

Mycorrhizal biofertilizer

an effective tool to manage abiotic stress in crop plants of
arid and semi-arid regions

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Mycorrhizal symbiosis is a natural relationship between plant roots and fungi, which produce fungal structure (vesicles arbuscular mycorrhiza) in cortical root cells. Under arid and semi-arid conditions the main benefit of mycorrhizae to plants is to increase phosphorus and other macro- and micro-nutrients like N, Ca, Mg, S, Cu, Fe, Zn and B uptake. Under drought stress conditions, VAM fungi enhances the uptake of water through the extension of root surface in the soil by the extra-radical mycelia. The application of VAM fungi in saline soil improve plant growth and salt tolerance ability through reducing the uptake of sodium and chloride ions as well as reducing their movement to plant aerial parts, keeping ionic balance by improving uptake of nutrients and stimulating selective uptake. The mycorrhizal inoculation with suitable fungi has been proposed as a promising tool for improving degraded land restoration in semi-arid degraded areas.

Key words: Aboitic stress, Arid region, Biofertilizers, Crop plants, Mycorrhiza, Semi-arid region

AGRICULTURE in arid and semi-arid areas is extremely sensitive to different abiotic stresses such as high temperatures, drought, salinity, soil P^H and strong light. Such adverse abiotic stress conditions have negative impacts on crop growth and productively. Under these circumstances, the mycorrhiza inoculation is an eco-friendly and cost-effective strategy that has high potential to help plants withstand abiotic stresses. This strategy involves the utilization of beneficial traits of mycorrhizal micro-organism in abiotic stress management for plant growth promotion.

Drought stress management

VAM fungi colonized plants can tolerate and recover more rapidly from drought stress than plants without VAM fungi, under drought stress conditions. VAM fungi enhances the uptake of water through the extension of root surface in the soil by the extra-radical mycelia in

addition to this, mycorrhizal root colonization indirectly influence the stomatal behaviour of host leaves. The stomatal conductance and leaf water potential are also altered. Mycorrhizal improvement of drought tolerance occurs *via* improved acquisition of phosphorus, nitrogen and other growth promoting nutrients. All these factors are collectively responsible for protecting host plants against detrimental effects caused by drought stress.

Application of mycorrhizal inoculants to the plants

Seed treatment: Mycorrhiza can be applied through seed treatment or mix with organic manure and apply directly on the field before planting and cover with soil or cultivate the field to mix mycorrhiza spores in the soil. Spores can be broadcast with organic manure on the soil and then irrigate the field. For this purpose the 10 kg commercially available formulation of VAM fungi is to be

mixed with 50 kg of organic fertilizer farmyard manure and made into slurry with optimal water. The VAM slurry preparation can be used for coating the seeds.

Soil application: The 10 kg of commercially available VAM formulation can be mixed with 1,000 kg of organic fertilizer (farmyard manure) or field soil and moistened to optimal level. It is applied along with seed sowing in the main field in a directly sowing crops or applied two days prior to transplanting of seedling in transplanted crops and as broadcasting and top dressing in narrow spaced crops. Irrigation must be followed within 24 hr after VAM fertilizer application and seed sowing and seedling transplantation must be done within 48 hr application.

Seedling dip application: This method is used for transplanted nursery fruit or vegetable plantlets. The rooted portion of plantlets/ crops is either dipped or dusted with the mycorrhizae before planting or can

Table 1. Beneficial effects of AM fungi (AMF) inoculation in crop plants under abiotic stress

Crop	AMF	Yield
Papaya	<i>Glomus</i> sp.	Growth, production, and fruit quality
Passion fruit	<i>Gigaspora albida</i> and <i>Scutellospora heterogama</i>	Production
Sweet orange	Mixed AMF strains of IARI), <i>Azospirillum</i> , and micronutrients sprays	
Kinnow mandarin	<i>Glomus deserticola</i> Mixed AMF	Growth, nutrient uptake and control of root damage by nematodes
Apple	AMF + <i>Azotobacter chroococcum</i>	Yield, P and Zn uptake
Mango	mixed strain of AMF and phosphate solubilizing bacteria	Growth, fruit yield and quality
Ber	<i>Glomus</i> sp.	Net photosynthesis and transpiration
Maize	AM fungi	Improves water relations
Green gram	<i>Glomus fasciculatum</i>	Water use and increased fertilizer efficiency
Maize	<i>Glomus mosseae</i>	Increased phosphorus uptake
Red gram	<i>Glomus mosseae</i>	Increased nitrogen uptake
Citrus karna	Mixed inoculum of <i>Glomus</i> sp. and <i>Gigaspora</i> sp.	Increased nitrogen uptake
Hemp	<i>Glomus macrocarpum</i>	Increased magnesium uptake
Cotton	<i>Glomus mosseae</i>	Increased chloride uptake

Table 2. Recommended arid crops for mycorrhizal inoculation

Cereals and Millets	Wheat, Barley, Maize, Sorghum and Pearl Millets
Legumes and pulses	Black gram, Green gram, Cowpea and Chickpea
Oilseeds	Groundnut and Castor
Vegetables	French bean, Cowpea, Cluster bean, Brinjal, Capsicum and Cucurbits
Tuber Crops	Carrot, Beetroot and Potato
Fiber Crops	Cotton
Fruit and orchards	Mango, Pomegranate, Sapota, Date palm, Ber and Guava

be applied directly into the planting pits.

Established tree : For applying mycorrhizae to establish trees there is need to make a hole near the roots with fork or augur and pour the mycorrhizae and water solution in the holes to reach the feeder roots of plant.

Factors affecting utilization of VAM fertilizer by plants

Climatic factors: It is generally considered that higher light levels (duration and intensity) and elevated CO₂ can enhance the efficiency of photosynthesis, which can contribute more carbon compounds to VAM fertilizer colonization and growth. A

temperature range of 18°-40°C with the optimum for most fungal-host species near 30°C are usually observed.

Soil factors: Soil pH influences VAM fungal species composition, colonization and efficiency. Fungus spore germination, hyphal elongation and plant root infection are suppressed on acidic or alkaline soil. Soil organic matter and fertility status especially phosphorus availability have significant influences on VAM fertilizer species diversity and root colonization. Root colonization, spore production, hyphal growth and response of plants to VAM fertilizer inoculation are reduced by abundance of phosphorus in soil.

Salinity: Salinity, not only affects the host plant but also the AMF. It can hamper colonization capacity, spore germination and growth of hyphae of the fungus. Colonization of plant roots by some AMF is reduced in the presence of NaCl probably due to the direct effect of NaCl on the fungi indicating that salinity suppresses the formation of arbuscular mycorrhiza.

Tillage and fertilization: Modern agricultural practices, such as tillage, heavy fertilizers and fungicides and poor crop rotations, hinder the ability of plants to form symbiosis with arbuscular mycorrhizal fungi. More tillage and heavy usage of phosphorus fertilizer can inhibit mycorrhizal colonization and growth.

Sustainable management of arbuscular mycorrhiza for plant growth

All agro-ecosystems can benefit by promoting arbuscular mycorrhizae establishment and management. Management of VAM fungi is especially important for arid, semi-arid and low-input agriculture systems where soil phosphorus is low. Proper management of arbuscular mycorrhiza in the agro-ecosystems like reduced tillage, low phosphorus fertilizer use and adaption of perennial cropping systems can improve the efficiency of mycorrhizal colonization and improve productivity of the land.

SUMMARY

Role of VAM fertilizer in alleviating abiotic stress in plants has been consistently demonstrated specially on arid and semi-arid crop species by various workers. The proper use of VAM fertilizer in major crops will be a boon in managing abiotic stress and making cropping system sustainable/profitable in fragile ecosystem of arid and semi-arid regions.

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