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**S. Gianinazzi, H. Schüepp, J. M. Barea, K. Haselwandter (eds):  
Mycorrhizal technology in agriculture: from genes to bioproducts**

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This book will interest a wide audience. Despite the emphasis in the title on technology, the 16 chapters by more than 60 researchers encompass subjects from the molecular/genetic level to the real-world problems of developing, producing and marketing mycorrhizal plants and biotechnology products. The book is the result of a decade of collaboration in the framework of European Scientific and Technical Cooperation Programs (COST) on arbuscular mycorrhizas. However, this does not make the book interesting only for a European audience. On the contrary, the broad range of subjects treated make it useful for people working with mycorrhizas around the world.

The first chapters are devoted to the relation between mycorrhizas and population ecology. They deal with such fascinating subjects as the rhizosphere of mycorrhizal plants, or the mycorrhizosphere. This complex habitat has effects on plant health and nutrient uptake, as well as on biological, physical and chemical aspects of the soil. A chapter about bacteria associated with mycorrhiza provides exciting data about endosymbiotic bacteria, a subject that is fundamental not only to those doing research on mycorrhiza, but also to those working with rhizobia and other associations between plants and microorganisms. There are chapters on the basis of obligate biotrophy in arbuscular mycorrhizal (AM) fungi and on the development of the fungal mycelium, with a treatment of mechanisms underlying the development of the symbiosis.

The discussion goes to a higher hierarchical level with the chapter by Berta and co-workers, who discuss how the association modifies root systems, a phenomenon with consequences at the community and ecosystem levels. It would be commonplace to say that the mycorrhizal fungal web is the concrete realisation, at least for plants, of Chief Seattle's justified saying that all things are connected through the web of life. The first section of the book unveils some of the factors and mechanisms involved in

this web. In short, in these first chapters, the authors show that plants are not individuals but complex biological systems intimately associated with fungi, and sometimes with other soil organisms, which link them more or less loosely to a great number of other biological systems present in the ecosystem. We have to be aware of these relationships if we are to use biotechnology products with success.

Application of mycorrhizas in plant production and ecosystem management requires a deeper understanding of some basic phenomena involving the symbiosis. This necessitates more specific approaches to elucidate plant genes involved in AM formation and functioning, which are discussed by Gollotte et al. They examine the potential and limitations of targeted and non-targeted molecular techniques to clarify the role of the genes involved. They emphasise how progress in this fundamental field may yield information for plant breeding, which should take into account the functioning and the performance of the mycorrhizal association. At the other end of the scale, D. J. Read authors a short and nicely written chapter pointing to the need for ecosystem-scale testing of hypotheses about the role of AM fungi. He points out a series of factors to be considered, like soil, host, and the soil biota. This chapter points the way for the remainder of the book, more directly dedicated to the applied aspects of knowledge about mycorrhizas.

The following chapters present basic information needed for immediate application, such as the mechanisms of plant defence responses, which have similarities to the induced systemic resistance induced by some rhizobacteria. This may clear the way for a wider use of the association in plant protection and biological control of diseases. Other chapters discuss membrane transport mechanisms, exchange of nutrients and energy between the plant and the fungal partner, and nitrate assimilation and reduction by AM fungi. Clear and direct information is given on the use of arbuscular mycorrhizas in the recovery of degraded areas, revegetation of desertified ecosystems, bioremediation, and control of plant pathogens. The texts integrate basic and applied aspects,

opening the way for local application. Among these chapters, the one by Tsimilli-Michael and Strasser makes an elegant point in integrating the role of mycorrhizas in stress alleviation, putting the establishment of the association in the light of modern non-equilibrium thermodynamics. They show that the introduction of mycorrhizas in a system minimise entropy, that is make the system attain a steady state. This means that a more balanced and healthy ecosystem needs the establishment of the symbiotic association.

In a chapter on AM fungi in low-input agriculture, Atkinson et al. focus on their increasing role as one advances from the intensive high-input systems to more environmentally integrated agricultural systems. This is a chapter where the European approach takes its toll. Whilst one should not expect examples from tropical and subtropical areas, the focus does leave aside procedures such as alley cropping and agroforestry systems, where the mycorrhizal web must have a profound impact. One of the most promising areas for application of mycorrhizal inoculation, namely micropropagation, is discussed in another chapter in terms of strategies for inoculant use and the possibility of building a custom-made rhizospheric community for these plants, through co-inoculation with other beneficial microorganisms. Vosatka and Dodd discuss the factors to be considered, from an ecological point of view, for successful screening and selection of AM fungi, pointing out that the origin of the fungi as well as the purpose intended, should be taken into account. They make a point of asserting that arbuscular mycorrhizal fungi should not be considered solely for their role in plant growth, due to improved nutrition and control of pathogen damage, but also for their role in the improvement of soil physical, chemical and biological properties, and also in promoting plant diversity. A nice chapter

written by Estaún et al. lays out the steps to be followed when selecting AM fungi for field application and this orientation is refined in the next chapter by Feldman and Grotkass. Using their own data, they show that multiplication of AM fungi must be performed in conditions similar to the ones found in the systems into which the AM fungi are to be introduced.

Finally, in the last chapter, people from different enterprises producing inoculants discuss a set of guidelines to bridge the science–business gap. It is encouraging to see that some experienced researchers, like the authors of this chapter, are venturing into the business of bioproducts. They propose a series of guidelines for inoculant quality-control and use, relating such guidelines to current European regulations on validation and certification of agricultural inputs. They suggest a set of “best practices” and propose that small and medium enterprises devoted to production of mycorrhizal inoculants should not just work on a hard-sell approach, but rather offer information and guidance to the producers. This means that the mycorrhizologist community should work towards offering not only a product, but also knowledge about the association.

Researchers, teachers, as well as graduate and advanced undergraduate students will find this inexpensive book a source of useful information, especially for those chapters that explore the latest advances in the field. Professionals in agricultural and horticultural production and landscape and site reclamation will also find it useful for the connection it makes between the fundamental and applied aspects of the AM association. Finally, those working in the biotechnology industry will find specific orientation for production and application of inoculants, as well as guidance for product quality control.