Role of mycorrhiza in plant nutrition

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Utilization of fertilizer to supplement plant nutrients, to promote plant growth and to increase crop productivity, food quality is one of the chief component of modern agriculture. Fertilizer provide the three major nutrients (nitrogen, phosphorus and potassium) required by plants. Among these nutrients, phosphorus is critical component because on one hand it is limiting for crop yield on a large proportion of global arable land and, on the other hand, it is a non-renewable resource.

The issue of phosphorus scarcity can be addressed with different approaches. So taking into consideration of soil microorganisms, such as mycorrhizal fungi, that can greatly enhance phosphorus uptake, could also be a very effective approach for a more efficient resource use.

Mycorrhiza is the association between fungi and the roots of higher plants. The term was introduced by the German scientist A.B. Frank in 1885. Mycorrhiza is considered as the most widespread association between microorganisms and higher plants. On a global scale, between 86 per cent and 94 per cent of plants are mycorrhizal. All Gymnosperms as well as 83 per cent and 79 per cent of dicotyledonous and monocotyledonous plants, respectively, are mychorrhizal.

Two major mycorrhizal groups according to how the fungal mycelium relates to the root structure:

Endomycorrhiza:

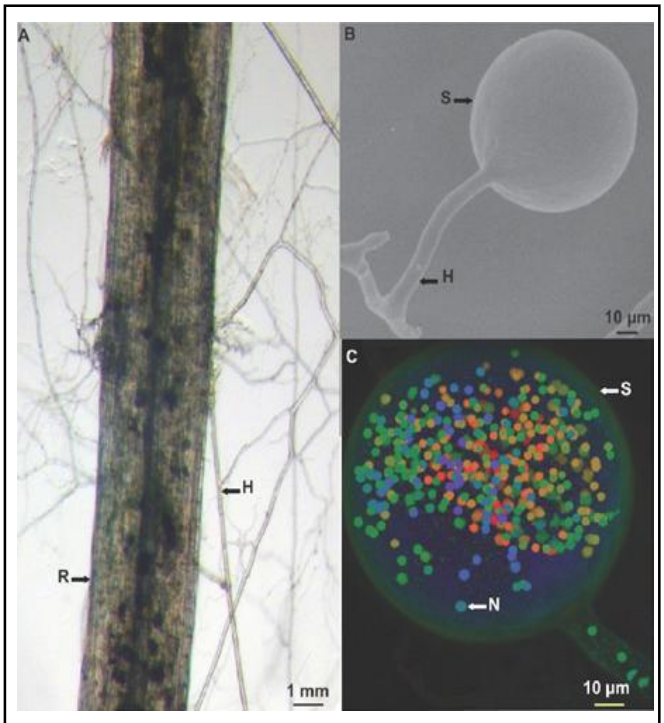
The fungi live inside the cortical cells of the roots and also grow intercellularly. The best known type is the vesicular-arbuscular mycorrhiza (VAM)/ arbuscular mycorrhiza (AM). This is widespread in cultivated soils.

Ectomycorrhiza:

This group of mycorrhiza occurs mainly on roots of woody plants and only occasionally on herbaceous and graminaceous perennial plants. Some temperate tree species like beech, oak, spruce and pine cannot survive without ectomycorrhiza. They form a sheath or mantle of fungal mycelium over the surface of fine roots. The hyphae penetrate into the intercellular spaces of the root cortex and it extends outward into the soil.

Mycorrhizae and phosphorus nutrition:

Mycorrhizal symbioses contribute significantly to plant nutrition, particularly to phosphorus uptake. First, because of its very large surface area, AM fungi hyphal network is very efficient in nutrient uptake. The fungal partners form extraradical mycelium, which can be very extensive in the soil and increase prominently the absorbing area of roots. Second, phosphorus is a highly immobile element because it is easily absorbed by soil particles and a phosphate free zone rapidly occurs around plant roots. Extra radical hyphae extend beyond this depletion zone, absorbing bio-available phosphate that is otherwise not accessible to the plant. Also, phosphate ions in soil become rapidly bound with cations, forming insoluble complexes that are unavailable to plants. It is known that the presence of mycorrhizal fungi in the soil improves phosphate solubility. Whether the fungus itself releases enzymes breaking the insoluble P complexes is still debated. Nevertheless, it is certain that AM fungi interact with rhizosphere microorganisms and enhance the establishment of bacteria, many of which secrete



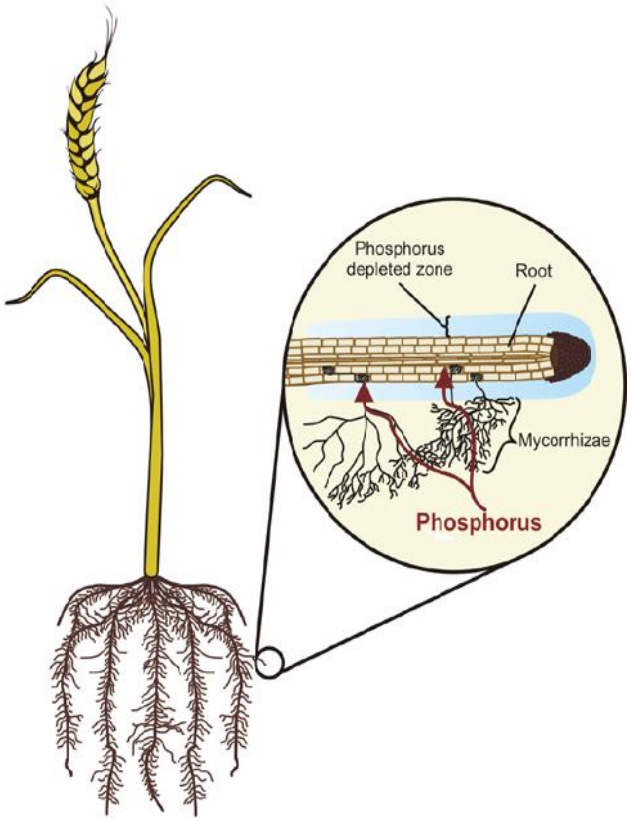
A- Colonized carrot-root showing fungal colonization that is restricted to the root cortex.

B and C- show typical multinucleated asexual spores produced in the soil.

B- Spore of the AM fungus *G. irregulare* observed by scanning electron microscopy.

C- Spore of the AM fungus *G. diaphanum* observed by confocal laser scanning microscopy.

H: Hypha; N: Nucleus; R: Root; S:Spore



Typical mycorrhized plant showing extraradical hyphae of AMF. Mycorrhizal fungal filaments in the soil act as extensions of the root system and are more effective at nutrient and water absorption than the roots themselves; they also explore the soil and reach places inaccessible to roots

phosphate solubilising enzymes. These interactions have positive synergetic effects resulting in enhanced plant nutrition, growth and survival. The nutrients mobilizing processes described above are particularly important in plant nutrition and explain why non-mycorrhizal plants require higher levels of soil fertility to maintain their health.

Other benefits of Mycorrhiza:

Improved phosphorus nutrition is probably the most widely known and most documented benefit of AM fungi for plants. It is also recognized that mycorrhizal symbioses improve other nutrients (such as nitrogen, zinc and potassium) uptake and enhance symbiotic N-fixation ability.

In addition, AM fungi have many non-nutritional benefits to plants. First, AM fungi hyphae enhance water uptake by increasing the absorbing surface of the root system and by accessing the smallest soil pores. Mycorrhizae therefore contribute significantly to increase plant resistance to drought and can also relieve other abiotic stresses. Second, AM fungi improve soils structure and contribute to soil aggregation, leading to increased soil stability and quality as well as decreased erosion. The mechanisms implied are biological, biochemical and physical processes. These mechanisms include, for example, the physical retention of aggregates by the mycelium and the secretion of glomalin, a glue-like fungal substance that bounds soil particles between them as well as to hyphae. Finally, AM fungi also help plants to resist and overcome pathogen infections.

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