Chapter 3

ARBUSCULAR MYCORRHIZAL FUNGI AS POTENTIAL BIOPROTECTANTS AGAINST PLANT PATHOGENS

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Abstract: Arbuscular Mycorrhizal (AM) fungi are ubiquitous and form symbiotic relationships with roots of most terrestrial plants. Their associations benefit plant nutrition, growth and survival due to their enhanced exploitation of soil nutrients. These fungi play a key role in nutrient cycling and also protect plants against environmental and cultural stresses. The establishment of AM fungi in the plant root has been shown to reduce the damage caused by soil-borne plant pathogens with the enhancement of resistance in mycorrhizal plants. The effectiveness of AM fungi in biocontrol is dependent on the AM fungus involved, as well as the substrate and host plant. However, protection offered by AM fungi is not effective against all the plant pathogens and is modulated by soil and other environmental conditions. AM fungi generally reduce the severity of plant diseases to various crops suggesting that they may be used as potential tool in disease management. AM fungi modify the quality and abundance of rhizosphere microflora and alter overall rhizosphere microbial activity. These fungi induce changes in the host root exudation pattern following host colonization which alters the microbial equilibrium in the mycorrhizosphere. Given the high cost of inorganic fertilizers and health hazards associated with chemical pesticides, AM fungi may be most suitable for sustainable agriculture and also for increasing the yield of several crops through biocontrol of plant pathogens. This chapter provides an overview of mechanisms of interaction which take place between soil-borne plant pathogens and AM fungi on different plants. The availability of new tools and techniques for the study of microbial interactions in the rhizosphere may provide a greater understanding of biocontrol processes in the near-future.

Keywords: Arbuscular mycorrhiza; biocontrol; plant diseases; plant pathogens; rhizosphere.

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1 INTRODUCTION

Arbuscular mycorrhizal (AM) fungi occur over a wide range of agroclimatic conditions and are geographically ubiquitous. They form symbiotic relationships with roots of about 90% land plants in natural and agricultural ecosystems (Brundrett, 2002). The AM association has been observed in 200 families of plants representing 1,000 genera and about 300,000 plant species (Bagyaraj, 1991). It is as normal for the roots of plants to be mycorrhizal as it is for the leaves to photosynthesize (Mosse, 1986). The AM fungi are included in the phylum Zygomycota, order Glomales (Redecker et al., 2000) but recently they have been placed into the phylum ‘Glomeromycota’ (Schussler et al., 2001). The Glomeromycota is divided into 4 orders, 8 families, 10 genera and 150 species. The common genera are Acaulospora, Gigaspora, Glomus and Scutellospora (Schussler, 2005). They are characterized by the presence of extra radical mycelium branched haustoria-like structure within the cortical cells, termed arbuscules, and are the main site of nutrient transfer between the two symbiotic partners (Hock and Verma, 1995; Smith and Read, 1997). AM fungi colonize plant roots and penetrate into surrounding soil, extending the root depletion zone and the root system. They supply water and mineral nutrients from the soil to the plant while AM benefits from carbon compounds provided by the host plant (Smith and Read, 1997; Siddiqui et al., 1999). AM fungi are associated with improved growth of host plant species due to increased nutrient uptake, production of growth promoting substances, tolerance to drought, salinity and synergistic interactions with other beneficial microorganisms (Sreenivasa and Bagyaraj, 1989). The soil conditions prevalent in sustainable agriculture are likely to be more favorable to AM fungi than are those under conventional agriculture (Bethlenfalvay and Schuepp, 1994; Smith and Read, 1997).

Any agricultural operation that disturbs the natural ecosystem will have repercussions on the mycorrhizal system (Mosse, 1986). The preceding crops affect growth and yield of subsequent crops (Karlen et al., 1994). The inclusions of non-mycorrhizal crops within rotations decrease both AM fungal colonization and yield of subsequent crops (Douds et al., 1997; Arihawa and Karasawa, 2000). In addition to crop sequence, varietals selection, cultivation and fallowing have been shown to affect mycorrhizal activity (Ocampo et al., 1980; Hetrick et al., 1996; McGonigle and Miller, 2000). However, impact of soluble fertilizers on colonization and function of AM fungi is contradictory. The application of soluble phosphorus decreased root colonization (Abbott and Robson, 1984) with occasional reports of increases (Gryndler et al., 1990). Similarly, contradictory results have also been reported with nitrogen fertilizer (Baltruschat and Dehne, 1988; Gryndler et al., 1990; Liu et al., 2000). Therefore, uses of AM fungi in the biocontrol for