Salt Stress, Microbes, and Plant Interactions: Mechanisms and Molecular Approaches

Mohd Sayeed Akhtar
Editor

Salt Stress, Microbes, and Plant Interactions: Mechanisms and Molecular Approaches

Volume 2

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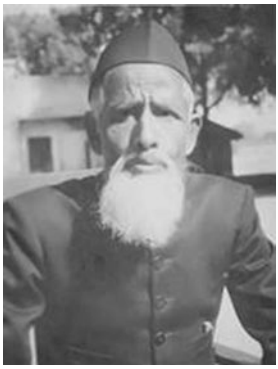
This book is dedicated to my grandfather, Nana



Muhammad Aziz-ur-Rahman (1907–1985)

A great scholar, statesman, social reformer, and famous hakim of the twentieth century

Foreword

Global warming and other potential climatic abnormalities associated with it cause different types of biotic and abiotic stress conditions that lead to affect plant growth and yield severely. Though not visible to our naked eyes, plant-microbe interactions occur in several ways. In fact, plant interacts with microbes at a certain phase of their life, and this communication is not inevitably harmful for the plant. Indeed, there are copious examples of plant-microbe associations that effectively benefit the plants by enhancing their growth, survivability, and productivity. The plant-microbe interaction is very essential for combating any stressful conditions. The microbes associated with plants secrete volatile compounds that encourage plant growth and/or provide resistance against abiotic and/or biotic stresses. Microorganisms, occupying in different environments, have variable biological and metabolic mechanisms to overcome ecological stresses. As the microbial diversity in the environment is very high, it is required to characterize and clarify microbial associations with plants in relation to protect them against several ecological encounters. The microbiota of different soils and their beneficial effect on plants need to be studied in detail, so that they can be used as a consortium to improve crop productivity under different agro-climatic conditions. Moreover, understanding the physiological and molecular mechanisms involved in plant-microbe interactions will be very useful for improving the agronomic applications of rhizospheric microbes. The recent advancements in modern techniques have helped in identifying and quantifying the microbial diversity linked with plants. This has allowed us to understand the immense interactions of microbes with the plants. The knowledge of these research

accomplishments provides a comprehensive understanding on multidimensional communications between microbes and plants. Thus, it is required to have a collective database on the existence of varied stress combinations in agronomically important areas, and this will allow one to make use of the beneficial microbes to provide stress tolerance.

The present volume to be published by "Springer," *Salt Stress, Microbes and Plant Interactions: Mechanisms and Molecular Approaches* (Volume 2), includes 13 chapters contributed by the authors from different parts of the world. Chapter 1 by the Indian authors provides information on the role of microbes in the management of crop salinity. Also, it discusses on the mechanisms and microbial applications in overcoming salinity stresses. Chapter 2 contributed by the Malaysian authors describes in detail about the adaptive mechanisms of plant responses to salts. In Chaps. 3 and 4, the Indian authors have summarized the molecular approaches and salt tolerance mechanisms in leguminous plants and crop improvement through microbial biotechnology. In Chapter 5, the Indian authors discuss the role of phytohormones in recuperating salt stress. Similarly, Chaps. 6 and 7 by the Malaysian and Indian authors, respectively, describe the genetic responses of plants to salt stresses and the use of microbial biotechnology in improving salt stress and crop productivity. Chapter 8 discusses the consequences of bioinoculants and intercropping approach to alleviate salinity stresses. However, Chap. 9 entails the pathways of signaling molecules in improving salt stress in plants. Chapter 10 by the Indian authors describes the mechanisms and molecular approaches for salt tolerance enhancement. Similarly, Chaps. 11 and 12 by Pakistani contributors describe the methods used to reduce and mitigate the adverse impact of soil salinity and to overcome salt stresses through bacterial inoculation. Lastly, Chap. 13 by the Indian authors describes the diverse roles of proline and its mechanism of tolerance and adaptation under salinity stress. In this edited volume, an attempt has been made to highlight both the hypothetical and practical aspects of salt stress tolerance in plants. Furthermore, it highlights on the physiological, ecological, biochemical, and molecular mechanisms involved in various plant-microbe interactions to overcome salt stresses. I personally congratulate Dr. Mohd Sayeed Akhtar for his noble academic efforts in bringing out this book volume.

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Mallappa Kumara Swamy

Preface

Salt stress has pessimistic crash on the yields of various agricultural crops, and it may directly affect the livelihood of farmers worldwide. The excessive salts in soil lower the availability of water, inhibit metabolic processes, and affect nutrient composition, osmotic balance, and hydraulic conductivity that result to stunted growth and low productivity of cultivated crop plants. Plants have developed number of processes involved in the tolerance mechanism, such as various compatible solutes, polyamines, reactive oxygen species and antioxidant defense mechanism, ion transport, and compartmentalization of injurious ions. To overcome this problem, the exploitation of genetic variation; the use of plant hormones, mineral nutrients, and soil microbes; and other mechanical practices are of prime importance. It is a fascinating subject, which is multidisciplinary in nature, and concerns scientists involved in plant heath. There have been marked advances in this field during the past few decades.

Salt Stress, Microbes, and Plant Interactions: Mechanisms and Molecular Approaches (Volume 2) is a very timely effort in this direction. This book volume describes both the theoretical and practical aspects of salt stress tolerance and the physiological, ecological, biochemical, and molecular mechanisms involved in

understanding these multi-tropic interactions. I hope that the book will be helpful to graduate students, teachers, researchers, and industry persons who are interested in agronomy, ecology, stress physiology, environmental science, crop science, and molecular biology.

I am highly grateful to all our contributors for readily accepting our invitation, for not only sharing their knowledge and research but also venerably integrating their expertise in dispersed information from diverse fields in composing the chapters, and for enduring the editorial suggestions to finally produce this venture. I greatly appreciate their commitments. I am also thankful to Professor Mallappa Kumara Swamy for his suggestion and for writing the foreword of this volume. Moreover, I am thankful to my beloved wife, Mrs. Shagufta Bano, and lovely sons, Mohd Rafaan and Mohd Almaan, for their unconditional encouragement, support, and moral boost up throughout the compilation of this book volume. I also thank the team of Springer Nature, especially Dr. Kapila Mamta, Raman Shukla, and Raagaipriya Chandrasekaran, for their generous cooperation at every stage of the publication.

Shahjahanpur, Uttar Pradesh, India Mohd Sayeed Akhtar

About the Book

The interaction between plant, soil, and microbes is fairly intricate and is essential for combating any stressful condition. The presence of excessive salt in soil lowers the availability of water, inhibits metabolic processes, and affects nutrient composition, osmotic balance, and hydraulic conductivity that resulted in the stunted growth and lower productivity of crop plants. *Salt Stress, Microbes and Plant Interactions: Mechanisms and Molecular Approaches* (Volume 2), along with the recently published *Salt Stress, Microbes and Plant Interactions: Causes and Solution* (Volume 1), provides a detail account on the physiological, ecological, biochemical, environmental, and molecular levels for this multi-tropic interaction. Specifically, these two titles are focus on both the theoretical and practical aspects and also provide a solid foundation for students, teachers, researchers, and industry persons interested in agronomy, ecology, stress physiology, environmental science, crop science, and molecular physiology.

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About the Editor

Dr. Mohd Sayeed Akhtar (PhD) is working as an assistant professor in Gandhi Faiz-e-Aam College, Shahjahanpur, UP, India. He has received his PhD degree from Aligarh Muslim University (AMU), India, in 2008, prior to conducting postdoctoral research at the Botanical Institute, University of Basel (BIB), Switzerland, in 2008–2010, and Chonbuk National University (CBNU), Republic of Korea, in 2011. He was an assistant professor at Jimma University, Ethiopia (2011–2014), and a fellow researcher at the International Institute of Tropical Agriculture, Universiti Putra Malaysia (UPM) (2014–2015). He has more than 15 years of research and 10 years of teaching experience in soil microbiology, applied microbiology, environmental microbiology, molecular biology, plant pathology, and plant nanobiotechnology. He is author and coauthor of more than hundred articles in peer-reviewed journals, conference proceedings, and book chapters and has edited 12 books with international publishers. He is serving the scientific community as editorial board member and reviewer of several high-impact international journals. His current research is focused on the rhizospheric plant-microbe interactions and their molecular biotechnology, bioremediation, biomineralization, nano-fertilizers, and nanobiotechnology.