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# Mycorrhizae Applications in Horticultural Production on Plant growth

ortas, ibrahim

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## Introduction

Soil biological properties, such as useful microorganism, are important for soil quality. Also the interactions between micro organisms, such as mycorrhiza, soil-borne fungi and nematodes are important for sustainable agriculture (Ortas, 2008). Arbuscular mycorrhizal fungi (AMF) form a symbiotic association with plants. In exchange for plant carbohydrates they increase the uptake of immobile nutrients, such as P, Zn, and Cu, and also $NH_4^+$-N, K and Mn (Cavagnaro, 2008).

Horticultural cultivation is becoming widespread in the Mediterranean coasts of Turkey. Soils in this region have high levels of clay and lime, which cause P, Zn, Fe and Mn deficiency; consequently, the major problem in the region is nutrient deficiency in several plant species (Ortas 2008). Cakmak et al. (1999) reported that zinc (Zn) deficiency is a critical nutritional problem for plants and humans in Turkey. Since the Zn is an essential element for several enzymes in plants, Zn deficiency reduces the plant growth dramatically. Zn deficiency can be alleviated by fertilization. However the recent rise in the use of fertilizers has affected both human health and ecosystems. In the last few decades, it has been observed that a reduction of fertilizer input resulted in the improvement of soil quality. We tested whether mycorrhizal inoculation of seedlings could completely or partially substitute fertilizer application.

In general, horticultural plants are mycorrhizal dependent. Our earlier results showed that mycorrhizal seedlings are more resistant to environmental stress factors, such as water deficiency and hot temperature. Under field conditions, the effect of mycorrhizal inoculation on the mortality of seedling was tested and it was found that inoculated seedlings had a greater survival rate than non inoculated plants (Ortas et al., 2004; Ortas, 2006; Ortas and Varma 2006). It is essential to screen efficient AM fungi in order to get the maximum benefit from mycorrhiza for a particular host. Lee and George (2005) have shown that *G. mosseae* inoculated cucumber (*Cucumis sativus* L) plants had increased P, Zn, and Cu concentrations, and mycorrhizal hyphae transported those nutrients to the plants. Since most horticultural crops are grown under controlled nursery conditions before being transplanted to the greenhouse or open field, it is possible to inoculate the seedlings in the nursery. The effect of inoculation with several mycorrhizal species on seedling survival and plant growth nutrient uptake and root infection of cucumbers, melons, watermelons and marrows were studied.

## Material and Methods

Several field experiments were carried out on an Arik clay-loam soil, which was classified as an Entic Chromoxerert in the Agricultural Experimental Station of Çukurova University, Adana, in southern Turkey, whose prevailing climate is Mediterranean. Soil is calcareous and pH is 7.7 and organic matter content is 1.46 %. Honey melon (*Cucumis melo* L.), watermelon (*Citrullus vulgaris* Schrad.), cucumber (*Cucumis sativus* L), and marrow (*Cucurbita pepo* L) seeds were sown in a sand: soil: organic matter (7:2:1 v/v) growth medium. The inoculation treatments were control, indigenous mycorrhiza, *G. mosseae, G. etunicatum, G. intraradices, G. caledonium, G.fasciculatum* and a mix of these species. The seedlings were grown in a greenhouse for 32 days before being transferred to the main field plots.

The experimental plots (3m x 5m wide, equal to $15m^2$) were randomized with three replicates. Each crop species was tested in a separate experiment. Seedling survival yield and nutrient uptake were measured. Fruits were collected several times and leaves and root samples were analyzed for nutrient content at flowering. Roots were stained and examined for the presence and degree of mycorrhizal infection according to Gioannetti and Mosse (1980).

## Results and Discussions

Inoculation with some mycorrhizal fungi increased plant yield and nutrient uptake of honey melons, watermelons and cucumbers (Figure 1), but the effect varied with plant species. For example, *G. mosseae* was the best inoculum for honey melon. While the indigenous fungi resulted in the highest yield in water melon and cucumber. *G. clarum, G. caledonium* and the mix of fungi were the least effective.

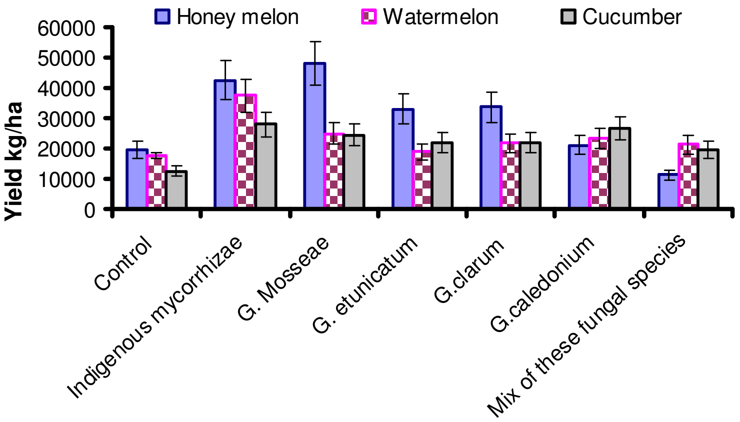

Figure 1. Effect of several mycorrhizae species on yield of honey melon, watermelon and cucumber

Mycorrhizal inoculation significantly increased P and Zn concentration in the plants (Table 1). Plants inoculated with indigenous mycorrhizae and *G. mosseae* inoculated plant had the highest P and Zn concentration (Table 1).

Table 1. Effect of mycorrhizal species on P and Zn content and root colonization of honey melon, watermelon and cucumber

| **Treatments** | **P (%)** | | **Zn (mg kg-1 DW)** | | **% Colonization** | |
|---|---|---|---|---|---|---|
| **Honey melon** | | | | | | |
| **Control** | 0.25 | ±0.01 | 25.6 | ±4.7 | 42 | ±11 |
| **Indigenous mycorrhizae** | 0.32 | ±0.04 | 36.0 | ±5.2 | 73 | ±16 |
| **G. Mosseae** | 0.33 | ±0.03 | 35.5 | ±4.4 | 77 | ±14 |
| **G. etunicatum** | 0.30 | ±0.12 | 31.6 | ±5.7 | 74 | ±14 |
| **G.clarum** | 0.27 | ±0.02 | 28.8 | ±6.5 | 71 | ±17 |
| **G.caledonium** | 0.31 | ±0.10 | 31.0 | ±7.2 | 62 | ±11 |
| **Mix of these fungal species** | 0.27 | ±0.05 | 26.0 | ±5.2 | 44 | ±6 |
| **Watermelon** | | | | | | |
| **Control** | 0.24 | ±0.02 | 26.1 | ±4.5 | 26 | ±12 |
| **Indigenous mycorrhizae** | 0.31 | ±0.02 | 34.1 | ±5.5 | 55 | ±13 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **G. Mosseae** | 0.30 | ±0.00 | 34.5 | ±3.9 | 53 | ±15 |
| **G. etunicatum** | 0.28 | ±0.08 | 31.2 | ±6.2 | 50 | ±17 |
| **G.clarum** | 0.28 | ±0.00 | 30.3 | ±5.9 | 57 | ±15 |
| **G.caledonium** | 0.26 | ±0.09 | 31.1 | ±6.1 | 48 | ±11 |
| **Mix of these fungal species** | 0.27 | ±0.06 | 28.0 | ±7.2 | 32 | ±10 |
| **Cucumber** | | | | | | |
| **Control** | 0.24 | ±0.02 | 25.8 | ±5.1 | 27 | ±8 |
| **Indigenous mycorrhizae** | 0.32 | ±0.03 | 35.0 | ±4.8 | 54 | ±17 |
| **G. Mosseae** | 0.33 | ±0.02 | 34.5 | ±3.6 | 50 | ±13 |
| **G. etunicatum** | 0.30 | ±0.10 | 32.9 | ±3.5 | 44 | ±8 |
| **G.clarum** | 0.27 | ±0.01 | 30.6 | ±5.7 | 55 | ±7 |
| **G.caledonium** | 0.28 | ±0.10 | 31.1 | ±6.1 | 50 | ±10 |
| **Mix of these fungal species** | 0.28 | ±0.10 | 29.0 | ±5.2 | 42 | ±13 |

Mycorrhizal inoculation also increased plant root colonization (Table 1). In non-inoculated plots the root colonization ranged from 24 to 27% depending on the plant species, however in inoculated plants root colonization ranged from 32 to 67%. Honey melon had the highest root colonization.

In 2004, an experiment was carried out with marrow plants with several mycorrhizal species. In general, inoculation increased yield compared to the uninoculated, particularly *G. caledonium, G. etinicatinum* and indigenous mycorrhiza (Figure 2).

Mycorrhiza inoculation increased marrow leaf P and Zn concentration (Table 2), particularly *G.caledonium*. Root colonization differed between mycorrhizae species, being highest with G. etunicatum and G. caledonium. .

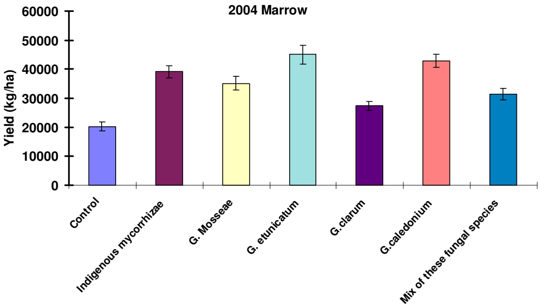

Figure 2. Effect of several mycorrhizal species on marrow yield.

Since phosphorus and zinc concentration in plant tissues are over critical level in all treatments (Jones, 1998), the yield increase by mycorrhizal inoculation may be due to protection against stress factors.

Table 2. Effect of mycorrhizal species on P and Zn content and root colonization of marrow plant

| **Treatments** | **P (%)** | | **Zn (mg kg-1 DW)** | | **% Colonization** | |
|---|---|---|---|---|---|---|
| **Control** | 0.21 | ±0.01 | 23.1 | ±4.7 | 37 | ±8 |
| **Indigenous mycorrhizae** | 0.26 | ±0.04 | 31.5 | ±5.2 | 54 | ±12 |
| **G. Mosseae** | 0.29 | ±0.03 | 30.1 | ±4.4 | 49 | ±11 |
| **G. etunicatum** | 0.30 | ±0.12 | 32.1 | ±5.7 | 60 | ±17 |
| **G.clarum** | 0.30 | ±0.02 | 29.8 | ±6.5 | 58 | ±10 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **G.caledonium** | 0.31 | ±0.10 | 32.3 | ±7.2 | 62 | ±16 |
| **Mix of these fungal species** | 0.29 | ±0.05 | 30.3 | ±5.2 | 51 | ±16 |

The results show that mycorrhizal inoculation in the nursery increases yield, and P and Zn uptake of several horticultural crops. However they also show that the effect of mycorrhizal fungi varies with plant species and differs between years. Clearly, the optimal crop-fungal combination has to be carefully chosen to maximize the effect of mycorrhizal inoculation. Previously it has been reported that mycorrhizal treatments had greater growth and Zn concentration, than non-mycorrhizal treatments with no supplemental Zn (Ortas et al., 2001). Thus the present results and previous studies suggest that mycorrhizal inoculation can at least partially replace fertilization.

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