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BOOK REVIEW

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S. Declerck, D.G. Strullu and J.A. Fortin (eds) (2005) In Vitro culture of mycorrhizas

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There is no doubt that this book will interest not only mycorrhizologists, but also more generally, researchers working with obligate plant biotrophic microorganisms recalcitrant to axenic culture in the absence of host roots. This volume of the *Soil Biology* series compiles experts' advice and know-how in the use of in vitro cultivation methods in AM symbiosis research. It consists of 17 chapters, which address a wide range of mycorrhiza-related features, including germplasm collection, systematics, life cycle, ecology, physiology, metabolism, and industrial production of AM fungi, which illustrate monoxenic cultivation as a multidisciplinary research tool. An introductory chapter on the state of the art by Fortin and collaborators presents a very comprehensive summary of each section, which mainly addresses author-highlighted results, hypotheses, or comments. With regard to the numerous terms employed in the literature to designate in vitro culturing of AM fungi, Fortin et al. propose a very useful definition, which merits to be retained as reference: "A monoxenic culture of an AM fungus is a reproducible and contaminant-free, in vitro coculture between a root organ and a glomalean species. A root–organ culture is the indefinite culture on a synthetic medium of a transformed or non-transformed, excised root."

Most of the chapters focus on culturing of AM fungi and mycorrhizal symbiosis. As specified in the chapter by Bago and Cano, Mosse and coworkers were pioneers in monoxenic culturing of AM fungi, the first report of in vitro coculture of *Endogone mosseae* now being 30 years old (Mosse and Hepper 1975). While addressing systematics and biodiversity of AM fungi, Dalpé et al. underline that monoxenic culturing is not aimed at mimicking natural ecosystems but at providing a tool to dissect their complexity and to test hypotheses. Monoxenic cultures were proven suitable for AM research, and Bago and Cano provide very elegant demonstrations of the use of this technique. These authors have shown for the first time that branched absorbing structures (BAS) are not artifacts formed under in vitro conditions. Because of the common features shared between arbuscules and BAS, they have proposed that they are homologous structures. The potential user of AM monoxenic culture will find helpful tips in this contribution to avoid misuses of this system. In the chapters by Dalpé et al. and de Souza et al., the comparison of in vitro life histories of *Glomus* and *Gigaspora* species leads the authors to suggest that they have evolved different ecological adaptive strategies. Gigasporaceae are proposed to be adapted to live in stable ecosystems, where competition is high for resources, and somatic growth rather than reproduction is favored (de Souza et al.). On the contrary, members of the Glomeraceae are more adapted to perturbed environments in which resources are available, favoring reproduction. Addressing the question of environmental factors that affect presymbiotic hyphal growth and branching in vitro, Nagahashi and Douds hypothesize the existence of two types of hyphal stimulators, one inducing elongation growth and another being responsible for hyphal branching. In a following chapter, Vierheilig and Bago further underline the importance of root exudates favorable to AM fungi for successful establishment of mycorrhiza. In their chapter, Grandmougin-Ferjani et al. propose a pathway for sterol biosynthesis in *Glomus intraradices* and point out the usefulness of monoxenic cultures to address such metabolism. Furthermore, fungal uptake of elements other than phosphorus, including radionuclides, and sequestration by the extraradical mycelium (ERM) can be demonstrated using bicompartmental monoxenic cultures (Rufyikiri et al.).

Regarding interactions of AM fungi with other soil inhabiting organisms, St. Arnaud and Elsen illustrate how the use of bicompartmental monoxenic cultures could be a prerequisite step to select organisms for biocontrol strategies, while Desjardins et al. report how the use of tripartite culture systems have also proved useful to test the hypothesis that AM fungal colonization in vitro could provide stress tolerance during acclimation ex vitro. Taken together, these different chapters also highlight the ecological

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significance of mycorrhizal associations with regards to plant fitness and soil bioremediation. Ectomycorrhizal (ECM) fungi can undergo saprophytic growth under axenic conditions, but they cannot complete their life cycle in the absence of a host plant. Consequently, root organ cultures in ECM research have also proved useful to test the extent to which saprophytically grown fungi differ from symbiotically cultivated ones (Coughlan and Piché). This technique was also used to reinvigorate ECM isolates, to acclimatize vitroplants to be colonized by ECM fungi, and to cultivate edible ECM fungi such as *Tuber* species (Giomaro et al.). Interestingly, this book also includes a chapter concerning *Geosiphon pyriformis*, a glomeromycotan fungus that forms endosymbiosis with Cyanobacteria (Schüßler and Wolf). From the detailed description of this interaction, the authors suggest that it could be a model for AM symbiosis. Likewise, members of the Sebacinaceae are presented as culturable mycorrhiza-like endosymbiotic fungi by Prasad et al.

From a biotechnological viewpoint, monoxenic cultures also have several advantages over conventional pot culture systems regarding inoculum and mass production of AM fungi, and this has been reported for several species (Adholeya et al.). Finally, a very comprehensive description of methodologies and protocols for in vitro cultivation of AM fungi is presented, which will be very useful for researchers intending to develop their own monoxenic cultures (Cranenbrouck et al). In conclusion, this book will be useful to researchers envisaging in vitro systems for conservation, production, and studies of mycorrhizal fungi. Provided that future users keep in mind recommendations made by Bago and Cano concerning the relevance of in vitro grown mycorrhiza generated data, root organ culture-based methods are likely to provide additional knowledge concerning interactions between plant roots and biotrophic microorganisms.