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Role of Mycorrhizae in Horticultural Crops: - A Review

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ABSTRACT

There is a chance that most vegetable crops will act as hosts for arbuscular mycorrhizal fungus (AMF). AMF can improve host plant resistance to nematodes and root diseases, as well as boost nutrition and water availability. It can also raise environmental stress tolerance. As commercial inoculation products are available, It should be remunerative to inoculate vegetable crops with AMF. While the impacts of AMF on several vegetable crops have been explored in the past, It is yet unknown how significant these effects will be for these crops in the horticultural industry. We examine AMF's cutting-edge capacities in this review to increase vegetable crop yield through growth promotion, stress reduction, bio control of illnesses, and chemical quality enhancement. In the natural world, there are interactions between plants and microorganisms that may either help or hurt the host plants. Encouragement of essential for plant growth interactions for increased agricultural production and quality is one method for producing crops in a way that is ecologically friendly and sustainable. The future challenge of employing AMF in the production of vegetables will be to optimise combinations of crop plant with AMF inoculum, inoculation procedures, and substrate or soil properties for mycorrhiza formation and application. AMF inoculations may be combined with other bio-fertilizers or biopesticides in certain promising ways. Plant growth and production are decreased by abiotic stresses. Abiotic challenges on crop production are now much more harsh as a result of climate change and agricultural malpractices such as heavy use of pesticides and fertilizers. There has also been harm to the ecosystem. Arbuscular mycorrhizal fungi (AMF) are one such environmentally friendly management technique that may be used to boost agricultural output. AMF are usually called "bio-fertilizers" in the industry. Also, it is well acknowledged that injecting AMF to host plants imparts resistance on them against a number of adverse situations, such as heat, salt, drought, metals, and extremely high temperatures. AMF supports plant development by balancing the nitrogen supply, greatly lowering seedling mortality after transplantation, and reducing nutrient waste. The goal of the current study was to characterise the AMF diversity that lives in the host rhizosphere, particularly that which is connected to vegetable crops.

Keywords:- Arbuscular mycorrhizal fungus(AMF), Abiotic stressors, biopesticides, rhizosphere

INTRODUCTION

Many plants that flourish in their natural environments have complex mycorrhizal associations instead of simple roots, which promote as a result of soil fungus infecting the roots. Only a few plant species, mostly those from the Cyperaceae, Chenopodiaceae, Cruciferae, Juncaceae, and Proteaceae families, are incompatible with mycorrhizal fungi, which make up more than 90% of plant taxa. Endomycorrhizas, ectendomycorrhizas, and ectomycorrhizas are the three physically dissimilar categories into which mycorrhizas are typically subdivided depending on whether or not fungi penetrate the root cells. There is currently ample evidence to support the significance of mycorrhiza for plant development and health. The AMF are the most prevalent, several, and well researched of these mycorrhizas. According to studies (Cheng et al., 2021; Wu et al., 2017, 2019b; Tian et al., 2021; Zou et al., 2021). The development of horticultural crops was boosted by the introduction of mycorrhizal fungus, which further enhanced fruit quality and increased intake of water and mineral nutrients. Phytochemicals and minerals found in horticulture crops have received more attention as essential components of normal meals in recent years due to growing understanding of their health-promoting and protective properties. According to (Singh & Prajapati (2018), horticultural crops also include flowers, decorative plants, medicinal and aromatic plants, as well as vegetables, fruits, spices, and nuts that are directly used as food by humans.

Smith and Smith (2011) examined and provided a thorough description of the application of arbuscular mycorrhizal (AM) colonisation of several commercially significant agricultural species. The focus of the current analysis was on vegetable crops grown in horticulture systems, which frequently differ from arable production systems by being grown in soils with little to no native mycorrhizal inoculum. Arbuscular mycorrhizal fungi (AMF) come in a variety of commercial inoculum types, and alternatives for producing AMF inoculum on-site for vegetable crops have already been discussed (Douds et al., 2012; Gauret al., 2000; Wertheim et al., 2014). This begs the issue of how much and how effectively AMF vaccinations can boost vegetable crop productivity and product quality.

Fungi are also utilised as biofertilizers and provide plants with inorganic nutrients including phosphate, nitrate, and ammonium. Microorganisms in the rhizosphere may outlast competition from other soil components and endure a range of environmental circumstances (Ferrara et al., 2012).. This fungus-plant partnership promotes plant growth and hastens root formation. A plant growing in a one-liter container may have one km of hypae (fine filaments), and it may reach water and nutrients in the soil's tiniest holes. Additionally, it lessens the plant's susceptibility to soil-borne diseases and other environmental challenges including salt and drought. The plant provides the fungus with glucose as well as additional nutrients in return. These carbohydrates are used by them for growth as well as for the synthesis and excretion of substances like glomalin, a glycoprotein. The discharge of glomalin into the soil environment enhances soil structure and boosts the amount of organic matter.

Positive effects of horticultural growth of crops using inoculants of arbuscular mycorrhizal fungus

Due to the decline in native AMF populations in the soil, AMF-inoculated horticultural crops are becoming more and more widespread, especially in intensive horticultural cropping systems. The least expensive method for spreading AMF is field propagation. In a nutshell, the AMF is allowed to grow and spread on its own by being grown on infected host plants in sandy soil. When the growth cycles are over, mycorrhizal roots and soil containing propagules are removed, dried, and utilised as inoculum. Despite the ease of use of this propagation strategy, there are a number of drawbacks, including inconsistent output, spore harvesting difficulties, and a high danger of insect, disease, and weed contamination of the inoculum. Many of these issues might be resolved by adopting soilless AMF inoculum generation in greenhouses with host plants grown in sterile materials like vermiculite. Additionally, mycorrhiza-helper bacteria and plant growth-promoting microorganisms (PGPM) may also be found in abundance in commercial AMF inoculum from unsterile production (Schneider and Döring, 2015; By stimulating phosphorus nutrition or other metabolic events in the host plant species, arbuscular mycorrhizal fungus can impact the quality of plant seeds by enhancing their protein and fat contents. One of the most important advantages of AMF for crop productivity is improved phosphorus nutrition (Hart and Forsythe, 2012). According to Tawaraya et al. (2012), AMF enhanced the availability of phosphorus for Welsh onions by causing the insoluble parts of inorganic phosphorus to dissolve. This boosted phosphorus absorption and concentration in the plant tissue. Similar to this, Aliasgharzad et al. (2009) showed that AMF inoculation increased P and K absorption of onions cultivated under drought stress. The ability of plant roots to absorb nutrients is increased when arbuscular mycorrhizal fungus colonise them (Sadhana, 2014). Additionally, they develop an exterior hyphal web that considerably increases the soil's surface area for nutrient absorption (Tawaraya et al., 2012). The nutritional values and yields of two genotypes of durum wheat (Triticum durum L.) were studied in a greenhouse experiment by Al- Karaki and Clark (1999) to ascertain the effects of arbuscular mycorrhizal fungus and soil phosphorus. They came to the conclusion that limiting the amount of phosphorus applied to the soil led to an increase in the root colonisation of arbuscular mycorrhizal fungi. Additionally, when arbuscular mycorrhizal fungi were applied to plants without soil phosphorus administration, the amount of lipid and seed dry weight increased significantly, however the amount of protein decreased significantly when compared to untreated plants. Plant phosphorus concentration was closely related to the protein and fat content of wheat seeds. On the other hand, about 30% of the world's agricultural lands are zinc deficient, mostly in tropical areas (Cavagnaro 2008), and this can significantly reduce crop productivity and zinc content, resulting in insufficient dietary zinc intake for many human populations as well as having a detrimental effect on human health. According to several studies, arbuscular mycorrhizal fungi can improve plants' ability to absorb zinc under field settings (Cavagnaro 2008; Seleiman et al. 2013). In this regard, the zinc content of mycorrhizal wild tomato plants' shoots and fruits was 50% greater than that of a mutant tomato plant with reduced mycorrhizal colonisation for roots (Cavagnaro et al. 2006).

Effects of endomycorrhiza on plant mineral nutrition, growth, and defence.

Endomycorrhizas have a primary function of enhancing plant development by improving the delivery of soil minerals to roots, especially those that are less mobile and have low concentrations in soil solutions. These include phosphate, ammonium, zinc, and copper for VA and ericoid endomycorrhizas. The activity of the endomycorrhizal fungi is primarily responsible for the higher absorbing capacity of endomycorrhizal plants. Hale and Sanders (1982) demonstrated that killing the fungus by adding fungicides like benomyl to the soil can significantly reduce the amount of phosphate that enters VA endomycorrhizal plants.

However, mineral uptake from soils is no longer restricted to the absorbing zone just behind the root apex but rather extends beyond the depletion zone formed at the root surface thanks to the absorbing surface offered by the ramifying mycelia extending out from endomycorrhizal roots. The size and rate of spread of their hyphae in roots and soil, as well as their capacity for uptake and translocation, are likely related to the different capacities of endomycorrhizal fungi to enhance nutrient uptake by the host (Gianinazzi-Pearson and Gianinazzi, 1983; Smith and Gianinazzi-Pearson, 1988).

Horticultural crops' nutritional quality has been proven to be improved by mycorrhizal inoculation in addition to increasing production (Baum et al., 2015; Rouphael et al., 2017).Several methods (such as soil disinfection, potting mixes or inert substrates, micropropagation, etc.) have been developed over the past ten years that either completely prevent or greatly reduce the likelihood of endomycorrhizal infection occurring. This is true even though endomycorrhizal fungi may be useful for improving plant production. Reduced plant growth rates, a need for more fertiliser, fragile plants, or even the failure to establish seedlings are possible effects on plant productivity.

Since most horticultural crops are grown in nurseries where AMF inoculation is done before transplanting to the field, better seedling survival and establishment is another advantageous consequence of AMF (Delian et al., 2011). The survival and establishment of the seedlings are supported by the increased intake of nutrients made possible by AMF. A productive crop and strong yield depend on quality seedlings. In plants infected with AMF, proteins, proline, and soluble sugars accumulated more on onion leaves, according to Bettoni et al. (2014). This improved the onion seedlings' resistance to environmental challenges and promoted their development. With or without P2O5, inoculating a seed of cucumber with Glomus mosseae and G. etunicatum increased seedling survival and growth.

AMF's reduction of abiotic stress

It has been believed that mycorrhiza maximises the plant's effective absorptive surface area. Nutrients acquired by extra matrical hyphae may improve plant growth and reproduction as well as minimise abiotic environmental stress in soils that are poor in nutrients or moisture. Because it reduces crop yield by more than 20% on more than 20% of the world's irrigated land, salinity is one of the most severe environmental stresses. AMF has been used to reduce salinity stress, according to Porcel et al. (2012). They discovered that, despite the negative effects salinity can have on AMF, several studies have found that mycorrhizal plants actually grow and perform better when exposed to salt stress. These beneficial effects could be attributed to better host plant nutrition, higher K+/Na+ ratios in plant tissues, better osmotic regulation via accumulation of compatible solutes like proline, glycine betaine, or soluble sugars, as well as improved photosynthetic and water use efficiency under salt stress. Through changes in plant physiology and gene expression, AM symbiosis improves vegetable crop plants' tolerance to water deprivation (Aroca et al., 2008). Their findings on lettuce plants suggest that AM plants adjust their levels of abscisic acid better and more quickly than NM plants, permitting a better balance between root water flow and leaf transpiration during drought and recovery. The founding of colonies with AMF improved the host plants' water status during chilling stress, particularly in areas with severe drought. AMF additionally decreased the chilling-related secondary water stress damage to their host plants.

AMF in Plant Mineral Nutrition

Endomycorrhizas have a primary function of enhancing plant development by improving the delivery of soil minerals to roots, particularly those that are less mobile and have low concentrations in soil solutions. These include phosphate, ammonium, zinc, and copper for VA and ericoid endomycorrhizas. The activity of the endomycorrhizal fungi is mainly liable for the higher absorbing capacity of endomycorrhizal plants. Hale and Sanders (1982) demonstrated that killing the fungus by adding fungicides like benomyl to the soil can significantly reduce the amount of phosphate that enters VA endomycorrhizal plants. It is clear that AMF inoculation may drastically raise the concentration of a variety of macro- and micronutrients, which results in higher photosynthate production and, ultimately, increased biomass accumulation. AMF form symbiotic relationships with host plant roots to absorb vital nutrients from them and then exchange them for mineral nutrients including N, P, K, Ca, Zn, and S. As a result, inside the root cells, AMF maintain the plants' nutritional needs even in unfavourable situations. Increased growth rate for AMF inoculation, which has a direct connection to the intake of N, P, and carbon, which travel towards roots and contribute to the formation of tubers, is directly related to increased photosynthetic activities and other leaf functions. Under various irrigation regimes, it has been found that AMF maintains P and N absorption, eventually assisting in plant growth at higher and lower P levels (Liu et al., 2014; Liu et al., 2018). Even in places with a sufficient number of animals and farmyard manure (FYM), nitrogen (N), a major source of soil nutrition, is a well-known mineral fertiliser. Numerous researchers have discussed how AMF aids in the uptake of soil nutrients, particularly N and P, which can significantly aid in the development of host plants (Smith et al.,2011).

Conclusion

In conclusion, mycorrhizae play a crucial role in enhancing the resilience and productivity of horticultural crops, particularly under drought conditions. The symbiotic relationship between mycorrhizal fungi and plant roots provides several benefits. Mycorrhizae increase water absorption by extending their hyphae into the soil, accessing water from deeper layers and making it available to plants during drought. This, in turn, improves water use efficiency, reducing the plant's water requirements for growth and development. Additionally, mycorrhizal associations promote osmotic adjustment, helping plants maintain cellular water potential and withstand drought stress. Moreover, mycorrhizae enhance nutrient uptake, especially phosphorus, which is vital for horticultural crop productivity. The fungi also contribute to soil structure, moisture retention, and nutrient cycling, further supporting plant health and resilience. Harnessing the benefits of mycorrhizae in horticultural crop production can enhance drought tolerance, increase yields, and improve overall plant health, making them valuable allies for sustainable and resilient agriculture. In horticulture, where the goal is to maximize productivity and quality, harnessing the benefits of mycorrhizae through practices like inoculation or creating favorable conditions for their growth can be advantageous. Utilizing mycorrhizal symbiosis in horticultural systems can lead to more sustainable and resilient crop production, ultimately benefiting both growers and consumers.

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