Journal of Applied Biology & Biotechnology
Vol. 10 (S1), pp. 1-5, March, 2022
Available online at https://www.jabonline.in/
DOI: 10.7324/JABB.2022.10s101

Microbes for Agricultural and Environmental Sustainability

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Agriculture is a significant part of the world's economies and can therefore contribute to achieving major continental priorities such as hunger, poverty eradication, rapid industrialization, economic diversification, sustainable resources, and environmental management. The world's population is estimated to be double by the end of 2033 and food demand is also expected to increase which in turn puts pressure on the agricultural systems. Traditional agricultural equipment and practices reach the limits of efficiency in increasing agricultural productivity and these pressures are multiplied by shrinking farmland and rising labor costs [1]. Further, the increased incidences of abiotic and biotic stresses negatively impact the productivity. To combat such issues, the agricultural sector depends on chemical fertilizers and pesticides. The excess utilization of these chemicals results in soil pollution, affects soil fertility and ultimately human health through bioaccumulation and biomagnifications along the food chain [2]. Evolving efficient, cost effective, easily adaptable methods for the stress management and increasing agricultural productivity is a major challenge. The natural role of the microbes in maintaining soil fertility, plant growth promotion and biocontrol of plant pathogens is an important area of research and one of the sustainable approaches under changing scenario.

Interaction among the organism is one the nature's finest gift and plant-microbe interaction is one of it. At stages of life, every plant organ of life interacts with certain microbes which could be positive or negative. Indeed, plenty of the of microbial interaction benefits the plants directly and even indirectly in return plant serves the shelter, nutrients and many other compounds to microbes. The microbes associated with plants in turns secrete compounds that favor the growth of plant by increasing the resistivity to biotic and abiotic stress. Microbes in plants colonize different parts of plant i.e. apoplastic spaces (endophytic region), plant surface areas (epiphytic region) and adjacent to root surface (rhizospheric region). The interaction between the plant and microbe has also been recommended for their potential use in the both the field of agriculture (biofertilizer and biocontrol) as well as environment (bioremediation) [3,4]. There are many finding available that these microbes could be use for the bioremediation of pollutants and improvement of plant health and growth (Figure 1).

Endophytes the microbes residing in the plant tissues is one of the plant-microbes interactions. This interaction is generally beneficial to both plant as well as microbes. Many studies have confirmed the benefits of this interaction in the agriculture as well as environment. In a study, endophytes, *Paenibacillus glycanilyticus* and *Pseudomonas brenneri* isolated from lupine plants were reported for exhibiting the multifarious plant growth promoting traits such as solubilization of phosphorus, production of siderophores and 1-aminocyclopropane-1-carboxylate [ACC] deaminase activity [5, 6].

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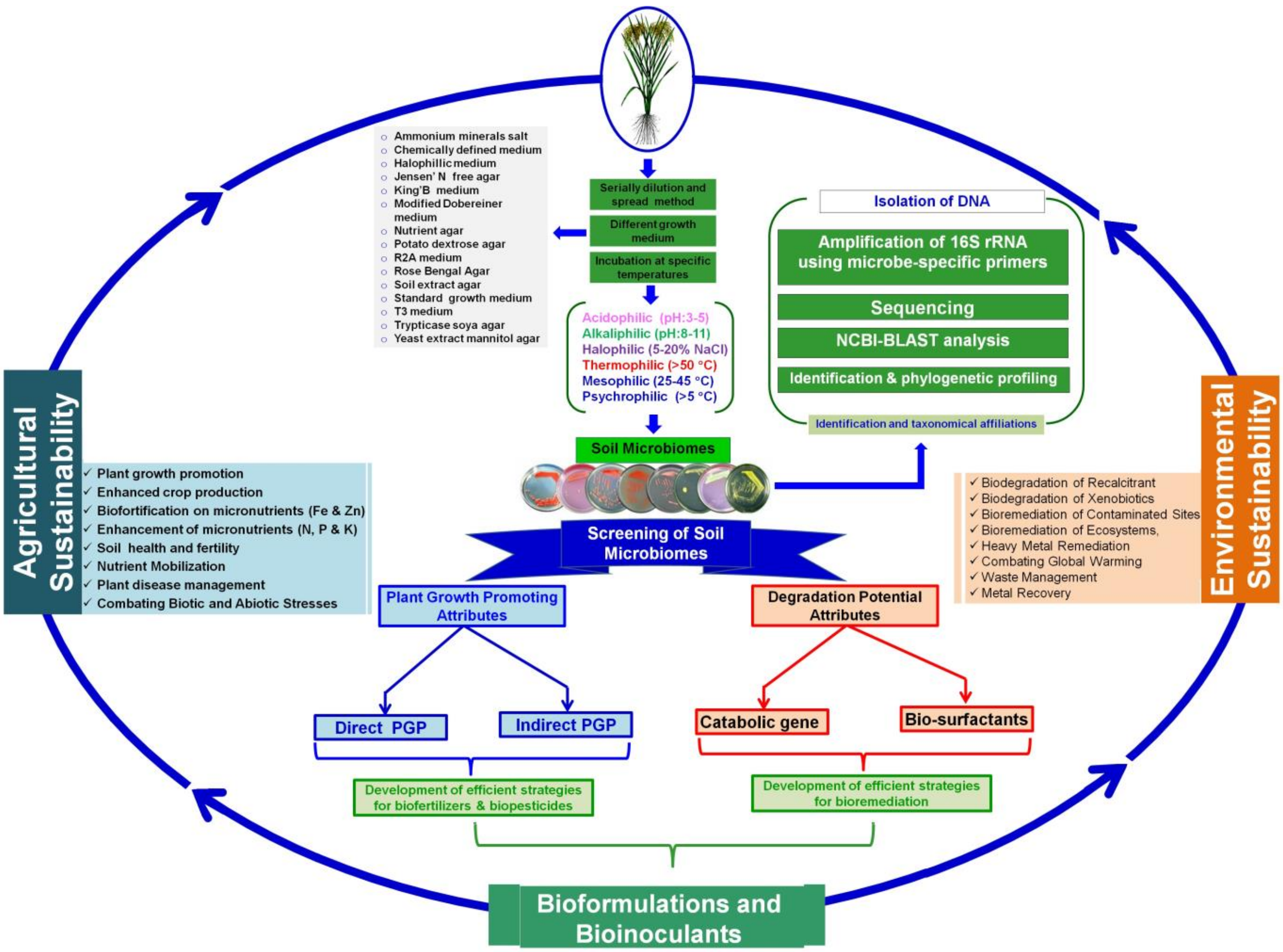

Figure 1: Microbes for Agricultural and Environmental Sustainability. Adapted with permission from Kaur et al. [9].

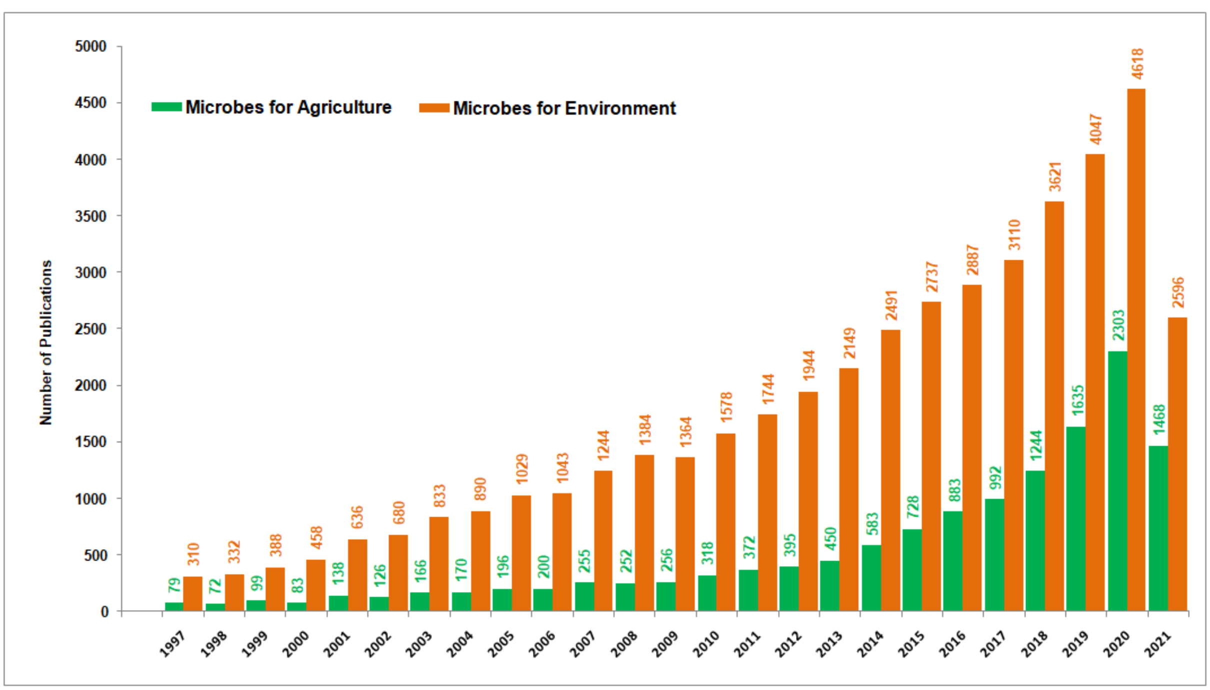

Figure 2: Microbes for agro-environmental sustainability [Source- PubMed]

These inoculations of these strains as biofertilizer in the lupine plant were reported for the enhancement of grain yield and nitrogen content in shoot [7]. Microbes interacting with plant through rhizospheric soil have also been widely studied as known to exhibits several applications. Phyllospheric/epiphytic microbes live on the up-ground plant parts such as leafs, stem, and flower. They have also known to have applications in the field of agriculture as well as environment. In a report, phyllospheric microbes plum i.e. *Bacillus thuringiensis* have been reported for having antagonistic activity against phytopathogenic bacteria [8]. In another report, the foliar spray of phyllospheric microbe *Enterobacter hormaechei* was reported for significantly increasing the shoot dry weight of maize crop as compared to control.

Microbes, the wonder creatures of earth have been also reported from wide variety of environments like natural normal conditions and even extreme harsh condition. Microbes residing in extreme harsh conditions have an ability to survive in the most aggressive environmental condition having extreme temperature i.e. low [-20 ºC to +20 ºC] and high [60 ºC to 115 ºC], pH [<4 or >9], salinity [2-5 M NaCl], pressure, heavy metals concentration, radiations and availability of water [drought and flooding conditions]. The extremophilic microbes surviving in such condition are known have extensive application in both the environmental and agricultural sector, so their biodiversity is largely explored. On exploring the biodiversity of microbial communities in the extreme habitats it was known that microbes are known belong to all these domains of life i.e. archaea, bacteria and eukarya [fungi]. The researches on the biodiversity of extremophiles different species belonging to different phylum have found in the published report i.e. Euryarcheota, Crenarchaeota, Firmicutes, Proteobacteria Actinobacteria, Bacteroidetes, Deinococcus-Thermus, Basidiomycota, and Ascomycota [9, 10]. In a study, biodiversity culturable heterotrophic bacteria were studied from Forlidas Pond and Lundstrom Lake, Antarctica. The study reported Actinobacteria, Bacteroidetes, Proteobacteria and Firmicute as a major phylum and the dominant genera was *Albidiferax, Bosea, Curvibacter*, *Luteimonas, Ornithinibacillus, Pseudoxanthomonas*, *Sphingopyxis* and *Spirosoma* [11]. In another report, mesothermal microbial mats *Candidatus Chloracidobacterium thermophilum* was reported from hotspring in Yellowstone National Park. The study have also reported that isolated microbes were mostly belongs phyla to Cyanobacteria, Chloroflexi, and Chlorobi [12]. *Arthrobacter* sp., *A. sulfonivorans, Bacillus baekryungensis, Brachybacterium* sp. *Cellulosimicrobium cellulans, Desemzia incerta, Exiguobacterium antarcticum, Kocuria kristinae, Paenibacillus xylanexedens* and *Vibrio metschnikovii* were the different bacterial diversity from this cold desert [13].

Agriculture is the mankind's one of the most important and needed practices which is vital for their survival and proliferation on this particular and only planet. The products of agriculture are always in demand and its increasing every year the increase of population worldwide. The unprecedented increase of population has mounted a pressure on agriculture and agriculturist. During the 19th and 20th century of the demand of agriculture was fulfilled by increasing the agricultural productivity through the agronomic methods such use of chemical based products to fertilize the plant and protection from plant enemies [14]. Slowly and steadily these agronomical methods have affected the health of environment. The used chemical based pesticides and biofertilizers in the past years have accumulated in environment and now they are considered as environmental pollutants. The accumulated chemical based products have known to affect the humans, animals both land and aquatic and the textures of the soil [15]. After the realization of the effects of chemical products usage agricultural sustainability have become a core agenda of the current times among the agriculturist and environmentalist.

After the decades of research, an alternative of chemical based fertilizers and pesticides have been found i.e. use of biofertilizers and biopesticides. These biofertilizers and biopesticides could be microbes or a plant extract. Microbial based bioformulations have is being advantageous over the plant based formulations because of the easy development in less time. On the other hand microbes also remediate the contaminated area and make the surrounding more fertile for the cultivation. Microbes for agricultural sustainability have been now widely accepted technique and it is being used and even further researched across the globe [16]. Till the time the researchers have been cleared of the mechanism of action through which the microbe enhances the plant even better than the chemical based fertilizers. Microbes mechanism of action is categories into two directly and indirect mechanism of action. In direct mechanism of growth enhancement microbes fulfills the growth required nutrients and compounds through the mechanism of like fixation of nitrogen, solubilization of zinc, phosphorus, potassium, production of siderophores and plant growth regulators such as auxin, cytokinin, gibberellin, ethylene and abscisic acid. The microbes that have capability of exhibiting the direct mechanism of actions they could be used as biofertilizers [17, 18]. There are huge numbers of findings worldwide as microbes for agro-environmental sustainability [Figure 2].

On the other hand, the indirect mechanism of action protect the plant from pathogens and pest and alleviating the stress conditions caused by the abiotic factors such as dryness, salinity, low or high temperature. Production of antibiotic, hydrogen cyanide, reactive oxygen compounds and 1-aminocyc lopropane-1-carboxylate deaminase are the various indirect mechanisms through which the microbes protect the plant from biotic and abiotic factor [9, 19]. Different microbes have been reported for the exhibiting such mechanism and reported to enhance the growth of plants. Moreover species like *Trichoderma* spp. [20], *Acinetobacter calcoaceticus* [21] reported for solubilizing phosphorus whereas *Pseudomonas libanensis* was reported for solubilization of phosphorus, potassium, zinc, and production of siderophores, hydrogen cyanide, ammonia as well as 1-aminocyclopropane-1-carboxylate deaminase [22]. Microbial species categorized under arbuscular mycorrhizal fungi *Glomus claroideum,* and *G. mossai* was reported for mobilization of phosphorus nutrient and reported for enhancing the growth of plants [23]. Different microbes have also been reported for producing the plant growth regulators for the growth enhancement such as *Providencia* sp. [24], *Pseudomonas plecoglossicida* [25], and *Bacillus toyonensis* [26].

The need for environmental sustainability to maintain a balance between future needs and available resources is a key issue at the global level. For the past few years the role of microbial communities in achieving agricultural and environmental sustainability got attention and even their application in agro ecosystems and solving key environmental issues have really shown outstanding results. The exploitation of beneficial microbes under natural conditions as well as extreme conditions of salinity, drought, heavy metal and temperature stress has become paramount importance. The potential microbes play a splendid role in environmental stability and conservation in an efficient and eco-friendly manner. Thus, plants are an important reservoir of beneficial microbes which through their amazing metabolic activities assist in maintaining plant health, soil fertility and ecosystem stability.

CONFLICTS OF INTEREST

There are no conflicts of interest.

REFERENCES

1. Yadav AN. Beneficial plant-microbe interactions for agricultural sustainability. J Appl Biol Biotechnol. 2021; 9(1):1-4. https://doi.org/10.7324/JABB.2021.91ed
2. Naik K, Mishra S, Srichandan H, Singh PK, Sarangi PK. Plant growth promoting microbes: Potential link to sustainable agriculture and environment. Biocatal Agric Biotechnol. 2019; 21:101326. https://doi.org/10.1016/j.bcab.2019.101326
3. Kumar A, Yadav AN, Mondal R, Kour D, Subrahmanyam G, Shabnam AA, et al. Myco-remediation: A mechanistic understanding of contaminants alleviation from natural environment and future prospect. Chemosphere. 2021; 284:131325. https://doi.org/10.1016/j.chemosphere.2021.131325
4. Kour D, Kaur T, Devi R, Yadav A, Singh M, Joshi D, et al. Beneficial microbiomes for bioremediation of diverse contaminated environments for environmental sustainability: present status and future challenges. Environ Sci Poll Res. 2021; 28(20):24917-39. https://doi.org/10.1007/s11356-021-13252-7
5. Suyal DC, Joshi D, Kumar S, Bhatt P, Narayan A, Giri K, et al. Himalayan Microbiomes for Agro-Environmental Sustainability: Current Perspectives and Future Challenges. Microb Ecol. 2021. https://doi.org/10.1007/s00248-021-01849-x
6. Yadav AN, Kour D, Kaur T, Devi R, Yadav A, Dikilitas M, et al. Biodiversity, and biotechnological contribution of beneficial soil microbiomes for nutrient cycling, plant growth improvement and nutrient uptake. Biocatal Agric Biotechnol. 2021; 33:102009. https://doi.org/10.1016/j.bcab.2021.102009
7. Ferchichi N, Toukabri W, Boularess M, Smaoui A, Mhamdi R, Trabelsi D. Isolation, identification and plant growth promotion ability of endophytic bacteria associated with lupine root nodule grown in Tunisian soil. Arch Microbiol. 2019; 201(10):1333-49. https://doi.org/10.1007/s00203-019-01702-3
8. Janakiev T, Dimkić I, Bojić S, Fira D, Stanković S, Berić T. Bacterial communities of plum phyllosphere and characterization of indigenous antagonistic *Bacillus thuringiensis* R3/3 isolate. J Appl Microbiol. 2020; 128(2):528-43. https://doi.org/10.1111/jam.14488
9. Kaur T, Devi R, Kour D, Yadav A, Yadav AN, Dikilitas M, et al. Plant growth promoting soil microbiomes and their potential implications for agricultural and environmental sustainability. Biologia. 2021. 76: 2687–2709 https://doi.org/10.1007/s11756-021-00806-w
10. Yadav AN. Biodiversity and bioprospecting of extremophilic microbiomes for agro-environmental sustainability. J Appl Biol Biotechnol. 2021; 9:1-6. https://doi.org/10.7324/JABB.2021.9301
11. Peeters K, Hodgson DA, Convey P, Willems A. Culturable diversity of heterotrophic bacteria in Forlidas Pond (Pensacola Mountains) and Lundström Lake (Shackleton Range), Antarctica. Microb Ecol. 2011; 62(2):399. https://doi.org/10.1007/s00248-011-9842-7
12. Ross KA, Feazel LM, Robertson CE, Fathepure BZ, Wright KE, Turk-MacLeod RM, et al. Phototrophic phylotypes dominate mesothermal microbial mats associated with hot springs in Yellowstone National Park. Microb Ecol. 2012; 64(1):162-70. https://doi.org/10.1007/s00248-012-0012-3
13. Yadav AN, Sachan SG, Verma P, Tyagi SP, Kaushik R, Saxena AK. Culturable diversity and functional annotation of psychrotrophic bacteria from cold desert of Leh Ladakh (India). World J Microbiol Biotechnol. 2015; 31(1):95-108. https://doi.org/10.1007/s11274-014-1768-z
14. Verma P, Yadav AN, Khannam KS, Kumar S, Saxena AK, Suman A (2016) Molecular diversity and multifarious plant growth promoting attributes of Bacilli associated with wheat (*Triticum aestivum* L.) rhizosphere from six diverse agro-ecological zones of India. J Basic Microbiol 56 (1):44-58. https://doi.org/10.1002/jobm.201500459
15. Aktar MW, Sengupta D, Chowdhury A. Impact of pesticides use in agriculture: their benefits and hazards. Interdis Toxicol. 2009; 2(1):1. https://doi.org/10.2478/v10102-009-0001-7
16. Singh JS. Microbes play major roles in the ecosystem services. Climate Change Environ Sustain. 2015;3(2):163-7. https://doi.org/10.5958/2320-642X.2015.00018.6
17. Kour D, Rana KL, Yadav AN, Yadav N, Kumar M, Kumar V, et al. Microbial biofertilizers: Bioresources and eco-friendly technologies for agricultural and environmental sustainability. Biocatal Agric Biotechnol. 2020; 23:101487. https://doi.org/10.1016/j.bcab.2019.101487
18. Yadav AN.Phytomicrobiomes for agro-environmental sustainability. J Appl Biol Biotechnol 2021; 9 (5):1-4. https://doi.org/10.7324/JABB.2021.95ed
19. Kumar A, Verma JP. Does plant—microbe interaction confer stress tolerance in plants: a review? Microbiol Res. 2018;207:41-52. https://doi.org/10.1016/j.micres.2017.11.004.
20. Bononi L, Chiaramonte JB, Pansa CC, Moitinho MA, Melo IS. Phosphorus-solubilizing *Trichoderma* spp. from Amazon soils improve soybean plant growth. Sci Rep. 2020; 10(1):1-13. https://doi.org/10.1038/s41598-020-59793-8
21. Kour D, Rana KL, Yadav AN, Sheikh I, Kumar V, Dhaliwal HS, et al. Amelioration of drought stress in Foxtail millet (*Setaria italica* L.) by

P-solubilizing drought-tolerant microbes with multifarious plant growth promoting attributes. Environ Sustain. 2020; 3(1):23-34. https://doi.org/10.1007/s42398-020-00094-1
22. Kour D, Rana KL, Sheikh I, Kumar V, Yadav AN, Dhaliwal HS, et al. Alleviation of drought stress and plant growth promotion by *Pseudomonas libanensis* EU-LWNA-33, a drought-adaptive phosphorus-solubilizing bacterium. Proc Natl Acad Sci India Sec B Biol Sci. 2019: 90: 785–795. https://doi.org/10.1007/s40011-019-01151-4
23. Hussain S, Sharif M, Ahmad W. Selection of efficient phosphorus solubilizing bacteria strains and mycorrhizea for enhanced cereal growth, root microbe status and N and P uptake in alkaline calcareous soil. Soil Sci Plant Nutr. 2021:1-10. https://doi.org/10.1080/00380768.2021.1904793
24. Rushabh S, Kajal C, Prittesh P, Amaresan N, Krishnamurthy R. Isolation, characterization, and optimization of indole acetic acid–producing *Providencia* species (7MM11) and their effect on tomato (*Lycopersicon esculentum*) seedlings. Biocatal Agric Biotechnol. 2020; 28:101732. https://doi.org/10.1016/j.bcab.2020.101732
25. Astriani M, Zubaidah S, Abadi AL, Suarsini E. *Pseudomonas plecoglossicida* as a novel bacterium for phosphate solubilizing and indole-3-acetic acid-producing from soybean rhizospheric soils of East Java, Indonesia. Biodiver J Biol Diver. 2020; 21(2). https://doi.org/10.13057/biodiv/d210220
26. Zerrouk IZ, Rahmoune B, Auer S, Rößler S, Lin T, Baluska F, et al. Growth and aluminum tolerance of maize roots mediated by auxin-and cytokinin-producing *Bacillus toyonensis* requires polar auxin transport. Environ Exp Bot. 2020; 176:104064. https://doi.org/10.1016/j.envexpbot.2020.104064

How to cite this article:

Yadav AN, Kour D, Abdel-Azeem AM, Dikilitas M, Hesham AE, Ahluwalia AS. Microbes for Agricultural and Environmental Sustainability. J Appl Biol Biotech. 2022; (S1), 1-5.