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Influence of Different Types Mycorrhizal Fungi on Crop Productivity

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ABSTRACT

Mycorrhizal fungi greatly enhanced the ability of plants to take up phosphorus and other nutrients those are relatively immobile and exist in low concentration in the soil solution. Fungi can be important in the uptake of other nutrients by the host plant. Zinc nutrition is most commonly reported as being influenced by the association, although uptake of copper (Cu) , iron, N, K, Ca and Mg has been reported to be enhanced. Water uptake may be improved by mycorrhizal association, making more resistant to drought condition. Often both water and nutrient uptake are higher in drought stressed mycorrhizal plants than in non mycorrhizal plants. The fungal strands are capable of altering the water potential of plants and can only alleviate moderate drought stress and in more severe drought conditions they become ineffective.

Key words: Association Mycorrhizal fungi, Phosphorus, Water, Drought.

INTRODUCTION

Mycorrhizal fungi have a close symbiotic relationship with plant roots. Mycorrhizal fungi colonize the plant's root system and develop a symbiotic association called "mycorrhiza". They form a network of fine filaments that associate with plant roots and draw nutrients and water from the soil that the root system would not be able to access otherwise. They are called mycorrhizae from the Greek "mukés", meaning fungus, and "rhiza," meaning roots Mycorrhizae are formed with more than 90% of plant species. This fungus-plant alliance stimulates plant growth and accelerates root development. One kilometer of hypae (fine filaments) may be associated with a plant growing in a one-liter pot and it can access water and nutrients in the smallest pores in the soil. It also makes the plant less susceptible to soil-borne pathogens and to other environmental stresses such as drought and salinity. In return the plant provides carbohydrates and other nutrients to the fungi. They utilize these carbohydrates for their growth and to synthesize and excrete molecules like glomalin (glycoprotein). The release of glomalin in the soil environment results in better soil structure and higher organic matter content. However, in soil that has been disturbed by human activity, the quantity of mycorrhizae decreases drastically so that there are not enough of them to produce a significant benefit on plant growth and health, hence the importance to compensate this lack.

Mycorrhizal Associations

The terms symbiotic and mutualistic have been used interchangeably to describe mycorrhizal associations. Fungal symbioses have been defined as ' all associations where fungi come into contact with living host from which they obtain, in a variety of ways, either metabolites or nutrients '.The term mycorrhiza (meaning fungus-root) was originated by Frank (1885) who was fairly certain that these symbiotic plant-fungus associations were required for the nutrition of both partners. More recently, mycorrhizas have been defined as associations between fungal hyphae and organs of higher plants concerned with absorption of substances from the soil. Mycorrhizas are now considered to differ primarily from other plant-fungus associations because they are intimate associations with a specialised interface where exchange of materials occurs between living cells

Types of mycorrhizae

There are two major groups of mycorrhizal fungi: ectomycorrhizal and endomycorrhizal fungi. Members of the former group develop exclusively on the exterior of root cells, whereas those of the latter penetrate the plant cells where direct metabolic exchanges can occur. Ectomycorrhizae are essentially found on trees and form visible structures whereas endomycorrhizal fungi colonize trees as well as shrubs and most herbaceous plants and do not form visible structures.

Endomycorrhizae

Among the types of endomycorrhizal fungi, arbuscular mycorrhizal (AM) fungi are the most prevalent in soils. The most important members of endomycorrhiza group are called arbuscular mycorrhizae (AM). Formerly these were called vesicular arbuscular mycorrhizae (VAM) , but this was shortened to AM since fungal hyphae actually penetrate the cortical root cell wall and once inside the plant cell, form small hyphae branched structures known as arbuscules. Fungi of the endomycorrhizae consist of aseptet hyphae are members of the Phycomycetes and Basidiomycetes. The hyphae of these fungi penetrate the cells of the root cortex forming an internal hyphae network. Some hyphae also extend into the soil. For many plant species including most agricultural crops the predominant type of fungal infection is vesicular arbuscular mycorrhizae (VAM). This name derives from the occurrence of two types of structures characteristics of the fungi belongs to the family Endogonaceae i.e. arbuscules (Arbuscules are finely-branched structures that form within a cell and serve as a major metabolic exchange site between the plant and the fungus) and Vesicles (sac-like structures, emerging from hyphae, which serve as storage organs for lipids). These structures are similar to haustoria but are produced by dichotomous branching of hyphae. The AM fungi are the most common and widespread group. 80% of plants have endimycorrhizae association.

Ectomycorrhizae

Ectomycorrhizal fungi are also found in natural environments, mainly in forests ecosystems. These fungi can form visible reproductive structures (mushrooms) at the feet of trees they colonize. Ectomycorrhizal fungi grow between root cells without penetrating them. Their hyphae grow externally, forming dense growth known as a fungal mantle. These fungi form symbiotic relationships with most pines, spruces and some hardwood trees including beech, birch, oak and willow, 5 to 7% of plants belong to this association.

How do mycorrhiza function

Mycorrhizal fungus hyphae are considered to function primarily by increasing the soil volume from which available forms of nutrients are absorbed and provided to roots.

Fungal hyphae release enzymes (chitinase, peroxidase, cellulase, and protease) ,which allows them to digest and penetrate substrates.

Secretion of enzymes breaks down tough organic substrates that can then be absorbed and used by the fungus and/or host plant as energy and nutrient sources for growth and reproduction.

Benefits of fungi

Mycorrhizal fungi allow plants to draw more nutrients and water from the soil. They also increase plant tolerance to different environmental stresses. Moreover, these fungi play a major role in soil aggregation process and stimulate microbial activity. According to the plant species and to the growing practices and conditions, mycorrhizae provide different benefits to the plants and to the environment: Produce more vigorous and healthy plants

- Increase plant establishment and survival at seeding or transplanting
- Increase yields and crop quality
- Improve drought tolerance, allowing watering reduction
- Enhance flowering and fruiting
- Optimize fertilizers use, especially phosphorus
- Increase tolerance to soil salinity
- Reduce disease occurrence
- Contribute to maintain soil quality and nutrient cycling

Importance of mycorrhizae

Mycorrhizal fungi greatly enhanced the ability of plants to take up phosphorus and other nutrients those are relatively immobile and exist in low concentration in the soil solution. Arbuscular mycorrhizal fungi can play a significant role in P nutrition of crop, increasing total uptake and in turn P use efficiency. This might be associated with increased growth and crop yield. Where colonization by arbuscular mycorrhizal fungi is disrupted either by cultural operation or suppressed due to high concentration of soil available P, uptake of p, growth and in some cases yield can be significantly reduced, even some times crops fail to response to colonization by native mycorrhizal fungi . Though P uptake in mainly translocated by the arbuscular mycorrhizal association, it has become increasingly apparent that arbuscular mycorrhizal fungi can be important in the uptake of other nutrients by the host plant. Zinc nutrition is most commonly reported as being influenced by the association, although uptake of copper (Cu) , iron, N, K, Ca and Mg has been reported to be enhanced

Water uptake may be improved by mycorrhizal association, making more resistant to drought condition. Often both water and nutrient uptake are higher in drought stressed mycorrhizal plants than in non mycorrhizal plants. Increased phosphorus levels generally increase drought resistance; calculations made from arbuscular mycorrhizal fungi indicate that the amount of water that could travel through the mycelia to the plant is not large enough to influence plant growth or survival.

Work on ectomycorhizae showed that the fungal strands are capable of altering the water potential of plants. Seedlings were maintained in a healthy state for at least 10 week period when the only source of water was through mycelia strands growing in moist peat. However, arbuscular mycorrhizal fungi can only alleviate moderate drought stress and in more severe drought conditions they become ineffective.

AM Fungi and crop productivity

Yasmeen *et al* (2012) suggested that the combined application of mix bacterial inoculants and AM fungus was more effective than other inoculation treatments and are suggested to be important bio-resource for efficient bio-inoculants development for *V. radiata* productivity .Increase in nodule number due to coinoculation with non-nodulating *Agrobacterium* sp. Ca-18 with nodulating *B. japonicum* MN-S and TAL-102 shows beneficial effect of *Agrobacterium* sp. Ca-18 as a phosphate solubilizer and *B. japonicum* MN-S and TAL-102 as nitrogen fixer. Daei *et al* (2009) concluded that the AM species have significant effect on root colonization of different wheat cultivars. Higher root colonization by *Glomus etunicatum* and *G. mosseae* relative to *G. intraradices* resulted in increased nutrient uptake and less Na^+ and Cl^- adsorption by plant, and hence, increased plant growth under salinity. Zaidi and Khan (2005) concluded that the mixed inoculation of N-fixing microbes, phosphate-solubilising bacteria and AM fungus improved plant vitality and nutrient uptake and caused a dramatic increase in yield in wheat crop. As the wheat crop require greater amount of P fertilization, especially when sown in alkaline soils or soils deficient in N and P, it is possible that N_2-fixing and P-solubilising bacteria could be managed in order to reduce external inputs. The combined inoculation of PSB+VAM+*Azotobacter* in sunflower recorded higher plant height and total chlorophyll content and also significantly increased yield attributes, *viz.* thalamus diameter, weight of thalamus, filled seeds capitulum-1, and 100 seed weight (g), as well as seed and biological yield and oil content as compared to PSB+*Azotobacter* and VAM+*Azotobacter* inoculation (Patra *et al*, 2013).

Crop management involves a range of practices which can impact on the AM association, both directly, by damaging or killing AMF and indirectly, by creating conditions either favourable or unfavourable to AMF. Reducing tillage has been repeatedly shown to increase AM colonisation and nutrient uptake. Galvez *et al* (2001) compared mouldboard ploughed soils with chisel disked and no-till soil. AMF spore numbers and colonisation of maize roots was highest in the no-till system (though phosphorus use efficiency was highest under the mouldboard plough system). Kabir *et al* (1998) studied AMF hyphal density and nutrient content of maize in plots that had been managed under no-till, reduced till or conventional till for 11 years. AMF hyphal length densities were highest in the no-till plots and lowest in the conventional till plots, while the reduced till plots contained intermediate AMF hyphal length densities. Terence *et al* (1999) concluded that colonization of both maize and soybean by AM fungi is susceptible to slower development in tilled systems.

Zaidi and Khan (2005) studied the interactive effect of rhizotrophic microorganisms on growth, yield, and nutrient uptake of wheat (*Triticum aestivum* L.) was determined in a pot experiment using sterilized soil deficient in available phosphorus (P). Positive effect on plant vigour, nutrient uptake, and yield in wheat plants was recorded in the treatment receiving mixed inoculums of nitrogen-fixing *Azotobacter chroococcum* + phosphate solubilising microorganism (PSM) *Pseudomonas striata* + arbuscular mycorrhizal (AM) fungus *Glomus fasciculatum*. The available P status of the soil improved significantly (P d" 0.5) following triple inoculation with *A. chroococcum, P. striata*, and *G. fasciculatum*.

Mycorrhizal plants often have greater tolerance to drought than nonmycorrhizal plants. This study was conducted to determine the effects of arbuscular mycorrhizal (AM) fungi inoculation on growth, grain yield and mineral acquisition of two winter wheat (*Triticum aestivum* L.) cultivars grown in the field under well watered and water-stressed conditions by Al-karaki (2004). Wheat seeds were planted in furrows after treatment with or without the AM fungi *Glomus mosseae* or *G. etunicatum.* Roots were sampled at four growth stages (leaf, tillering, heading and grain-filling) to quantify AM fungi.

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