

# Plant, Soil and Microbes



Khalid Rehman Hakeem • Mohd Sayeed Akhtar  
Editors

# Plant, Soil and Microbes

Volume 2: Mechanisms and Molecular  
Interactions

 Springer

*Editors*

Khalid Rehman Hakeem  
Faculty of Forestry  
Universiti Putra Malaysia  
Serdang, Malaysia

Mohd Sayeed Akhtar  
Department of Botany  
Gandhi Faiz-e-Aam College  
Shahajahanpur, Uttar Pradesh, India

ISBN 978-3-319-29572-5

ISBN 978-3-319-29573-2 (eBook)

DOI 10.1007/978-3-319-29573-2

Library of Congress Control Number: 2016930561

© Springer International Publishing Switzerland 2016

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

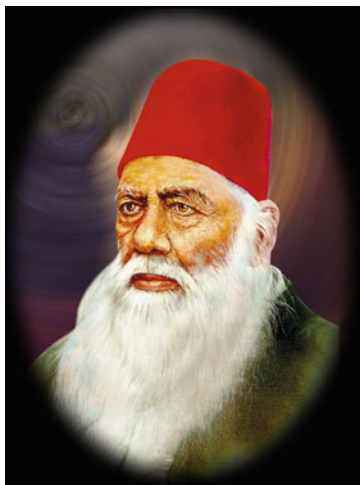
The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made.

Printed on acid-free paper

This Springer imprint is published by Springer Nature  
The registered company is Springer International Publishing AG Switzerland

This Book is Dedicated to



Sir Syed Ahmad Khan  
(1817-1898)

*A great visionary, statesman, Muslim reformer of the 19th century  
and founder of Aligarh Muslim University, India*



# Foreword

Worldwide considerable research in the area of belowground plant-microbe interaction is quite important to enrich soil fertility and in the enhancement of crop productivity. It seems imperative to understand the modifications of belowground interactions under specific plant and microbe communication system accomplished by molecular dialogues. It is, therefore, essential to decode and explore this molecular language so as to establish a successful tripartite relationship among plant, soil and microbes. The soils are the product of rocks, minerals and organic matters with a pivotal role in ecology. Most of the plants depend on soil, but plants and their associated microorganisms are also important component together in the formation and sustainability of rhizospheric ecology. The understanding about plant, soil and microbe interaction is limited; molecular mechanisms and other several consequences may reveal with other process yet to be explored. This book entitled *Plant, Soil and Microbe, Volume 2: Mechanisms and Molecular Interactions* deals with how plant-microbe interactions occur using molecular pattern and applied in environment scavenging such as pesticide degradation and polycyclic aromatic hydrocarbons (PAHs) remediation. The importance of fungal symbiosis, tripartite interactions among plant-*Trichoderma*-pathogen with special reference to proteomic tools in biocontrol, has been described. The mechanism of plant growth promoting rhizobacteria-soil-root interaction, their ability towards growth, secondary metabolite production and nutrient uptake in medicinal and aromatic plants has been suitably mentioned. The bacterial determinants and plant defence induction in sustainable agriculture have an added advantage to strengthen the concept of biocontrol of deleterious phytopathogens. The elaborative description on the molecular identification of phytoplasma diseases in ornamental plants is itself appealing. The introductory account on allelochemicals from ascocarp of *Tuber* species is a point of difference. Besides, mycorrhizal associations, the biocontrol potential of *Bacillus thuringiensis*, genomics of plant-soil microbial diversity and the importance of root exudates in rhizosphere ecosystem and phytohormones in abiotic stress tolerance of plants have been elaborated. It is oceanic to gain update in the quest for knowledge of plant-soil-microbial interactions and their applications in a befitting manner. The editors *Khalid Rehman Hakeem* and *Mohd. Sayeed Akhtar* have put some

outstanding efforts to compile subject experts' contribution in a very attractive manner with an understanding of sequences of the chapters. *Plant, Soil and Microbe, Volume 2: Mechanisms and Molecular Interactions* includes broad contributions from all dimensions of agronomy. Specifically, this volume describes a holistic view of plant-microbe interactions, and its recent molecular mechanism emerged from studying multi-tropic interaction. The editors have immensely provided a solid foundation of the subject interesting for the researchers involved in soil microbiology, plant pathology, ecology and agronomy.

Faculty of Life Science  
Department of Botany and Microbiology  
Gurukul Kangri University  
Hardwar, Uttarakhand, India

D.K. Maheshwari



# Preface

Plants are exposed to a huge diversity of microbes in the environment. Owing to the broad range of microbes, a complex set of molecular mechanisms mediates the plant-microbe interactions. These interactions have been seen to possess both negative and positive effects on either or both the members. Considering the importance of these ground rhizospheric microorganisms in the plant disease protection, it came into highlight from research that the combined application of these microorganisms is more beneficial than the use of a single agent and provides a better management against the soil-borne plant pathogens. The interaction of these microorganisms also provides an overview about the biological functions of soil and its interaction with the plant-microbe system, nutrient management, biogeochemical cycling, water various environmental condition in response to biotic and abiotic stresses, signalling of molecules during host-pathogen interaction, role of phytohormones against the environmental stresses and the major challenges in the formulation of microorganisms for the biocontrol products. The molecular approach of these microorganisms is also the basis for understanding the mechanism involved in disease suppression by these hidden underground beneficial microbes.

This volume with 18 chapters from experts on the subject describes a holistic view of plant-microbe interactions and its recent molecular mechanism emerged from studying multi-tropic interaction. It is imperative to understand the modifications of belowground interactions under specific plant and microbe communication system accomplished by molecular dialogues. We hope that the book will be helpful for the graduate students, teachers, researchers and industry persons, who are interested in soil microbiology, plant pathology, ecology, environmental sciences and agronomy.

We are highly grateful to all our contributors for readily accepting our invitation for not only sharing their knowledge and research but for venerably integrating their expertise in dispersed information from diverse fields in composing the chapters and enduring editorial suggestions to finally produce this venture. We greatly

appreciate their dedication. We are also thankful to Prof. (Dr.) D. K. Maheshwari for his suggestions and writing the foreword for this volume. We also thank Springer-International team for their generous cooperation at every stage of the book production.

Serdang, Malaysia  
Shahjahanpur, Uttar Pradesh, India

Khalid Rehman Hakeem  
Mohd Sayeed Akhtar

# Contents

<b>Plant-Microbe Interactions: A Molecular Approach .....</b>	<b>1</b>
Mustafeez Mujtaba Babar, Sumayyah Fareed Khan, Muhammad Kazim Zargaham, Najam-us-Sahar Sadaf Zaidi, and Alvina Gul	
<b>Interaction Between Pesticide and Soil Microorganisms and Their Degradation: A Molecular Approach .....</b>	<b>23</b>
Talat Parween, Pinki Bhandari, Sumira Jan, and S.K. Raza	
<b>In Silico Functional Analyses of SWEETs Reveal Cues for Their Role in AMF Symbiosis .....</b>	<b>45</b>
Muhammad Sameeullah, Tijen Demiral, Noreen Aslam, Faheem Shehzad Baloch, and Ekrem Gurel	
<b>Root Exudates and Their Molecular Interactions with Rhizospheric Microbes.....</b>	<b>59</b>
Mallappa Kumara Swamy, Mohd. Sayeed Akhtar, and Uma Rani Sinniah	
<b>A Proteomic Approach to Understand the Tripartite Interactions Between Plant-<i>Trichoderma</i>-Pathogen: Investigating the Potential for Efficient Biological Control.....</b>	<b>79</b>
Chetan Keswani, Kartikay Bisen, S.P. Singh, B.K. Sarma, and H.B. Singh	
<b>Mycorrhizal Association and Their Role in Plant Disease Protection .....</b>	<b>95</b>
Julio Alves Cardoso Filho, Sergio Florentino Pascholati, and Roberto Ramos Sabrinho	
<b>Response of PGPR and AM Fungi Toward Growth and Secondary Metabolite Production in Medicinal and Aromatic Plants .....</b>	<b>145</b>
Mallappa Kumara Swamy, Mohd Sayeed Akhtar, and Uma Rani Sinniah	

<b>Interaction Among Rhizospheric Microbes, Soil, and Plant Roots: Influence on Micronutrient Uptake and Bioavailability .....</b>	<b>169</b>
Vivek Kumar, Manoj Kumar, Neeraj Shrivastava, Sandeep Bisht, Shivesh Sharma, and Ajit Varma	
<b>Bacterial Determinants and Plant Defense Induction: Their Role as Biocontrol Agents in Sustainable Agriculture .....</b>	<b>187</b>
Stuti Patel, Riyaz Z. Sayyed, and Meenu Saraf	
<b>Occurrence, Distribution, and Molecular Identification of Phytoplasma-associated Diseases in Ornamental Plants .....</b>	<b>205</b>
Akil Ahmad Khan, Shoeb Ahmad, and Mohd Sayeed Akhtar	
<b>Isolation and Identification of Allelochemicals from Ascocarp of <i>Tuber</i> Species .....</b>	<b>225</b>
Paola Angelini, Emma Bricchi, Mohd. Sayeed Akhtar, Alessandro Properzi, Jeri-Lynn Elizabeth Fleming, Bruno Tirillini, and Roberto Venanzoni	
<b>Mycorrhizal Association: A Safeguard for Plant Pathogen.....</b>	<b>253</b>
Madhumati Bora and Ami Lokhandwala	
<b>Potential of <i>Bacillus thuringiensis</i> in the Management of Pernicious Lepidopteran Pests .....</b>	<b>277</b>
Md. Aslam Khan, Bishwajeet Paul, Wasim Ahmad, Sangeeta Paul, Chetana Aggarwal, Zehra Khan, and Mohd. Sayeed Akhtar	
<b>Genomics of Plant, Soil, and Microbe Interaction.....</b>	<b>303</b>
Syeda Hafsa Ali, Syeda Ayesha Ali, Syed Abdul Munam, Mustafeez Mujtaba Babar, and Alvina Gul	
<b>Soil Microbe Diversity and Root Exudates as Important Aspects of Rhizosphere Ecosystem .....</b>	<b>337</b>
Owais Bashir, Kamran Khan, Khalid Rehman Hakeem, Naseer Ahmed Mir, Gh Hassan Rather, and Rehana Mohiuddin	
<b>An Insight into the Legume–<i>Rhizobium</i> Interaction.....</b>	<b>359</b>
G. Yamal, Ankita Bidalia, Krati Vikram, and K.S. Rao	
<b>Role of Phytohormones in Stress Tolerance of Plants .....</b>	<b>385</b>
Sajid Mahmood Nadeem, Maqshoof Ahmad, Zahir Ahmad Zahir, and Muhammad Ali Kharal	
<b>Soil Pollution and Remediation .....</b>	<b>423</b>
Sameen Ruqia Imadi, Zeshan Ali, Hamna Hasan, and Alvina Gul	
<b>Erratum .....</b>	<b>E1</b>

## About the Editors

**Khalid Rehman Hakeem, PhD** is working as a fellow researcher at the Faculty of Forestry, Universiti Putra Malaysia (UPM), Serdang, Selangor, Malaysia, and also visiting professor at Fatih University, Istanbul, Turkey. He has obtained his MSc (Environmental Botany) as well as PhD (Botany) from Jamia Hamdard, New Delhi, India, in 2006 and 2011, respectively. He did his postdoctorate in the fields of forest dynamics and biotechnological studies from Universiti Putra Malaysia from 2012 to 2013. Dr. Hakeem has more than 8 years of teaching and research experience in plant ecophysiology, biotechnology and molecular biology as well as in ecological and environmental sciences. Recipient of several fellowships at both national and international levels, Dr. Hakeem has so far edited and authored more than 15 books with international publishers. He has also to his credit more than 100 publications in peer-reviewed international journals, including 35 book chapters with International publishers. He is also an editorial board member and reviewer of several high-impact international journals. Dr. Hakeem is currently engaged in studying the plant processes at ecophysiological as well as proteomic levels.

**Mohd. Sayeed Akhtar, PhD** is working as an assistant professor in Gandhi Faiz-E-Aam College, Shahjahanpur, affiliated to M.J.P. Rohailkhand University, Bareilly, U.P., India. He has received his PhD degree from Aligarh Muslim University (AMU), India, in 2008. He has conducted his postdoctoral research at the Botanical Institute, University of Basel (BIB), Switzerland (2008–2010), and Chonbuk National University (CBNU), Republic of Korea, in 2011, respectively. He also works as an assistant professor, Department of Biology, College of Natural Sciences, Jimma University, Jimma, Ethiopia (from 2011 to 2014), and fellow researcher UDQ9 at the Institute of Tropical Agriculture, Universiti Putra Malaysia (UPM), Serdang, Selangor, Malaysia (from 2014 to 2015). Dr. Akhtar has more than 12 years of research and teaching experience in soil microbiology, applied microbiology, environmental microbiology, molecular biology, plant pathology and plant nanobiotechnology. Dr. Akhtar has received several prestigious fellowships at national and international levels. His promising approach and dedication stands him in the row of foremost scientists in the field of plant-microbe interaction and plant

nanobiotechnology. He is author and coauthor of about 50 research articles in peer-reviewed journals, contributed 12 book chapters in the books published by Springer-Verlag and also edited 4 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.