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Review Article

Arbuscular Mycorrhizal and Citrus Growth: Overview

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Abstract

The important role of mycorrhizae for citrus orchards recognized from last century (1935), there are about 18 arbuscular mycorrhizae (AM) species belong to five families, however *Glomus aggregatum* and *Claroideoglomus etunicatum* are the dominant species worldwide.

The arbuscular mycorrhizae are highly effective in citrus orchards particularly in low fertility soil, however, *Glomus aggregatum* is the dominant species in citrus orchards, AM hyphae inhabits plant roots and surrounding soils too.

There are various benefits for arbuscular mycorrhizae in citrus orchards such as improve water uptake, increase phosphorus and micronutrient absorption, enhance plant tolerant for stress conditions, improved shoot and root growth of citrus rootstock, also, inoculation citrus seedlings by arbuscular mycorrhizae enhancing seedling growth and increase survival rate after transplanting.

Keywords: Arbuscular Mycorrhizae; Citrus Orchard; *Glomus aggregatum*; Water Uptake; Stress Conditions

Background

Arbuscular mycorrhizae (AM) considered one of the main species symbioses into the soil, it could colonize more than 80% of the higher plant species [1]. There is an imperative role for Arbuscular mycorrhizae in the preservation of agro-ecosystem stability and sustainable agricultural development.

There are five families of Arbuscular mycorrhizae (AM) were identified, it contains about 18 AM species as follow:

- Family Glomeraceae (nine species).
- Family Acaulosporaceae (four species).
- Family Claroideo glomeraceae (two species).
- Family Pacisporaceae (two species).
- Family Gigasporaceae (one species).

However, *Glomus aggregatum* and *Claroideoglomus etunicatum* are the main species in different regions worldwide [2].

Citrus is one of the major fruit crops in Egypt, due to cultivated area or total production which reached to 4272886 metric tons, or economic values [3], also, Egypt ranking as the sixth biggest producer of orange throughout the world after Brazil, China, US, EU, and Mexico [4].

Citrus trees are cultivated in various regions in Egypt and in different types of soil, most varieties of citrus have small root hairs or short in soil systems, and are thus mostly dependent on AM hyphae [5].

Farm management practice like the intensity of cultivation, irrigation techniques, plant protection, weed control, concentrated fungicide application and other agricultural practices could effect on AM population [6].

Read and Fremont (1935) was the first authors recognize the essential role of mycorrhizae for citrus orchards. However, Srivastava., *et al*. (2002) reported that mycorrhizae are highly effective in low fertility soil.

Main function of Mycorrhizal

1. Improve water uptake: in arid and semi-arid soil regions, AM increases water uptake to host plants.
2. Increase nutrient absorption like P, Zn, Cu, K, and NH4 sometimes

3. Enhanced acquisition nutrient to the host plants [9].
4. Enhancing water relations under water deficit conditions: AM inoculation increases plant resistance against stress conditions such drought and high temperature [10].
5. Provide pathogen protection.
6. Increase plant tolerant for salinity conditions (Gohre and Paszkowski 2006) [11].

Also, mycorrhizal hyphae increase soil fertility by increasing soil aggregation and improve water holding capacity.

Mechanism of AM

After plant infection, Arbuscular mycorrhizae (AM) hyphae penetrate the plant cells without any injury and the typical organs, such as arbuscules and vesicular formed in the roots, AM inhabits plant roots and surrounding soils too, they can assist their host plants in various ways [9].

AM fungus colonization plays an important role under drought stress, AM hyphae absorbed water and transport directly to host plants. AM colonization affecting the soil moisture retention via glomalin's effect on soil water-stable, AM fungi hyphae produced immune-reactive glycoprotein (Glomalin) [12], which used in bind soil particles into water-stable aggregates [13].

Therefore, AM maintained more water in soil by increase water-stable aggregates and improves soil structure, therefore, soil reserve more water in rhizosphare and water-stable aggregates improve soil structure.

The most important effects of AM on the physiology of plants are to increase the absorption of phosphorus, micronutrient and water as follow:

- Water and Phosphorus transport through AM pathway.
- Root and fungal aquaporins,
- Phosphorus and sugar transporters.
- Accumulation of osmolytes [proline and sugars]

Role of arbuscular mycorrhizae

The main importance of AM increased with the phosphorus deficit in the plant tissues, it increases the uptake of phosphorus and improving plant growth, the potential of mycorrhizae is to improve the nutrient uptake efficiency from depleted nutrient in the soil [14].

AM fungi enhancement the activity of soil enzymes, such as dehydrogenase, phosphatase, and urease for instance.

Increasing AM colonization increased soil phosphatase activity directly, phosphotase enzyme improves plant tolerance for stress conditions.

Mycorrhizae and citrus

There are different species of AM found in citrus orchards, and many of this species could habitation citrus root system at the same time, there is a wide contribution of AM fungi on plant growth and nutrient absorption.

Inoculation citrus orchards with AM fungi have many positive effects on tree growth, as growth rate, increase flower number, and fruit set, also AM infection at low nutrients soil improve citrus yield as quantity and quality.

AM inoculation at the nursery stage improve seedling growth and increase survival rate, also mycorrhizae increased seedling quality and maintain good growth after transplanting from greenhouse to field conditions.

In citrus orchards, water deficit stress inhibits vegetative growth and decrease total yield, also, it has a harmful effect on fruit characters [15], and drought could change root-distribution [16].

The positive effects of AM fungi to alleviate drought stress symptoms have been reported, there are many papers indicated that, the AM enhance water relation and play an essential role in citrus growth under drought stress [17].

Mycorrhizae Species and Nutrient Uptake in citrus

Inoculation citrus orchards soil with selected AM species increasing the citrus growth and enhancing nutrient and water uptake [18].

There are different types of mycorrhizae fungi mainly endo and ecto mycorrhizae, including *Glomus aggregatum, Claroideoglomus etunicatum, Sclerocystis, Gigaspora,* and *Acaulospora*. But, *Glomus aggregatum* and *Claroideoglomus etunicatum* are the major species in various areas [2]. Gadkar., *et al*. (2001) reported that, Arbuscular mycorrhizae (endo-mycorrhizae) considered the most extensive plant-root symbiosis, about 90% of plant species including citrus trees.

There are over 150 species of AM colonize more than 200 thousand of different plant host [17], also, various AM species found in citrus orchard like Gigaspora, Glomus, Acaulospora, and Sclerocystis species [20,21].

Glomus species is the predominant AM species in citrus root rhizosphere in different region worldwide [22], Fidelibus., *et al*. (2000) found that *Glomus occultum* represent more than 80% of the total AM fungal spores in citrus orchards at Yuma, however, in Nagpur mandarin orchards at central India the Glomus spp. was the main species [23].

Effect of arbuscular mycorrhizal inoculation on citrus rootstocks

Citrus rootstocks differ in their nutrient acquisition due to their root system, root growth patterns, and mycorrhizal dependency which can influence nutrient absorption, inoculations citrus rootstocks with AM fungi improved shoots and root growth through improved nutrient and water uptake [24].

Conclusion

There are different species of arbuscular mycorrhizae colonizing citrus roots and many of this species could habitation citrus roots at the same time, however *Glomus aggregatum* is the dominant species in citrus orchards.

The arbuscular mycorrhizae are highly effective in citrus orchards particularly in arid area and in low fertility soil, infection citrus orchards soil with AM species increases vegetative growth, nutrient uptake, and improve fruit quality. Also, AM, enhance citrus tolerant for drought stress, and improved root growth of citrus rootstock.

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