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MYCORRHIZA: ITS ROLE IN PLANT GROWTH AND SOIL FERTILITY

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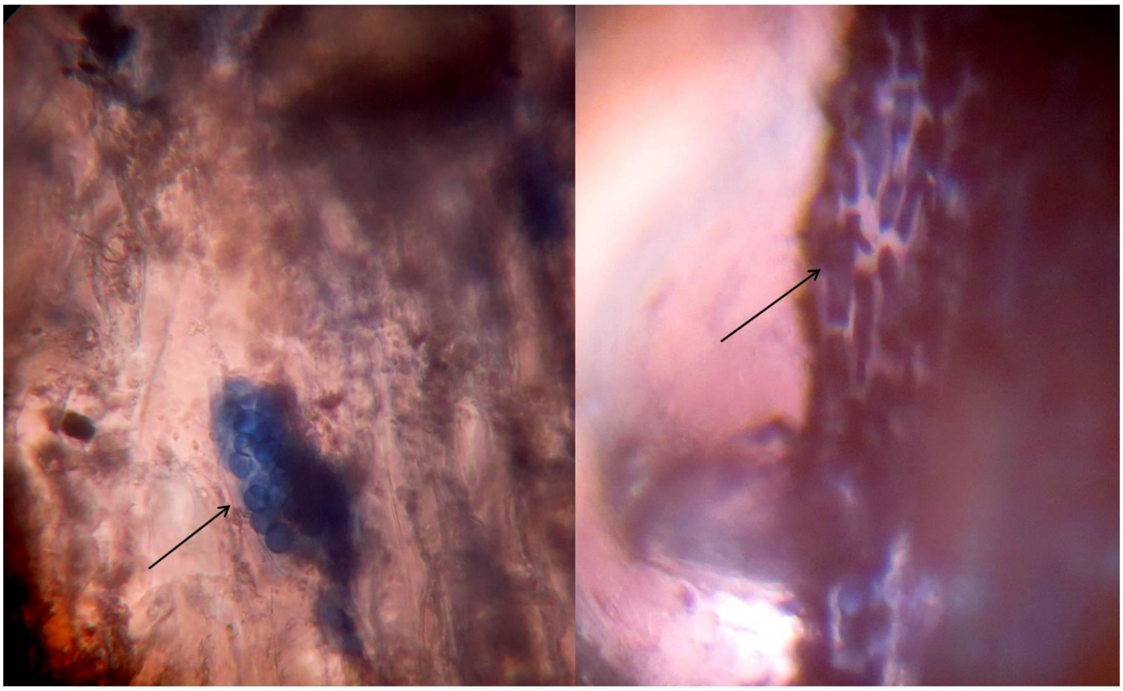
The term "Mycorrhiza" meaning fungi to the root was coin by Frank in 1885. Mycorrhiza is ubiquitous component in the agro-ecosystem whether it is in the symbiotic association with the plants or certain soil fungi or in the adjoining soil. It is one of the important component of the rhizosphere and the colonization of mycorrhiza enhances the branching of plant roots by modifying the morphology of the root and the hyphae enable the plant roots to contact with wider area of soil surface thereby increasing water and nutrient absorption and in turn the extra radical mycelia help in the translocation of the nutrients to the host plant. This modification in the roots by mycorrhiza increases the pathway for the uptake of nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, zinc, copper, *etc*. and to develop the resistance in the plants against the abiotic (*e.g.* drought, chilling, salinity, acidity, pollution *etc*.) and biotic stresses (bacterial and fungal diseases). Besides, mycorrhizal fungi are also known to produce a glycoprotein, glomalin which is deposited on their outer hyphal walls and on adjacent soil particles which is stable hydrophobic glue. This influence greatly toward the positive effect in water stable soil aggregation and reduce the disruption during wetting and drying events due to water movement into and out of the pores, hence determining the strong soil structure.

Classification and the Common Species of Mycorrhizae in Different Ecosystems

Broadly mycorrhiza can be classified into seven types *viz*. (i) vesicular arbuscular mycorrhiza (VAM, endo mycorrhiza) (fig. 1), (ii) ecto mycorrhiza (produces a netlike structure called the Hartig net covering the feeder roots and found in woody plants ranging from shrubs to forest trees), (iii) ericoid (cells of inner cortex become packed with fungal hyphae but a true mantle is not formed and found in plants such as *Calluna*, rhododendron, azaleas and vaccinium and typically grow in acid, peaty soils), (iv) arbutoid (characteristics of both ecto- and endo-mycorrhizae are present and found mostly in *Arbutus*, *Arctostaphylos*, and several species of the *Pyrolaceae*), (v) monotropoid (the fungi colonize achlorophyllous plants in *Monotropaceae* e.g., Indian pipe, producing the Hartig net and mantle), (vi) orchidaceous mycorrhizae (found mostly in orchids) and (vii) ectendo mycorrhiza (it forms a typical ecto mycorrhizal fungi structure except the mantle is thin and replaced by ecto mycorrhiza as the seedling matures). Some plants can even support both ecto- and endo-mycorrhiza *viz*. *Alnus* (alders), Salix (willows), Populus (poplars), Eucalyuptus *etc*.

Even though there are numerous species of mycorrhiza, but extensive work has been done only on two types *i.e.* ecto mycorrhiza (*e.g. Pisolithus microcarpus*, *Pisolithus tinctorius*, *Thelephora terrestris etc*.) and endo mycorrhiza (*e.g. Glomus mosseae*, *G. geosporum*, *G. albidum*, *G. etunicatum etc*.) and with limited literature in other types of mycorrhiza. The ecto mycorrhiza is being typically important for the forest trees and the endo mycorrhizal (VAM) fungi are the common type of mycorrhizal association found in the agricultural system and its diversity is explored worldwide extensively in the forest trees, cereals, pulses, fruit trees (*e.g.* peach, avocado, citrus, strawberry, *etc*.), woody ornamentals and vegetables.



Vesicles inside Khasi mandarin roots | Arbuscules inside Khasi mandarin roots

Fig. 1 Vesicles and arbuscules of vesicular arbuscular mycorrhiza in Khasi mandarin roots

Isolation Techniques for Mycorrhizal Fungi

A number of approaches have been developed to study the diversity and characteristics of mycorrhiza by isolation. This includes direct observation under the microscope after appropriate staining of the samples. Isolation of mycorrhiza to be carried out from root as well as soil samples depending on the type of mycorrhiza. For isolation, freshly collected root samples are washed to make free of soil particles and ultrasonic treatment is given to effectively disperse soil particles closely adhered to roots. Roots are then treated with 10% KOH solution for 30 min to 1-2 hours in a hot bath, depending on thickness of root structure. Treated roots are washed with distilled water and treated with 2% HCl solution. Acidified root samples are stained with 0.05% trypan blue (or acid fuchsin) in lactic acid for 10-15 min in a hot bath or for a few hours without heating. The roots are de-stained with lactic acid or lacto-glycerol and are observe under the stereomicroscope. Spores of arbuscular micorrhizal (AM) fungi in soil can be collected by the wet sieving and decanting method or the spores can also be seperated by the sucrose density gradient centrifugation. The gravity of spores is a little lighter than that of soil particles. Successive decantation of soil suspension followed by sieving with fine mesh can concentrate the spores from soil and can be observe under the dissecting microscope.

For advance studies and for the quantification of the production and turnover of extramatrical mycorrhizal mycelia in the field can be done by minirhizotrons, and through isotopic studies. DNA sequence analysis is a suitable tool to study the taxonomy and phylogenetic relationships of AM fungi and to analyse the diversity of natural AM populations. Fingerprinting techniques, using gel electrophoresis of PCR-amplified rDNA fragments, are being applied. In particular, temporal temperature gradient gel electrophoresis (TTGE) is used for identifying AM fungal species colonizing the rhizosphere soil and the root.

Efficacy Of Mycorrhiza Under Different Stress and Management Practices

The effectiveness of the mycorrhiza depends on the type of the management practices. Under normal condition beneficial association is found in the natural ecosystem, and the diversity, and activity decreases gradually with the disturbance. Experiments carried out in the pot as well as in the field conditions have revealed that the mycorrhiza can tolerate various soil stress conditions. The symbiotic relationship of mycorrhiza with plant roots is shown to play a great role in low pH with toxic level of aluminum and limited accessibility to phosphorus by reducing the phytotoxic symptoms in the plants (sweet potato) compared to non-mycorrhizal plants in acidic soil conditions (Balota *et al*., 2011; Sequel *et al*., 2013). Under saline conditions also the mycorrhiza inoculated tomato plant alleviated salt induced reduction of root colonization, growth, leaf area, chlorophyll content, fruit fresh weight and fruit yield (Latef and Chaoxing 2011). The functions of mycorrhizae are influenced by the environment where they are residing. The diversity and activity of mycorrhiza is affected by degraded soil conditions most importantly by mining activities. Both ecto mycorrhiza and VAM are reported to be found on mined sites, but VAM species have been found to colonize mine wastes more than ecto mycorrhiza. Gypsum mining activity has been shown to reduced diversity of plants and of active AMF in the mining areas. In one study the mycorrhizal inoculation showed the highest dry matter yield in the pot experiment conducted with the medicinal plants representing coal mine soil, copper mine soil, fly ash, skeletal soil and forest soil (Chandra *et al*., 2010) compared to non-inoculated. Mycorrhizal association with the roots of the vegetables (14 species) from six different families were reported and the infection spectrum in families were 10-22%, 25-52%, 46-65%, 49-60% and 55-87% respectively for Brassicaceae, Solanaceae, Fabaceae, Malvaceae and Cucurbitaceae and no association was found in Basellaceae (Akond *et al*., 2008). Growth was noticeably enhanced by VAM fungi (*Glomus etunicatum* and *Glomus intraradices)* inoculation to roots in welsh onion, asparagus, pea, celery, cucumber and *Allium* spp. (Galvan *et al*., 2011).

Conclusion

Although progress has been made on the mycorrhizal studies but our understanding is still limited and further research is required to explore the unexploited part. But it is certain that mycorrhiza plays the major role in nutrient absorption, improve the plants growth and increase the tolerance to the disease attack and environmental stresses, which makes it the suitable option to replace the expensive fertilizers and the pesticides. It is also known for the effective soil aggregator and therefor its management can be a good biological technique for improving soil structure. Overall we can say that the mycorrhizal fungi are the foundation for the growth of sustainable agricultural system.

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