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# Arbuscular Mycorrhizal Fungi: Potential Bio Stimulants in Horticultural Crops

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The term "bio stimulants" was coined by Zhang and Schmidt. The "2018 Farm Bill" (AI Act) describes bio stimulant as "a substance or microorganism, when applied to seeds, plants, or on the rhizosphere, stimulates natural processes to enhance or benefit nutrient uptake, nutrient use efficiency, tolerance to abiotic stress, or crop quality and yield. Among various bio stimulants, arbuscular mycorrhizal fungi (AMF) indeed hold significant potential as bio stimulants in horticultural crops, considering the widely accepted benefits of the symbioses to nutrition efficiency (both macronutrients, especially P and micronutrients), water balance, biotic and abiotic stress protection of plants".

Mycorrhizal fungi are a heterogeneous group of fungi which establish symbiosis with over 90 % of all plant species, where fungal hyphae of Glomeromycota species penetrate root cortical cells and form branched structures called arbuscules. AMF form symbiotic associations with plant roots, extending their hyphae into the soil and effectively increasing the surface area for nutrient absorption. This results in improved uptake of essential nutrients such as phosphorus, nitrogen, potassium, and micronutrients. AMF often induces modifications in the root architecture of plants, in particular root length, density, diameter, and number of lateral roots (Wu et al., 2013).

Better root system architecture in mycorrhizal plants allowed the extraradical hyphae to extend beyond depletion zones of plant rhizosphere making the uptake of water and low mobile nutrients (*i.e*. P, Zn and Cu) more efficient under a water-deficient environment. Xu et al. (2014) demonstrated that the soil P concentration required for maximum growth of asparagus (*Asparagus officinalis* L.) could be lowered by AMF (*F. mosseae*) inoculation associated with improved phosphorus utilization efficiency. In fact, the maximum asparagus growth was obtained at soil phosphorus of 59.3 mg kg-1 610 in inoculated compared to 67.9 mg kg-1 611 in non-inoculated plants, indicating that AMF improves P efficiency in particular under low soil P concentration.

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AMF are known to act as an effective and sustainable tool which enhance drought, salinity and other abiotic tolerance in horticultural crops, including fruit trees, vegetables and flowers. Many studies have shown that inoculation with AMF improved drought tolerance of citrus plants by lowering the osmotic potential through the net accumulations of inorganic and organic solutes, with the latter also potentially acting as osmoprotectants (Wu et al., 2013).

Khalil (2013) and Wu et al. (2010) reported that grapevine rootstocks (*Vitis vinifera* L., ‘Dogridge’, ‘1103’ ‘Paulsen’ and ‘Harmony’) and citrus seedlings inoculated with *R. intraradices* (for grapevine), *F. mosseae* and *Paraglomus occultum* (for citrus) exhibited greater growth parameters (plant height, stem diameter, shoot and root biomass) compared to the non-inoculated plants. The higher crop performance in inoculated grapevine and citrus seedlings was attributed to a lower concentration of Na and Cl and the higher K, Mg concentration in leaf tissue and also to the higher K/Na ratio (Wu et al., 2010; Khalil, 2013). This might indicate that toxic ions might be retained in intraradical AM fungal hyphae or compartmentalized in the root cell vacuoles without moving into the root cell cytoplasm, which could be translocated to the shoots.

Some strains of AMF have been found to suppress soil-borne pathogens through mechanisms such as competition for resources, induction of plant defense responses, includes the activation of defense-related enzymes, such as chitinases and β-1,3-glucanases, which degrade fungal cell walls and inhibit pathogen growth. Additionally, AMF colonization can induce the production of secondary metabolites with antifungal properties, such as phenolic compounds and phytoalexins, which contribute to the plant's resistance against pathogens.

**Conclusion**

The use of arbuscular mycorrhizal symbionts as a biostimulant in horticultural crops has greatly increased in the last two decades, mostly due to their ability to secure production and yield stability in an environmentally sustainable way with benefits ranging from improved nutrient uptake and stress tolerance to disease suppression and soil health enhancement.

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