Preface

This book was conceptualized during finalizing the Soil Biology volume "Root engineering: Basic concepts and Applications" edited by Asuncion Morte and Ajit Varma (2014). Soon it was realized that the basic functions of roots are heavily regulated by the microorganisms around them and thus a new volume "PGPR and Medicinal Plants" was depicted. The prime aim and objective of this volume is to highlight various aspects of action, effect, and application of PGPRs in medicinal plants to lend a hand to scientists throughout the world working in this field.

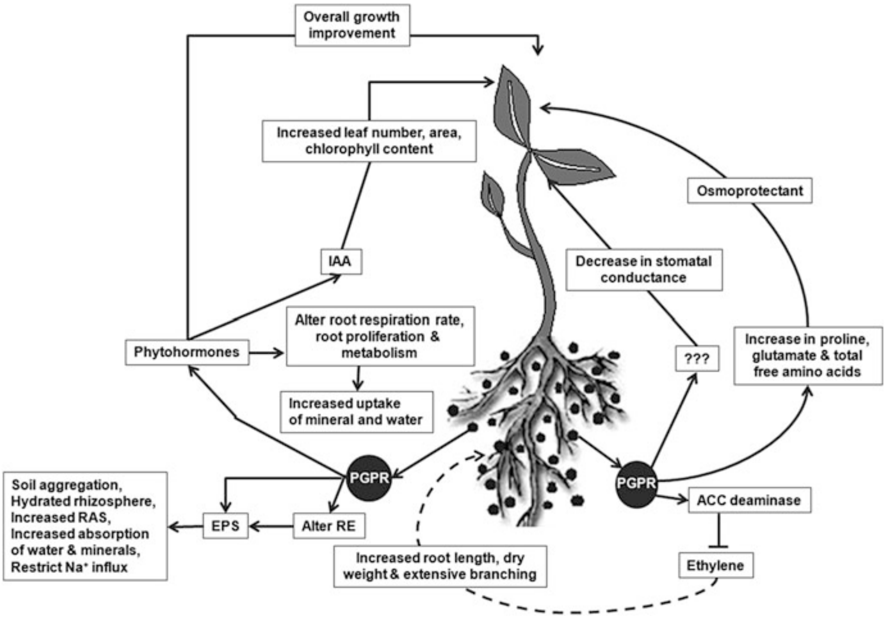
The rhizosphere concept was first introduced by Hiltner (1904) to describe the narrow zone of soil surrounding the roots where microbial populations are stimulated by root activities. The term "plant growth-promoting rhizobacteria (PGPR)" was first used by Joseph W. Kloepper in the late 1970s and has become commonly used in scientific literature. A large number of microorganisms such as bacteria, fungi, protozoa, and algae coexist in the rhizosphere; however, the most abundant organism is bacteria. Plants select those bacteria contributing most to their fitness by releasing organic compounds through exudates creating a very selective environment where diversity is low. Since bacteria are the most abundant microorganisms in the rhizosphere, it is highly probable that they influence the plants' physiology to a greater extent, especially considering their competitiveness in root colonization, hence, referred as plant growth-promoting rhizobacteria (PGPR). PGPRs are the group of microorganisms which colonize and have symbiotic relationship with the plant roots and promote plant growth via various plant growth-promoting substances and also act as biofertilizers.

The world today comes up with a new ailment after every short span of time and thus our requirement of medicines and drugs continues to amplify. Natural compounds are most preferred over synthetic drugs for curing diseases and these natural compounds are variedly obtained from medicinal plants. All we need is to enhance quality and quantity of plant secondary metabolites, which can be skillfully used for drug production. Numerous plant growth-promoting rhizobacteria are well known to exhibit beneficial effects on plenty of medicinal plants.

PGPRs have different relationships with different species of host plants, mainly rhizospheric and endophytic. Rhizospheric relationships consist of the PGPRs that colonize the surface of the root, or superficial intercellular spaces of the host plant, often forming root nodules. The dominant species found in the rhizosphere is a microbe from the genus *Azospirillum*. Endophytic relationships involve the PGPRs residing and growing within the host plant in the apoplastic space. It is well established that only 1–2 % of bacteria promote plant growth in the rhizosphere while acting as PGPR. PGPRs have been known to be present within many different bacterial taxa, among which most commercially industrial PGPRs are species of *Bacillus* which form endospores that confer population stability during formulation and storage of products. The main groups of PGPR can be found along with the phyla *Cyanobacteria, Actinobacteria, Bacteroidetes, Firmicutes,* and *Proteobacteria.* Fluorescent pseudomonads are identified to suppress soilborne fungal pathogens by producing antifungal metabolites and by sequestering iron in the rhizosphere through the release of iron-chelating siderophores, rendering it unavailable to other organisms.

PGPRs have several applications like increasing the availability of nutrients in the rhizosphere, increased root volume which is related to more nutrient absorption, to stimulate plant growth, e.g., through the production of plant hormones, to control or inhibit the activity of plant pathogens, to improve soil structure, and mineralization of organic pollutants, i.e., bioremediation of polluted soils, and are also used as biofertilizers and also known for phytohormone production, phosphate solubilization, siderophore production, biocontrol agents, and biological fungicides, etc. PGPRs are a healthier choice to improve the crop efficiency as well as quality. PGPRs improve the chemical and microbial property of soil and enhance the amount of plant enzymes for better defense mechanism in plant.

During the past couple of decades, the use of PGPRs for sustainable agriculture has increased tremendously in various parts of the world. Significant increases in growth and yield of agronomically important crops in response to inoculation with PGPR have been repeatedly reported. Recent reports have identified several volatile organic compounds produced by a variety of bacteria that promote plant growth and induce systemic resistance in *Arabidopsis thaliana*. Beneficial effects of PGPRs have also been attributed to shifts in the microbial ecology of the rhizosphere. Previous research has shown the practicality of introducing PGPR into commercial peat-based substrates for vegetable production in order to increase plant vigor, control root diseases, and increase yields. Results of tomato (*Lycopersicon esculentum*) and pepper (*Capsicum annuum*) trials in Florida included significant increases in tomato and pepper transplant growth during greenhouse production in response to various formulations of PGPR tested. As a result of increased growth, the time required to produce a standard sized transplant was reduced as were greenhouse applications of fertilizer. Also, transplant vigor and survival in the field were improved by PGPR treatments in both tomato and pepper. An overall view on the salient functions of PGPRs is depicted in the diagram below.



Morphological and physiological changes in plants by application of PGPR leading to abiotic stress tolerance [Adopted from Dutta and Khurana (2015)]

This volume is composed of 20 chapters, divided into 5 parts, encompassing various aspects of effect of PGPRs on medicinal plants. The first chapter provides an overview on PGPR and medicinal plants and their state of the art. The first section of this book focuses on plant improvement and is composed of 5 chapters. Chapter 2 provides a wide and comprehensive account on interaction of rhizosphere microbes with medicinal plants. Chapter 3 covers the handsome story toward enhancement of efficiency of medicinal and aromatic plants on interaction with PGPRs, and Chap. 4 deliberates the usefulness of vermicompost and associated microorganisms in enhancing soil health and agriculture productivity. Following this Chap. 5 describes the effect of Arbuscular mycorrhizae fungus and plant growth-promoting rhizobacteria of potential bioinoculants on growth, yield, and forskolin content of *Coleus forskohlii*, and Chap. 6 beautifully describes emergence and future facets of plant growth-promoting rhizobacteria upon interaction with medicinal plants. The second part with Chaps. 7, 8, and 9 relates to alleviation of plant stress tolerance with the help of PGPRs. The third section of this book focuses on biological control activity of PGPRs. Chapters 10, 11, and 12 highlight the ecological manifestation of rhizobacteria for curbing medicinal plant diseases, mechanism and control of plant associated diseases, and role of PGPRs in increasing soil fertility and plant health, respectively. The fourth part of the book brilliantly highlights some mechanisms of actions of PGPRs. It includes Chaps. 13–16 and highlights systemic induction of secondary metabolites, new frontiers for phytochemicals, and rhizosphere microflora in advocacy of heavy metal tolerance in plants. The last part, composed of Chaps. 17–20, evidently describes diversity and characterization of PGPRs and also focuses locations like North West Himalayas and Argentina.

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