Mycorrhizosphere and Pedogenesis

Ajit Varma • Devendra K. Choudhary
Editors

Mycorrhizosphere and Pedogenesis

Springer

Editors
Ajit Varma
Amity Institute of Microbial Technology
Amity University
Noida, Uttar Pradesh, India

Devendra K. Choudhary
Amity Institute of Microbial Technology
Amity University
Noida, Uttar Pradesh, India

ISBN 978-981-13-6479-2 ISBN 978-981-13-6480-8 (eBook)
https://doi.org/10.1007/978-981-13-6480-8

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

It is based on consensus that agriculture has a long history of research targeted on how to improve the efficacy of root symbionts, namely, rhizobia and mycorrhiza. A hopeful approach has been engaged to understand how natural selection regulates changes in mutualistic exchanges. An eloquent understanding of basic evolutionary processes can be employed to develop agricultural management practices that favor the most effective symbionts. It has been reported that mutually beneficial interactions between plant and associated rhizospheric microorganisms are ubiquitous which is important for ecosystem functioning. Reports observed that in rhizosphere, symbiotic nitrogen fixation has incurred through bacteria not in order, namely, *Rhizobium*, *Bradyrhizobium*, *Mesorhizobium*, *Sinorhizobium*, *Azorhizobium* spp., and several other so-called rhizobia. In addition, mycorrhizal fungi supply their host plants with mineral nutrients, namely, phosphorus (P) and other benefits.

Glimpses on microbial commune in the rhizosphere: What is the need of rhizobacterial assortment and commune investigation in rhizosphere? (i) Assists in measurement of soil health and biological displacement (ii) Provides commune fingerprinting (iii) Describes niche selectivity and ecological adaptation (iv) A parametric to analyze appropriate inoculants and transgenics in soil (v) Assists in differentiation of viable cells from nonviable.

The microbial commune in the rhizosphere has demonstrated to be a challenging task due to the vast diversity and the atrociousness of the population inhabiting the environment. An investigation has incurred through widespread perturbation of microbial community by changes in environmental conditions and soil management practices. In the present scenario, we should have interest in understanding the cooperative activities among microbial populations and how they affect agroecosystems when applied in agricultural soils.

Based on preceding reports, it has been reported that more than 80% of the terrestrial ecosystem is able to form mycorrhizal association wherein it involves bidirectional flow of nutrients and several other benign properties. In addition, mycorrhizal fungi are able to provide protection to the host plant against root and shoot pathogens.

Glimpses on mycorrhizal commune in the rhizosphere: An importance of mycorrhizal symbiosis! (i) Most of the land plants are mycorrhizal that appx. >80% (ii) Helps in bidirectional flow of nutrients in an ecosystem (iii) C- flow from plant to fungus (iv) ii Mineral flow from fungus to plant (v) An extension of hypha beyond

nutrient depletion zone (vi) An extension into soil pores that helps in nutrients absorption (vii) Shows biocontrol mechanisms against root/shoot and soil pathogens (viii) Antibiosis through antibiotics (ix) Antibiosis through enzyme secretion (x) Induced systemic resistance (xi) Systemic acquired resistance.

Published reports reflect that several mycorrhizosphere bacteria also help in mycorrhiza formation wherein a variety of Gram-positive and Gram-negative strains are involved, the so-called mycorrhiza-helper bacteria (MHB). It was also shown subsequently that in natural agroecosystem, the occurrence of MHB along with diversity of AM fungi is considered as a key contributor to the diversity and productivity of plant community. The symphony of root-inhabiting AM community shows seasonal variation within individual host plants, and this can change with plant maturity. Various farming practices, namely, fertilizer input, cultivation, and fumigation, put forth deleterious effects on AM commune.

Therefore, in the present book, editors compiled research carried out on microbial occurrence and diversity of mycorrhiza, various tools to characterize them, and its impact on soil formation/health together with crop productivity.

Chapter 1 provides glimpses on the mycorrhizal fungi and their prominent role in nutrient transfer into host plants, presenting a view on the application of mycorrhiza for crop biofortification.

Chapter 2 focuses on the role of microorganisms in soil formation and the mechanisms for weathering process employed by such microflora, highlighting the current and advanced molecular approaches for studying soil microbial diversity.

Chapter 3 focuses on the role and significance of AM fungi in phytoremediation of hydrocarbon-contaminated sites. Additionally, metabolite formation during bioremediation of organic compounds is discussed. Furthermore, the factor affecting the bioremediation process is also summarized.

Chapter 4 focuses on crop rotation, soil processing, and other management factors that can affect the level and benefits of mycorrhizas. All field crops are included in the product rotation. To learn more about the benefits of mycorrhizas to field crops, more work should be done on product rotation.

Chapter 5 describes awareness about mycorrhiza utility among policy-makers and agriculturists which is a step toward sustainable agriculture, reforestation, and climate change-resilient farming and enhanced food security.

Chapter 6 represents a systematic review of the role of mycorrhiza in soil genesis using scientometric approach.

Chapter 7 highlights the concept of mycorrhizosphere, xenobiotic metabolism, molecular approaches for detoxifying the organic xenobiotics, and the role of mycorrhizosphere in stabilizing the environment in an eco-friendly way.

Chapter 8 represents definitions, descriptions, and histories of the important allied and/or corollary activities of soil morphology, survey, interpretation, and characterization.

Chapter 9 highlights the positive influence of microbial interactions on plant diseases and plant growth-promoting effect considering updated knowledge.

Chapter 10 describes nutrient development in soil which is carried out via biological transformation through action of microorganism. Without microbes, soil

would be a virtually inert (lifeless) body, but with them, soil is truly a living, dynamic system. Microbes and the humus produced by them work as a glue to hold soil particles together in aggregates, hence improving soil tilth and decreasing soil depletion or erosion.

Chapter 11 focuses on the recent tools and techniques to study the mycorrhizosphere.

Chapter 12 focuses on the present scenario of pedosphere in terms of its structural composition, functions, and the interrelationship of the microflora and microfauna with the different layers of soil.

Chapter 13 focuses on the role of metagenomic analysis in exploring the AM fungi which are the most widespread symbionts in agroecosystems worldwide.

Chapter 14 highlights the mechanisms adapted by AM fungi for the biocontrol of soilborne phytopathogens.

Chapter 15 describes the role of various fungal species for biodegradation and transformation of environmental contaminants by enzymes and biomass.

Chapter 16 aims at dealing with the two processes together and thus has a comprehensive review literature on how this symbiosis drives pedogenesis and determines terrestrial biome of a particular ecosystem.

Chapter 17 focuses on term "phytoremediation" that has got more and more attention over the past decade. Due to the multifaceted applications of AM fungi, it has been widely used as a xenobiotic tool.

Chapter 18 focuses on the importance of mycorrhizal fungi which are nearly an indispensable part of the rhizosphere, because of their immense potential for bringing sustainability and stability in crop production.

Chapter 19 focuses on optimization of crop management practices, agriculture practices which increased proliferation, and diversity of mycorrhizal fungi which in turn increased agriculture production.

Chapter 20 emphasizes the exploration of metagenomics data over recent years, with special reference to extreme habitats that have given access to diverse and novel biocatalysts that may be of great value in mycorrhizosphere and pedogenesis.

Chapter 21 addresses the significance of mineral weathering by microbial interactions and the contribution of plant microbial communities on soil formation through nutrient cycling which further improves the soil functionality.

Chapter 22 deals with the role of microflora and microfauna in soil health and the various roles played by these two groups of organisms.

Chapter 23 focuses on various PCR-based and non-PCR-based molecular techniques that may be utilized to study the microbial diversity and structure within the mycorrhizosphere.

Noida, Uttar Pradesh, India — Ajit Varma
Noida, Uttar Pradesh, India — Devendra K. Choudhary

Contents

About the Editors

Ajit Varma completed his M.Sc. (1959) and Ph.D. (1964) degrees at Allahabad University, Allahabad, India. In the course of his professional career, he has also served as a Microbiologist (Assistant Professor), Indian Agricultural Research Institute (IARI), New Delhi (1963–1971), Senior Microbiologist (Associate Professor), IARI, New Delhi (1971–1974), Associate Professor, Jawaharlal Nehru University (JNU), New Delhi (1975–1984), and Professor, JNU, New Delhi (1985–2004). He has been a Visiting Professor and Visiting Research Scientist at the Technical University, Graz (Austria); University of Tuebingen, Tuebingen (Germany); Friedrich Schiller University, Jena (Germany); Philipps University, Marburg (Germany); Technical University, Munich (Germany); Kingston (Jamaica); Max Planck Visiting Professorship (Germany), Helmholtz Zentrum, Muenchen (Germany); Gutenberg University, Mainz (Germany); Consejo Superior de Investigaciones Científicas (CSIC), Madrid (Spain); University of Dundee (Scotland); University of Ljubljana (Slovenia); and International Centre For Genetic Engineering and Biotechnology (ICGEB) (Italy). His international awards/fellowships include the Commonwealth Fellowship (Australia); National Research Council (Canada); Alexander von Humboldt Foundation (Germany); National Science Foundation (USA); Indo-Czechoslovakia Exchange Programme (Prague); DAAD Fellowship (Germany); the Deutsches BMFT Programme, George-August University, Gottingen (Germany); and RAISA Fellowship. He was awarded a fellowship for Innovative Research in Biotechnology (Italy), Swiss Federal Research Fellowship (Switzerland), the BP Koirala Award (Nepal), and DFG-INSA Fellowship (Indo-Germany), as well as the FAMI Award, Association of Microbiologists of India, and Honorary Diploma, UMF, Cluj-Napoca, Romania. Dr. Varma has successfully completed major projects as PI sponsored by DBT, DST, DRDO, and ICAR. Besides, he has supervised more than 60 Ph.D. students and published over 300 research articles for national and international journals of repute, as well as several major review articles and chapters in books. He has published 90 books in the area of microbial technology, published by Academic Press, London; CRC Press, Florida, USA; IDRC, Canada; and Springer-Verlag, Germany. Dr. Varma has been the series editor for Springer-Verlag's series on soil biology, and has edited 50 volumes on soil biology. He was also nominated as Editor-in-Chief by IK International to make series of books on microbial and

biotechnological research. Dr. Varma has been a member of the National Academy of Agriculture Sciences (FNAAS); International Society of Symbiosis, Boston, USA; Indian Science Congress Association; Executive Council, Amity University Uttar Pradesh; University Research Council, Amity University Uttar Pradesh; Academic Council, Amity University Rajasthan; ASSOCHAM Knowledge Millennium Council, ASSOCHAM Expert Committee on Agriculture and Food Processing; and ASSOCHAM Expert Committee on S&T and Innovation. He has vast experience in organizing national and international training workshops/symposia and congresses.

Devendra K. Choudhary has 16 years of research experience in microbiology and microbial biotechnology. He is an Associate Professor at Amity Institute of Microbial Technology (AIMT). Recently, he was associated with PDM and worked as Professor (Ad hoc) for 3 months. Before joining Amity University, he spent several years in Mody University of Science and Technology (MUST), Lakshmangarh, Rajasthan, preceded by Barkatullah University, Bhopal, as Lecturer cum Scientist. He pursued his Ph.D. in microbiology on July 11, 2005 from GB Pant University of Agriculture and Technology, Pantnagar, preceded by M.Sc. in microbiology from Maharshi Dayanand Saraswati (MDS) University, Ajmer, and qualified CSIR-UGC-NET in 2002. He is an active researcher and operated major projects with worth amount 10 million sponsored by DBT, DST, and SERB, New Delhi, India, as principal investigator and co-investigator. He has involved and contributed in NAAS policy paper number 36 in the year 2006. He has published more than 80 research/review articles along with several book chapters for reputed journals and edited books (Springer, Elsevier, and Taylor Francis/Wiley-Blackwell). He has supervised/supervising 11 research scholars for their doctoral program as supervisor and co-supervisor, wherein 7 have been awarded at MUST and four ongoing at AIMT. In addition, he is a recipient of NASI-membership 2016 along with Indian National Science Academy (INSA) visiting and summer research fellowship-2014, and his team received DR. RS Rana Memorial best research award 2013 sponsored by Association of Microbiologists of India. His team submitted bacteria to public domain and incurred two accession numbers from MTCC, IMTECH for submitted bacterial cultures (MTCC, 12057 & 12058) along with one MCC no 2607. Besides, his team submitted approximately 25 functional bacterial genes and 80 I6S rDNA sequences to National Center for Biotechnology Information (NCBI) with Accession Numbers. In recent times, he has edited seven books through Springer and filed three patents to India Patent Office, New Delhi.