AgriCos e-Newsletter
ISSN: 2582-7049
Open Access Multidisciplinary Monthly Online Magazine
Volume: 03 Issue: 05 May 2022 Article No: 24

Vesicular Arbuscular Mycorrhiza (VAM) Fungi as a Bio-Fertilizer

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SUMMARY

Mycorrhiza is the result of a fungus interaction with a plant root. The symbiotic relationship between certain phycomycetous fungi and angiosperm roots forms vesicular-arbuscular mycorrhiza (VAM). The fungus colonises the root cortex, generating a mycelial network and vesicles (bladder-like structures) as well as arbuscules (branched finger-like hyphae). Mycelia are either aseptate or septate, ramifying intercellularly and producing little tissue injury. The arbuscules having an absorptive function and the vesicles have a storage function. There are six genera of fungi form mycorrhizal associations: *Glomus, Gigaspora, Acaulospora, Entrophospora Sclerocystis* and *Scutellospora*. These are mainly identified by their characteristic spores and sporocarps which are formed mostly in the soil surrounding the roots and rarely inside the roots.

INTRODUCTION

Despite the fact that mycorrhizae have been recognised for over a century, mycorrhizal research has recently gained traction with the discovery that VAM fungi improve plant phosphate use efficiency (Baylis, 1967; Gray and Gerdemann, 1969). Agricultural scientists have been attempting to use VAM fungi to improve phosphorus utilisation by plants in poor soils since the 1970s. VAM mycelia have the ability to extend the absorption zone beyond the phosphorus depletion zone that occurs around absorbing roots. Due to improved nutrient uptake, synthesis of growth promoting chemicals, resistance to drought, salt, and synergistic interactions with other beneficial microbes, mycorrhizal fungi are responsible for boosting the growth of host plant species (Sreenivasa and Bagyaraj, 1989). Soil conditions in Sustainable agricultural are more likely to be friendly to AM fungus than traditional agriculture soil conditions (Bethlenfalvay and Schuepp, 1994; Smith and Read, 1997). The AM fungi have been found to be associated with more than 80% of land plants, liverworts, ferns, woody gymnosperms, angiosperms, and grasses in both natural and agricultural settings. The AM fungi enhance the ability of plants to absorb phosphorus from soil, which is relatively inaccessible to the plants, increase the phytoavailability of micronutrients, e.g., copper and zinc. In a study, absorption of trace elements, such as boron and molybdenum, was thought to be enhanced by VA mycorrhizae (Sieverding, 1991). Some AM associations are able to mobilize organically bound nitrogen, which the plants are unable to absorb.

Role of VAM fungi in plant growth

VAM fungus generally colonize agricultural crops, with the exception of a few plant groups (Chenopodiaceae, Cruciferae). VAM fungi invade plant roots by spreading infection from fungal entrance sites into the root cortex. Hyphae multiply in the cortex and create arbuscules (branch-like structures) within root cells. Mineral nutrient (from fungus to plant) and carbohydrate (from plant to fungus) exchange takes place in arbuscules. In the root, the fungus produces storage organs (vesicles). In all agroecosystems, VAM colonization of roots occurs. The fungus' extraradical hyphae are capable of absorbing nutrients like phosphorus, zinc, and copper and transporting them to the host plant, enhancing plant nutrition. When growing in soils lacking in essential nutrients, VAM fungus can be critical for proper growth of plant species with a limited root surface area. Furthermore, a common fungal mycelium connects the roots of each plant in the field, allowing for a very limited movement of nutrients across plants. VAM hyphae are unlikely to transfer huge amounts of water, although mycorrhizal plants may be more drought resistant than non-mycorrhizal plants due to a variety of direct and indirect VAM fungal effects.

Under rainfed conditions, however, mycorrhizal plants may be more sensitive to drought stress during seed filling due to increased vegetative development and lower root/shoot ratios. In addition to direct and indirect effects on nutrient and water uptake, VAM fungi can also increase plant resistance to root pathogens. In exchange for the nutrients taken up, the fungus receives carbohydrates from the host plant to sustain its growth. When the carbohydrate drain of the fungus is higher than the benefit plants derive from their VAM, mycorrhizal colonization of roots may lead to a reduction in plant growth. The carbohydrate demand by VAM fungi may be of particular importance in legumes where symbiotic nitrogen fixation also is a strong sink for photoassimilates.

Various benefits attributed to the plant through mycorrhizal symbiosis:

- The VAM increases plant tolerance to various biotic and abiotic stresses including alkalinity, toxicities associated with mining operations, heavy metals and mineral imbalance.
- The VAM have a potential use as biofertilizer and replaces the fertilizer requirements of trees in areas of marginal fertility and reduces the needs of current levels of chemical fertilizers.
- The mycorrhizal symbiosis plays a vital role in changing the ecology of a given site and mycorrhiza promotes mineral cycling and are key component of efficient and closed nutrient cycle of natural ecosystems.

VAM fungi as a potential tool in bio-control of plant parasitic nematodes

VAM fungi increase host tolerance of pathogen attack by compensating for the loss of root biomass or function caused by pathogens including nematodes and fungi. Root-knot nematodes have been reported to cause an annual loss up to 29% in tomato, 23% in egg plant 22% in okra, 28% in beans and so on, that may vary from crop to crop and country to country. Root-knot nematodes and VAM fungi are members of the microbial population of the root region and they can compete with each other for the same site in the rhizosphere. The primary effect of VAM fungi on nematode infection appears to increase host tolerance in spite of damaging levels of plant parasitic nematode populations. The basis appears to be physical or physiological. The VAM fungi have also been shown to enhance the uptake of Ca, Cu, Mn, S and Zn in addition to P. Nematode damaged plants frequently show impaired water conductance through roots and deficiencies of N, B, Fe, Mg and Zn, particularly VAM induced Zn uptake has been shown to contribute tolerance to *Melodogyne incognita* in cotton. Hence, the beneficial VAM fungi might be expected to reduce or even eliminate the harmful effects imposed by root-knot nematodes and substantially reduce nematode development.

CONCLUSION

Plants inoculated with VAM can effectively combat various environmental cues, like salinity, drought, nutrient stress, alkali stress, cold stress, and extreme temperatures, and thus help to increase per hectare yield of a large number of crops and vegetables. Encouragement of VAM usage is of immense importance for modern global agricultural systems for their consistent sustainability. Exploitation of VAM for agricultural improvement can significantly reduce the use of synthetic fertilizers and other chemicals, thereby promoting the bio-healthy agriculture.

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