# Plant Growth Promoting Rhizobacteria: The Stress Busters in Nature

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**Abstract**

Beneficial bacteria living around plant roots (PGPR) come to the rescue of plants facing harsh conditions (biotic and abiotic stresses). These tiny helpers allow plants to thrive even in tough times and boost their harvest through various strategies, both direct and indirect. With the help of PGPR, plants can harness nitrogen from the air, produce their own growth hormones, enhance water and nutrient uptake, unlock phosphorus sources, and improve their access to iron using special molecules called siderophores.

**Introduction**

Plant growth promoting rhizobacteria (PGPR) are bacteria that colonise the plant's root and stimulate plant development. Joseph W. Kloepper used the term PGPR for the first time in 1978.

External factors that hinder plant growth are known as plant stress. The abiotic stresses like temperature, drought, salts and heavy metal; biotic stresses like plant pathogens, diseases, and pests directly or indirectly influence the global the agricultural productivity. Stress-tolerant plant growth-promoting rhizobacteria serve a crucial role in alleviating abiotic and biotic challenges, hence enhancing plant growth.

**PGPR is a fantastic fit for plants**

They play a vital role in the essential cycles for carbon, nitrogen, phosphorus, and sulphur in soil. They have the remarkable ability to make beneficial nutrients more available to plants while keeping harmful ions in check. Their synthesis of growth regulators promotes plant growth. They act as both a fertilizer and a soil conditioner; and can influence plant enzymes in a way that helps them tolerate abiotic stress environments.

PGPR can be classified as extracellular (e PGPR) or intracellular (i PGPR) depending on how they live. In the apoplast of the root cortex, e PGPR live in the spaces between cells or the rhizosphere, while i PGPR are found inside the specialised nodular structures of root cells. *Arthrobacter* sp., *Agrobacterium* sp., *Bacillus* sp., *Burkholderia* sp., *Erwinia* sp., *Caulobacter* sp., *Chromobacterium* sp., *Flavobacterium* sp., *Micrococcus* sp., and *Pseudomonas* sp., are among the bacterial genera classified as e PGPR. The majority of the endophytic bacteria that are part of the i PGPR belong to the genera, *Mesorhizobium*, *Frankia*, *Bradyrhizobium*, *Allorhizobium* and *Rhizobium*, which have been extensively documented in higher plants to fix atmospheric nitrogen.

**Plant Growth-Promoting Mechanism: PGPR as a Mediating Factor**

**Nutrient Acquisition:** Certain PGPR act as nitrogen fixers, converting atmospheric nitrogen into a usable form readily absorbed by plants. This reduces dependence on chemical fertilizers while promoting sustainable agriculture.

**Phosphate Solubilization:** Phosphorus, a vital nutrient, often gets locked up in soil in forms unavailable to plants. PGPR secrete organic acids that chelate (bind) and liberate these phosphates, making them readily accessible for plant growth.

**Ion Homeostasis and Osmotic Balance:** Plant osmotic equilibrium is frequently disturbed by salt ion accumulation. Through increased osmolyte generation for plant absorption at the root surface, Plant growth promoting rhizobacteria (PGPR) enhances the plant-water connection. Promoting the uptake of suitable solutes, or osmolytes, such proline, glycine, polyamines, etc., and allowing them to accumulate is crucial for preserving osmotic equilibrium and preventing oxidative damage to the constituent parts of cells. Hydraulic conductivity influences stomatal opening and water potential management through suitable solutes

**Phytohormone Production:** Plant growth hormones such as gibberellins, cytokinins, and auxins are synthesised by PGPR. These hormones function as natural growth regulators, encouraging the elongation of shoots, the formation of roots, and general plant health.

**Antimicrobial Activity:** Some PGPR produce antibiotics and other bioactive compounds that suppress harmful pathogens like bacteria, fungi, and nematodes in the soil. This strengthens the plant's natural defences.

**Stress Mitigation:** Plants are constantly under pressure from environmental stresses like drought, salinity, extreme temperatures, plant pathogens, diseases, and pests PGPR can help alleviate these stresses by producing exopolysaccharide (EPS) Production, volatile organic compounds and hydrolytic enzymes (chitinases, cellulases, etc.).

**Applications of PGPRs**

**Biofertilizers:** In order to promote plant growth, PGPR biofertilizers actively remove the detrimental aspects of pesticides that contaminate the soil. The production of amino acids is increased by PGPR biofertilizers, enabling the root system to function more actively and support plant growth. It stimulates photosynthesis, enabling plants to develop continuously even under various stress conditions. It reduces dependence on chemical fertilizers and promoting soil health.

**Biocontrol Agents:** Plant pathogens are biocontrolled by PGPR. The primary biocontrol mechanism is the generation of metabolites. This mechanism uses a broad range of substances with numerous antibacterial properties to serve as a barrier against harmful bacteria. The generation of siderophores, bacteriocins, and antibiotics is one aspect of the antagonist mechanism that can stop or minimise the growth of phytopathogenic microorganisms. (Beneduzi *et al*., 2012).

**Rhizo-remediation:** PGPR strains can be used to degrade pollutants in the soil, contributing to rhizo-remediation (soil restoration).

**Conclusion**

Agricultural productivity is negatively impacted by environmental stressors. Rhizobacteria that promote plant growth aid in improving plant's ability to withstand stress and lessen its detrimental effects on growth. Plant growth-promoting rhizobacteria (PGPRs) have the ability to express stress-responsive genes, change hormonal balance and cellular physiology, and generate biomolecules. By promoting plant growth, nutrient uptake, and stress tolerance, PGPR can significantly enhance crop yields. This is crucial for ensuring food security for a growing population. PGPR offer a natural alternative to chemical fertilizers and pesticides, promoting environmentally friendly agriculture. This reduces pollution and improves soil health. A thriving PGPR population contributes to a healthy soil ecosystem, promoting nutrient cycling and organic matter decomposition. This ultimately leads to better soil fertility and long-term agricultural sustainability.

**References**

Beneduzi, A., Ambrosini, A. and Passaglia, L.M., 2012. Plant growth-promoting rhizobacteria (PGPR): their potential as antagonists and biocontrol agents. *Genetics and molecular biology*, *35*, pp.1044-1051.

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