Role of Arbuscular Mycorrhizal Fungi in Agriculture and Environmental Remediation

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Abstract

As obligatory biotrophs, Arbuscular Mycorrhizal Fungi (AMF) forms a strong symbiotic cooperation with the root of living plant host so that they can complete their life cycle. Eighty to ninety percent of terrestrial plant species have Arbuscular mycorrhizal fungal mycelia in their roots. They serve as a plant-soil interface, allowing plants to grow their mycelia both inside and outside of their roots. AMF gives the plant nutrients, water and defense against pathogen in exchange the fungus obtained photosynthetic chemicals from the plant. AMFs also interconnect with broad range of crop plants including fruit trees, vegetables and cereals so that the possibility of Arbuscular mycorrhizal importance increases in agricultural sustainability, horticulture, landscaping and forest re-establishment are gaining more attention. Arbuscular mycorrhiza also plays vital role in maintaining ecological balance by maintaining biogeochemical cycle, maintaining soil vitality by protecting soil microflora and fauna.

Keywords: *Arbuscular mycorrhiza, Symbiosis, Rhizophagus, Ecological balance, Horticulture.*

1. Introduction

The Latin word 'arbuscula' which means tiny tree or shrub is the source of the phrase "arbuscular" which refers to a distinctive structure found in the cortex region of many terrestrial plants root system. AMFs are obligatory symbionts and they live on the host plant for their survival. They establish plant roots with the help of spores, fungal hyphae and fragments of infected roots [1]. AMFs are the important components of

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soil microorganisms and is a member of the glomeromycota phylum. Rather from being a parasite, AMF is an obligatory symbiont that need a host plant to accomplish its life cycle. According to a recent study, AMF increases agricultural yield by enhancing the mechanism of nutrient and water uptake, nitrogen, phosphorus and potassium intake also increases [2]. The properties of Arbuscular mycorrhizal fungal mycelium are amenable for the increased intake of nutrient by the host plant. AMF have important characteristic mycelium which enhanced the plants nutrient up taking is from host plants. Osmotrophs absorbs the nutrient to enhance the increase in surface area as compared to non-mycorrhizal plants root [3]. The hyphae or mycelia have distinctive characters to produce stable soil aggregations. Through the extrametrical mycelia's synthesis of the glycoprotein glomalin, they function as an extended soil binding agent [4]. The glomalin is resistant to heat and is hydrophobic, and thermotolerant to the high soil temperature. As a kind of glue that holds together all of the soil micro-aggregations, glomalin's primary job is to maintain soils accumulation [5, 6]. Plants are impacted by the fungal mycelium of AMF, which causes the roots to spread out and enhances the plant's capability of absorbing the water and minerals from the rhizosphere [7]. Additionally, plants can detect and respond to an array of chemical signals produced by AMF, among them chitin oligomers, which have been shown to initiate defence mechanisms in a variety of different species of plants [8, 9]. Strong disease resistance and resistance to soil-borne pathogens are characteristics of mycorrhizal plants [10-14]. According to few studies arbuscular mycorrhiza fungi (AMF) have been on Earth since prehistoric times. They exhibit obligate symbiosis with plants; without the help of host plants, they are unable to survive on their own [15]. Only in the cooperation with the host plants they can accomplish their life cycle. As a way of helping their host plants thrive in stressful environments, arbuscular mycorrhizal fungi (AMF) regulate a complicated communication chain that boosts water absorption, increase in photosynthesis and ameliorated the other gaseous exchange-related features. Arbuscular mycorrhizal fungal mycelia can enhance the plants and soils health at the same time changes the assemblage of contaminating substances in the plant. AMFs forms hyphae, vesicles and arbuscules in rhizosphereic root; along with this they form spores and hyphae around the regions of the soil in contact with the roots of plant. The strong network formed by the mycelia of arbuscular mycorrhizal fungi

and plants root crucially ameliorates the ability of plant root system to enter a larger surface area in the soil and helps in plants growth. Mycelial network of fungal hyphae can also accelerate the breakdown process of complex soils organic matter into simpler forms so that plant can absorb efficiently. AMFs helps plants to grow in adverse condition, can tolerate organic pollutant and increases crop productivity leading to increase in biomass of agricultural yield. Mycorrhizal association of plants decreases the transport of heavy metals to the shoot system of plant by binding of heavy metal to the cell wall of fungal hyphae. In these ways Mycorrhiza adaptability and survivalist enhanced in polluted habitat.

2. Literature Review

Mycorrhizas are obligatory biotrophs which show the symbiotic relation between the fungus and the roots of plant. They show as mutualistic relation because photosynthetically derived carbon compounds from the plants is received by fungus and in return plants get mineral nutrients and sometimes water. "Mycorrhiza" is the Greek term which is made up of *mykes* and *rhiza* which means fungus and root. This type of interaction is benefitted by the both partners and exchange of material is done between them. The two most prevalent mycorrhizas associations are called arbuscular endomycorrhizas (AM), and they are distinguished by the fungal hyphae that both septate and aseptate fungi use to pierce the cortical cells of the host root tissues. They lack an external sheath and the hyphae seen in the roots produced by Zygomycete fungus that are both intracellular and intercellular. Ascomycetes, Basidiomycetes, and a few Zygomycetes generate the ectomycorrhizas (ECM), which are defined by the abundance of fungus hyphae like a dense network like structure which are interlinked in the cortex region of roots referred to as "Hartig net. According to Brundrett et al. (1996), there are additionally more mycorrhizal relationships between the monotropoid, ericoid, arbutinoid, ectendo-mycorrhizas, and orchid [8]. Almost ninety percent of plants species like bryophyta, pteridophyta and angiospermous plant develops interdependent connections with Arbuscular fungal mycelium [16]. AMF appeared to be originated from the common ancestor and rapidly colonizes the earth in cooperation with the higher plants species [17]. Sometimes mycorrhizal roots considered as Rhizophagus (Greek for "root eater") because they show very strong fungal association with the root intercellular as well as intracellular and

infect nearly to the root length's tip [18]. Arbuscular mycorrhizal fungi have "non-nutritional" functions such as maintaining soil aggregation, reduces soil eroding activity and decreasing the plant stress brought by the some biotic, abiotic, external as well as internal factors. They also improve the intake of nutrients and other essential minerals present in the soil for better growth of plant. The enhanced amount of water received by AM fungal branching mycelial networks through soil pores, AMF helped the host crop endure dry conditions. The cooperative relation between arbuscular mycorrhizal fungal mycelia and roots of plant is thought to control a number of physiological mechanisms in plant, including balancing of increased osmotic concentration [19], managing Abscisic acid regulation to control the stomatal closing and opening mechanism [20], and increases the production of certain amino acids, such as proline [21, 22] or enhanced the production of Glutathione which reduces the metal toxicity in plants [23]. In dry environmental condition certain plant species from cooperative relationships with AM fungus can enhance biomass, leaf area, and root size and efficiency [24]. Facilitations are the idea of mycorrhizal plants have a distinct benefit as compared to the plant which are not associated with the mycorrhiza [25, 26] Arbuscular mycorrhizal fungi can be considered as an important biotechnological tool for inoculating plant in progressive condition and restore damaged environment. Plants that grow in metal-contaminated sites have resistant and metal-tolerant microbial communities in their rhizosphere [27]. These microbial communities in the rhizosphere secrete plant growth promoting substances, siderophores, and plant chelating agents to reduce metal toxicity, enhance metal bioavailability (phytoremediation), and metal complexation (plant stabilization) [28]. In this way arbuscular Mycorrhiza can improve the agronomical productivity and stability of ecosystem by reducing the environmental stresses and natural resource deterioration [29].

3. Conclusion

Arbuscular Mycorrhizal Fungi help plants in stress tolerance by oxidative stress mitigation with the help of upregulating antioxidant activity, attenuating lipoxygenase mechanism, balancing of ABA responsive gene, plant hormone biosynthetic pathways and transcription factors. They also enhance nutrient uptake mechanism by specific transporters which translocate nutrients from external environments to the internal by the

modification of roots' anatomical as well as morphological structure of the plants. Improves soil health by maintaining soil moisture, fertility level, soil quality and soil microorganisms. Arbuscular mycorrhizal (AM) used to ameliorates the ecosystem and environmental stresses. AM fungal diversity play the crucial role in bioremediation, phytoextraction and improves the accumulation of mineral activity. Arbuscular mycorrhizal fungal mycelia colonize the root and this kind of use of the crops associated with mycorrhiza in rotation with the normal crops increases the number of Arbuscular mycorrhizal fungal activity in the soil which in return eliminate harmful and toxic substances present in the soil and provide the ample number of benefits which improves agronomical productivity and stability of environment.

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