly improved the growth and vigor of transplanted plantlets compared to untreated control. All PGPR colonized the roots and the rhizosphere soil. Combined application of PGPR consortium and VAM (T_3) significantly increased plantlets biomass compared to T1, T2 and untreated control. Inoculated plantlets showed a well branched root system with larger and more root hairs than control. There was a remarkable increase in root length (40%) and mass (90%) besides shoot growth (46%). The enhanced root system increased biomass, photosynthetic pigments, nutrients, and protein. Total phenol content increased significantly (24%) in treated plants compared to the control. Inoculation enhanced survival rate of the plantlets by 85%. Our study showed that PGPR and VAM inoculation improved the growth and nutrition of tissue cultured banana plantlets, reduced transplantation shock and enhanced their survival rate. The potential of PGPR as mycorrhiza helpers need to be exploited in tissue culture systems in commercial micropropagation to reduce the cost of tissue cultured plants.

P2

ACC deaminase producing bacteria regulates ethylene emission for enhancing stress tolerance of rice (*Oryza sativa* L.) under heat and UV-B stress

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The penetration of ultraviolet-B (UV-B) radiation due to ozone depletion and the rise in global temperature has affected agricultural productivity around the globe and have adverse effects on rice plants. Plants emit elevated levels of ethylene under environmental stress conditions that results in activation of innate stress response and eventual growth retardation. The use of ACC deaminase producing bacteria has been proven to be a sustainable approach for alleviation of various environmental stresses and enhancement of plant growth. This study evaluates the efficiency of ACC deaminase producing bacteria *Brevibacterium linens* RS16 in modulating ethylene emission induced by heat and UV-B stresses for enhancing stress tolerance. *B. linens* RS16 was able to colonize the endosphere of rice plants. The plants exposed to high temperatures had shown higher ethylene emission, ROS concentration, proline concentrations and small heat shock protein (*sHSP*) expressions compared to the plants grown under control conditions. Furthermore, the inoculation of *B. linens* RS16 had shown significantly lower ethylene emission in plants exposed to 40°C and 45°C of heat stress and resulted in decrease in ROS concentrations and also assisted in the inhibitory effect on *sHSP* expressions. On the other hand, the ethylene emission, ROS concentrations, polyphenol concentrations and electrolyte leakage were higher for plants exposed to UV-B radiation. However, *B. linens* RS16 inoculation resulted in decrease in ethylene emission, ROS concentrations, polyphenol concentrations and electrolyte leakage from stressed rice plants. Hence, these collective data present the efficiency of *B. linens* RS16 in colonization of rice endosphere and enhancement of plant tolerance against heat and UV-B stresses by regulating the ethylene emission levels.

P3

Efficacy of *Pseudomonas aeruginosa* and *Chryseobacterium proteolyticum* against *Phytophthora palmivora*, the causal agent of cocoa black pod disease in Malaysia

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Black pod, caused by *Phytophthora palmivora* occurs worldwide and is a major problem for cocoa farmers in Malaysia. It causes yield losses at 30-40% annually, worldwide. To counter these drawbacks, producers rely heavily on agrochemicals leading to pathogen resistance and environmental hazards. There is also increasing demand by cocoa consumers for pesticide-free seeds. Therefore, biological control through the use of microbial antagonists is more rational and safer crop management option. Hence, this study was conducted to isolate, identify, and characterize bacterial endophytes from cocoa plants and evaluate their efficacy against black pod disease. One hundred endophytic bacterial isolates were isolated from healthy cocoa plants (leaves, branches, and fruits) grown across seven states of Malaysia. The isolated bacteria were identified, characterized, and screened for their antagonistic activity against *P. palmivora in vitro* by dual and culture filtrate assays. Among one hundred, two best isolates (AS1) and (AS2) which inhibited more than 80% inhibition of radial vegetative growth of the fungus were selected for further experiments. Identification of these two isolates were conducted using nucleotide analysis of the 16S rRNA region and found high similarity to *Pseudomonas aeruginosa* (AS1) (99-100%) and *Chryseobacterium proteolyticum* (AS2) (99-100%), respectively. In our further studies, the mode of action as well as their ability to reduce black pod rot disease were investigated. Gas chromatography-mass spectrometry (GC-MS) was used to identify bioactive volatile compounds from ethyl acetate crude extract. Our results showed that there were three major compounds present in both *P. aeruginosa* and *C. proteolyticum* extracts and characterized them as eicosane, hexatriacontane and tetratetracontane. These compounds were demonstrated to have antifungal and antimicrobial activities in other studies. The efficacy of P. *aeruginosa* and C*. proteolyticum* isolates were also assayed for inhibition of black pod lesions on detached cocoa pods and found significant inhibition of lesions by these isolates. These results indicate that the two bacterial isolates have potential to be used as biocontrol agents against P*. palmivora* in cocoa*.*

P4

Studies on the performance and efficacy of coropulse (a PGPR) on soybean (*Glycine max*) under rainfed conditions in India

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Dhana Crop Sciences offers nutritional's, PGRs, organic chelates, organic mineral gluconates and glycinates, protein hydrolysates, organic fungicides, virucide and other natural aids for better plant protection. The various products of Dhana Crop Sciences are very cost effective and with better performance than the products available in the market. Quality, prompt shipment and most economical prices of the products has made products of Dhana Crop Sciences well accepted in the market, especially among organic growers. As an on-going R & D, efforts, we have evaluated coropulse, which is a unique product to enhance nodulation in soybean under rainfed conditions during Kharif season during 2020 at the R & D centre of Dhana Crop Sciences Limited, Choutuppal, Hyderabad, India. The experiment was conducted in a randomized complete block design with five treatments. Each treatment was replicated four times. The treatments were 1: Coropulse @ 2.5 ml/l of water applied at 15 days of crop growth, intervals, 2: Coropulse @ 2.5 ml/l of water applied at 25 days of crop growth intervals, 3: Coropulse @ 2.5 ml/l of water applied at 15 + 25 days of crop growth, intervals and 4: conventional farmer practice and 5: untreated control. During the experiment, nodule numbers were assessed at 40 and 50 days after application of treatments and yield was collected at harvest. Our results showed that coropulse enhanced significantly more nodules per plant compared to other treatments. More pods per plant was also significant for treatment at 15+25 days interval application of coropulse compared to other treatments. The yield of soybean was significant (2021.5 Kg/ha) by coropulse compared to farmers practice (1068 Kg/ha) and untreated control (848 Kg/ha). We have concluded that application of coropulse has a beneficial effect to enhance nodulation and yield of soybean.

P5

Evaluation of arbuscular mycorrhizal fungi, PGPR and rice husk biochar on soil properties and maize growth

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The use of beneficial microorganisms such as arbuscular mycorrhizal fungi (AMF) and plant growth-promoting rhizobacteria (PGPR) and rice husk biochar (RHB) as soil amendment for their positive effects in both soils and plants have been widely acknowledged. Symbiotic fungi, AMF via its hyphal networks in soils expand more soil volume for root growth, to enhance the water and nutrient uptake while PGPR is dominant for N nutrition. Hence, combined inoculation of AMF and PGPR could meet the requirement of both N and P for plant growth and yield production. The rice husk biochar (RHB) which is a carbon rich, porous material produced under combustion with low oxygen. The RHB helps to improve soil retention of nutrients and water for plants while enhancing the activity of beneficial soil microbes. Thus, the present study was aimed to evaluate the effects AMF and PGPR in the presence of RHB on soil properties and maize growth. There were eight treatments included in our experiments: T1 (control), T2 (AMF), T3 (PGPR), T4 (RHB), T5 (AMF+PGPR), T6 (AMF + RHB), T7 (PGPR + RHB) and T8 (AMF + PGPR + RHB). Experiments were conducted under glasshouse conditions in a randomized complete block design with five replications for each treatment. The experiment was run for 45 days. Our results showed that combination of AMF + PGPR + RHB (T8) was the best treatment compared to all other treatments. The combined application of AMF, PGPR and RHB resulted in increased roots volume, leaf and roots dry weight. The results suggested that the combined application of biochar, PGPR and AMF led to the highest levels of maize plant growth, microbial biomass, and soil nutrient activity specifically soil P.

P6

Optimization of seed coating with plant growth-promoting rhizobacteria

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In modern agriculture, imbalanced use of fertilizers, specifically nitrogen and phosphorous, and indiscriminate use of chemical pesticides have led to depletion in soil fertility and environmental pollution. In this case, plant growth-promoting rhizobacteria (PGPR) could provide a sustainable solution to the problem. The PGPR product developed in this study was based on the concept of plant seeds treated with the PGPR as a biofertilizer for plant growth. The shelf-life of the PGPR used in this study was monitored by measuring the optical density at 600 nm with the UV spectrophotometer. The optimization for coating plant seeds was conducted with the concentration of 2 to 10% sodium alginate with different polymerization times at 5, 10, 15, and 20 minutes. Our results showed that PGPR treated plant seeds with 5% sodium alginate and a polymerization time of 10 minutes was the best to enhance the shelf-life of PGPR for 12 months when assessed by total plate counting method. The results showed that after 12 months of storage at 4 and 25°C, the PGPR population was more than 1×10^4 cfu/ml. We conclude that this PGPR product has the potential for coating seeds due to its slow release without its colonization loss on the seed and in the soil to benefit the plant growth.

P7

Consortium of agronomically important microorganisms for soybean production in Kazakhstan

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One of the main problems of the agriculture is the lack of protein in human nutrition and the lack of food supply for the animal husbandry. A possible way to solve the problem is to increase the production of high-protein soybean. Soybean is a main source of protein in countries where meat and dairy products are not available physically, economically or for other reasons. Mineral nitrogen and phosphorus fertilizers are used to increase the productivity of soybean. The use of these will allow to achieve high yields, but they lead to negative consequences. At the same time, nitrogen and phosphorus are the main nutrients for plants and it is impossible to grow crops without them. The goal of this study was to create a consortium of agronomically important microorganisms to increase soybean production. The object of our study was to isolate rhizobia from soybean nodules and phosphate-solubilizing bacteria from soybean rhizosphere and to assess their nitrogenase activity. The nitrogenase activity was determined by the acetylene method (ARA). Bacteria was identified by the Sanger molecular genetic method. The plant growth promoting activity (PGP), nitrogenase, phosphate-solubilizing ability and nodulation ability were assayed for selective microbes and prepared a consortium. Our results showed that the consortium have a high PGP activity. Seed inoculation with consortia significantly increased the stem length (by 1.8–2.0 times), root length (by 2.5–2.7 times), the number of nodules (by 2.7–3.2 times), nitrogen fixation (by 2.8–3.0 times), and phosphorus uptake (by 20-25%). Also increased the protein content in soybean plants (by 1.5-2.0 times) compared with control. The consortium consisted of *Bradyrhizobium lupini* RH-7 and phosphate-solubilizing bacteria *Pseudomonas putida* FT-1 was the best for soybean. The application of consortium is more effective than the individual will be more useful approach for soybean production in Kazakhstan.

P8

Development of formulation carrier for *Bacillus subtilis* to enhance shelf-life for commercial application

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Maximizing the potential for successfully developing and deploying a biocontrol microbial product begins with a carefully crafted microbial screening procedure, proceeds with developing mass production protocols that optimize product quantity and quality, and ends with devising a product formulation that preserves shelf-life, aids product delivery, and enhances bioactivity. *Bacillus subtilis* is widely used to control agricultural diseases due to its strong adaptability and good antimicrobial activity in soil. Therefore, optimizing a formulation carrier is essential to prolong the bacterial shelf-life. Thus, a study was undertaken to develop a carrier for a locally isolated B. subtilis strain. In this study, we have used humic acid (HA) as an amendment to growth B. subtilis. Four doses of HA include 0%, 0.01%, 0.05%, and 0.1% w/v were added to tryptic soy broth (TSB) and inoculated with *B. subtilis* (UPMB10), *B. tequilensis* (UPMRB9) alone and the combination of both strains and allowed them to grow under laboratory conditions. The shelf-life of these strains were enumerated as viable cell counts and measuring optical density at monthly intervals. The endospore formation was assayed with malachite green staining method. Our results showed that after 12 months of incubation, TSB amended with 0.1% HA significantly recorded the highest population of UPMRB9, followed by mixed strains and UPMB10, at $1.8x10^7$ $CFUmL^{-1}$, $2.8x10^7$ $CFUmL^{-1}$ and $8.9x10^6$ $CFUmL^{-1}$, respectively. Further our results showed that a higher concentration of HA has successfully prolonged the bacterial shelf-life with minimal cell loss. Thus, this study has shown that the optimum concentration of HA could be used to extend the bacterial shelf-life of B. subtilis for commercial application to enhance plant growth, disease control and yield enhancement. Further studies are in progress to evaluate this formation carrier under field conditions.

P9

Utilization of antagonistic fungi from house-old organic waste for control of moler disease in shallots in west Nusa Tengara of Indonesia

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Shallots (*Allium ascalonicum* L.) is one of the vegetable commodities that have important meaning for the community due to its high economic value and nutritional content in Indonesia. One of the obstacles for the cultivation of shallots, in Indonesia is the occurrence of moler disease. The moler disease caused by Fusarium spp. is a major disease in shallot-producing areas particularly in the North Coast of West Java. The research was aimed to select rhizosphere bacteria and develop an antagonistic bacterial-based formulation for its and field trials. The field trials were carried out using randomized complete block design with four replications at the shallot farmer condition]. This study was conducted to determine the potential use of antagonistic fungi isolated from household organic waste to control moler disease in shallots. This research was conducted from February 2020 to November 2021. This study was designed using a completely randomized complete design. Our results showed that the antagonist fungus could be used to control the pathogenic fungi causing moler disease in shallots by *Trichoderma asperellum.* In our experiment, we have used 30 grams of corn flour, 150 g of bran, 25 g of sugar, 775 g of compost from household organic waste, and 20 ml of suspension of *T. asperellum* and with an application dose of 50 g/polybag, which could reduce the incidence of moler disease in shallot plants by up to 90% in a greenhouse.

P10

Transcriptional trade-off between plant growth and defense induced by endophyte *Pseudomonas putida* to elicit defense responses in rice against blast disease incited by *Magnaporthe oryzae*

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Plant defense elicitation against crop diseases by endophytic microbial organisms can be one of the sustainable crop protection strategies in agriculture. Black pepper-associated endophyte *Pseudomonas putida* BP25 displayed broad spectrum endophytism in plants with consequence defense activation. Here, we show altered transcriptional response of rice cultivar (cv.) Pusa Basmati 1 upon priming with *P. putida* BP25. RNA-seq was performed on bacterized rice seedlings yielded 34,503,680 to 56,212,177 transcriptional sequence reads (GC45.02 to 46.94%) with a coverage of ~84% of the reference rice genome. Qualitatively, a total of 110 down-regulated and 68 up-regulated genes (p=<0.005) were observed in bacterized seedlings. Interestingly, most of the down regulated genes (*OsTPX2, OsDREB1B, OsCESA7, OsUDP76C2, OsGermin like protein3-3, OsRPP13-like protein1* and *OsZFP179*) represented rice growth and development while the up regulated genes (*OsBBTI12; OsRING-H2; OsGID1L2; OsZOS1-15-C2H2 zinc finger protein; OsCLAVATA3/ESR-related (CLE); OsRPP13-like protein1*) were associated with defense pathways. Gene expression study targeting randomly selected DEGs using q-PCR assay confirmed the validation of transcriptome data. The defense elicited rice seedling displayed altered root and shoot phenotype as an indicator of Microbe Associated Molecular Pattern (MAMP) triggered immunity in rice. The data further indicated a transcriptional trade-off between growth and defense during bacterial interaction. Confocal laser scanning microscopic imaging (CLSM) of *P. putida* BP25 bacterized rice leaf showed delayed conidial germination, and reduced mycelial growth of *M. oryzae* RMg_Plm::gfp. A detached leaf assay was designed to screen the *P. putida* BP25 against rice blast pathogen *M. oryzae*. The data showed prophylactic blast suppressive activity of *P. putida* BP25 with 79.8% disease reduction seven days post-inoculation. The endophyte *P. putida* BP25 eliciting defense responses in rice against blast disease can be a potential bioagent for sustainable rice crop production and protection in the future.

P11

Potential of commercial biocontrol agents against rhizome rot of ginger caused by *Pythium myriotylum* in Malaysia

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Ginger (*Zingiber officinale* Roscoe) is a high value cash crop in Malaysia, planted in large areas of Pahang and Sabah. The supply of good quality of ginger is limited due to rhizome rot caused by *Pythium myriotylum*. One factor that greatly affects its growth and yield is the prevalence and occurrence of rhizome rot disease spreads easily and destroys ginger rhizome in storage. Various strategies have been reported to control the rhizome rot. Chemical pesticides are commonly used to control the disease throughout the planting cycle. However, accumulation of residue in the rhizomes has led to severe environmental impacts and causes adverse effect to consumer health. Thus, in this study, *in vitro* screening of potential biocontrol agent to control *P. myriotylum* was conducted using commercial biological products includes *Bacillus subtilis* and *Trichoderma* sp. and *B. cereus*. Screening results showed that *B. subtilis* had significant antagonistic effect with the highest inhibition percentage (61%) against *P. myriotylum* growth. This was followed by 43% inhibition of *P. myriotylum* by *B. cereus* and chemical pesticide (mancozeb) with 20% percent inhibition. The *in vitro* effect of these biocontrol agents will be verified in the field application in the near future.

P12

Potential leguminous cover crop *Vigna marina* for soil improvement and crop productivity under high salinity conditions

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The saline soil has electrical conductivity (EC) of more than 4dSmL^{-1} (approximately 40 mM NaCl) in the root zone at 25°C and an exchangeable Na concentration of 15%. From an agricultural perspective, the presence of neutral soluble salts may inhibit the development of most crop plants. However, a tropical legume, *Vigna marina* grows in nutrient-deficient, high-salinity sandy soil, has potential as a cover crop under high salinity soil conditions. The symbiotic connection with root-nodulating bacteria of *V. marina* could be adapted to these hard circumstances and may contribute to nitrogen fixation. Thus, cover crops may contribute to low-input sustainable agriculture. As a potential leguminous cover crop, *V. marina* can reduce soil environmental stress conditions and improve soil fertility and nutritional status. In view of this, two experiments were conducted to explore the possibility of *V. marina* as a viable leguminous cover crop under high salinity conditions. Seed germination and growth of *V. marina* were optimized in a greenhouse before being planted in the field. The development and nodulation of *V. marina* were compared to those of established leguminous cover crops, *Pueraria javanica* and *Mucuna bracteata*. Additionally, the impact of commercialized rhizobia compost (CRC) on the growth and nodulation of *V. marina* was also examined. Our results showed that the CRC has negligible effect on the development of *V. marina* under high salinity soil conditions (coastal vs. inland soils). The results also showed that *V. marina* could quickly outgrow *P. javanica* and *M. bracteata*. In conclusion, we suggest that *V. marina* was a potential alternative leguminous cover crop, especially for saline soil conditions.

P13

Insights into the molecular mechanisms related to auxin transport genes underlying PGPR-plant interaction

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The use of biocontrol agents with plant growth-promoting activity has emerged as one of the best approache to support sustainable agriculture. From our previous field studies, the application of *Pseudomonas fluorescens* 100 and *Serratia rubidaea* 119, showed positive growth effect in potato. Hence, in this study, experiments were conducted to investigate *P. fluorescens* 100 and *S. rubidaea* 119 for their growth promoting activity in potato and their molecular mechanisms involved under *in vitro* conditions. Our results showed that both strains stimulated adventitious root development in the aerial plant part and shoot growth of potato. Generally, the root formation and development are highly regulated by auxin. Furthermore, the changes in the expression level of selected auxin-related genes were investigated. In this study, strains, 100 and 119 were altered the expression levels of genes known to involve in auxin transport and homeostasis. Strain 100 transcriptionally upregulated gene coding for auxin-efflux carrier, *StPIN1*, in the root, auxin transporter gene, *StPIN6,* in the shoot and a gene coding for auxin-influx carrier, *StLAX5,* and auxin transporter gene *StPIN5* in both plant parts but, downregulated *StPIN6* in the root. Meanwhile, strain 119 transcriptionally upregulated *StPIN1* in the root, *StLAX5* in the shoot and *StPIN5* in both plant parts. These results suggests that the formation of adventitious roots at the aerial plant part was promoted due to enhanced polar auxin transport in the root and auxin homeostasis in both plant parts during PGPR-plant interaction.

P14

Rhizosphere microbiome engineering of chickpea for drought tolerance with a novel seed priming delivery system

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Drought is accepted as a serious threat to crops worldwide, more specifically to the areas where there is less rain fall. Water scarcity leads to loss of grain yield in cereal and legume crops, and this is a determining factor of stress tolerance. Chickpea (*Cicer arietinum)* is the most important legume crop and a source of nutrition to millions of people globally due to its richness in protein, fibre, and minerals. It grows in semi-arid regions as post-monsoon crop and terminal drought stress is one of the major challenges as it accounts up to 50% of the yield loss. Soil moisture is critical for the survival of crop and yield retention. Drought stress impairs key physiological and biochemical processes ranging from photosynthesis, CO_2 availability, cell growth, respiration, stomatal conductance, to other essential cellular metabolisms leading to yield loss. Water use efficiency is an important strategy for improving drought tolerance in crop plants, includes chickpea. Genetically modified, genomic, or molecularly altered chickpea is the alternate, which is in focus, but it has its limitations as it is a time-consuming process. Crop microbiome engineering is an emerging tool in modern agriculture and rhizosphere optimization with functional microbial communities for improving the plant's ability to withstand drought stress is an immediate and an effective alternate. This paper describes the development of seed priming with multi-microbial strains which have showed promising results in *in vitro* and field trials to mitigate drought stress in chickpea which is a novel, user-friendly and prophylactic approach.

P15

Bio-pelleting of PGPR's for enhancement of seed yield and quality of green gram in India

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Pulse crops play an important role in Indian agriculture. Bio-pelleting with strains of Rhizobium and *Pseudomonas striata* have potential to be used as PGPR's for enhancement of seed yield and quality of green gram. The experiment was designed to evaluate bio-pelleting of green gram seeds with PGPR's. The seeds of Green gram cv. DDGV-2 were manually cleaned, and the moisture content was brought to 8% before pelleting. The filler material, talc powder was obtained locally and sterilized. The pelleted seeds were dried under the shade to bring down the moisture content to 8% before used in field experiment. The significant differences were noticed due to bio-pelleting of seeds with PGPR's for all seed quality parameters. Seeds treated with Rhizobium NC-92 at 50 g/kg of seed + *P. striata* at 50 g/kg seed showed higher seed germination (95.54%), seedling length (35.31 cm) and seedling vigor index (3373) and field emergence (94.02%) over untreated control. The growth and seed yield parameters differed significantly due to fertilizer doses and bio-pelleting at harvest. Seeds treated with Rhizobium NC-92 at 50 g + P. striata 5 g/kg seed resulted in significantly higher plant height (73.14 cm), number of branches (5.37), number of leaves (23.46) at harvest over control. Seed bio-pelleting with Rhizobium NC-92 and *P. striata* at different concentration and combinations resulted in enhancing the seed quality and seed yield compared to individual PGPR's. Our results suggest that bio-pelleting of green gram seeds with PGPR's could enhance its productivity in India.

P16

Role of arbuscular mycorrhizal fungi and its population density on soybean grown in dryland of central Lombok, Indonesia

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Arbuscular mycorrhizal fungi (AMF) facilitate host plants to grow vigorously under stressful conditions. AMF mediates a series of complex communication events between the plant and the fungus leading to enhanced photosynthetic rate, increased water uptake and resistance to a variety of stresses including drought, salinity, and diseases due to fungal symbiosis. In view of this, the study was conducted on the role of AMF and its population density in soybean roots. The study was carried out in rainfed land of Gerupuk sub village of Sukadana Village, Pujut District arranged in a randomized block design with six treatments. The treatments were: D0 = control, D1 = 100 g AMF propagule/kg seed, D2 = 150 g propagules/kg seed, D3 = 200 g propagules/kg seed, D4 = 250 g propagules/kg seed, D5 = 300 g propagules/kg soybean seed. Each treatment was replicated four times. The results showed that the highest number of propagules were found in treatment D5 compared to all other treatments. The dose of AMF propagules affected the number of infected soybean roots where root infection in soybean plants was higher at higher dose of AMF applied (root infection 70-100%). The dose of AMF in soybean root increased with density of propagules. The role of AMF as a bio-fertilizer can potentially strengthen plants adaptability to changing environment. Thus, further research focusing on the AMF-mediated promotion of crop quality and productivity is needed.

P17

The progression of endophytes from seeds to the seedlings in oil palm

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The plant halobiont is a complex entity composed of the host plant and its organisms that harbour including its microbiota. The plant microbiota includes bacterial endophytes, which could invade living plant tissues without causing disease symptoms. The interaction between the endophytic bacterial microbiota and their plant host profoundly influences plant fitness influenced by biotic and abiotic stresses. For these interactions to be established, the bacteria must be present at right time in the right place either colonizing the rhizosphere or the seed. In view of this, in our study, we assessed the bacterial endophytic seed microbial dynamics of five different DxP genotypes through the first month of the plant's life cycle, i.e., plumule and radicle of germinated seeds before planting into the soil and after shoot and root emergence a month later. Based on 16S rRNA targeted amplicon sequencing, our results showed high similarity in bacterial assemblages in seeds irrespective of the plant genotype (>84% similarity), regardless of plant age. With one-month-old seedlings, the shoot microbiome was resembled more closely the seed microbiome. However, greater dissimilarity was observed in the root microbiome. It was attributed to horizontal transmission of bacteria originated from the soil. The genera of Burkholderia were distributed to be a dominant taxon in all the five genotypes' microbiome (41%) and in one-month-old seedlings (27%). Nevertheless, our results showed that the latter genera were highly transmitted to the shoots but not to root tissues. Our results provide an important foundation for developing plant microbiome engineering through the modification of native seeds. However, further studies are needed to understand the ecological processes involved in germinating seed and its soil for inoculation of beneficial microorganisms or modify environmental conditions that might influence its outcome.

P18

Influence of biochar and liquid sheep manure on plant growth

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Amongst the innovative and novel organic materials, biochar product formed by a process involving phyrolysis of fresh organic materials in an oxygen deficient environment has shown promises against many plant pathogens. Recent studies have revealed that the application of biochar in combination with liquid fertilizer has synergistic effects on growth and nutrient uptake by plants. Moreover, it has also been proposed that the combination of biochar and liquid fertilizer induce modifications in physical and chemical properties of soil, leading to better plant growth and production. The influence of application of sheep manure and sheep manure biochar has been examined in this s tudy. The roots in the soil were to determine the growth of plants. Soil physic, chemical and biological characteristics were important in providing adequate soil nutrients. The soil ameliorants could be applicable in the soils for less nutrients. The application of soil ameliorant and liquid fertilizer of sheep urine was aimed to improve the soil from lack of nutrients in the root areas of plants. The application of soil ameliorant biochar about 15 tons per hectare in combination with sheep urine liquid fertilizer significantly enhanced root and vegetative growth of pakcoy vegetable plants. The application of biochar and liquid fertilizer of sheep urine showed a significant contribution to soil health by increasing soil organic C.

P19

Antagonistic activity of Bacillus spp. and botanical extracts against *Drosophila melanogaster*

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Antagonistic microorganisms produce a diverse type of antimicrobial metabolites. Plant growth promoting rhizobacteria (PGPR) produce secondary metabolites including siderophores, toxins, lytic enzymes, antibiotics, and cyanide that exhibit antagonism. *Bacillus subtilis* complex species has been emphasized as potential biocontrol agents against economically important plant pathogens. Plants also contain phytochemicals that are antagonistic to pests, such as flavonoids, phenolic acids, tannins. Thus, Bacillus spp and plant can be used as an alternative to chemical pesticides for pest control. *Drosophila melanogaster* serve as model pest of homes, fruit markets and restaurants. This study was aimed to investigate the antagonistic activity of *Bacillus* spp. and botanical extracts against *D. melanogaster.* Sixty-two *Bacillus* spp. were isolated from soil, leaves and dead insects. The methanolic extracts of seeds of *Abrus precatorius* L*, Datura metel* and *Diploknema butyracea* were extracted by Soxhlet extraction method. *Bacillus* spp. and methanolic extracts were mixed separately with diet and fed to different larval stages of *D. melanogaster*. The mortality of larval and pupal stage was recorded every day. Seventeen *Bacillus* spp. exhibited lethality on 2nd instar larvae. Among the seed extracts, *D. metel* extract (10 mg/ml) exhibited a higher lethality (60-85%) on 3rd instar larvae after 72 hours. This lethality could be attributed by the bacillary toxins and various bioactive compounds in seed extracts. The lethality demonstrated that these could be possible biocontrol agents. Further molecular studies are in progress to identify the specific bioactive compounds responsible for lethality.

P20

Effect of foliar nutrition and bio-inoculants on yield of black gram (*Vigna mungo* L.) under rainfed conditions

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India is the largest producer and consumer of pulses in the world. Among the grain legumes, black gram (Vigna mungo L.) commonly called urdbean adapted to a wide range of Agro-climatic conditions because of its morphological parameters perfectly suiting for intercropping. Some of the soils are having poor water and nutrient holding capacity which leads to decrease in the available nutrient to crops and ultimately result in lower productivity and less profitability to the farmers. Foliar application of water-soluble fertilizer nutrients and bio-inoculants may be the best option to maximize the productivity of any crops in such soils. Under such situation, a field experiment was conducted to assess the effect of foliar nutrition and bio-inoculants on yield, yield parameters and quality of black gram under rainfed conditions during *kharif* 2020 at Main Agricultural Research Station, UAS, Dharwad with 11 treatments, which includes foliar spray of Dharwad nutrient mixture (DNM), water soluble fertilizer (19:19:19), Di-ammonium phosphate (DAP), urea and pink pigmented facultative methylotrophs (PPFM) with and without soil application with mycorrhizal consortium and their combinations. The treatments were replicated three times and arranged in a randomized complete block design. Among the treatments, soil application with mycorrhizal consortium @ 15 kg ha^{-1} at the time of sowing as in-furrow application and spraying of DNM @ 2% at flowering and pod formation stage improved the yield parameters such as pod $plant^{-1}$ (51), seed weight (13.28 g $plant^{-1}$), 100 seed weight (4.46 g), seed yield (1,180 kg ha^{-1}), protein content (23.52%), protein yield (277.57 kg ha^{-1}), net return (₹45,985 ha^{-1}) and B:C ratio (2.85) compared to recommended practice. Also, the same treatment increased the seed yield up to 32% compared to recommended practice. Spraying of PPFM @ 2.5 l ha^{-1} at flowering stage and soil application of mycorrhizal consortium @ 15 kg ha^{-1} at the time of sowing showed 28.65% higher seed yield and additional net returns of ₹ 13,765 ha^{-1} over recommended practice. We conclude that black gram responded to bio-inoculants such as PPFM, mycorrhizal consortium and foliar nutrition of Dharwad nutrient mixture under conditions tested.

P21

Efficacy of liquid organic waste for control of Fusarium wilt in shallot

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Shallot (*Allium cepa* var. *ascalonium* Barker) is an important *Allium* crop in many countries includes Indonesia. It is preferred over the common onion for its shorter growth cycle and its distinct flavour that persists after cooking. Fusarium wilt caused by *Fusarium oxysporum* is one of the major problems of shallot. It attacks roots and bulbs of shallot and onion, producing symptoms ranging from rotting of roots, slight discoloration to total necrosis of the basal plate. Effective control of the disease has been reported by soil fumigation with methyl bromide or treatment of transplants with benomyl. One of the effective techniques to suppress soil-borne diseases in biological control with antagonistic rhizobacteria or by liquid organic waste. The purpose of this study was to determine the formulation of liquid organic waste which could increase the resistance of shallots from Fusarium wilt disease. This study was conducted during April 2021 to December 2021. The organic waste formulation was made as a liquid formulation with the following components in one liter of water includes 20 g of corn flour, 60 g of bran, 20 g of sugar, 100 g of potatoes, plus pure inoculant of the *Saccharomyces cereviciae.* Experiments were carried out in the greenhouse of SMKPPN Mataram. The experiment was a randomized complete block design with five treatment dosages of the formulation which includes 50 ml/polybag (d1), 100 ml/polybag (d2), 150/polybag (d3), 200 ml/polybag (d4), and control (d5, without liquid organic waste formulation). Our results showed that the shallot was more resistant to *F. oxysporum* attack, and the symptoms of Fusarium wilt was lower. The best results were obtained at a dose of 150 ml/polybag and 200 ml/polybag.

P22

Efficacy of organic liquid waste on growth of shallots in west Nusa Tenggara

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The purpose of this study was to determine the effect of liquid organic waste on growth and resistance of shallots in West Nusa Tenggara. This research was carried out from August 2020 to August 2021 at the Greenhouse of the Faculty of Agriculture University of Nahdlatul Wathan Mataram. The study was designed as a completely randomized design with the following treatments: d0 (without organic fertilizer/ 0 ml per polybag), d1 (100 ml per polybag), d2 (200 ml per polybag), and d3 (300 ml per polybag). The liquid organic waste was applied once a week until the optimum vegetative phase of shallot plants. Our results showed that different doses of liquid organic waste had different effects on the growth and resistance of shallot plants. The best dose that increased the growth and resistance of shallot plants was of 300 ml per polybag, with plant growth up to 84.62%. We conclude that the higher the dose of liquid organic waste increased higher growth of shallot plants.

P23

Association of causal agents inciting boll rot complex of cotton and its management

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Cotton is the most important cash crop of India contributing 7% to our GDP, fetching an export earning besides providing employment in the production, promotion, processing, and trade of cotton. The present investigations were undertaken at Agri. Research Station, Dharwad during 2019-20. The study clearly identified based on pathogenicity, morphological and molecular characteristics *as Alternaria macrospora, Fusarium oxysporum* f. sp. *vasinfectum, Exserohilum rostratum, Colletotrichum gossypii, Phoma* sp., *Trichothecium roseum, Aspergillus niger, Nigrospora oryzae* and *Rhizopus stolonifer* were associated in causing boll rot complex of Bt. Cotton. The various symptoms were characterized as small brown or black dots, infected inner tissue and rotted seeds and lint. Among the areas surveyed, more than two pathogens associated at two places while more than three and four pathogens were associated in four and three areas. Based on our results of pathogens associated in boll rot complex have been divided into three groups *viz*., those capable of penetrating intact bolls, those which are introduced by insects and those are introduced after the boll were damaged by insects or after the suture of the boll lobes were broken. Among eleven different new molecules tested, spraying with trifloxystrobin 25%+tebuconazole 50%WG @ 1.0/lit at 75 and 90 days after sowing was found effective followed by tebuconazole 25.9 %EC at the rate of 1.0 ml/lit was found economical with the highest B:C ratio(1.52:1) followed by trifloxystrobin 25%+ tebuconazole 50%WG @ 1.0/lit with B:C ratio of 1.43:1. Among biocontrol agents spraying with *Trichoderma harzianum* @10 g/lit at 75 and 90 days after sowing was found effective followed by *Psudomonas fluoreosens* @10 g/lit at 75 and 90 days after sowing was found effective with the B:C ratio of 1.20:1 and 1.18:1. Present study clearly demonstrated the association of more than four pathogens in causing boll rot complex and can be managed by triazole fungicides and biocontrol agents in northern Karnataka.

P24

Pathogenicity of *Trichoderma longibrachiatum* in red lettuce (*Lactuca sativa* L.) and the potential of rhizobacterial antagonists to manage the disease

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Overuse of chemical fungicide has caused detrimental effects to agroecological space in cropping systems. Hence, the use of antagonistic microbes has become one of the favourable approaches to manage fungal diseases. The pathogenic *Trichoderma longibrachiatum* has recently found causing wilt in red lettuce could pose a new threat to vegetable industry. In view of this, this study was aimed to evaluate seven different antagonistic rhizobacterial isolates against *T. longibrachiatum* in a dual *in vitro* antibiosis assay. Our results demonstrated the *T. longibrachiatum* pathogenicity in red lettuce by injecting the culture to the stem of red lettuce under growth room conditions. In the pathogenicity trial, red lettuce plants were visually found diseased after 36 days of growth with foliar symptoms. These were chlorotic and reduced plant height, leaf length, diameter, wilted, dried up before it was collapsed at day 45 of lettuce growth. Dual culture assay of antagonistic bacteria against *T. longibrachiatum* found that *Pseudomonas putida* (SC14), *Bacillus cereus* (UPMLH24) and *P. veronii* (SC5) were the most promising antagonistic bacterial strains to control this pathogenic fungus. Further studies on mode of action by antagonistic bacteria against *T. longibrachiatum* are in progress.

P25

Potential of rhizobacterial isolates in rooting enhancement of *Piper nigrum* L. stem cuttings

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Chemical growth regulators are used to promote rooting in black pepper stem cuttings. However, the repeated usage of chemicals in the farming system could result an increased cost of production and environmental issues. This study was aimed to investigate the effect of three different isolates of plant growth-promoting rhizobacteria, *Bacillus cereus* (UPMLH24), *Acinetobacter radioresistens* (UPMLH19) and *Pseudomonas putida* (SC14) on root growth of black pepper stem cuttings under nursery conditions. Also, in this study, production of indole-3-acetic acid (IAA), by the PGPR isolates was evaluated. Our results showed that producing *B. cereus* (UPMLH24) produced highest IAA without tryptophan while *P. putida* (SC14) produced highest IAA with added tryptophan. Black pepper one-node stem cuttings assay was conducted by dipping the lower half including node of cuttings in bacterial suspension ($\sim 10^9$ cfu ml^{-1}), IBA solution or sterile distilled water (control) for 30 minutes prior to transplanting in the black polythene bags. After 45 days of planting, results showed that *B. cereus* (UPMLH24) promoted most of the vegetative parameters as compared to untreated control. UPMLH24 significantly increased ($p<0.05$) sprouting rate (74%), rooting rate (30%), total number of roots (11), total length of roots (328 mm), length of longest root (67 mm) over untreated control at 45%, 19%, 2, 56 mm, 36 mm, respectively. UPMLH24 was also better than IBA at 1000 ppm for sprouting rate (4%), total number of roots (4), and total length of roots (124 mm). UPMLH was comparable with IBA at 1000 ppm in terms of survival rate, and length of longest roots. The present findings suggest that replacing synthetic auxin with organic management by PGPR inoculants, particularly *B. cereus* strain UPMLH24 could be employed in organic nurseries for growth of seedlings production.

P26

Biogas production from lignocellulosic wastes integrated with microalgal cultivation for use in agriculture

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Great quantities of digestate produced after anaerobic digestion of lignocellulosic wastes causes problems related to transport costs, gas emissions and sludge accumulation while nitrogen and phosphorus remain available. It is necessary to find alternative paths for valorisation to reduce its environmental impact and improve economic profitability of anaerobic installations. One approach is involving this waste as a fertilizer or use its potential as a source of nutrients for microalgal growth. In our study, the algae were cultivated for reduced organic components at the expense of increased biomass production which was then immobilized and applied for soil improvement. The digestate was obtained as a by-product in the anaerobic fermentation of wheat straw to produce biogas and it was tested as a cultivation medium for microalgae after active carbon pre-treatment for clarification. Two different strains of microalgae were cultivated such as red marine *Porphyridium cruentum* and green freshwater *Scenedesmus acutus.* The uptake of nitrogen and phosphorus from digestate during algae cultivation was monitored. Intensive cultivation was carried out at 25°C, illumination and 2% CO_2. The growth was evaluated by algal biomass production and the pigment content. Our results showed that *S. acutus* growth was highest (7.3 mg/mL). The growth of *P. cruentum* reached to 4.3 mg/mL dry matter. The total amount of pigments of *S. acutus* at the end was 217 mg/L (43 times increase) since the beginning of the process. For *P. cruentum,* the increase in pigments content was 18 times. The nitrogen decreased more than four times and phosphorus was completely utilized. The obtained algal biomass was immobilized, and plants were grown in soil, supplemented with immobilized preparations and positive effect was registered. Our results suggest that the cultivation of microalgae in waste digestate is a promising cost-effective strategy for algal valuable products to save the fresh water and to use microalgae as a biofertilizer. This work was supported by the Bulgarian National Science Fund with a Grant KP-06-N - 26/5.

P27

Improvement of compost quality with microbes and vegetable waste for sustainable organic farming

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Organic farming is an agricultural system that uses fertilizers of organic origin such as compost manure, green manure, and bone meal and places emphasis on techniques such as crop rotation and companion planting. Organic farming is the least risk to the environment and enhances the high-quality healthy food for humans and animals. Application of compost to the soils increases its agricultural productivity and organic matter content of the soil. The plant residues and especially straw for preparing compost could provide a stable source of organic matter and nutrients to plants. Therefore, the strategies to improve the compost quality is needed. In preparation of compost, organic materials and incorporation of microorganisms are needed in different phases of composting. Inoculation by exogenous actinobacteria could promote the conversion of cellulose into sugars via sugar-amine condensation reaction to form humic substances. Different factors could be managed during composting process such as C:N ratio, moisture content, aeration, temperature, and colonized microorganisms. During composting process, the activity of a mixed microbial community was increased. Vegetable waste of tomatoes was used as a starting material for isolation of microorganisms. Addition of microbial inoculum improved the quality of the compost with increased bacterial and fungal enzyme activity. The fungi and bacteria from vegetable waste and wheat straw as plant substrate, together with thermophilic actinomycetes isolated from the soil surrounding tomato plant roots improved the enzymatic activity and compost quality. The C:N ratio was estimated and cellulose degradation and enzymes activities when assessed and found higher during the process of composting. Our results suggest that the intensive use of plant waste could result in a significant reduction of the cost associated for transport and storage in controlled landfills, which in turn will reduce environmental and health problems. This work was supported by Bulgarian National Science Fund with a Grant KP-06 H 36/1.

P28

Evaluation of various types of composts in soil organic matter tor sustainable agriculture

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Sustainable development is a political priority for Europe especially in agriculture, which implies a reasonable and sparing use of natural resources. Soil is a source of wealth and national prosperity. Maintaining it in a state of "healthy soil" requires limiting and minimizing the decomposition processes. The main alternative for this is the inclusion of natural and safe waste products in maintaining the balance of agro-ecosystems. Sustainable agriculture involves development of technologies that allow active use of arable land. The aim of the study was environmentally friendly utilization of waste products from various industries, the use of natural products and plant residues from agricultural practices as composts for soil fertility improvement. Identification of waste products and their possibilities for use for compost production with a certain composition was carried out. Physio-chemical characteristics of the starting materials before composting was carried out. Estimation of their effectiveness as soil improvers on two types of soils includes leached cinnamon forest soil from Chelopechene village near Sofia and alluvial meadow soil from the area of Calapitsa, Plovdiv region, Bulgaria was evaluated. Our results showed that when composting the ameliorants with first type of soil, all additives led to positive changes in soil organic matter. When composting ameliorants with second type of soil, the added organic materials provided a lower degree of storage of organic matter. The compost addition to a leached cinnamon forest soil provided a good stock in the form of humic acid. Our results suggest that environmentally friendly and cost-effective solutions applicable to large areas as well as to small farms are sought everywhere. This is especially true for areas affected by environmental processes, leading to deteriorating soil fertility and limiting opportunities for organic sustainable farming. Our work was supported by the Bulgarian National Science Fund with a Grant KP-06 H 36/1.

P29

Wastewater treatment from tofu industry with anaerobic PGPR's

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Anaerobic systems are used in many industrial systems including food production and municipal sewage treatment systems. Anaerobic digestion is commonly used to treat sludges in wastewater treatment plant. This process is popular because it is able to stabilize the water with little biomass production. Anaerobic treatment occurs in many different stages. The key microorganisms are anaerobic PGPR's. The tofu industry in Kartasura village in Indonesia is a small-scale home industry in which it directly disposes its wastewater into river. The waste can be in solid form referred to as tofu dregs from washing of tofu. The disposal of tofu industrial wastewater directly into river without the treatment could increase the value of biochemical oxygen demand (BOD) and decrease the value of dissolved oxygen (DO) in the water. This impact could lead to an unpleasant odor, a decrease in the quality of agricultural products to crop failure. The aims of this research were to identify the anaerobic PGPR's for the treatment of tofu industrial wastewater at the tofu production site. In our study we used the combination of qualitative and quantitative methods such as laboratory-scale biofilter processing unit. The following materials were employed in the process such as fibers, zeolite, activated charcoal, silica sand and gravel with a flow rate of 50 mL/min; 100 mL/min; and 150 mL/min under anaerobic conditions. Our results showed that the wastewater exceeded the quality standard with a parameter value of BOD 4010.03 mg/L; COD 6000.11 mg/L; TSS 335 mg/L and pH 3.8. The results of the standard stream evaluation showed that the TSS and COD parameters were still above the river water quality standards with values of 65.0348 and 334.1703. The biofilter unit could be proposed as a treatment with a flow rate of 50 mL/min and the efficiency of BOD, COD, TSS, and pH, respectively, which was at 21%, 49%, 85% and 80% to achieve maximum degradation while meeting the strict regulations set by the environmental agencies that regulate what is released into the air, ground, or water.

P30

Efficacy of Streptomyces sp. against rice bacterial leaf streak caused by *Xanthomonas oryzae* pv. *oryzicola*

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Bacterial leaf streak (BLS) caused by *Xanthomonas oryzae* pv. *oryzicola* (*Xoc*) is one of the most important bacterial diseases of rice. There is a need to use environmentally safe approaches to overcome the loss of grain yield in rice due to this disease. The *Streptomyces* sp. has enormous promise in protecting plants against various pathogens and provides a sustainable and safer alternative as a biocontrol agent. Thus, our study was aimed to evaluate the potential utilization of *Streptomyces* sp. SS8 to control BLS under *in vitro* conditions. The *in vitro* assessment of *Streptomyces* sp. SS8 against the BLS caused by *Xoc* was evaluated with the chloroform vapor method. Our results showed that the inhibition zone of 17.67 mm indicated the ability of *Streptomyces* sp. SS8 to suppress *Xoc* radial vegetative growth. The *in vivo* biocontrol assay conducted under greenhouse conditions showed the suppression of disease severity caused by *Xoc* with *Streptomyces* sp. SS8 when introduced as seed and soil drench during transplantation. In this assay, forty-day-old, transplanted seedlings were challenged with *Xoc* by spray method. The results showed that the suppression of *Xoc* was 77.02% by *Streptomyces* compared to untreated control. The accumulation of defense-related enzymes such as peroxidase, phenylalanine ammonia-lyase and polyphenol oxidase were significantly higher compared to the untreated at 0 days of post inoculation (dpi), 2 dpi, 6 dpi, and 12 dpi. Thus, our results confirmed the potential of *Streptomyces* sp. SS8 in controlling BLS disease through induction of rice-systemic resistance. The results provide evidence that novel secondary metabolites produced by *Streptomyces* sp. SS8 may contribute to its activity as a biological control agent against *Xoc* and its potential to elevate the defense-related enzymes in rice plant.

P31

Biocontrol potential of plant growth-promoting rhizobacteria against anthracnose caused by *Colletotrichum gloeosporioides*

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Anthracnose is one of the most serious diseases caused by the fungal pathogen *Colletotrichum gloeosporioides* (Penz.) Penz. & Sacc. Biocontrol is an efficient green way for the disease control, and numerous research have focused on exploring the potential biocontrol bacteria strains against *C. gloeosporioides*. Currently, applications of chemical fungicides are still the effective means to prevent the infection and dispersal of anthracnose. However, the excessive and long-term use of chemical fungicides has led to the evolution of drug resistance of pathogenic fungi. Even more, chemical fungicides result in serious environmental pollution because of the difficult degradation and non-target toxicity. Therefore, increasingly research have focused on developing and applying alternative methods that are less reliant on fungicides and more environmentally friendly. Biological control is high efficiency and safer for the environment to be used in disease management. Plant growth-promoting rhizobacteria have long been recognised as potential biological control agents for controlling plant diseases as alternatives safer antifungal agents. In this study, antifungal activities against *C. gloeosporioides* of twelve endophytic isolates from healthy plants were investigated *in vitro* by the dual culture assay. These isolates were purified and identified as *Bacillus subtilis*, *B. velezensis*, *B. licheniformis*, *B. aryabhattai* and *B. megaterium*. The antifungal activity was determined by measuring the inhibition of fungal radial vegetative growth. Our results showed that *B. velezensis* reduced 90% radial growth and is highly significant compared to nontreated control at $P<0.05$, followed by *B. subtilis* at 73%, *B. aryabhattai* at 38%, *B. licheniformis* at 34% and *B. megaterium* was the least at 30%. Our study suggests that Bacillus spp. demonstrated promising antifungal activity and could be used as potential biocontrol agents for controlling Anthracnose caused by *C. gloeosporioides* in various crops. The efficacy studies are in progress to confirm the *in vitro* antibiotic activity under field conditions.

P32

Application of biostimulants in paddy production under field conditions

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Seaweeds are the important marine resources available at negligible cost and rich in diverse bioactive compounds like lipids, proteins, carbohydrates, amino acids, phytohormones, osmoprotectants, mineral nutrients and antimicrobial compounds. They are key component in food, feed, and medicine since ancient times. Recent trend of organic farming has exploited the possible application of seaweed as an organic bio-fertilizer in agriculture. The commercialized seaweed extracts as biostimulants are already available in the market, but, mostly imported from other countries. Many studies to-date have demonstrated the benefits of seaweed in enhancing the plant growth and productivity of many agricultural crops. These are known to be a promising soil conditioner, protect the plants under abiotic and biotic stresses and increase plant resistance against pest and diseases. Malaysia produced 188,110 tonnes of seaweed which accounts to 0.53% of global seaweed production in 2019. In Malaysia, Sabah is the main state for seaweed cultivation activity because of its natural abundance resources and good climate. The Department of Fisheries Sabah reported that seaweed production in Sabah has been increased every year with a production of 205,989.20 metric tonnes worth RM43.38 million in 2016. In this study, *Kappaphycus alvarezii* extract enriched with endophytic bacteria, *Rhodopseudomonas palustris* was formulated to be used as a plant biostimulant for our study in paddy production. The strain of *K. alvarezii* was selected because of its cultivated type of seaweed to be used in Malaysia. The formulated biostimulant, the Bactostimulant was tested using paddy variety MR220 CL2. It was found through field tests that the application of the formulated biostimulant (Bactostimulant) (75% subsidy fertilizer + 2.5% biostimulant) increased the yield of paddy by 5% while reducing 25% of the usage of subsidy fertilizer. This could benefit Malaysian farmers and government of Malaysia to reduce their cost.

P33

Glycoprotein Producing AM Fungi, Lifestyle and Energetic Role in Global Sustainable Agriculture to Green Technology for Future Generation

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The rhizosphere is a modest area of soil that is directly affected by root secretion and soil-associated microorganisms called the root microbiome. The rhizosphere, which surrounds the soil stomata, contains many beneficial bacteria, fungi, and various other microbes. The term green technology is an umbrella term that describes the use of technology and science to create environmentally friendly products. The main goal of green technology is to protect the environment and repair past environmental damage. Sustainable agriculture can play a crucial role in today's biosphere as it offers the potential to meet agricultural needs. A perfect agricultural system is sustainable, maintains and improves human health and surrounding communities, and produces enough food for the world's growing population. Microorganisms play an essential role in the rhizosphere, significantly influencing the availability of soil nutrients to plants, thereby altering the standard and quality of root exudates. Carbon fixation is a key determinant of rhizosphere behavior, as root exudate is a rich source of carbon. Root exudate outflow and decaying plant material provide heterotrophic soil biota with a source of carbon compounds, either as growth substrates or as the structural material for root-associated microbiota. Various types of microorganisms exist in soil and play vital roles in many physiological activities. These dynamic activities are mediated through microbial relationships that engage in saprophytic, pathogenic, and symbiotic relationships with roots. Mycorrhizal fungi are ubiquitous and found in all natural ecosystems in most climates around the world. Mycorrhizal habitats likely evolved as a survival mechanism for both partners of the association, allowing them to survive in environments of low fecundity, drought, disease, and extreme temperatures where each cannot survive on its own. Early morphological classifications separated mycorrhizas into Ectomycorrhizas, Endomycorrhizae, and Ectoendomycorrhizas, Arbutoid mycorrhizae, Monotropoid mycorrhizae, and Orchid mycorrhizae associations based on the relative location of fungi in roots. Arbuscular mycorrhizal fungi (AM fungi) are a type of endo mycorrhizae. The diagnostic hallmark of AM fungi is the development of highly branched arbuscules within cortical root cells. The fungus initially grows between cortical cells, but quickly invades the host's cell wall and multiplies intracellularly. As the fungus grows, the host cell membrane invaginates and envelops the fungus, creating new compartments in which macromolecular complex substances are deposited. AM fungi are the most studied mycorrhizal species because they are found in most agricultural and natural ecosystems and play an important role in plant growth, health, and productivity. There are very few genera belonging to the Brassicaceae family. Chenopodiaceae and Cyperaceae are toxic to fungal growth due to the presence of glucosinolates and their hydrolysis products, isothiocyanates, in and around their roots. AM fungal colonization begins with hyphae arising from soil-borne spreads, large dormant spores of AM fungi, or mycorrhizal root fragments. AM Fungal hyphae penetrating the roots between epidermal cells and form appressorium in the first cell layer. This stage indicates autotrophic

growth of the fungus. The colonizing hyphae enter the root tissue by passing through intercellular spaces and spreading between and through the cells of the cortical root layer. When the hyphae reach the inner cortex, they grow into cells and form tree-like structures called 'arbuscles'. These branched hyphae are tightly surrounded by the host's intact plasma membrane, providing a large surface area of cellular contact between both symbionts. These facilitate the exchange of metabolites between the host and the fungus. Arbuscles are probably the major transfer sites for mineral nutrients, mainly phosphorus, from fungi to plants and from carbon compounds to fungi. As internal colonization spreads, the outer root hyphae branch and grow along the root surface, creating more penetration points. They also grow outwards into the surrounding soil, thus developing an extensive tridimensionality network of mycelium that interfaces with soil particles and the length of the external hyphae growing in soil associated with mycorrhizal roots reach an average of 1m cm^{-1} root, but values of up to 10-14 m cm^{-1} root have also been recorded. This mycelial network can extend several centimeters outwards from the root surface, bridging over the zone of nutrient depletion around roots to absorb low-mobile ions from the bulk soil (mineral nutrients). In return, the plant provides the fungus with sugars, amino acids, and vitamins essential for its growth. AM fungi are found in the rhizosphere of several vascular plants and have important roles in sustainable agriculture as well as agricultural ecosystem management. The beneficial effect of indigenous AM fungi on the nutrition of agricultural plants depends on both the abundance and type of fungi present in the soil. However, the potential for employing AM fungi on a wide scale in agriculture is dependent on the development of crop-growth-promoting strains of AM fungi, which are superior to the native soil population of AM fungi. Glomalin, a type of glycoprotein produced by AM fungi of the phylum Glomeromycota, helps mitigate soil degradation. Moreover, AM fungi and glomalin are highly correlated with other soil physicochemical parameters and sensitive to environmental changes. It is also recommended for monitoring the restoration of degraded soils or stages of soil degradation. AM fungi are commonly known as biofertilizers/biostimulants. Moreover, it is widely believed that inoculation of host plants with AM fungi confers resistance to a variety of stresses, including heat, salinity, drought, metals, and temperature extremes. AM fungi, natural root symbionts, provide host plants with essential inorganic phytonutrients, thereby enhancing plant growth and yield under unloaded and stress-free conditions. The role of AM fungi as biofertilizers/biostimulants can potentially enhance the adaptability of plants to environmental changes. They also improve plant resistance to plant diseases and root system development, allowing better uptake of nutrients from the soil. As a result, they can be used as biofertilizers/biostimulants and as biocontrol agents. The current manuscript demonstrates the potential of AM fungi as biostimulants that likely enhance the ability of plants to transform agriculture systems into technology for future generations.

P34

Phyllomicrobiome assisted suppression of blast disease in rice

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With its adapted microbiota, the phyllosphere brings unique microbiome to the plant-holobiont-pool with a potential for modulating plant phenotypic and agronomic traits. However, the ecological factors driving the phyllomicrobiome assemblage and functions are among the underestimated aspects in plant-biology. In the present study, we combined the mNGS with microbiological methods to decipher the core-phyllomicrobiome of rice-genotypes differing for their reaction to rice blast disease grown in contrasting agroclimatic-zones. Principal coordinate-analysis by *Bray Curtis* and *ANoSIM* method indicated an influence of environmental-factors rather than the genotype *per se* on phyllomicrobiome assembly. The predominance of phyla such as Proteobacteria, Actinobacteria, and Firmicutes encompassing the core-microbiome consisting of 24 bacterial genera on the phyllosphere. The linear discriminant analysis (LDA) effect size (LEfSe) method revealed 10 and 2 distinct bacterial genera in blast-resistant and -susceptible genotypes, respectively. The study further indicated 15 and 16 climate-zone specific genera for Mountain and Island -zones, respectively. SparCC network showed hundreds of complex intra-microbial interactions on the phyllomicrobiome. The microbiological validation of mNGS data confirmed Acinetobacter, Aureimonas, Curtobacterium, Enterobacter, Exiguobacterium, Microbacterium, Pantoea, Pseudomonas, and Sphingomonas on the phyllosphere. Strikingly, the agroclimatic-zones showed genetically identical bacteria on phyllosphere that could be attributed to intergenerational transmission of core-phyllomicrobiome. We identified functional microbiome showing blast suppressive activity leading to the proposal of phyllomicrobiome assisted blast management. Upon phyllobacterization the core-bacteria such as Acinetobacter, Aureimonas, Pantoea, and Pseudomonas elicited plant-defense and contributed to blast suppression. Transcriptional-analysis indicated induction of innate-immunity genes such as *OsPR1.1*, *OsNPR1, OsPDF2.2*, *OsFMO, OsPAD4, OsCEBiP*, and*OsCERK1* in phyllobacterized rice seedlings. Multi-pronged activities of phyllomicrobiome on *Magnaporthe oryzae* (antifungal activity), rice (defense elicitation), and blast disease (blast suppression) have been elaborated for management of blast by phyllomicrobiome reengineering.

P35

Optimization of DNA isolation protocol from wheat rhizosphere soil for metagenomics applications

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In order to unravel the unexplored microbial community, it is necessary to develop an inhibitor-free DNA isolation procedure. One of the major challenges for soil metagenomics study is to develop a method to capture the diverse characteristics of soil microbial communities. During soil DNA isolation, one of the co-extractant is humic acid which will interfere with the PCR amplification. In the present work, three different PEG-NaCl methods for soil DNA isolation were compared with a commercial kit available. For efficient cell lysis, we have used combination of physical (heating), chemical, and mechanical lysis method. To remove humic acid impurities calcium chloride ($CaCl_2$) and polyvinylpolypyrrolidone (PVPP) were incorporated in lysis buffer. To precipitate DNA, polyethylene glycol (PEG), sodium chloride (NaCl) and sodium acetate was used. An additional purification of extracted DNA was done by using chloroform: isoamyl mixture and spin column and then eluted with TE buffer. The yield of the DNA isolated by using modified method was 57.33±2.3115 ug/g of soil. The purity of DNA extracted by using this method was equivalent to 1.8. As compared to the commercial kit available, the modified PEG-NaCl method, gave good quality of DNA suitable for the downstream applications like sequencing and cloning. The DNA isolated by this method served as a template for PCR amplification using prokaryotic 16s primer. The isolated DNA was then subjected to for 16 amplicon metagenomic analysis which gave the presence of potential PGPRs.

P36

Molecular characterization and management of wheat foot rot caused by *Sclerotium rolfsii*

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Wheat foot rot is caused by *Sclerotium rolfsii* Sacc., a soil-inhabiting pathogen with a broad host range. In wheat, this pathogen causes blighted appearance and death of seedlings. Studies on morphological, physiological, and pathogenic variability of organism have been reported, but molecular diversity analysis using internal transcribed spacer (ITS) has not been attempted. Our study explained the BLAST analysis of the aligned ITS5/4 sequences of the five isolates showed sequence homology with other *Athelia rolfsii* (teleomorph of *S. rolfsii*) sequences reported on other crops, while no previous sequences have been reported from wheat. Phylogenetic relationships showed significant variability between the isolates by grouping them into two clades, in which *Sr* DWR (MT133526), *Sr*BVG (MT133525), *Sr* MUL (MT129499) and *Sr* UGK (MT129498) along with reference isolates formed a group, while *Sr* BGL (MT128720) was grouped separately DWR and *Sr* BVG were more similar to each other and were clustered with *Sr* UGR to form a subgroup. *Sr* MUL fell into a different subgroup with a closer association with JN241550. Isolates were further used for management studies with potential bio control agents.

P37

Role of foliar application of bio-inoculants and nutrients on productivity of cotton

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Cotton (*Gossypium* spp.) popularly known as "the white gold" is an important commercial fiber crop grown under divers agro-climatic conditions around the world. It provides fiber and raw material for textile industry along with cotton seed and plays a vital role in economy of the country. A field experiment was conducted to assess the efficacy of foliar application of bio-inoculants to maximize the productivity of cotton under field conditions. Yield, morphological, physiological, and bio-physical parameters were assessed during Kharif 2020-21 at Agri. Research Station of Dharwad, UAS, India. There were eight treatments which includes foliar spray of 2% urea, 1% KNO3. 0.5% PPFM 1% PPFM 1.5% PPFM and control. Our results showed that foliar spray with 1% PPFM at flowering and boll development stage recorded higher cotton yield (2175 Kg/ha) followed by KNO3 1% (2032K g/ha and lowest yield was recorded in control 1910 kg/ha.). Among the other treatments PPFM at 1% recorded higher rate of photosynthesis (26.1 µ mol CO_2 m^2 S^{-1}) RWC (82.5%), chlorophyll content (3.21 Mg/gl fr.wt) compared to control and other treatments. We conclude that foliar application of 1% PPFM at following and boll development stage was more effective in increasing the yield, and yield attributing parameters compared to control.

P38

Ability of Endophytic Nitrogen Fixation Bacteria *Paenibacillus alvei* M3-12 to Reduce Inorganic Fertiliser's Usage in Oil Palm Seedlings through Different Application Techniques.

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The ability of endophytic nitrogen fixation bacteria *Paenibacullus alvei* M3-12 to reduce the use of inorganic fertiliser on oil palm seedlings was evaluated. The isolate was applied on 3-month old oil palm seedlings, a week before transplanted into main nursery. The application of M3-12 was done once throughout the trial. The efficacy of two different application techniques; drenching and foliar spraying was also compared in this trial. Each seedling was applied with 30mL diluted suspension of M3-12 in N-free broth medium at concentration of 106 CFU mL-1. Seedlings treated with isolate M3-12 received half-rate NPK Blue and Yellow compound fertiliser, while seedlings not treated with any microbe received full-rate fertiliser, as per FGV nursery standard practise. Vegetative growth of the seedlings was monthly recorded until the seedlings reached 12-month old before destructed for determination of dry weight of the seedlings and N content of the leaves. Isolation was done on both roots and shoots of the treated seedlings to determine the presence of isolate M3-12. Although the seedlings were applied with half dose fertiliser, there was no significant difference in vegetative growth and dry weight between seedlings applied with isolate M3-12 either through drenching or foliar spraying compared to control seedlings. There was also no significant difference in N content between the treated and control seedlings, demonstrating the ability of isolate M3-12 to fix atmospheric nitrogen for plant use. The results also showed presence of isolate M3-12 in both root and leave tissues of the treated seedlings at the end of trial.

P39

Influence of chemical fertilizer application on rhizosphere bacterial dynamics

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The rhizosphere is a narrow soil zone surrounding plant roots that is inhabited by various microbes. These microbes are involved in various complex biological processes, and the rhizosphere is considered to be one of the most dynamic interfaces in cropping system. Crop plant roots regulate the soil pH, soil nutrients, and secrete various metabolites to form a rhizosphere microbial community structure enriched with beneficial microbes. Hence, to improve plant growth and health, it is crucial to determine the microbial dynamics in the rhizosphere. This study was conducted to determine the effect of fertiliser on bacterial community composition in the rhizosphere using the 16s amplicon sequencing. The aerobic rice MRIA 1 was planted in sandy clay loam soil (Ultisols order) and its rhizosphere was selected for this study. The fertiliser was applied at 200 kg/ha at seeding of the rice and rhizosphere samples were collected at 90 days after sowing for microbial dynamics. Our results showed that the 16s amplicon sequencing altered significantly by the application of fertilizer to the rice field. Generally, *Gammaproteobacteria* was the crucial genera present in sandy clay loam. However, in our study, the abundance of Clostridia and Solirubrobacter. Dechloromonas, Desulfovibrio, and Telmatospirillum were not detected in fertilizers amended rhizosphere. It is concluded that fertiliser application influenced the bacterial community dynamics by shifting its communities. We hypothesized that the application of chemical fertilizers could increase the diversity and richness of the bacterial community in rice rhizosphere soil.

P40

Indole acetic acid production by *Enterobater cloacae* 38 through fermentation of various carbon and nitrogen sources using response surface methodology.

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Indole acetic acid (IAA) was known as phytohormone which involves critically in stimulating plant growth. Plant growth promoting rhizobacteria (PGPR) which part of microbes that living in the soil known as natural IAA-producer directly helps in plant development through L-tryptophan metabolism pathway. This study attempt to optimize IAA production by using various carbon and nitrogen source to achieve an optimal condition by the selected strains. The current works deals with selection of the best IAA producing strains among the pre-isolated bacterial cultures followed by optimizing cultural conditions of the selected strain through fermentation using response surface methodology. *Enterobacter cloacae* 38 presented as the best IAA-producer compared to the other bacterial strains which achieved highest IAA concentration (529.71 mg/L) at 120 h fermentation. IAA production of this strain showed the highest when cultured with 200µg/ml tryptophan and unfortunately, addition of carbon source showed inhibit the IAA development. Meanwhile, among nitrogen source tested, skim milk does influence more towards IAA production followed by yeast extract and tryptophan after 5 days incubation at pH 7 and 37°C.

P41

Influence of Rhizobium in Leguminous cover crops in oil palm plantation

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Leguminous cover crop (LCC) plays an important role in reducing competition from noxious weeds, conserving soil moisture and improving soil fertility through nitrogen fixation. LCC alone is not able to efficiently convert atmospheric nitrogen into available form for plant uptake, but it relies on symbiotic association with Rhizobium, a nitrogen-fixing bacteria. Extensive studies in Rhizobium have been conducted in other crops, however, such beneficial information is still lacking in oil palm plantations. The objective of this study was to evaluate the influence of Rhizobium in leguminous cover crop, particularly, nodule formation and presence of Rhizobium populations in the soil. Two different mixtures of Rhizobium were tested in LCC in coastal soil. The LCC mixture group 1 (G1) consisted of *Pueraria javanica (PJ), Calopogonium mucunoides (CM)* and *C. caeruleum (CC)* and LCC mixture group 2 (G2) consisted of *Pueraria javanica (PJ), Calopogonium mucunoides (CM)* and *Mucuna bracteate (MB).* The LCC seeds were coated with Rhizobium served as treatment while non-coated LCC seeds served as control. Application of Rhizobium to LCC seeds caused massive pink nodule formation on its roots, while non-coated LCC seeds showed no nodule formation after 90 days of application. As Rhizobium is known nitrogen fixing bacteria, this combination may serve as an alternative way to reduce chemical-based fertilizer application in oil palm plantation.

P42

Innovative bioherbicide from discovery to application - industrial perspective

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Any successful strategy aimed at enhancing crop productivity with microbial products ultimately relies on the ability to scale at regional to global levels. Microorganisms that show promise in the lab may lack key characteristics for widespread adoption in sustainable and productive agricultural systems. This presentation provides an overview of critical considerations involved with taking a strain from discovery to application. General processes associated with commercializing viable microbial products are in two broad categories, bio-fertilizer inoculants and bio-control products. Specifically, we will address biocontrol products for control of noxious weeds. Invasive weeds pose a serious threat to the biodiversity of natural ecosystems and agricultural production worldwide. Due to the recent trends in environmental awareness concerning the side effects of herbicides, public pressure is mounting to force industry to develop safer, more environmentally friendly approaches for controlling weeds. Microbes or their metabolites-based pesticides, referred to as mycoherbicide, for the management of weeds offer such an approach. Some of the advantages of mycoherbicide over traditional chemical herbicides are their specificity for the target weed, absence of adverse effects in humans, wildlife or domestic animals, rapid degradation and absence of residues in surface or ground water, crops, soil or food chains. Our research has made significant progress in the development of patented fungal pathogens for control of some invasive weeds viz. Parthenium, Water hyacinth and Lantana. We will also cover all detail about how mode of action informs decisions on product applications, the influence of variation in laboratory and field study data, challenges with scaling for mass production, and the importance of consistent efficacy, product stability and quality. This presentation will discuss the progress on our mycoherbicide for the management of invasive weeds, product application, laboratory and field efficacy, challenges with mass production, consistent efficacy, product stability and quality. The possibility and perspectives for obtaining new mycoherbicides with unique mode of action from these fungi will outline in this presentation.

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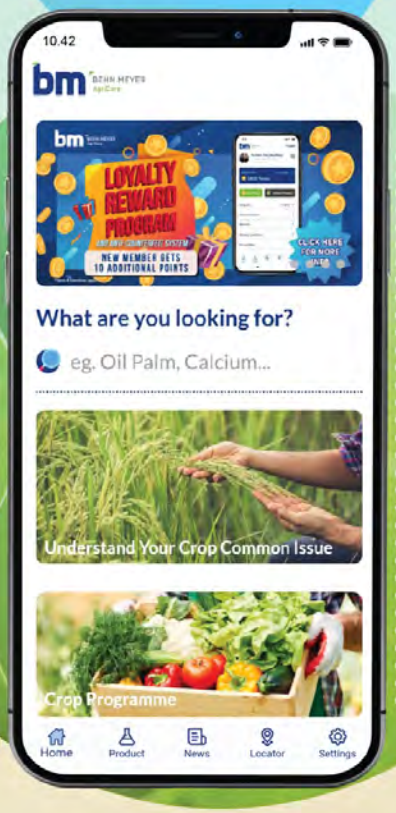

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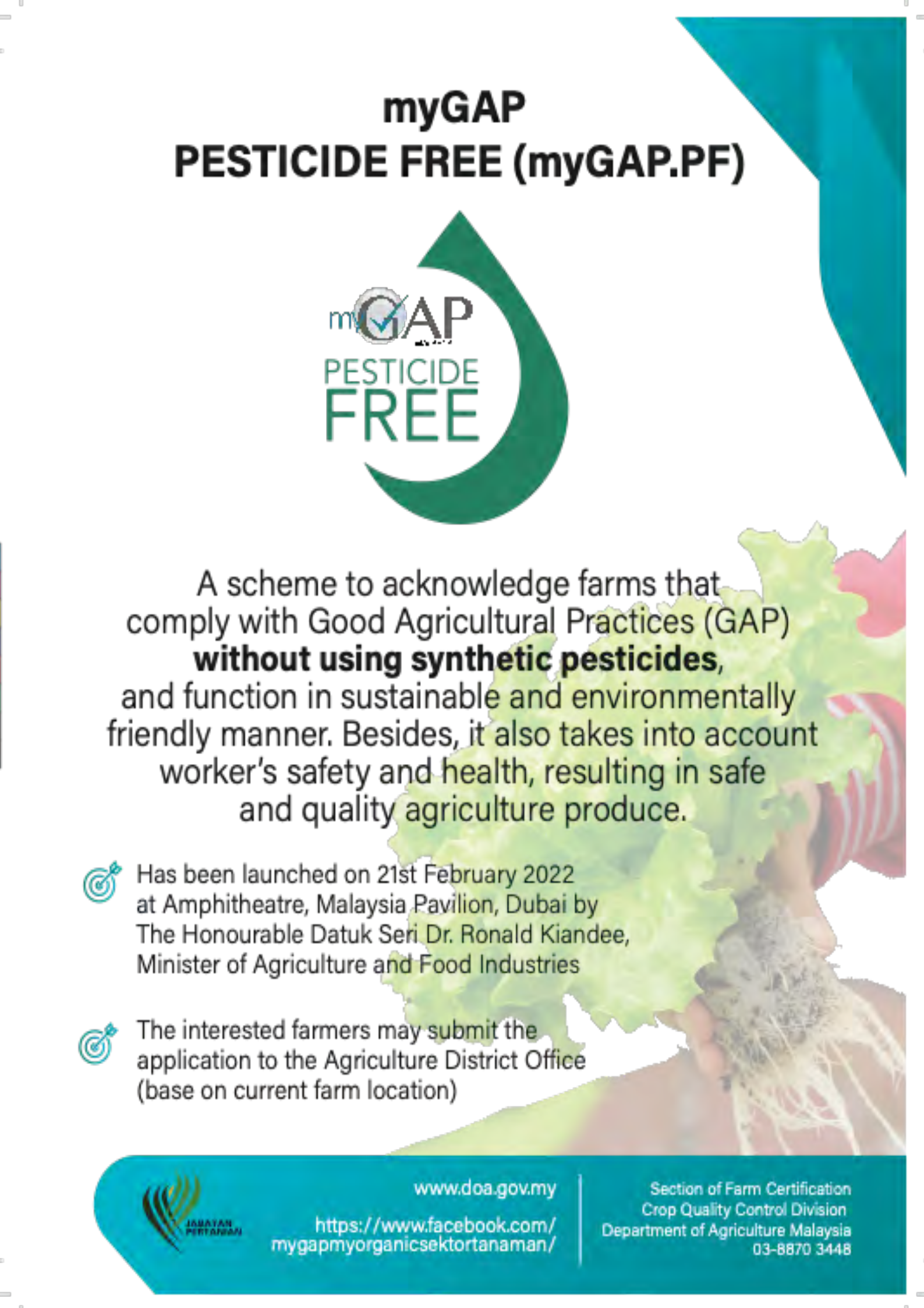

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