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Arbuscular Mycorrhizal Fungi in Plant Disease Management

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SUMMARY

Micro-organisms antagonistic to plant pathogens may be derived from the resident microbial community or may be of foreign origin. Arbuscular mycorrhizal fungi (AMF) form one such group of organisms that can act as bioprotectors of plants. These zygomycetous fungi that form specialized structures such as arbuscules and/or vesicles are obligate biotrophs and utilize host photosynthates for their growth. They are ubiquitous and co-exist with over 80% of terrestrial plants including agricultural or horticultural crops. An incompatible association between the host plant and the indigenous AMF community can lead to serious losses in crop yields, indicating the significance of AMF in crop production.

INTRODUCTION

Fungi, bacteria, viruses and plant parasitic nematodes cause a great threat to the world agriculture; as these cause an annual losses to the tune of 1000 million US $ in cereals and other crops. Indiscriminate use of chemicals *viz*; fungicide, bactericide, nematicide and pesticide to protect the crops causes a global concern on bio-degradation, ground water pollution and high residual toxicity in human and animal health hazards. Keeping this in view, the novel eco-friendly approach of managing the plant diseases; through mycorrhiza played an important role. The use of mycorrhizal fungi in biological control of plant diseases is a fascinating and challenging field of research. Over 90% of the 300,000 sp. of vascular plants in the world are associated with Vesicular- Arbuscular Mycorrhiza (VAM) (Kendrick and Berch, 1985).

What are mycorrhiza?

The word Mycorrhiza originated from the Greek word “Mykes” means “fungus” and “Rhiza” means “roots”. Mycorrhiza is a symbiotic mutualistic relationship between special fungi and higher plant roots. Since, the association is mutualistic, both organisms gets benefits from the association.

Classification of mycorrhiza

Schenck and Perez (1988) have reported 140 sp. of Mycorrhiza and classified them on the basis of characteristic of spore formation, spore morphology, spore bearing structures, ornamentation and germination. Further Almeida (1989) reported 150 sp. of Mycorrhiza in the world belongs to phylum: *Zygomycetes*, order: *Glomus*, Family: *Glomaceae*, *Acaulosporaceae*, *Gigasporaceae* and *Endogonaceae* having 8 different genera.

Types of mycorrhiza

There are five types of Mycorrhiza viz. Ectomycorrhizae, Endomycorrhizae (VAM), Ect-endomycorrhizae, Ericaceous mycorrhizae and Orchid mycorrhizae. Among them two main types of mycorrhizae are listed below have great significance in agriculture.

Ectomycorrhizae (Ectotrophic types)

It causes a drastic change in the root shape. The ectomycorrhizal fungus penetrates between the cell wall of the cortex and forms a covering sheath or mantle of fungal hyphae around the root. The fungal partner of the symbiosis in ectomycorrhizal belongs to Basidiomycota and Ascomycota. They are found in roots of trees such as Pines, Birches and Oaks.

Endomycorrhizae (Endotrophic types/ VAM)

Such fungi do not form a mantle over the root and the fungus actually enters within the root cortical cell. They are also known as a Vesicular Arbuscular Mycorrhizae (VAM). They are found in most cereals, legumes, vegetables and fruit crops. It is characterized by the presence of arbuscules in the region of root cortex; vesicle may or may not be present; and may function as a reserve organ.

Fig. Ectomycorrhizae

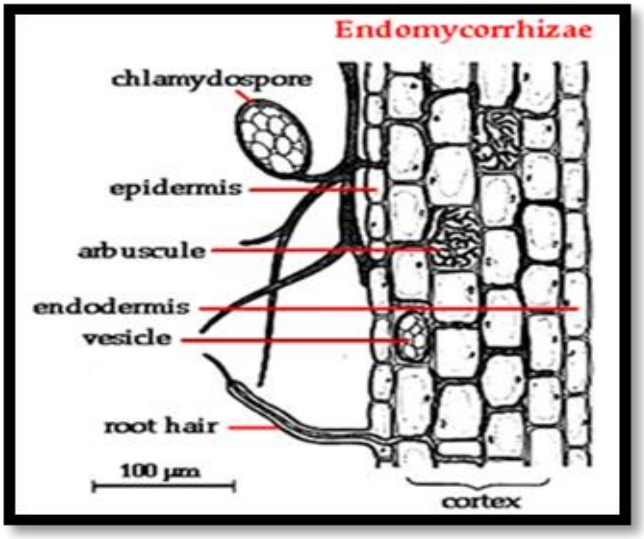
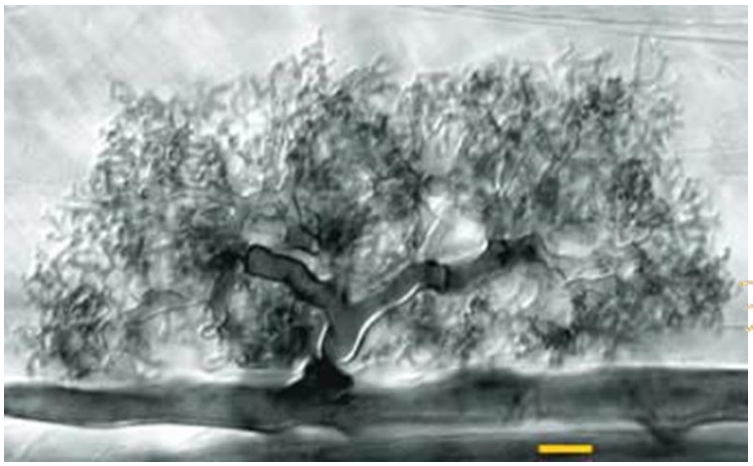


Fig. Endomycorrhizae



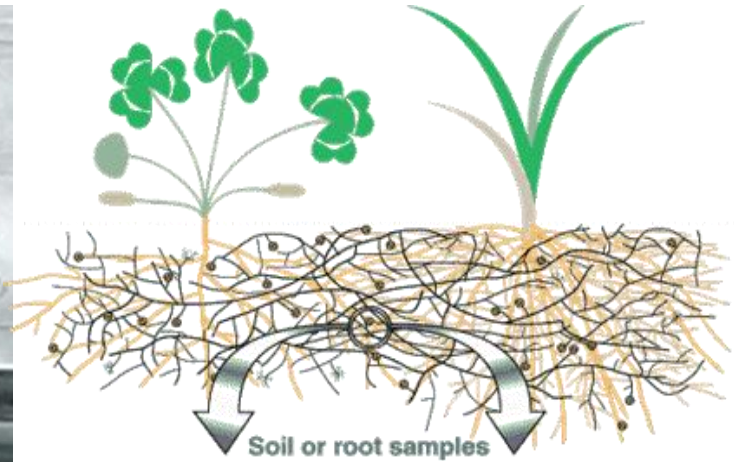


Fig. Arbuscules

Vesicles: Vesicles are thin or thick walled, spherical to oval in shape, borne at the tip of hyphae growing intercelluraly in the cortical region which serve as food storage organ as well as reproductive structure of the fungus.

Arbuscules: Arbuscules are minute, tree like, dichotomously hyphal branched much like haustoria which grow intercelluraly in the cortical cell. It helps in absorbing nutrients from the plant cell and also releases mineral elements for the plants.

Modes of mycorrhizae-mediated disease control

1. Host nutritional effects
a. Improved plant nutrition
b. Tolerance to pathogen
c. Qualitative and quantitative alterations in pathogen biomass
2. Competition for nutrients
3. Physiological and biochemical alterations of the host
a. Systemic-induced resistance
b. Phytoalexins and phytoanticipins production
c. Hydrolases
4. Antibiosis

Importance of mycorrhiza

- Increase overall absorption capacity of roots.
- Increase mobilization and transfer of nutrients from soil to plants.
- Better development of P- solubilizing bacteria.
- Increase establishment, nodulation and atmospheric N fixation capacity of plants in legumes.
- Modification of plant pathogen relations.
- Secretion of antibiotics.
- Increase production of plant growth hormones.
- Nutrient transfer dead to living plants.
- Some ECM and ericoid fungi have the capacity to breakdown phenolic compounds in soils which can interfere with nutrient uptake.
- Root colonization by ECM and VAM fungi can provide protection from parasitic fungi and nematodes.
- Mycorrhizal benefits can include greater yield, nutrient accumulation, and/or reproductive success.
- Networks of hyphae supported by dominant trees may help Seedlings become established or contribute to the growth of shaded plants.
- Suppression of competing non host plants by Mycorrhizal fungi has been observed.

Methods of VAM inoculation

- Pre inoculated transplant
- Direct incorporation in seed furrows
- Fluid drilling
- Seed pelleting
- Multi seeded pellet
- Highly infective soils with VAM

Mycorrhiza as a bio-control agent for

a. Fungal diseases

Interaction of *Glomus etunicatum* + *Macrophomina phaseolina* + Carbendazim seed treatment gave minimum root- rot (*M. phaseolina*) incidence (5%) of cowpea and also observed that the inoculated (*G. mosseae*) plants gave less incidence (11%) of wilt as compared to uninoculated (non-mycorrhizal) plants (46%). Whereas, inoculation of VAM alone gave complete control of wilt incidence in 3 genotypes JG-62, K 850, WR-315 of chickpea. However, application of mycorrhizae along with soil solarization and seed dressing chemical carbosulfan (3% w/w) gave lower wilt incidence (7.78%) and root- knot index (2.33), respectively in chickpea (Rao *et al.*, 1995).

Rhizome rot of ginger (*Pythium aphanidermatum)* could be effectively controlled by native arbuscular mycorrhizal fungi (*Glomus* spp.). While, wilt pathogens *viz. Fusarium, Cephalosporium* and other parasitic fungi are reduced in rhizosphere soil of VAM infected sugarcane plants as compared to rhizosphere soil of VAM free plants. Moreover, black pepper plant inoculated with AMF (*G. monosporum*) showed higher root colonization (88%) and resulted in minimum foot rot incidence (16%) which followed by *Glomus etunicatum* (81%). Interestingly, lower (44.8%) wilt of trees in a combination with 5.0kg VAM + 20 kg FYM which gave 85 per cent colonization of VAM as compared to control (100% wilt) and 50 per cent colonization in guava. reported the lowest root necrosis (29% RNI) in the plant inoculated with (*Glomus* spp.) whereas; few differences were observed between the three other *Glomus* strains (37 to 40% RNI) in banana crop (Declerck *et al*., 2002).

AMF isolates M_9 gave complete reduction of damping-off (*Pythium aphanidermatum)* of chilli, which was at par with M_8 (7.4 PDI). reported that VAM inoculation has enhanced shoot and root length (27.50 & 30.20 cm, respectively) and reduced the severity of *Fusarium* wilt by 40 per cent, that also reported that decreased per cent disease index (14.50 and 22.33 at 2^{nd} and 4^{th} week after sowing) of early blight of tomato. Plant inoculated

with *G. fasciculatum* and *G. monosporum* gave minimum infection and mortality per cent (8.3 and 33.3%, respectively) in a foot rot (*Phytophthora capsici*) disease of blackpepper (Shivprasad *et al.*, 2006).

b. Nematode diseases

Plant inoculated with *G. mosseae* along with carbofuran @ 2kg a.i. /ha reduced the gall formation (5.2%), highest per cent colonization (83%) and effective against root-knot nematode (*Meloidogyne incognita*) of tomato under field conditions. However, inoculation of *G. fasciculatum* in tomato plants significantly reduced the number of root- knot galls (0.0) of *Meloidogyne javanica* and *M. incognita* followed by *Glomus* spp. + *Meloidogyne* spp. Integration of *G. fasciculatum* with *Verticillium chlamydosporium* gave maximum shoot and root weight (412 and 128 gm) and lower number of nematodes (76 & 82, respectively) in 5gm of root and 100cc of soil, there by resulted in maximum fruit yield (7.9 kg/plot) and maximum root colonization of *G. fasciculatum* (48%) along with reduction in number of galls (52/10 seedlings) in brinjal. Whereas, inoculation of *Glomus* spp. alone has effectively controlled the nematode population and number of eggs/egg masses, increased the per cent root colonization of VAM (46.1%) and no. of mycorrhizal spores/50g soil, which were followed by *G. mosseae* in cotton (Rao *et al*., 1995; Bagyaraj *et al.*, 1999)).

Application of VAM + Carbofuran @ 1.5 kg a.i. /ha effectively reduced root-knot index (2.0), initial and final nematode population (291.5 & 127.3/250cc of soil, respectively) and gave 75 per cent reduction over control in brinjal. Moreover, inoculation of *G. fasciculatum* @ 12g/hill along with soil solarization with 400 gauge LLDP and seed treatment with carbosulfan @ 3% W/W gave maximum seedling emergence of 88.33 per cent in chickpea (Rao and Krishnappa, 2004).

CONCLUSION

Different species of mycorrhizal fungi viz. *Glomus fasciculatum, G. monosporum, G. etunicatum* differ in their ability to manage the fungal and nematode diseases in plants. After application of VAM fungi the inoculum multiplies in the rhizosphere, decrease the population of targeted pathogen and survive in the root-zone area. Pre-inoculation with VAM fungi was found effective in reducing disease severity and enhanced the nutrient absorption capacity and improved the vigour of the plants.

FUTURE THRUST

- Genetic transformation of ectomycorrhizal fungi has been accomplished for at least one species.
- Demonstration of benefits of VAM fungi under field condition.
- Existing VAM propagules can be restored by means of good agronomical practices.
- Inhibition of nematode parasitism by incorporation of capability to develop nematicide or nematostatic gene products.
- Development of feasible method for large- scale production of VAM inoculum.
- Study on parasitic ability of VAM fungi.
- Study on impact of biotic and abiotic factors affecting VAM in rhizosphere.

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