JOURNAL OF PURE AND APPLIED MICROBIOLOGY, October 2011. Vol. **5**(2), p. 937-940

Biological Control Mechanisms of Mycorrhiza in Plant Disease Management

Gurupad B. Balol*, B.L. Raghunandan[1], M. Raaghavendra[1], B.L. Divya[2], Y.S. Mahesh[2] and Shilpa D. Hucchannavar[3]

*Department of Plant Pathology, UAS, Dharwad - 580 005, India.
[1]Department of Agricultural Microbiology, [2]Department of Plant Pathology,
[3]Department of Food science and Nutrition, UAS, GKVK, Bangalore - 65, India.

(Received: 10 December 2010; accepted: 18 January 2011)

Plant diseases need to be controlled to maintain the quality and abundance of food, feed and fiber produced globally. Different approaches may be used to prevent, mitigate or control plant diseases. The symbiotic association of various genera of arbuscular mycorrhizal fungi with medicinally important plants and their role as biofertilizers for promoting plant growth through increased uptake of water, phosphorus and other nutrients and as a biological control of soil-borne diseases is recognized as well. It was found conclusive that VAM are effective in suppression of root disease, particularly those caused by nemetodes, fungi and bacteria.

Key words: Plant pathogens, Mycorrhizae, Disease management, Inoculation, Biocontrol.

Frank (1885) coined the term "Mycorrhiza". Mycorrhiza literally means 'Fungus roots' which arise from the mutualistic symbiosis between roots and certain fungi. Mycorrhizal fungi have evolved in association with plants, acting to greatly increase the ability of plants to take up water and certain nutrients, while often protecting associated plants from pests and diseases. They live in and around the root zone of plants, extending far out from the plant's roots with their own network of thread-like filaments known as hyphae. They are known to improve the nutritional status of plants and growth and development, protect plants against root pathogens and confer resistance to drought and soil salinity conditions.[1] The symbiotic association of various genera of arbuscular mycorrhizal fungi (e.g. *Acaulospora*, *Glomus*, *Gigaspora* and *Entrophospora*) with medicinally important plants and their role as biofertilizers for promoting plant growth through increased uptake of water, phosphorus and other nutrients and as a biological control of soil-borne diseases is recognized as well. [2] Studies suggest that AM fungal taxa vary in their ability to protect host plants against pathogens.[3] Therefore, it is plausible that assemblages of AM fungi derived from multiple species may exhibit greater potential to protect host plants against pathogens than a single AM fungal species.[4]

* To whom all correspondence should be addressed.
Mob.: +91-9986784979
E-mail: gurupadbalol@gmail.com

VAM in bio -control

Crop	Pathogen	Vam
Cotton	Theilaviopsis basicola	Glomus mossae
Tomato	*F.oxysporum f*.sp.*lycopersici*	*G. fasiculatum*
Mung bean	*Rhizoctonia solani*	*Glomus* spp
Chick pea	*F oxysporum* f.sp.*ciceri*	*Glomus* spp
Wheat	*Geaumannomyces graminis* var. *tritici*	*G. fasiculatum*
Soybean	*Macrophomina phaseolina*	*G. mossae*
Groundnut	*Sclerotium rolfsii*	*G. fasiculatum*
Tomato	*Pythium aphanidermatum*	*G. fasiculatum*
Pea	*Aphanomyces euteiches*	G. fasiculatum
Rice	R. solani	*G. mossae*
Maize	*Fusarium moniliformae*	*G. fasiculatum*
Chick pea	*Sclerotium rolfsii*	*G. fasiculatum*
Mung bean	*M. phaseolina*	*G. fasiculatum*
Cowpea	*M. phaseolina*	*G. fasiculatum*

Mechanism of VAM

Increased root growth and function: VAM fungi through an increase in P nutrition enhance root growth, expand the absorptive capacity of the root system for nutrients and water and affect cellular processes in roots. Thus they will compensate for the loss made by the pathogen.[5]

Nutrition effects other than P: VAM fungi can enhance the uptake of Ca, Cu, Mn, S and Zn in addition to P. Thus VAM fungi may increase host tolerance to pathogens by increasing uptake of essential nutrients other than P that would be deficient in a non mycorrhizal root.[6, 7]

Alteration in root exudation: Changes in the exudation pattern can affect fungal spore germination and root penetration. Enhanced P status of the plants due to VAM infection caused a decrease in the root exudates used by the pathogen for spore germination and infection and thus reduce the pathogen population

Competition for host photosynthates: VAM Fungi are totally dependent on soluble carbohydrates produced by the host for their carbon source. Hence competition takes place between the VAM Fungi and pathogen for nutrients.[8]

Competition for space (or) infection sites: Because VAM fungi, soil borne fungal pathogens and plant parasitic nematodes occupy similar root tissues; direct competition for space has been postulated as a mechanism for pathogen inhibition by VAM fungi.[9]

Morphological changes

VAM fungi may induce morphological changes such as lignification and wound barrier formation that accounted for the inhibition of some of the soil born plant pathogens like *Fusarium oxysporum* f.s*p lycopersici* and *Thielaviopsis basicola*.

Changes in chemical constituents of plant tissues: Dehne *et al* found increased concentration of chitinase in VAM roots, which accounted for the inhibition of *Thielaviopsis* sporulation. Similarly some of the phytoalexin like Glyceollin, Coumestrol and Diadzein were found in the VAM roots of soyabean. This shows such materials account for increased resistance to fungal pathogens compared to non VAM plants.[10]

Alleviation of Abiotic stress

VAM fungi increase plant tolerance to nutritional stress, soil drought and soil toxicities by absorption of nutrients like P, Cu and Zn and water through extra radical hyphae. Thus plant can resist against this abiotic stress.

Microbial changes in the mycorhizosphere

VAM fungi alter the population of beneficial microorganisms, some of which can antagonize root pathogens. For example sporangium and zoospore production by the root pathogen *Phytophthora cinnamomi* was reduced in the presence of rhizosphere leachates of VAM Plants. VAM fungi are highly rhizosphere competant and are compatible with antagonist and even function in concert with them.

ECTO mycorrhiza in bio-control

Crop	Pathogen	Mycorrhizae
Spruce	*Rhizoctonia* spp	*Pisolithus* spp
Pines	*Rhizoctonia solani*	*Pisolithus tinctorius*
Pines	*Pythium* spp	*Scleroderma bovista*
Pines	*Rhizoctonia* spp	*Suillus granulates*
Sand pine	*Phytophthora cinnamomi*	*Pisolithus tinctorius*
Pine	*Phytophthora cinnamomi*	*Pisolithus tinctorius*
Fir	*Fusarium oxysporum*	Laccaria laccata
Pines	*Fusarium oxysporum* f.sp. *lini*	*Paxillus involutus*
Douglas fir	*Fusarium oxysporum*	*Laccaria bicolor*
Eucalyptus	*Pythium* spp	*Pisolithus tinctorius*
Picea abies	*Fusarium* spp	*Hebeloma* spp

Mechanism ECTO mycorrhiza in bio-control

Utilization of surplus carbohydrates: Mycorrhiza utilizes the carbohydrate present in the root and thus the pathogen cannot able to get enough amounts of nutrients for their growth and it will not affect the root.

Production of antibiotics

Some of the mycorrhiza like *Amanita caesaria, Boletus edulis, Coenococcum graniformae, Lactarius* sp, *Scleroderma bovista* produce antibiotics which are having antifungal and antibacterial activities. Marx and Davey (1969) extracted diatretyne nitrile and diatretyne 3 from mycorrhizae formed by *Laccaria cerialis* var *piceina* on pines seedlings.

Mechanical barrier created by fungal mantle

The fungal mantle of mycorrhizae creates a unique and totally different type of obstruction of pathogens attempting penetration. In mature mycorrhizae the mantles are composed of tightly inter woven hyphae often in well-defined layers which usually completely cover the root meristem and cortical tissues. The thickness of mantle varies from 20-80 mm. The Hartignet surrounding the cortical cells may function as additional physical barrier.

Chemical inhibitors produced by host

Plant cell exposed to mycorrhizal association produce some of the chemical substances *viz*., orchinol, coumarin, sesquiterpines, isobutanol and isobutyric acid which are having anti fungal properties. Eg. *Boletus edulis* - isobutanol and isobutyric acid.

Protective microbial rhizosphere population

The microbial rhizosphere populations of mycorrhizal roots were different from that of non-mycorrhizal roots. *Pythium* and *Fusarium* are completely absent from the rhizosphere of mycorrhizae. Mycorrhizal roots supported only some the non-pathogenic fungi. This shows mycorrhizae have an inhibitory effect of pathogen on the root surface.

Synthesis of plant growth regulators

Mycorrhizae synthesis some of the plant growth regulators like auxin, ethylene etc. These substances will enhance the growth of the plants and thus compensate for the loss made by the pathogen.[11]

CONCLUSION

The use of mycorrhizal fungi for biocontrol of plant pathogens is relatively new and is a non-chemical method of disease control. The combination of bio control agents -VA mycorrhizal fungi may be applied to plants as dual inoculum to accomplish the dual purpose of increased plant growth and health and has even become essential for the survival of certain types of plants. Avocados, bamboos, bananas, cassava, coconuts, coffee, mahogany, mangoes, palms, papayas, soybeans, and sweet potatoes are just a few examples of plants that benefit from mycorrhizae. There is evidence that VAM are effective in suppression of root disease, particularly those caused by nemetodes, fungi and bacteria.

REFFERENCES

1. Bagyaraj, D.J. and Varma, A., Interactions between arbuscular mycorrhizal fungi and plants: their importance in sustainable agriculture in arid and semiarid tropics. *Advances in Microbial Ecology* 1995; **14**: 119–142.
2. Babu, K.S. & C. Manoharachary. Occurrence of arbuscular mycorrhizal fungi in rhizosphere soils of some medicinal plants. *Indian Phytopathology* 2003 **56**: 223-227.
3. Sikes, B.A., K. Cottenie and J.N. Klironomos, Plant and fungal identity determines pathogen protection of plant roots by arbuscular mycorrhizas. *J. Ecol*., 2009; **97**: 1274-1280.
4. Maherali, H. and J. Klironomos, Influence of phylogeny on fungal community assembly and ecosystem functioning. *Science*, 2007; **316**: 1746-1748.
5. Abdel-Fattah, G.M. and Y.M. Shabana, Efficacy of the arbuscular mycorrhizal fungus *Glomus clarum* in protection of cowpea plants against root rot pathogen *Rhizoctonia solani*. *J. Plant Dis. Prot.*, 2002 **109**: 207-215.
6. Shaul-Keinan, O., V. Gadkar, I. Ginzberg, J. Grünzweig and I. Chet *et al*., Hormone concentrations in tobacco roots change during arbuscular colonization with *Glomus intraradices*.*NewPhytol.*,2002 **154**: 501-507.
7. Aysan, E. and S. Demir, Using arbuscular mycorrhizal fungi and *Rhizobium leguminosarum*, *Biovar phaseoli* Against *Sclerotinia sclerotiorum* (Lib.) de bary in the common bean *Phaseolus vulgaris* L.). *Plant Pathol. J*., 2009; **8**: 74-78.
8. Whipps, J.M., Prospects and limitations for mycorrhizas in biocontrol of root pathogens. *Can. J. Bot*., 2004; **82**: 1198-1227.
9. Vigo, C., J.R. Norman and J.E. Hooker, Biocontrol of the pathogen *Phytophthora arasitica* by arbuscular mycorrhizal fungi is a consequence of effects on infection loci. *Plant pathol.*, 2000; **49**: 509-514.
10. Pozo, M.J., C. Cordier, E. Dumas-Gaudot, S. Gianinazzi, J.M. Barea and C. Azcon-Aguilar, Localized versus systemic effect of arbuscular mycorrhizal fungi on defence responses to *Phytophthora* infection in tomato plants. *J. Exp. Bot.*, 2002; **53**: 525-534.
11. Frankenberger, Jr. W.T. and M. Arshad, Microbial Synthesis of Auxins. In: Phytohormones in Soils, Frankenberger, Jr. W.T. and M. Arshad (Eds.). Marcel Dekker Inc.NewYork,USA., 1995; pp:35-71.