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Mycorrhizal Associations and Soil Health Improvement

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Introduction

Mycorrhizal associations represent a mutualistic relationship between soil fungi and plant roots. The term "**mycorrhiza**" is derived from greek words meaning fungus (mykes) and root (rhiza). These associations are widely distributed in terrestrial ecosystems and are considered essential for plant nutrition and soil sustainability (Smith & Read, 2008). Mycorrhizal fungi play a key role in improving soil health, enhancing plant growth and supporting sustainable agriculture (Brundrett, 2009). The plant makes organic molecules by photosynthesis and supplies them to the fungus in the form of sugars or lipids, while the fungus supplies the plant with water and mineral nutrients, such as phosphorus, nitrogen, or zinc taken from the soil.

Types of Mycorrhizal Associations

1. **Ectomycorrhizae**: Ectomycorrhizal fungi form a dense sheath around plant roots and penetrate the intercellular spaces without entering root cells. They are commonly associated with forest trees such as pine and oak (Smith & Read, 2008).
2. **Endomycorrhizae**: Arbuscular mycorrhizal fungi penetrate root cortical cells and form specialized structures such as arbuscules and vesicles for nutrient exchange. They are the most common type found in agricultural crops (Smith & Smith, 2011).
3. **Orchid mycorrhizae**: Orchid mycorrhizal fungi, which mostly originate from Ascomycota and Basidiomycota, are less understood. Some fungi that participate in orchid mycorrhizal symbiosis can also form ectomycorrhizal symbiosis with other plants or live independently of a plant host. Some orchid mycorrhizal fungi can also live as plant pathogen.
4. **Ericoid mycorrhizae:** Ericoid mycorrhizal associations have the most recent origins and the lowest species richness among both plant and fungal partners. Ericoid mycorrhizal relationships are found in extremely nutrient poor soils in the northern and southern hemispheres. Ericoid mycorrhizae also retain saprotrophic abilities, allowing them to extract nitrogen and phosphorus from un mineralized organic material and resist negative outcomes from high concentrations of toxic cations in the acidic soil environment.

Role in Soil Health Improvement

Enhanced Nutrient Uptake: Mycorrhizal fungi increase the effective root surface area through an extensive hyphal network, improving the uptake of nutrients, particularly phosphorus, zinc and copper (Smith & Read, 2008; Smith & Smith, 2011).

Improved Soil Structure: The hyphae of mycorrhizal fungi contribute to soil aggregation by binding soil particles together. They also produce glomalin, a glycoprotein that enhances soil stability and structure (Rillig, 2004).

Increased Water Absorption: Mycorrhizal associations enhance plant water relations by extending the root system into deeper soil layers, thereby improving drought tolerance

(Auge,2001). The mycorrhizal mutualistic association provides the fungus with relatively constant and direct access to carbohydrates, such as glucose and sucrose. The carbohydrates are translocated from their source (usually leaves) to root tissue and on to the plant's fungal partners. In return, the plant gains the benefits of the mycelium's higher absorptive capacity for water and mineral nutrients, partly because of the large surface area of fungal hyphae, which are much longer and finer than plant root hairs, and partly because some such fungi can mobilize soil minerals unavailable to the plants' roots. The effect is thus to improve the plant's mineral absorption capabilities.

Biological Soil Activity: Mycorrhizae stimulate microbial activity in the rhizosphere, contributing to nutrient cycling and improving soil biological health (Jeffries et al., 2003).

Disease Suppression: Mycorrhizal fungi can reduce the incidence of soil-borne diseases by competing with pathogens and enhancing plant defense mechanisms (Pozo & Azcon-Aguilar, 2007). Mycorrhizal plants are often more resistant to diseases, such as those caused by microbial soil-borne pathogens. These associations have been found to assist in plant defense both above and belowground. Mycorrhizas have been found to excrete enzymes that are toxic to soil borne organisms such as nematodes.

Importance in Sustainable Agriculture

Mycorrhizal fungi are increasingly recognized as vital components of sustainable agriculture. They reduce dependence on chemical fertilizers, improve nutrient efficiency and enhance crop productivity (Jeffries et al., 2003). Their use as bio-fertilizers is gaining importance in organic farming systems and integrated nutrient management practices.

Factors Affecting Mycorrhizal Activity

The effectiveness of mycorrhizal associations depends on various environmental and management factors, including soil pH, temperature, moisture, crop species and agricultural practices. High levels of phosphorus fertilizers can suppress mycorrhizal colonization (Smith & Read, 2008).

Conclusion

Mycorrhizal associations play a crucial role in improving soil health and ensuring sustainable agricultural production. By enhancing nutrient uptake, improving soil structure, increasing drought tolerance, and suppressing diseases, they contribute significantly to soil fertility and ecosystem stability. Their integration into farming systems is essential for achieving long-term agricultural sustainability.

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