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Mycorrhizal Fungi Fortification: Healthy Planting Material Production in Black Pepper

Research affirms that Arbuscular mycorrhizae play a crucial role in mobilizing essential soil nutrients such as phosphorus, nitrogen, zinc, iron, calcium, magnesium, manganese, sulphur, etc. They achieve this by enzymatically releasing these nutrients from tightly held chemical bonds and transporting them back to the plant. Additionally, mycorrhizae have been acknowledged for enhancing plant disease resistance, improving its ability to thrive under drought conditions, and enhancing soil structure. The paper discusses its beneficial applications in nursery condition on black pepper.

ARBUSCULAR mycorrhizal (AM) fungi play a crucial role in horticultural ecosystems by forming a mutually beneficial relationship with a majority of plants. This symbiotic association is characterized by the exchange of resources as the fungi receive sugars from the plant, and in turn, their hyphae, which are thread-like structures, function as extensions of the plant's root system. This extension enhances the plant's access to essential, immobile nutrients like phosphorus, zinc, and copper. The symbiosis involves a flow of carbon compounds (such as sugars and lipids) from the plant to the fungus, while inorganic nutrients and water move from the fungus to the plant. Consequently, the relationship establishes a critical linkage between the plant and the soil, benefiting both organisms. While the root hairs of plants typically extend only 1-2 mm into the soil, the hyphae of mycorrhiza explore a significantly larger soil volume, reaching up to 15 cm away from the plant's roots. The association between mycorrhizae and crop plants not only often boosts plant growth and yield but also, even in the absence of observable growth enhancement, plays a major role in phosphorus uptake.

Arbuscular Mycorrhizal Fungi's Benefits

Improved nutrient uptake: Arbuscular mycorrhizal (AM) fungi form a symbiotic relationship with plant roots, enhancing the plant's ability to absorb essential nutrients such as phosphorus, nitrogen, and micronutrients.

Increased drought tolerance: Mycorrhizal associations can improve a plant's water retention and resistance to drought, which is beneficial in nurseries where maintaining proper moisture levels can be challenging.

Enhanced plant growth: The improved nutrient and water uptake facilitated by AM fungi leads to increased plant growth, promoting healthier and more robust seedlings and young plants.

Disease resistance: AM fungi can help protect plants from certain soil-borne pathogens (eg. *Phytophthora capsici*) by enhancing the plant's immune responses and promoting the growth of other beneficial microorganisms.

Reduced fertilizer requirement: By enhancing nutrient uptake, mycorrhizae reduce the need for synthetic fertilizers.

Soil health improvement: Mycorrhizal associations contribute to soil health by improving soil structure and increasing microbial diversity.

Sustainable practices: Incorporating AM fungi in nursery operations aligns with sustainable and environmentally friendly practices, reducing the need for chemical inputs.

Transplant success: Using mycorrhizae during the nursery phase prepares young plants for successful transplanting into gardens or larger agricultural systems, as they are already adapted to a mycorrhizal association.

Crop quality: Improved nutrient uptake results in higher-quality plants with better nutritional content, making them more desirable for sale or transplantation.

Cost savings: While there may be initial costs associated with introducing mycorrhizae in the nursery, the long-term benefits can lead to cost savings through reduced fertilizer and water usage and increased plant quality.

Incorporating AM fungi into nursery practices can be a sustainable and effective way to optimize plant growth and health, ultimately leading to more successful plant establishment under field conditions.

Occurrence of AM in spice crops

Based on our observations, most of the spices possessed AM fungal spores as a regular component of the soil microflora. Especially spices like black pepper, ginger, turmeric and cardamom harbour endo mycorrhizae. It was also found that positive correlation between the

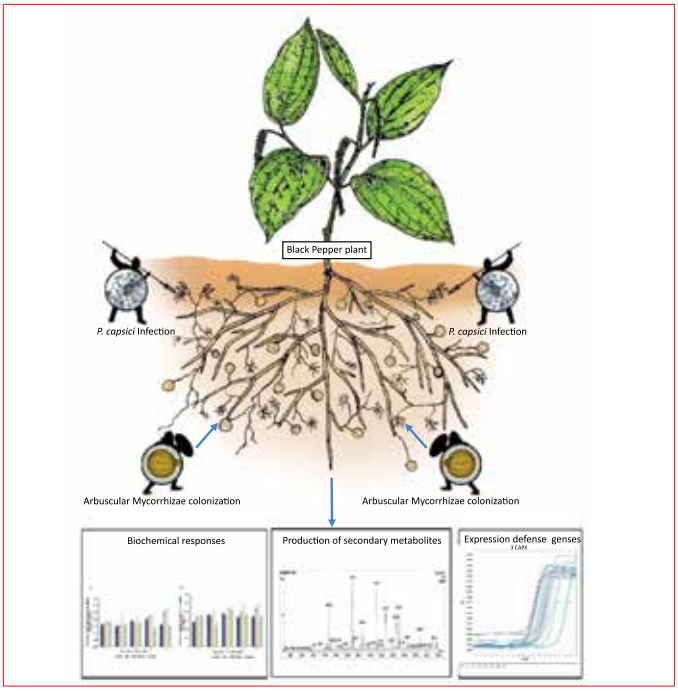
performance of black pepper cuttings and the percentage of root colonization by arbuscular mycorrhizal (AM) fungi. The inoculation of AM fungi exhibited synergistic effects on the growth and nutrient absorption of black pepper cuttings. The protective effect of AM symbiosis accompanied by the systemic activation of genes involved in induced systemic resistance confers plant immunity against pathogens.

Effect of AM (*Rhizophagus irregularis*) fungi on black pepper cuttings

- AM enhances the rooting of black pepper cuttings and also increases root biomass as well as uptake of nutrients.
- AM association with black pepper enhances the defense-related enzymes mainly peroxidases which ultimately provide protection from diseases.
- AM pre-inoculation significantly increased the activity of pathogenesis-related genes CAPX (PR7), Osmotin (PR5) and -1,3-glucanase (PR2), phenylalanine ammonia-lyase (PAL) and NPR in black pepper leaves and roots upon *Phytophthora* inoculation.
- AM inoculation increased the soil enzyme activity and other beneficial microbes of the black pepper rhizosphere.
- AM increase in the biochemical defence parameters such as phenols, lignin and peroxidase activity was noticed upon AM application
- The roots of black pepper plants produce fatty acids in response to arbuscular mycorrhizal (AM) colonization. These fatty acids help boost the plant's immune response.

Effect of arbuscular mycorrhizal inoculation on growth promotion and defence responses in black pepper

Already several packages are available for AM fungi application in nurseries as well as under pot culture for horticulture crops. The method of AM application for black pepper is given below.



Production methodology for AM-fortified black pepper cuttings

Black pepper cuttings production involves preparing a nursery mixture with soil, farmyard manure, and sand (2:1:1 ratio). The mixture is solarized to eliminate pathogens and combined with *Rhizophagus irregularis* (AM fungus). For 100 kg potting mixture, one kg of arbuscular mycorrhizae (AM) will be added. Mycorrhizal spores of colonized crop roots, and viable mycorrhizal hyphae function as active propagules of AM fungi that can be used as inoculum to "infect" other plants. The AM inoculum will be prepared with vermiculite as the carrier, containing 100 propagules per gram of the inoculum in the form of spores, hyphae, and mycorrhizal roots. Black pepper cuttings are generally propagated by adopting a serpentine layering technique in the nursery mixture, enriched with arbuscular mycorrhizae. Single plant can produce 40-60 rooted cuttings annually. This method integrates soil health management, mycorrhizal symbiosis, and efficient cutting multiplication. By continuing with host plants and providing favourable conditions, an effective and self-sustaining population of beneficial arbuscular mycorrhizae fungi can be established on the farm to improve crop yields.

Point to be considered while applying Arbuscular Mycorrhizae under nursery conditions

- Maintain adequate soil moisture for mycorrhizal establishment. Well-drained and sterile soil mix helps to promote mycorrhizal colonization.
- Do not use contaminated or low-quality inoculum, as it may introduce pathogens or ineffective mycorrhizal species.
- Do not apply mycorrhizae in soils with high salinity, as it may negatively impact their effectiveness.
- Refrain from using fungicides immediately following the application of mycorrhizae, as they can hinder the establishment of mycorrhizal fungi. In such cases, re-inoculation may be necessary to reintroduce arbuscular mycorrhizal (AM) fungi.
- Do not excessively fertilize the plants, as this may reduce their reliance on mycorrhizal associations.
- Do ensure that the soil pH is within the optimal range for the establishment of mycorrhizal fungi.

CONCLUSION

AM inoculation with potting mixture improves the root and shoot growth, and increase the colonization of black pepper cuttings. This method integrates soil health management, mycorrhizal symbiosis, and efficient cutting multiplication. By consistently creating favourable conditions, it is possible to establish a healthy and self-sustaining population of arbuscular mycorrhizal fungi on the farm. Additionally, this practice helps reduce nutrient loss and maintains soil fertility, making it an effective effort to mitigate climate change.

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