Microorganisms for Sustainability

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Plant Growth Promoting Rhizobacteria for Sustainable Stress Management

Volume 1: Rhizobacteria in Abiotic Stress Management

Springer

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Foreword

National Academy of Agricultural Sciences

Prof. Panjab Singh
President

Achieving sustainable agricultural production while keeping the environmental quality, agroecosystem functions, and biodiversity is a real challenge in the present agricultural scenario. The traditional use of chemical inputs (fertilizers, pesticides, nutrients, etc.) poses serious threats to crop productivity, soil fertility, and the nutritional value of farm produce. Global concern over the demerits of chemicals in agriculture has diverted the attention of researchers toward sustainable agriculture by utilizing the potential of plant growth-promoting rhizobacteria (PGPR). Therefore, management of pests and diseases, agroecosystem well-being, and health issues for humans and animals has become the need of the hour. The use of PGPR as biofertilizers, plant growth promoters, biopesticides, and soil and plant health managers has gained considerable attention among researchers, agriculturists, farmers, policymakers, and consumers.

The application of PGPR as a bioinoculant can help in meeting the expected demand of global agricultural productivity to feed the world's booming population, which is projected to reach around 9 billion by 2050. However, to be a useful and effective bioinoculant, PGPR strain should possess high rhizosphere competence, usefulness to soil rhizobacteria, broad-spectrum activity and tolerance to various biotic and abiotic stresses. PGPR-mediated plant growth promotion and biocontrol is now gaining worldwide importance and acceptance as eco-friendly and effective bioinoculants for sustainable agriculture. However, the performance of PGPR is subject to various abiotic factors such as salinity, temperature (high/low), drought, metal ions, and presence of various toxic compounds. Only those PGPR that establish themselves and can manage such abiotic stress can perform better as plant growth-promoting and biocontrol agents.

This book, which has 17 chapters encompassing the influence of various abiotic factors on the performance of PGPR and written by different experts from India and abroad, is to highlight salient features on the application of PGPR in agricultural crop plants to lend a hand to scientists working in this field. ***PGPR in abiotic stress management*** is a timely effort for sustainable agriculture. I compliment the authors and hope the teachers and researchers working in this area will make use of this publication.

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Prof. Panjab Singh

Preface

The future of agriculture greatly depends on our ability to enhance crop productivity without sacrificing long-term production potential. Agriculture primarily depends on the use of natural resources such as land, soil, water, and nutrients. As demand for food increases and climate change and natural ecosystem damage imposes new constraints, sustainable agriculture has an important role to play in safeguarding natural resources, reducing greenhouse gas emissions, halting biodiversity loss, and caring for valued agricultural practices. Agricultural productivity rests on the foundation of microbial diversity in the soil. The application of microorganisms, such as the diverse bacterial species of plant growth-promoting rhizobacteria (PGPR), represents an ecologically and economically sustainable strategy for agriculture. PGPR are associated with plant roots and augment plant growth and disease management, elicit "induced systemic resistance" to salt and drought, and increase nutrient uptake from soils, thus reducing the need for fertilizers and preventing the accumulation of nitrates in soils. Increased incidences of abiotic and biotic stresses impacting agricultural productivity in principal crops are being witnessed all over the world. Extreme events like prolonged droughts, intense rains and flooding, heat waves, and frost damages are likely to further increase in the future due to climate change. Enhancement of plant drought stress tolerance by PGPR has been increasingly documented in the literature. However, most studies to date have focused on PGPR-plant root interactions, but very little is known about PGPR's role in mediating physiochemical and hydrological changes in the rhizospheric soil that may impact plant drought stress tolerance. A reduction in fertilizer use would lessen the effects of water contamination from fertilizer runoff and lead to savings for farmers.

There is a need to develop simple and low-cost biological methods for the management of abiotic stress, which can be used on short-term basis. PGPR could play a significant role in this respect if we can exploit their unique properties of tolerance to extremities, their ubiquity and genetic diversity, and their interaction with crop plants and develop methods for their successful deployment in agriculture production.

With the advent of climate change, global agriculture faces a multitude of challenges. The most prominent among these are abiotic stresses imposed by increased incidences of drought, extremes of temperature, and unseasonal flooding. Such atmospheric threats, coupled with edaphic stresses, pose severe challenges to food production. While several agronomic and plant breeding strategies have been proposed to overcome these phenomena, the utilization of PGPR is receiving increased attention globally.

Achieving sustainable agricultural production while keeping the environmental quality, agroecosystem function, and biodiversity is a real challenge in the current agricultural practices. The traditional use of chemical fertilizers and pesticides poses serious threats to crop productivity, soil fertility, and the nutritional value of farm produce. Global concern over the demerits of chemicals in agriculture has diverted the attention of researchers toward sustainable agriculture by utilizing PGPR. Therefore, management of pests and diseases, agroecosystem well-being, and health issues for humans and animals has become the need of the hour. The use of PGPR as biofertilizers, plant growth promoters, biopesticides, and soil and plant health managers has gained considerable attention among researchers, agriculturists, farmers, policymakers, and consumers.

The application of PGPR as biostimulants can help in meeting the expected demand of global agricultural productivity to feed the world's booming population, which is predicted to reach around 9 billion by 2050. However, to be a useful and effective bioinoculant, PGPR strains should possess high rhizosphere competence, safety to the environment, plant growth promotion and biocontrol potential, compatibility with agronomic practices with broad-spectrum activity, and tolerant to various biotic and abiotic stresses. In view of this, the need for a better PGPR to complement the increasing agro-productivity as one of the crucial drivers of the economy has been highlighted.

PGPR-mediated plant growth promotion and biocontrol is now gaining worldwide importance and acceptance as eco-friendly and effective bioinoculants for sustainable agriculture. However, the performance of PGRR is subject to various abiotic factors such as salinity, temperature (high/low), drought, metal ions, and presence of various toxic compounds. Only those PPGR that establish themselves and can manage such abiotic stress can perform better as plant growth-promoting and biocontrol agents.

The prime aim and objective of this book is to highlight salient features on the application of PGPR in agricultural crop plants to lend a hand to scientists throughout the world working in this field. PGPR in abiotic stress management is a timely effort for sustainable agriculture. These also provide excellent tools for understanding the stress tolerance, adaptation, and response mechanisms that can be subsequently engineered into crop plants to cope with climate change-induced stresses.

This book is composed of 17 chapters encompassing the influence of various abiotic factors on the performance of PGPR to comprehend the information that has been generated on the abiotic stress-alleviating mechanisms of PGPR and their abiotic stress alleviation potential. Agricultural crops grown on saline soils suffer on an account of high osmotic stress, nutritional disorders and toxicities, poor soil physical conditions, and reduced crop productivity. The various chapters in this book focus on the enhancement of productivity under stressed conditions and increased resistance of plants against salinity stress by the application of PGPR.

It has been an immense pleasure to edit this book, with continued cooperation of the authors. We wish to thank Dr. Mamta Kapila, Ms. Raman Shukla, and Mr. Sivachandran Ravanan at Springer, India, for their generous cooperation in completion of this book.

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Naveen Kumar Arora, PhD in Microbiology, professor and head in the Department of Environmental Science, Babasaheb Bhimrao Ambedkar University (A Central University), Lucknow, Uttar Pradesh, India, is a renowned researcher in the field of Environmental Microbiology and Biotechnology. His specific area of research is rhizosphere biology and plant growth-promoting rhizobacteria (PGPR). He has more than 60 research papers published in premium international journals and several articles published in magazines and dailies. He is editor of 15 books, published by Springer, member of several national and international societies and in editorial board of 4 journals and reviewer of several international journals. He is also the editor in chief of the journal *Environmental Sustainability* published by Springer Nature. He has delivered lectures in conferences and seminars around the globe. He has been advisor to 118 postgraduate and 9 doctoral students. He has also received awards for excellence in research by the Honorable Governor of Uttar Pradesh, Asian PGPR Society and Samagra Vikas Welfare Society. Although an academician and researcher by profession, he has a huge obsession for the wildlife and its conservation and has authored a book, *Splendid Wilds*. He is president of the Society for Conservation of Wildlife and is also secretary of the Society for Environmental Sustainability (website: www.ses-india.org).

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