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Plant Growth Promoting Rhizobacteria (PGPR): A Biological Tool for Improving Plant Health

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Abstract

A number of microbes such as fungi, bacteria and viruses and their microbial products that stimulate plant growth have been marketed. Among these beneficial microorganisms, we restrict ourselves to bacteria that are derived from and exert this effect on the root. Such bacteria are generally designated as Plant growth-promoting rhizobacteria (PGPR). Generally, PGPR stimulate the plant growth directly as (a) biofertilization, (b) stimulation of root growth hormone, (c) rhizoremediation, and (d) plant stress control or indirectly by reducing the level of disease, including antibiosis, induction of systemic resistance, and competition for nutrients and niche. Such bacteria may also decrease the global dependence on hazardous pesticides which destabilize the agro-ecosystems, thereby developing an effective ways of sustainable agriculture for improving crop productivity with a minimal disturbance to the environment. In this review we explicit outlooks on the different mechanisms of rhizobacteria mediated plant growth promotion with the recent development and research.

Introduction

Although plant physiologists sometimes view soil as simply a source of nutrients to plants, but actually it is a complex ecosystem hosting bacteria, fungi, protists, and animals. Such soil-dwelling microbes exhibit a diverse array of interactions with plants, which span the full range of ecological possibilities (competitive, mutualistic commensal, exploitative, and neutral). Throughout modern plant science, most interaction studies have focused on alleviating pathogenic effects such as herbivory and infection, or attenuating abiotic stress condition. However, there has also been longstanding interest in characterizing the positive ecological interactions that promote plant growth. For instance, mycorrhizal fungi as well as the bacteria present in modulated legumes were both recognized as root symbionts from the second half of 19th century. Already in the 1950's, crop seeds were coated with bacterial cultures (*Azotobacter chroococcum* or *Bacillus megaterium*) to improve growth and yield. Of all bacteria, about 2–5% of rhizobacteria, when reintroduced in soil by plant inoculation, exert a beneficial effect on plant growth and are termed as plant growth promoting rhizobacteria (Kloepper and Schroth, 1978). Most of Rhizobacteria are Gram-negative with rod shaped, however, a lower proportion being Gram-positive cocci, rods, or pleomorphic. Moreover, many actinomycetes are the major components of rhizosphere microbial communities showing marvelous plant growth (Bhattacharyya and Jha, 2012) (Table 1).

Mechanism of Plant Growth Promoting Rhizobacteria

PGPR exerted both direct and indirect effect to achieve the maximum growth of plant. The direct mechanism involve to increasing the availability of nutrients to

Table 1: List of Plant Growth Promoting Rhizobacteria

Extracellular Plant Growth Promoting Rhizobacteria (e PGPR)	Intercellular Plant Growth Promoting Rhizobacteria (i PGPR)
Agrobacterium	*Rhizobium*
Azospirillum	*Bradyrhizobium*
Azotobacter	*Allorhizobium*
Pseudomonas	*Azorhizobium*
Burkholderia	*Mesorhizobium*
Caulobacter	
Flavobacterium	
Chromobacterium	
Serratia and	
Micrococcous	

plant (Biofertilizers), stimulating plant hormone for plant growth promotion (Phytostimulators) and degrading organic pollutants in soil (Rhizoremediators). However indirect mechanisms involve to controlling plant diseases, mainly by antibiosis, competition for food and niches and induce systemic resistance in crop plant. The mechanism of PGPR is discussed below:

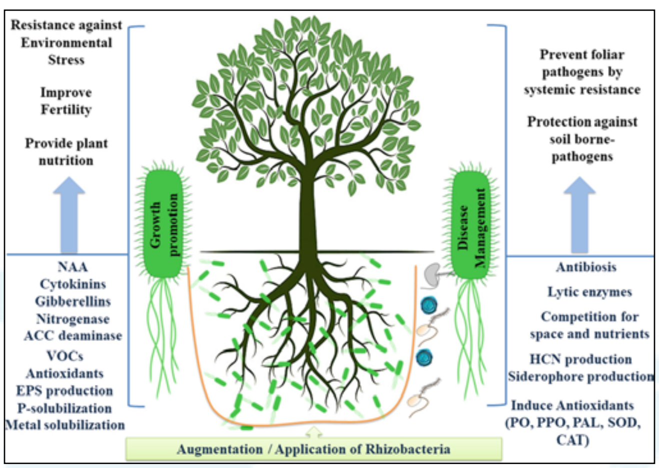

Figure 1: Mechanism of Plant Growth Promoting Rhizobacteria

Direct Mechanism

1. Biofertilizers

Various reports suggest that PGPR increase plant growth through facilitation in absorbing of essential nutrients and minerals such as $N(NO_3^-)$, $P(H_2O_4^-)$, and $K(K^-)$ as well as micronutrients. There are several discussions about the PGPR mechanisms in the absorption of mineral elements. Many studies have shown that rhizosphere organisms increase the capability of mineral absorption by plant roots mainly because of increase in the extension of root system, increase in root numbers and thickness (fresh and dry weight).

i) Nitrogen Biofixation

Nitrogen is known as a key nutrient in producing agricultural crops and also one of the main constituents of protein synthesis, nucleic acids, and the other essential cellular components. Being the major constitutes of the air volume (78 %), it is still of the most limiting factors for plant growth in which to address its deficiency, nitrogen fertilizers are applied, but this issue, by itself, also causes the cost of production to be increased. Under these conditions, the utilization of fixed atmospheric nitrogen attained by symbiotic relationships in leguminous cover crops (affected by Rhizobium species) and/or non-symbiotic mutualism in non-leguminous crops (affected by free-living molecular N_2-fixing microorganisms) mainly through nitrogen biofixation process supplies the required nitrogen input for arable soils and helps with the role of Plant Growth-Promoting Rhizobacteria. Nitrogen biofixation is considered as the first proposed mechanism to enhance plant growth by the plant growth-promoting rhizobacteria. Although native populations of these bacteria are found in the soil, they likely may not be capable of fulfilling the assumed performance in terms of nitrogen fixation. So the efficient and effective strains of such bacteria are applied in the form of biofertilizers. Most bacterial species, such as *Rhizobium, Azotobacter, Azospirillum, Bacillus, Beijerinckia* etc**.** are capable of fixing nitrogen.

ii) **Increased Absorption and Availability or Nutrient-Solubilizing Ability in the Area around the Roots**

Phosphorus (P) is the next most important nutrient after nitrogen for crop yield. It is present in soil, plant and a number of organic and inorganic compounds. However, the average total P content in soil is very low i.e. 0.05%, and only 0.1% of total P present in the soil is available to plants. Their low availability to plants is due to its low solubility and fixation. It has been reported that about 80% of applied P fertilizers are immobilized in soil because of the formation of complex with Fe or Al in acidic soils or Ca in calcareous soil. This problem in soil can be coupled with phosphate-solubilizing activity of microorganisms which serve an alternative way to circumvent P deficiency in soil and to improve crop production.

Most of the rhizosphere bacteria that help in solubilizing P fertilizers are known as phosphate-solubilizing bacteria (PSB). These PSB act as a potential biofertilizers, which liberate phosphorous; otherwise, they supply P either by solubilization or mineralization. Bacterial genera like *Rhizobium, Enterococcus, Bacillus, Stenotrophomonas, Serratia Enterobacter, Flavobacterium,* and *Pseudomonas* are reported as the potential phosphate solubilization rhizobacteria (Bhattacharyya and Jha, 2012).

2. Phytohormone Production

The PGPRs produced several plant hormones especially indole acetic acid (IAA) both naturally as well as in liquid cultures as secondary metabolites. The formation of

IAA via indole-3-acetic aldehyde and indole-3-pyruvic acid is found most of bacteria like, *Erwinia herbicola*; certain representatives of *Rhizobium, Bradyrhizobium, Azospirillum, Klebsiella,* and *Enterobacter* and saprophytic species of the genera *Pseudomonas* and *Agrobacterium* and most. The synthesis of IAA by PGPRs influenced of the development of root hair, root proliferation, metabolism and respiration rate that resulted in better mineral uptake of the inoculated plants.

3. Stress Controllers

Plant-growth promoting bacteria that contain the enzyme 1-aminocyclopropane-1-carboxylate (ACC) deaminase facilitate plant growth and development by decreasing plant ethylene levels. Such bacteria take up the ethylene precursor ACC and convert it into 2-oxobutanoate and NH_3. Several forms of stress are relieved by ACC deaminase producers, such as effects of phytopathogenic bacteria, and resistance to stress from polyaromatic hydrocarbons, from heavy metals such as Ca^{2+} and Ni^{2+}, and from salt and draught.

Indirect Mechanism: Disease control

The PGPRs can control plant pathogens by competing their nutrients, niche exclusion, producing antifungal metabolites and induced systemic resistance (Lugtenberg and Kamilova, 2009). Most of the rhizobacteria have ability to produce several antifungal metabolites like, phenazines, HCN, 2,4-diacetylphloroglucinol, pyoluteorin, pyrrolnitrin, tensin and viscosinamide (Bhattacharyya and Jha, 2012). However, interaction of some rhizobacteria with the plant roots induced resistance in plant against a number of pathogenic fungi, bacteria, and viruses and such phenomenon is called induced systemic resistance (ISR). *Pseudomonas* and *Bacillus* spp. are two most important Rhizobacteria that mostly studied to trigger ISR. Many individual bacterial components can also induce ISR in crop plant, such as lipopolysaccharides (LPS), siderophores, 2,4-diacetylphloroglucinol, flagella, homoserine lactones, cyclic lipopeptides, and volatiles like, 2,3-butanediol and acetoin (Lugtenberg and Kamilova, 2009).

Conclusion

Soil is a living system, highly sensitive and vulnerable, and biofertilizers are considered as an important natural and environment-friendly approach for keeping soil essential systems alive and active. Certainly application of biofertilizers is also accompanied with challenges such as difficulty in application, failure to respond quickly and economically, susceptibility of living organisms to their environment, complex relationship among different microbial communities, and antagonistic reaction. But at the same time, the exudates excreted by these inoculating bacteria (PGPRs) located on the root surface are found to be directly/ indirectly involved in promoting plant growth and development. The PGPRs assist in plant growth via three approaches: regulating hormonal level, nutrient resource acquisition, and biocontrol of different pathogens. Their application to different plant species under stressed and non-stressed conditions has shown to be a panacea in terms of plants' health and development and in bettering yield. It can be concluded that in future the application of PGPRs as biofertilizers is expected to increase across the globe and could play an important role in stabilizing agricultural ecosystems by reducing the indiscriminate use of synthetic agrochemicals that have long-term negative impact on the local ecosystems and the environment.

References

Bhattacharyya, P.N., Jha, D.K., 2012. Plant growth-promoting rhizobacteria (PGPR): emergence in agriculture. *World J. Microbiol.Biotechnol*. 28, 1327–1350.

Kloepper, J.W., Schroth, M.N., 1978. Plant growth promoting rhizobacteria on radishes.Proc. 4th Int. Conf. Plant path. Bact., Angers, P., 879–882.

Lugtenberg, B., Kamilova, F., 2009. Plant-growth-promoting rhizobacteria. *Annu. Rev. Microbiol*., 63, 541–556.