Preface

The coexistence of plant and microbes has had major effects on the development of civilization since humans began to rely extensively on cultivated crops for food, soon after the emergence of agriculture, dating back to about 10,000 years before the present (BP). The refinement of our knowledge on this system is brought about by the interaction between existing social values and the integrity of our measuring tools- with interplay of scientific and philosophical rationale. Thus, the wisdom gained and practices adopted have been passed down through generations. The ecological competence of traditional farmers is now reflected in the resurgence of organic agriculture. The available ancient literature includes the four Vedas, Susruta Samhita, Charaka Samhita, Krishi-Parashara, and Surapala's Vriskshayurveda. This literature is most likely to have been composed between 8000 and 1000 BP. Indeed, ancient civilizations often worshipped the soil as the foundry of life itself. We are becoming increasingly aware that microbes are the basis of the biosphere. The interactions of plant roots with soil microorganisms are spatially and temporally complex; however, it is becoming increasingly apparent that these interactions are fundamental to soil carbon dynamics and the availability of inorganic and organic N to plants. The primary source of mineral nutrients for plants is the decomposition of organic matter by humble soil microbes. The present book on molecular mechanisms of plant and microbe coexistence thus reflects upon the world of microbes in the soil that cause a soil to become biologically alive and assist other organisms in withstanding the rigors of life. We know that microbes inhabitated the Earth long before multicellular life appeared and diversified. Following their appearance, multicellular plants and animals coexisted, interacted and coevolved with microbes. The evolution and activity of all plants and animals has thus been influenced by microorganisms, often as a result of intimate interactions.

We are at a time when the confluence of technological advances and the explosion of knowledge on plant-microbe coexistence will enable significant advances over the next decade. Thus, mechanisms controlling the multiple interactions between plant roots, other organisms and the soil environment are currently arousing great scientific interest. As plant and microbe coexistence research is a true interdisciplinary field of biological and soil sciences, the volume deals with new scientific findings and cutting-edge technologies, including molecular biological and functional genomic approaches. The present book has been organized in four sections, covering molecular mechanisms of plant and microbe coexistence from the point of view of populations, genomes, molecules and methods, respectively. Opening the first section, Chap. 1 provides an overview of plant-associated soil microorganisms and places the other book chapters into perspective. Chapter 2 deals with the role of microbial diversity in enhancing soil and plant health. Chapter 3 seeks to examine the structure of soil microbial communities in the light of evolution. Particular emphasis is placed on the defining role of plant-microbe mutualistic symbioses. Chapter 4 deals with new techniques, based on the genomics of rhizosphere colonization that offer opportunities for greatly expanding our knowledge of signaling, recognition and interaction in the root zone. Chapter 5 describes how the arbuscular mycorrhizal fungi, by maintaining belowground endosymbiosis with the roots of vascular land plants, influence the interactions between their host plant and aboveground insects.

The second section of the book describes the molecular processes that are crucial in establishing successful plant-microbe coexistence. Chapter 6 relates to macromolecular structure and evolutionary genomics, examining how these relate to the evolution of function in transcript RNA and protein molecules. This approach, involving the definition of rooted phylogeny of proteomes and fold architectures, is leading to fundamental understandings on genome coexistence. Chapter 7 highlights the main features of the currently known complete genomes of nitrogen-fixing symbiotic rhizobia, comparisons between these genomes revealing their evolution. Chapter 8 discusses the pathogen stress-induced epigenetic changes occurring in plants as a result of the production of a plant-derived signal, named the systemic recombination signal (SRS), which triggers the destabilization of the somatic and meiotic cell genomes and leads to heritable changes in response to stress. Functional genomics and proteomics are two rapidly expanding research areas. Chapter 9 deals eloquently with recent advances in functional genomics and proteomics of plant-associated microbes which will form the basis for new microbial inoculant-based strategies to combat infectious plant diseases promote plant growth and regulate nutrient supply to plants. Chapter 10 discusses how recent advances in molecular genetics will contribute to our knowledge of biocontrol process, and suggest new avenues for solving intriguing problems that the biocontrol industry faces, like inconsistency in performance of *Trichoderma* spp. under field conditions.

The third section relates to studies indicating a significant role for signaling in successful plant-microbe coexistence. Dedicated studies are needed to unravel the function and mechanism of signaling during the different stages of plant-microbe coexistence. Many Gram-negative, plant-associated bacteria use *N*-acyl homoserine lactone (AHL)-mediated quorum sensing to regulate traits involved in symbiotic, pathogenic or surface-associated relationships with their corresponding host plant. Chapter 11 presents an overview of the diverse phenomena regulated by quorum sensing in representative groups of these bacteria and illustrates the regulatory complexity often associated with these signaling networks. Chapter 12 then synthesizes eloquently the information available on the various types of signaling interactions that occur in the rhizosphere between microorganisms and plants. The investigation of host proteins interacting with viral proteins is a very promising approach to dissect the molecular basis of viral infections and to understand how viruses integrate in the complex structural and regulatory networks controlling plant growth; these plant-viral relationships are examined in Chap. 13. Given the major effects of rhizodeposition on composition and activities of microbial communities inhabiting rhizosphere soil, Chap. 14 discusses the state-of-the-art of studies on microbial activity and microbial diversity in the rhizosphere soil.

The fourth section explores questions related to the extent of diversity within naturally occurring microbial communities and addresses the challenge of studying as yet uncultivable prokaryotes. Techniques as described in methods-based Chaps. 15–18 offer opportunities for greatly expanding our knowledge of interaction of various eukaryotes in the root zone. Chapter 15 sets in motion as an example siderotyping as a particularly promising method for the characterization and identification at the species level of fluorescent and non-fluorescent *Pseudomonas*. Offering simplicity and rapidity of execution, siderotyping could advantageously replace a phenotypic numerical analysis. Chapter 16 deals with recent advances towards understanding oomycetes, which have been facilitated by the development of genomics databases and proteomics-based strategies. These new tools have usefully complemented traditional methods of gene cloning and classical genetics. Advanced molecular methods that can be used to analyze rhizosphere and soil-derived nucleic acids have been described in Chap. 17, along with examples where the use of these approaches has contributed significantly to our understanding of microbial life in soil and of microbial interactions with plants. Chapter 18 concentrates on in-depth morphotyping and molecular methods to characterize the ecto-mycorrhizal fungi. It is anticipated that these methods will allow us to understand the interplay of genes and functions in an ecosystem.

We could not have completed this book without the unflinching cooperation of our invaluable contributors who are authorities from varied background and, despite being heavily occupied, were always willing to accede to our demands to focus on exciting sub disciplines via simple schematic diagrams or at times even sharing their unpublished work. While editing the chapters we have taken care that personal style of the contributors is not influenced by our own. Without the legendary elephantine cool patience and composed posture of Professor Ajit Varma, Series Editor, this book could have remained indefinitely as an idea in our minds. We wish to thank Dr. Dieter Czeschlik and Dr. Jutta Lindenborn, Springer Heidelberg, for excellent feedback and professional support throughout the book preparation process. Jutta deserves special recognition of her very kind and supportive nature. Our thanks are also extended to Puneet S. Chauhan for help in compiling the chapters and those who have participated in the production of this book, whose indispensable help has significantly improved the quality of individual chapters and of the book as a whole, but the mistakes that are left remain our

responsibility. Shekhar in particular is grateful to Professor Y.S. Rajan for writing a poem exclusively for the book despite the fact he is not a biologist but has worked on Indian satellite, launching and space application programmes. Shekhar would like to convey his indebtedness to his wife Manju and daughters Shikha and Isha, and Patrice to his family for their all-time support, encouragement and understanding in the face of lost evenings, weekends, holidays and for the break they gave to us to write uninterrupted. Finally, it is hoped that the excitement and significant opportunities presented in this volume about our newfound understanding of the relationships and the challenges that this brings for studying plant microbial coexistence will stimulate readers to push the field forward to new frontiers.

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October 2007

Springer
http://www.springer.com/978-3-540-75574-6

Molecular Mechanisms of Plant and Microbe
Coexistence
Nautiyal, C.S.; Dion, P. (Eds.)
2008, X, 486 p., Hardcover
ISBN: 978-3-540-75574-6