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Plant microbe interaction of rhizospheric bacteria and their potential as antagonists and biocontrol agents: A short review

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Abstract
Plant microbe interaction encounters can be friendly. Densely colonized colonized colonies contains beneficial mycorrizhal fungi and rhizobia, Which associated with roots and provide plants with minerals nutrient and fixed nitrogen and breakdown of organic compound in inorganic forms, respectively, in exchange for carbon. The most abundant plants are constantly exposed to a range of mycorhizal fungal, bacterial and viral pathogens due to production of some phytohormones, siderophore and HNC production they have unique defense mechanism to fight the infection the plant growth promoting rhizobacteria have interesting and diverse relationship.

Keywords: Plant microbe's interaction, PGPR, rhizobia, HCN Siderophore

Introduction
There has been an increasing demand for food throughout the world. If global food production is to keep pace with an increasingly urbanized growing population while formulating new food production strategies for developing countries, the great challenges to modern societies is to boost plant productivity in an environmentally sustainable manner. (Malviya J, 2014) [9]. Microbes in this context provide the best alternative. Also they can be useful in reducing pollution of chemical fertilizers. Microorganisms as biofertilizers and biocontrol agents have proved to be useful in increasing crop productivity and to control diseases in an environment friendly manner. India is the country who is based on agricultural for their survival. Microbial diversity for agricultural importance is field of study concerned with plant-associated microbes. (Malviya J, 2011, 2012) [12] It aims to address problems in agricultural practices usually caused by a lack of biodiversity in microbial communities. An understanding of microbial strains relevant to agricultural applications is useful in the enhancement of factors such as soil nutrients, plant-pathogen resistance, crop robustness, fertilization uptake efficiency, and more. (Malviya J, 2011, 2014) [11, 9] The many symbiotic relationships between plants and microbes can ultimately be exploited for greater food production necessary to feed the expanding human population, in addition to safer farming and improvement of soil fertility techniques for the sake of minimizing ecological disruption in the agricultural land.

Plant-microbe symbiosis
Strains of free-living bacteria, actinomycetes, fungi, and protozoa have coevolved with a variety of plants to produce symbiotic relationships that often benefit one or more of the organisms involved. A majority of these plant growth promoting organisms colonize rhizospheric region of crops (Malviya J *et al.*; 2014; Ahmad *et al.* 2008) [9, 8]. Among these, there are three major groups of microbial inoculants used on agricultural crops:

Arbuscular mycorrhizal fungi (AMF)
AMF species produce structures like arbuscules and vesicles (sites of nutrient transfer and storage, respectively). They also build scaffoldings of hyphal networks surrounding the plant roots they colonize (Malviya J; 2017) [13]. AMF species are highly abundant and play a vital role in their ecosystems by promoting plant growth through numerous mechanisms

(Smith *et al*., 2010) [3] AMF symbiosis promotes host plant uptake of nitrogen and phosphorous. They are most commonly found in well-aerated and cultivated top soils. Common genera include *Aspergillus, Mucor, Penicillium Trichoderma, Alternaria, and Rhizopus*. (Adesemoye *et al*., 2009) [4].

Plant growth-promoting rhizobacteria (PGPR)
This broad group of soil bacteria colonizes developing plant roots. Plant growth is promoted in a variety of fashions; some bacteria synthesize plant growth hormones like indoleacetic acid and other auxins (W. Kloepper *et al.* 2010), while others supply the plant with nutrients from the soil. Phytohormoneexpression by PGPR have also been proposed to promote the growth of roots through improved water and mineral uptake (W. Kloepper *et al.* 2010; Malviya; 2011, 2014, 2017) [9, 11, 17].

Nitrogen-fixing rhizobia
Triple-bonded diatomic nitrogen, constituting about 78% of our atmosphere, is highly stable and unable to be used by plants (Kiran singh *et al.* 2011). Symbiotic rhizobia form anaerobic nodules on the roots of legumes and express genes for enzymes like nitrogenase to fix nitrogen into bioavailable compounds for their host plants. Nitrogen is an element ubiquitously found in amino acids, proteins, and many other cellular components; its bioavailability is crucial to the growth of a plant (Tengerd, 1998) [5].

Mechanisms of plant growth promotion
On the microscopic landscape of a root surface, different symbionts use unique methods to infect. Once anchored, some bacteria express genes that convert soil and atmospheric molecules into compounds valuable to the plant, such as nitrogen and phosphorous containing compounds. Others like mycorrhizal fungi produce vast networks of hyphae that essentially function as additional root surface area to mine soil for nutrients; they also provide some pathogen protection to the host roots (Malviya J. 2012) [10]. At the plant-fungi interface, fungi provide plants with compounds—ammonium, nitrate, amino acids, inorganic phosphate, and organic compounds like urea—in exchange for plant carbohydrates acquired through photosynthesis (Kale, Radha D *et al.*1998). The sloughed off cells from plant roots are important sources of carbon for organisms dwelling in the rhizosphere. These symbiotic relationships not only increase the bioavailability of crucial elements to plants, but also improve soil fertility by increasing labile carbon and nitrogen levels. (Berg and Gabriele 2009) [7] Crop rotation, especially involving legumes and their *Rhizobia* symbionts, is practiced precisely for this reason.

Pathogen deterrence
Plant-associated microorganisms also exhibit traits that increase host plant fitness indirectly through the suppression of plant pathogens. Some PGPRs produce siderophores, compounds that bind iron in the soil. Fe^{3+} scarceness is due to its low solubility. At the same time, iron happens to be essential for several cellular processes; PGPR siderophores chelate and uptake iron from the rhizosphere, leaving little to none left for pathogens. Many of these PGPRs also synthesize enough HCN to produce an antifungal effect, among other fungicides. (Malviya J. *et al.* 2012, 2014) [10, 9].

Cycling of bioavailable elements
Microbes in terrestrial environments are important catalysts of global carbon and nitrogen cycles, including the production and consumption of greenhouse gases in soil. Some microbes produce the greenhouse gases carbon dioxide (CO_2) and nitrous oxide (N_2O) while decomposing organic matter in soil. Others consume methane (CH_4) from the atmosphere, thus helping to mitigate climate change. The magnitude of each of these processes is influenced by human activities and impacts the warming potential of Earth's atmosphere. Absorption of nitrogen, phosphorous, and other nutrients from the soil by plant roots is limited by transporters located on root cells. This partially explains the importance of symbiotic soil microbes in their supportive roles of promoting crop health, growth, and yield.

Nitrogen
Nitrogen fixation, nitrification, denitrification, and nitrogen mineralization are the four dominant microbial processes that drive nitrogen through producer ecosystems. Nitrogen fixers such as Rhizobacteria and Azospirillum convert atmospheric nitrogen into ammonia. It is then transported to the plant to take part in cellular growth through processes like DNA replication, protein synthesis, and more. (Adesemoye, 2009) [4].

Phosphorous
Likewise, phosphorous is also a vital element necessary for plant prosperity. It is mostly found in insoluble rock reserves, with some phosphates present as organic phosphorus compounds in soil organic matter. Another reason why plants experience difficulty obtaining phosphorous is because a majority of soil phosphorous precipitates with metals such as iron, aluminum, and calcium, preventing its uptake by plant roots. AMF and PGPR inoculants aid plants by solubilizing mineral phosphates, converting them to forms able to be assimilated by plants (Berg, Gabriele; 2010)

Fertilizer efficiency
In an attempt to promote as much growth as possible, farmers often apply large quantities of fertilizer to crops. This brute-force method is not an effective option. Depending on qualities of the soil, the crops involved, and microbial symbionts, only 10% to 40% is taken up by crops. Thus, roughly 60% to 90% of applied fertilizer is lost to watersheds, groundwater, and other aquatic systems. (Adesemoye, 2009) [4].

Maximization of food production
As the human population continues its climb, land available for agriculture continues to shrink over time. In order to produce supplies to meet the demands of mouths, farm animals, and biofuel production, the efficiency of food production per acre must be optimized. Microbial inoculants are one of the ways in which food production efficiency can be improved. Plant growth-promoting soil organisms increase net crop uptake of soil nutrients, resulting in larger crops and higher yields of harvested food. Besides farmland inoculants, practical applications of agricultural

microbiology also include potting soil with mycorrhizal spores included (Malviya J, 2011, 2017) [11, 13].

Minimization of ecological harms

With regards to agricultural food production, there is a balance between two opposing human desires. On one hand, it is highly desirable to produce as much food as possible—on the other, we must also keep in mind our obligation to as little harm as we can manage to our home. Since 1985, the India applies over twenty million tons of agricultural fertilizers to crop fields each year. A majority of the fertilizers remain unabsorbed and travel into other parts of adjacent ecosystems, where they are utilized by organisms such as algae. This ultimately results in a series of events those off-sets the pre-existing balance of the ecosystem. Applications of microbiology in agriculture aim to minimize the use of fertilizer, but at the same time, provide another mode for environmental disruption. We must be mindful of the fragility of nature, and cautiously monitor the conditions of microorganisms produced in laboratories and inoculated into farmland.

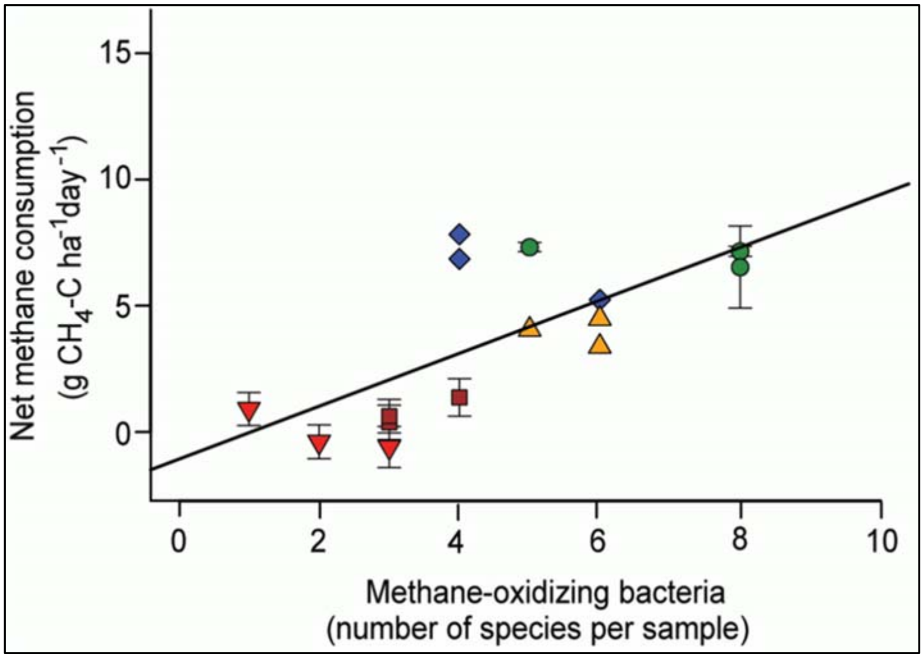

Fig 1: Levine, Teal, Robertson and Schmidt (2011) ISME Journal

The rate of methane consumption by soils at the KBS LTER is related to the diversity of methane oxidizing bacteria present. Methane consumption is lowest in sites managed for row-crop agriculture (red triangles), and increases in early successional sites (brown squares), managed grasslands (blue diamonds), and both successional (orange triangles) and deciduous forests (green circles).

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