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Plant Growth Promoting Rhizobacteria: A Brief History and Its Role in Agriculture

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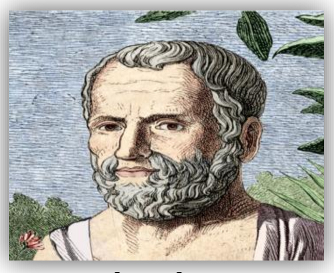
Introduction:

PGPR can be defined as the indispensable part of rhizosphere biota that when grown in association with the host plants can stimulate the growth of the host. Soil contains a plethora of microbes, including beneficial including beneficial microorganisms that exhibit plant growth-promoting (PGP) traits. Bacteria, fungi and algae are some of the beneficial plants associated microbes that imparts favourable effect on plants under several environmental stress. PGPR colonizes roots and imparts favourable effects on plants which includes biofilm formation, increase in shoot length, root length, number of lateral roots, root nodules, etc. by production of siderophores, exopolysaccharides, and phytohormones including indole acetic acid (IAA), cytokinin (CK), and via several other direct and indirect mechanisms. The yield and growth of various crops are enhanced by PGPR through modification of root functioning and plant nutrition via improving nitrogen fixation and phosphate solubilization mechanism. As in present context of agriculture, abiotic stresses such as drought, salinity, extreme temperature and metal stresses are endured by the crops. Many soil microorganisms like *Bacillus, Pseudomonas* and *Azospirillum* have been proposed as suitable PGPR for agricultural crops, considering their phytobeneficial and abiotic stress tolerance properties.

Brief history:

- Theophrastus (372–287 BC) suggested the mixing of different soil samples for remedying defects and adding heart to soil.
- Virgil recorded the establishment of legumes on the cultivated land and demonstrated the beneficial



Theophrastus

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effects of legume crops in increasing the fertility of soil.

- Hellriegel and Wilfarth (1888) investigated the rhizosphere root colonization in grasses and legumes and suggested the ability of soil bacteria to convert atmospheric N2 into plant usable forms.
- Kloepper and Schroth (1978) introduced the term 'rhizo-bacteria' to the soil bacterial community that competitively colonized plant roots and stimulated growth and thereby reducing the incidence of plant diseases.
- Kloepper and Schroth (1981) termed these beneficial rhizobacteria as plant growth-promoting rhizobacteria (PGPR).

Schroth

J. Kloepper

PGPR Mechanism:

PGPR increased plant growth by changing the whole microbial community structure in rhizosphere. PGPR promotes plant growth through associative nitrogen fixation, lowering of ethylene levels, production of siderophores and phytohormones, inducing resistance to pathogens. They might also indirectly provide stimulation by biocontrol which includes antibiotic production, chelation of available Fe in the rhizosphere, synthesis of extracellular enzymes to hydrolyze the fungal cell walls. Promotion of plant growth by PGPR can be through

1. **Production** of ACC deaminase to reduce the level of ethylene in the roots of developing plants
2. Production of plant growth regulators like indole acetic acid (IAA)
3. Asymbiotic nitrogen fixation
4. Exhibition of antagonistic activity against phytopathogenic microorganisms by producing siderophores, b-1,3-glucanase, chitinases, antibiotics, fluorescent pigment and cyanide
5. Solubilization of mineral phosphates and other nutrients.

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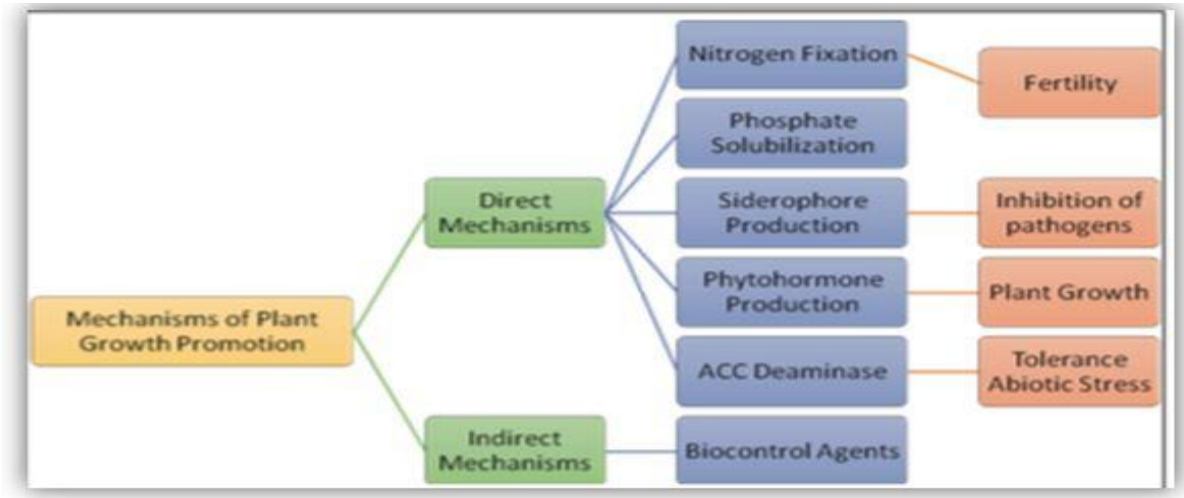
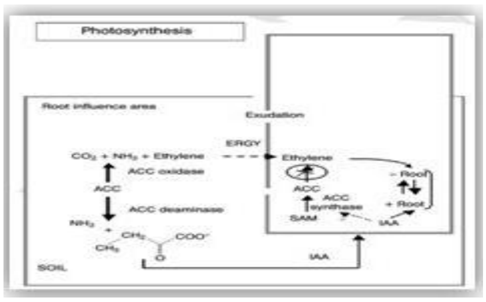


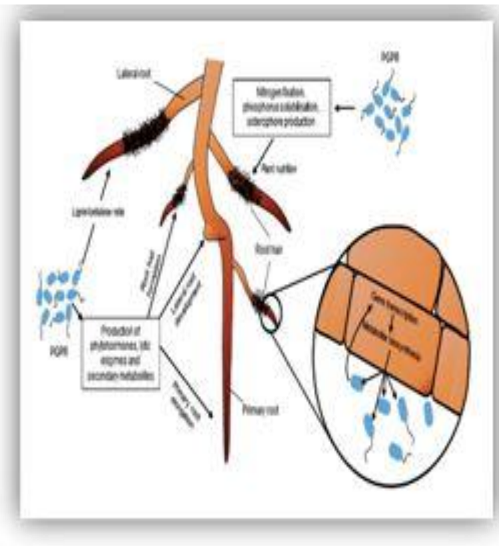
Role of PGPR in Agriculture:

1. **Bio fertilizers:** In crops such as Soybean, pea, peanut and alfalfa, bacteria such as *Rhizobium* and *Bradyrhizobium* forms nodules on their roots in which they convert N_2 into ammonia. In wheat, sorghum and maize, *Azospirillum* inoculation leads to increase in yield through increased root development leading to increased rates of water and mineral uptake. Some plant growth promoting bacteria solubilises phosphate from either organic or inorganic bound phosphate which facilitates plant growth. Enzymes such as phosphatases, phytases, phosphonatases, and C-P lyases, release soluble phosphorus from organic compounds in soil. In organophosphate, C-P links are cleaved by C-P lyases. Production of organic acid such as gluconic acid is directly related to release of phosphorus from mineral phosphate.
2. **Rhizoremediators:** It was developed by Kuiper *et al.* This strategy involves the selection of pollutant degrading rhizobacteria that live on roots or close to roots which can use root exudate as their major nutrient source. It uncouples the energy needed for primary metabolism from the energy required for pollutant degradation.
3. **Phytostimulators:** Bacteria produce substances that stimulate the growth of plants in the absence of pathogens. The root growth promoting hormone auxin is usually synthesized from the exudate amino acid tryptophan where the concentration is differs



strongly among the plants. Hormone auxin and the cofactor the pyrroloquinoline quinone (PQQ) are the best-known examples that stimulate plant growth. Ethylene regulates many processes such as the ripening of fruits, the abscission of leaves or the ripening of fruits.1-aminocyclopropane-1-carboxylate (ACC) is synthesized by plants, which is the precursor for ethylene, in response to exposure to various types of environmental stress, such as cold, drought, flooding, infections with pathogens, and the presence of heavy metals.

4. **Production of hormones:** Phytohormones, influence physiological processes at low concentrations. Since hormones stimulate or inhibit plant growth, they are also referred to as plant growth regulators that are produced from PGPR. A few notable plant hormones such as auxins, ethylene, gibberellins, abscisic acid (ABA), and a few notable plant hormones such as auxins, ethylene, gibberellins, abscisic acid (ABA), and cytokinin may well regulate plant growth and development.



5. **Production of Siderophores:** The natural form of iron is Fe , which is highly insoluble. Siderophores secreted by PGPR solves this problem. Siderophores, which are low molecular weight iron binding protein compounds, involved in the process of chelating ferric iron (Fe (iii)) from the environment.

6. **Production of Enzymes:** PGPR promote plant growth through the control of phytopathogenic agents, primarily for the production of metabolites contributing to the antibiosis and antifungal properties used as defence systems.

It is quite evident that PGPR exerts a positive impact on agriculture, in relation to crop productivity and ecosystem. Owing to its good impact, implementation of PGPR in agriculture should be encouraged. The usage of PGPR will bring stability and productivity of the agro-ecosystem and will ultimately lead towards an ideal agricultural system.