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A REVIEW ON PLANT GROWTH PROMOTING RHIZOBACTERIA FROM SOIL

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ABSTRACT

In this review we restrict ourselves to bacteria that are derived from soil and exert the positive effect on the plants, such microbes are by and large assigned as PGPR (plant growth - promoting rhizobacteria). The beneficial effects of those rhizobacteria on plant growth are often direct or indirect. To apply their helpful impacts, microscopic organisms (bacteria) typically should colonize the premise surface productively. They help in providing nitrogen, increase supply of other nutrients, produce plant hormones, enhance other beneficial bacteria or fungi, control bacterial and fungal diseases and help in controlling insect pest. These bacteria are not simply additional elements to biological diversity within the rhizosphere but are essential components to the survival of other microorganisms and plants. PGPR helps plant that results in plant growth stimulation, plant protection as well as production of antibiotics, geochemical cycling of minerals and plant colonization.

Keywords: **PGPR, *Pseudomonas aeruginosa*, *Bacillus subtilis*, growth promotion**

INTRODUCTION

Global food demand is rapidly increasing due to human induced factors all over the world. Because of over using of harmful chemical fertilizers and plant protecting chemicals that caused degradation of ecosystem and lead to environmental problems **[1]**. This review centers around on rhizosphere microbes that are beneficial for the plant. Some beneficial do so by promoting plant growth directly, i.e., in the absence of pathogens. Others do that indirectly by protecting the plant against soil borne diseases, most of which are caused by fungi **[2]**. Hiltner discovered that the rhizosphere, i.e., the layer of soil influenced by the root, is much richer in bacteria than the surrounding bulk soil is. These rhizosphere organisms advantage since plant roots discharge metabolites that can be used as supplements or nutrients. This rhizosphere effect is caused by the fact that a substantial amount of the carbon fixed by the plant, 5–21%, is secreted, mainly as root exudate. Although the concentration of bacteria in the rhizosphere is 10 to 1000 times higher than that in bulk soil, it is still 100-fold lower than that in the average laboratory medium. Accordingly, the way of life of rhizobacteria is best portrayed as starvation. To exert their beneficial effects in the root environment, bacteria have to be rhizosphere competent, i.e., able to compete well with other rhizosphere microbes for nutrients secreted by the root and for sites which will be occupied on the root.

In this review, we start with an outline of how bacteria live on the root, which nutrients are available, and how the bacteria colonize theroot. Serious rhizosphere colonization is essential for some mechanism of activity of plant valuable microorganisms **[2]**. Which bacterial traits areimportant for root colonization when bacteriacompete with one another and with other organisms like fungi, nematodes, and protozoa. Finally, we describe various mechanisms used by specialized beneficial rhizobacteria to positively influence plant growth. Then we discuss so-called biocontrol bacteria, which promote plant growth because they will reduce harm caused by pathogens and therefore act as bio pesticides **[3]**.

Over using of fertilizers to increase crop yield production has adverse effects on the soil health. Improvement in agriculture sustainability requires optimal use and management of soil fertility and soil physical properties, both of which believe soil biological processes and soil biodiversity. In this context, the long-lasting challenges in soil microbiology are development of effective methods to understand the kinds of microorganisms present in soils, and to work out functions which the microbes perform in situ **[4]**.

Table 1: PGPR along with their traits

Name of Microorganism	PGPR Traits	Reference
Pseudomonas **sp.**	**Phosphate Solubilization**	**[5]**
Bacillus **mucilaginosus**	**Potassium solubilization**	**[6]**
Pseudomonas fluorescens	**IAA overproducing**	**[7]**
Azospirillum	**Phytohormone production, IAA production**	**[8]**
Flavobaterium **sp**	**Phosphate Solubilization**	**[9]**
Bacillus subtilis	**Production of siderophore, hydrogen cyanide (HCN)**	**[10]**
Pseudomonas aeruginosa	**Phosphate solubilization, siderophore production, biological nitrogen fixation, phytohormone production**	**[11]**

It is basic to comprehend the relationship of soil and plant with the variety of related microbes, characterizing the parts of plant growth promoting bacteria (PGPR) to advance procedures for their better abuse. PGPR live in mutualistic interactions with the plant. They benefit from rhizo deposition-derived nutrients and in some cases from other root-derived factors like micro-Oxic conditions, protein, attractants or maybe inducers of enzyme activity. Beneficial rhizobacteria can increase plant vigor and soil fertility. The application of plant growth promoting rhizobacteria (PGPR) as biofertilizers, phytostimulators and biocontrol agents would be an attractive alternative to decrease use of chemical fertilizers, which lead to environmental pollution **[8]**.

One of the alternatives to reduce these costs is the use of Plant Growth Promoting Microorganisms (PGPM), such as nitrogen-fixing bacteria, Plant Growth-Promoting Rhizobacteria (PGPR and mycorrhizal fungi). These microorganisms can play a relevant and strategic role to ensure high productivity at low cost, in addition to environmental benefits. Many plant-growth promoting rhizospheric bacterial genera have been depicted such as *Azospirillum, Pseudomonas,* and *Bacillus* are the most predominant. The genus *Bacillus* is part of the main rhizobacteria group, which can induce plant development either directly or indirectly **[12]**.

Since many beneficial bacteria are not rhizospheric bacteria, Bashan and Holgin (1998) had proposed replacing "rhizobacteria" with "bacteria", creating the modified term plant growth promoting bacteria (PGPB). Genera of PGPB include *Acetobacter, Agrobacterium, Arthrobacter,* *Azotobacter, Azospirillum, Burkholderia, Bacillus, Caulobacter, Chromobacterium, Erwinia, Flavobacterium, Frankia, Micrococcous, Paenibacillus, Pseudomonas and Serratia.* Actinomycete strains such as *Micromonospora spp.*, *Streptomyces spp., Streptosporangium spp.,* and *Thermobifida spp.*, are reported to colonize the plant rhizosphere showing their immense potential as biocontrol agents against a range of pathogenic fungi. *Bacillus* and *Pseudomonas spp*. are the most predominant PGPB genera **[13]**. Plant growth-promoting bacteria or plant growth-promoting rhizobacteria (PGPR) can stimulate plant growth directly or indirectly. The main mechanisms by which PGPB directly contribute to the plant growth are production of phytohormones such as auxins, cytokinins and gibberellins; enhancing plant nutrition by solubilization of minerals such as phosphorus (P) and iron, production of siderophores and 1-aminocyclopropane-1-carboxylic acid (ACC) deaminase **[5]**. PGPB indirectly benefit the plant by biocontrol of deleterious microorganisms or root pathogens through the production of antibiotics and volatile compounds, synthesis of fungal cell wall degrading extracellular enzymes, induction of systemic resistance and competition for nutrients and niches within the rhizosphere **[6]**. More recently, bacteria have also been used in soil for mineralization of organic pollutants i.e. bioremediation of polluted soils. Thus, based on their mechanisms of action, PGPB can be categorized into three general classes such as biofertilizers (phytostimulators), bio pesticides and phytoremediators/rhizoremediators) **[14]**.

Phosphate solubilization

Phosphorus (P) is one the essential nutrient for plants that plays an important role in all major metabolic processes, including energy transfer, respiration, photosynthesis, signal transduction, macromolecular biosynthesis. Although the P reserve in soils is large in size, it is available basically as insoluble mixtures that can't be consumed by plants, restricting their development. Plants absorb phosphate only in the form of monobasic (H_2PO4−PO4-) and dibasic ions (HPO−24HPO4-2).

Microorganisms consume important part in P change in the soil, including the P solubilization needed for plant development. The capacity to solubilize and mineralize P by phosphate-solubilizing bacteria is an important significant characteristic. Phosphate solubilizing microbes have members of the genera *Arthrobacter, Bacillus, Beijerinckia, Burkholderia, Enterobacter, Microbacterium, Pseudomonas,* *Erwinia, Rhizobium, Mesorhizobium, Flavobacterium, Rhodococcus*, and *Serratia* **[14]**.

Potassium Solubilization

Potassium (K) is the third most significant macronutrient needed for plant growth and this component plays a vital role in different plant physiological and metabolic processes, including photosynthesis, metabolism, assimilation, sugar accretion, and plant growth, plant development and improvement. The fundamental mechanism of K solubilization is the making of organic acids, inorganic acids and protons (the acidolysis mechanism), which are fit for changing insoluble K (mica, muscovite, and feldspar biotite) into soluble forms of K that are effortlessly consumed by plants **[15]**.

Siderophore and HCN Production

To get iron for their growth, improvement and development, few bacteria combine low-atomic-weight iron-chelating particles/ molecules called siderophores. Siderophore-producing bacteria can invigorate plant development directly, improving plant Fe nutrition, or indirectly, repressing the movement and activity of plant pathogens in the rhizosphere, which thus restricts their Fe availability. In other words, solubilization and the competitive procurement of iron under restricting conditions reduces the accessibility of iron to other soil occupants, subsequently restricting their growth **[16]**.

Ammonia Production

The creation and synthesis of ammonia by PGPR (Plant growth promoting rhizobacteria) are free of their genus, and their effects recommended their likelihood to use as organic compost or biocontrol to improve crop production. Lots of authors reported ammonia producing PGPB and their utilization as a biofertilizer in growth advancement and yield enhancement upgrade. In an investigation, isolated cyanogenic strain of *Pseudomonas fluorescence* reported to perform role as biocontrol, enhancement in length of stem and roots, germination rate of rye, wild barley, and wheat. Moreover, ammonia production by PGPB gathers and supplies nitrogen to their host plant and advances promotes root and shoot stretching, elongation and their biomass **[10]**.

Phytohormone Production

Phytohormones are required for plant development improvement and permit plants to endure diverse pressure conditions. Some rhizobacteria can deliver phytohormones, including auxins, cytokinins, ethylene, gibberellins and Abscisic acid (ABA), which play a role in various development and growth processes in plants, including cell multiplication, which brings about expanded cell and root expansion. Though, the making of ABA by rhizobacteria viewed as indirect method of promoting plant growth and development **[9]**.

Indole Acetic Acid:

Indole-3-acetic acid (indole acetic acid, IAA) is one of the most widely recognized as well as the most studied auxins, and much of the scientific literature considers IAA and Auxin to be interchangeable terms **[16]**. Its main function is, differentiation, cell elongation, cell division, and extension. However, it has been realizedthat plant responses to IAA shift or vary from plant to plant in terms of sensitivity. Usually, IAA delivered by rhizobacteria hinders with many plant developmental processes for the reason that the endogenous pool of plant IAA may be changed by the procurement of IAA that has been secreted by soil bacteria. IAA act to bud development and promote growth of auxiliary bud. There are many ways by which IAA supports the plant.

DISCUSSION

PGPR- Plant Growth Promoting Rhizobacteria are the group of microorganism that are found mostly in the root system or root soil of the plants. PGPR are responsible for the growth and yield of the plant. They actively colonize in the root system of the plants, even in the presence of a competing microflora, they colonize all the ecological niche of root to all the stages of plant and development. 2-5% of total rhizospheric bacteria are PGPR. These microorganisms are able to enhance the recycling of the plant nutrients that are essential for the plant growth and development and also decrease the use of chemical fertilization. Hence, it can be used as biofertilizers.

The PGPR comprises bacterial species such as *Pseudomonas, Azospirillum, Azotobacter, Klebsiella, Enterobacter, Alcaligenes, Arthrobacter, Burkholderia, Bacillus, and Serratia,* which enhance the plant growth and yield of crops.

CONCLUSION

It can be concluded from the above discussion that PGPR enhance the plant growth due to the production of IAA, Phosphate solubilization, Siderophore and HCN production. Such investigation is necessary as it advocates that use of PGPR as bio-inoculants is an efficient approach to replace chemical fertilizers and these PGPR isolates can be used as bio fertilizers to enhance the growth and productivity for commercially grown plants under local agro-climatic conditions. Simultaneous screening of PGPR from field is a good tool to select effective PGPR for biofertilizer development technology.

REFERENCES

[1] B. Alaylar, M. Güllüce, G. Karadayı, M. Karadayı. 2018. "Isolation of PGPR strains with phosphate solubilizing activity from Erzurum and Their Molecular Evaluation by Using Newly Designed Specific primer for pqqB Gene" in International Journal of Scientific & Engineering Research, Volume 9, Issue 5,

[2] Heerendra Prasad, Paramjeet Sajwan, 2017 " Effect of Organic Manures and Biofertilizer on Plant Growth, Yield and Quality of Horticultural Crop: A Review" in International Journal of Chemical Studies; 5(1): 217-221

[3] Ben Lugtenberg and Faina Kamilova. 2009. "Plant- Growth- Promoting Rhizobacteria." in Annu. Rev. Microbiol. 2009. 63: 541–56.

[4] Pratibha Sharma and D. K. Shrivastava. 2017 "Isolation and Characterization of PGPR from Rhizospheric Soil" in International Journal of Scientific & Engineering Research, Volume 8, Issue 4,

[5] Puri, A. (2015). Plant growth promotion and nitrogen fixation by Paenibacillus polymyxa in corn and canola (Doctoral dissertation, University of British Columbia).

[6] Seema Rawat, Asifa Mushtaq, 2015 "Characterization of plant growth promoting rhizobacteria from legume rhizosphere" in Asian Journal of Plant Science and Research, 5(4): 38-42

[7] Glick BR, Cheng Z, Czarny J, Duan J. 2007. Promotion of plant growth by ACC deaminase-producing soil bacteria. Eur. J. Plant Pathol. 119: 329–39

[8] Agbodjato, N. A., Noumavo, P. A., Baba-Moussa, F., Salami, H. A., Sina, H., Sèzan, A., & Baba-Moussa, L. (2015). Characterization of potential plant growth promoting rhizobacteria isolated from Maize (*Zea mays* L.) in central and Northern Benin (West Africa). Applied and Environmental Soil Science, 2015.

[9] Santos, R. M., Dias, P. A., Lobo, L. L., & Rigobelo, E. C. (2020). Growth-promoting rhizobacteria in maize and sugarcane. Frontiers in Sustainable Food Systems, 4, 136.

[10] Tilak, K. V. B. R., Ranganayaki, N., Pal, K. K., De, R., Saxena, A. K., Nautiyal, C. S., ... & Johri, B. N. (2005). Diversity of plant growth and soil health supporting bacteria. Current science, 136-150.

[11] K.P. Ingle and D.P. Padole, 2017 "Phosphate Solubilizing Microbes: An Overview," Int. J. Curr. Microbiol. App. Sci, 6(1): 844-852.

[12] Ivica Dimkić, Tanja Berić2018 "Biological control of plant pathogens by *Bacillus* species" in Journal of Biotechnology 285:44–55

[13] Gupta, G., Parihar, S. S., Ahirwar, N. K., Snehi, S. K., & Singh, V. (2015). Plant growth promoting rhizobacteria (PGPR): current and future prospects for development of sustainable agriculture. J Microb. Biochem Technol, 7(2), 096-102.

[14] Ahmed, E., & Holmström, S. J. 2014. Siderophores in environmental research: roles and applications. Microbial biotechnology, 7(3), 196-208.)

[15] Sakthivel N, Sivamani E, Unnamalai N, Ganamanickam SS. Plant growth promoting rhizobacteria in enhancing plant growth and suppressing plant pathogens. *Curr Sci.,* 1986, 55: 22–5

[16] Andy, A. K., & Gour, V. S. 2020. Isolation, screening and characterization of plant growth promoting rhizobacteria from rhizospheric soils of selected pulses. Biocatalysis and Agricultural Biotechnology, 101685. doi:10.1016/j.bcab.2020.101685