

Plant growth promoting bacteria as source of secondary metabolites: an emergent principle in plant science

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The biological phenomena of soil consist of life, macro and microfauna and flora which make a big contribution to soil health and fertility. Soil, plant and rhizosphere microorganisms have a strong relationship to sustain plant growth and development. Bacteria and fungi constitute the most abundant groups in the rhizosphere. The beneficial rhizobacteria have a number of positive effects on the environment, soil conditions, and plant growth and are known as plant growth promoting rhizobacteria (PGPR). PGPR have positive effects on plant physiology and growth when used as biofertilizer and biocontrol, root colonization, induced systemic resistance, phytopathogen biocontrol, etc. The use of PGPR or other microbial-based products is increasing as the most suitable option for reducing the use of chemicals and to sustain productivity as well as soil health. However, there are a few bottlenecks such as biotic and abiotic stresses and commercialization of PGPR. In this review, we have therefore discussed the mechanisms of PGPR, different secondary metabolites that are being produced by *Bacillus* and *Pseudomonas*; their synthesis pathways and ecological interactions in nature.

Keywords: Biofertilizers, metabolites, plant growth promoting rhizobacteria, phytohormone, stress.

Prokaryotes (archaea, bacteria and viruses) and eukaryotes (fungi, oomycetes, nematodes, protozoa, algae and arthropods) make up the majority of the microbial communities in the rhizosphere, with bacteria and fungi being the most prevalent. About 2–5% of the bacteria in the rhizosphere are plant growth promoting rhizobacteria (PGPR), which have many advantageous effects on soil quality, plant growth and the environment⁴. PGPRs are free-living soil bacteria that thrive in the rhizosphere, actively colonize plant roots and boost plant growth. Through different direct and indirect mechanisms, PGPR strains not only increase the plant development but also aid the plants to overcome the hostile external environment by producing various plant growth regulators, mobilizing nutrients in the soil, controlling or inhibiting phytopathogens, improving soil structure and bioremediating polluted soils by sequestering toxic heavy metal species and breaking down xenobiotic compounds like pesticides^{5–7}.

In order to enhance plant nutrient availability and create a more sustainable environment, PGPR is a significant practise and essential for sustainable crop production^{8,9}. The use of PGPR as a tool for sustainable agriculture has got attention worldwide during the last couple of decades. Several research studies are being conducted to understand the diversity, dynamics and importance of soil PGPR