# Preface

Plants and the associated (micro)-organisms are in constant exchange of information. Those microorganisms may be associated with the host plant on different levels from facultative epiphytic or occasional colonisations to very intimate endophytic symbiosis. The notion that plants and associated microorganisms form stable communities promoted the use of the term holobiont to describe such multi-organismic systems. The exchanged information is usually encoded in different small molecules, polymeric structures and ions. Those are perceived by one or both partners and can influence very profoundly their physiology. The rhizosphere with its dense population of microorganisms is one of the so-called environmental hot-spots, in which interactions between the partners reach a very complex level.

The canonical definition of rhizosphere describes this part of the soil, which is directly influenced by the root system. This influence is the diffusion of root exudates such as sugars, acids, proteins and other low molecular weight organic compounds, together with the resulting chemical and physical changes of the soil structure. By definition the rhizosphere is limited on one side by the rhizodermis. However, since root cells are usually shed and replaced during growth and members of the endophytic community are regularly recruited from the soil, the actual border between the root and the rhizodermis is rather loose. Without doubt, the root surface and the adjoining soil layer are intensively colonized and both the quantity and quality of the colonizing microflora is controlled by the host plant to a significant extend.

This book gathers reviews and opinion papers on diverse aspects of the interactions which occur in the rhizosphere between the host plant and the microorganisms. The various reviews focus on particular phenomena, at the same time they represent the different levels of the interactions, from a biochemical and genetical basis to complex inter-organism communication.

Metabolism, "the underpinning force that sustains life", is the topic of the first chapter. The microbial community with its metabolic potential is shaped by the combination of plant genotype and the physiochemical properties of the soil. In addition, external influences such as climate, the degree of water saturation and anthropomorphic inputs influence metabolism throughout the rhizosphere community. The chapter describes the metabolic functions that occur in the rhizosphere either during bacteria-plant interactions or bacteria-bacteria interactions and discusses the mainly heterotrophic metabolism of organic substrates. The external influences mentioned above require a rapid adaptation to stresses and changing environmental conditions. Plasmids play an important role in bacterial adaptation. Their potential role is described in the second chapter. In the plant environment, plasmids can provide a selective advantage for the host bacteria, for example by carrying genes encoding metabolic pathways, metal and antibiotic resistances or pathogenicity related genes. This chapter provides an update on plasmids and horizontal gene transfer between plant-associated bacteria and their role in plant-bacteria interactions. Furthermore, it describes tools available to study the plant-associated mobilome. As well as microbial physiology and the flexible genetical equipment, the plant's response plays a crucial role in the interaction between the plant host and the associated microorganisms. One of the primary responses to microorganisms is a defense reaction termed microbe-associated molecular pattern (MAMP)-triggered immunity (MTI). Successful pathogens, however, can attenuate MTI by various effectors. This results in effector-triggered susceptibility and disease. Certain host plants have developed mechanisms to detect effectors and can trigger effector-triggered immunity (ETI), thereby diminishing pathogen propagation. Despite the wide acceptance of the above concepts, more and more accumulating evidence suggests that the distinction between MAMPs and effectors and MTI and ETI is often more complicated than originally thought. The following chapter discusses the complexity of MTI and ETI signaling networks and elaborates on the current definitions of MAMPs, effectors, MTI and ETI. It is clear that plant interactions with microorganisms are rarely (if ever) bilateral, rather interaction networks are the reality. One such example is described in the fourth chapter: a tripartite interaction between the host plant, its fungal endophyte and endofungal bacteria. There is increasing evidence that endofungal bacteria, alone or in combination with their fungal hosts, play a critical role in symbioses with plants. This chapter summarizes the current knowledge on endobacteria and their role in different types of fungal symbioses with plants. Since the frequency of bacteria in fungi is generally low, novel technology such as molecular taxonomy and advanced laser scanning microscopy were required to establish the functional contribution of these bacteria in those symbioses. In addition, isolation of those endobacteria permitted the study of the beneficial impact on plant hosts: plant growth promotion and resistance-inducing activity. Plant resistance to pathogens is indeed one of the central determinants of plant-microbe interactions and of the general health of the plant. The latter is strongly influenced by the interactions between pathogens and beneficial microorganisms. The fifth chapter focuses on soil suppressiveness, a phenomenon based on the impact of particular beneficial microorganisms on pathogens. Here, the authors describe soil suppressiveness as a biological tool against phytonematodes and explore the nature of monoculture versus crop rotation in this regard. Also, studies on the induction of the plant defence system and the establishment of so called induced systemic resistance by nematode-associated microbes (bacteria and fungi attached to phytonematodes) are discussed. Finally, this chapter discusses the importance of the knowledge on plant-nematode-microbe interactions in integrated pest management. The level of interaction relevant for agriculture is probably the most challenging to assess. To assure sufficient food production and high quality produce, farmers and relevant commercial companies need to manage quite complex situations. The sixth chapter describes a phenomenon, called apple replant disease (ARD). This is a poorly understood, soil-borne disease, resulting in severe growth suppression and decline in yield and fruit quality. The authors propose a new definition for ARD, highlighting its multiple causes including soil properties, faunal vectors, trophic cascades and genotype-specific plant secondary metabolism, particularly the biosynthesis of phytoalexins. Importantly, culture management with the emphasis on the improvement of soil microbial and faunal diversity as well as habitat quality rather than soil disinfection are suggested as a promising remedy. This accentuates even further the impact of interactions between (micro)-organisms and the plant on the overall plant performance.

Taken together, the exchange of information between the organisms in the rhizosphere not only influences the organisms themselves but also shapes the structure of the communities inhabiting this ecological niche. This impact is observable on different levels. The aim of this volume is to provide insights into phenomena which are exemplary for those diverse types of exchange. Since the advancement of technologies permits very fast progress in this field, it is very probable that the coming years will bring very detailed data on the interaction networks as well as on the possibility of managing the outcome of plant-microbe interactions for our benefit. This type of approach should be of great interest for new agricultural strategies and future plant protection practices.

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