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Short Communication

Effect of different concentrations of potassium and magnesium on mycorrhizal colonization of maize in pot culture

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The rate of root colonization by mycorrhizal fungi largely depends on the concentration of nutrient elements in roots and soil. In this study, the effects of different concentrations of potassium and magnesium on mycorrhizal colonization of maize grown in pot cultures were studied. This experiment was performed using natural soil containing spores of *Glomus* spp. Mycorrhizal spores were exposed to 3 concentrations of K solution, that is, 0.61 (soil K content), 0.92 and 1.23 meq/l and 3 concentrations of Mg, that is, 4.8 (soil Mg content), 7.2 and 9.6 meq/l, concurrently in 500 ml pots containing three seedlings of maize per pot. Forty (40) pots were cultured and kept in greenhouse under ambient conditions. Plants were watered every 4 days for 16 days with 50 ml distilled water. A pot with sterilized soil was used as negative control. For study of mycorrhizal colonization, very thin longitudinal sections of plant roots (>1 mm in diameter) were prepared manually and were stained with lactophenol-cottonblue. Mycorrhizal percentage was determined by the grid-line intersect method. Results indicated a significantly (P≤0.05) higher percentage of mycorrhizal colonization in natural soil than sterilized soil in all treatments. Percent of mycorrhizal colonization was lower in all treatments as compared to that of natural soil, except in treatments with Mg (7.2 meq/l) and combined treatment of K (0.92 meq/l) and Mg (7.2 meq/l). Latter treatment produced the highest colonization rate (56%). This may suggest the synergistic effect of these nutrients on mycorrhizal development when present in specific concentrations in soil.

Key words: Mycorrhizal colonization, maize, vesicular-arbuscular mycorrhiza (VAM)

INTRODUCTION

Mycorrhizae are mutually beneficial associations between plant roots and fungi (Safir, 1987). Most plant species and particularly crops are mycorrhizal (Ortas, 1996; Safir, 1987; Subba, 1998). As such, application of mycorrhizal technology in arid environments, such as Iran, seems promising. However, despite symbionts contributing to alleviating nutritional needs of each other under stressful circumstances, both are affected by the physical, chemical and biological paramenters of soil. Some soil elements such as phosphorus, potassium, magnesium, calcium and zinc affect crop production and yield as well as mycorrhizal development in roots (Saleh Rastin, 2001). In this context, and in light of variations in elemental content in soils of different regions of Iran, this investigation was carried out to determine the effects of different concentrations of Mg and K on mycorrhizal colonization of maize in natural and sterlized soils.

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MATERIALS AND METHODS

Pot culture

Seeds of maize (*Zea mays* Cv.Sc 700) with 86% germination rate were used. Seeds were washed in detergent solution for 30 s and

Table 1. Results of chemical analysis of soil sample.

pH	EC (ds/m)	K (meq/l)		P (available)	Na	Cl	Ca	Mg
		Total	Available	meq/l	(meq/l)	(meq/l)	(meq/l)	(meq/l)
7.7	1.43	0.69	0.61	0.11	4.9	7	6	4.8

rinsed in distilled water for 3 times. Seeds were then surface sterilized in sodium hypochlorite solution (5%) for 5 min and rinsed in distilled water again. Sterilized seeds were placed on moist Whatman #1 filter papers in sterilized Petri dishes and moistened with distilled water daily for 7 days. Later, intact seedlings were transferred to sterilized (with 70% alcohol) plastic pots containing a mixture of spores of *Glomus* spp. embedded in 500 g of natural silty-loam soil (clay 12%, silt 74% and sand 14%) in plastic pots. Fungal spores were separated using wet sieving technique under 50% sucrose density gradient centrifugation (Fritz et al., 2003). Each pot contained approximately 50 to75 spores. Chemical characteristics of soil are shown in Table 1. To improve soil drainage, 50 g of sand was used at the bottom of each pot. Treatments with K, Mg and combined K and Mg were done in pots containing natural and sterilized soil. Three maize seedlings were planted in each pot equidistantly. Four replicate pots were treated for each of the 4 treatments as follows: 1) potassium treatment in 3 concentrations (K_c, 0.61 meq/l, K concentration in natural soil and as control, K_1: 0.92 meq/l and K_2: 1.23 meq/l; 2) Magnesium treatment (Mg_c, 4.8 meq/l, Mg concentration in natural soil and as control, Mg_1: 7.2 meq/l and Mg_2: 9.6 meq/l; 3) combined K and Mg treatment (K_1Mg_1: 0.92 meq/l of K and 7.2 meq/l of Mg; K_1Mg_2: 0.92 meq/l of K and 9.6 meq/l of Mg; K_2Mg_1: 1.23 meq/l of K and 7.2 meq/l of Mg and K_2Mg_2: 1.23 meq/l of K and 9.6 meq/l of Mg) and 4) sterilized soil treatment (no spores and 0.61 meq/l K and 4.8 meq/l Mg_c).

In all treatments, K and Mg were supplied using solutions of KNO_3 and $MgSO_4.7H_2O$, respectively. Pots were watered with 50 ml of distilled water at the beginning and every 4 days for 35 days. Later, each pot was watered with 50 ml of respective treatment solutions every 4 days, regularly for 16 days. Soil in each pot was nutritionally enriched 2 times with modified Hoagland solution (1/2 of P content) every 2 weeks.

Root preparation

The fine roots with diameter less than 1 mm were fixed in glycerin-alcohol. For study of mycorrhizal colonization, thin longitudinal sections of plant roots were prepared manually. Root sections were then cleared in 10% KOH, rinsed with distilled water, neutralized with 1 N HCl, and stained with lactophenol cottonblue (Raju et al., 1990). Stained sections were examined under Olympus BH2 light microscope. Mycorrhizal percentage in each root section was determined using grid-line intersect method of Giovannetti and Mosse (1998). T-test was used to analyze data statistically ($P \leq 0/05$).

RESULTS

Percentage of mycorrhizal colonization in all treatments was greater in natural soil than that of sterilized soil (Figure 1). Mycorrhizal colonization rate in pots containing different amounts of K and Mg as compared to pots containing only natural soil (positive control) decreased significantly, except in pots treated with combined quantities of 0.92 meq/l of K and 7.2 meq/l of Mg (K_1Mg_1) and/or 7.2 meq/l Mg (Mg_1). The former treatment had the highest mycorrhizal colonization rate (56%) in roots (Figure 1). Increased concentration of K in treatments correlated with decreased mycorrhizal colonization rate. Mycorrhizal colonization in Mg treated plants increased due to concentrations of up to 7.2 meq/l but was reduced at higher concentrations.

DISCUSSION

Nutrients status of soil and plant are key factors in the development initiation of mycorrhiza in plant root (Taiz and Zeiger, 1991). In this study, effects of different concentrations of K and Mg ions in natural and sterilized soils on mycorrhizal colonization of maize roots were investigated in pot cultures. Results showed that percentage of mycorrhizal colonization was affected negatively and reduced significantly in heat sterilized soil. This is attributed to death and neutralization of mycorrhizal propagules in soil.

Treatments with combined quantities of 0.92 meq/l of K and 7.2 meq/l of Mg (K_1Mg_1), and 7.2 meq/l Mg (Mg_1) showed increased mycorrhizal colonization rate. Concentration of K in treatments correlated with decreased mycorrhizal colonization rate. Reduction in VAM mycorrhizal growth in roots grown in soils with higher nutrient content has been reported. Studies have shown that high levels of nutrient elements in soil decrease mycorrhizal colonization (Liu et al., 2000). Conversely, enhancement of mycorrhizal growth in roots harboring in nutritionally poor soils has also been documented (Azcon et al., 2003). It is very likely that reduction in mycorrhizal growth in roots is attributed to a reduction in the ability to develop arbuscules in higher concentrations of K (Mirhosseini, 1995; Karimi, 2004; Vogel-Mikus et al., 2005).

There is a correlation between increased concentration of Mg ion in soil and increased mycorrhizal colonization. This trend was true in lower to medium concentrations (upto 7.2 meq/l) of Mg but it reversed when Mg content of soil was high (Azcon et al., 2003). Jarstfer et al. (1998) reported that high levels of $MgSO_4$ reduced root colonization and sporulation by *Glomus* sp. and high magnesium concentration induced premature root

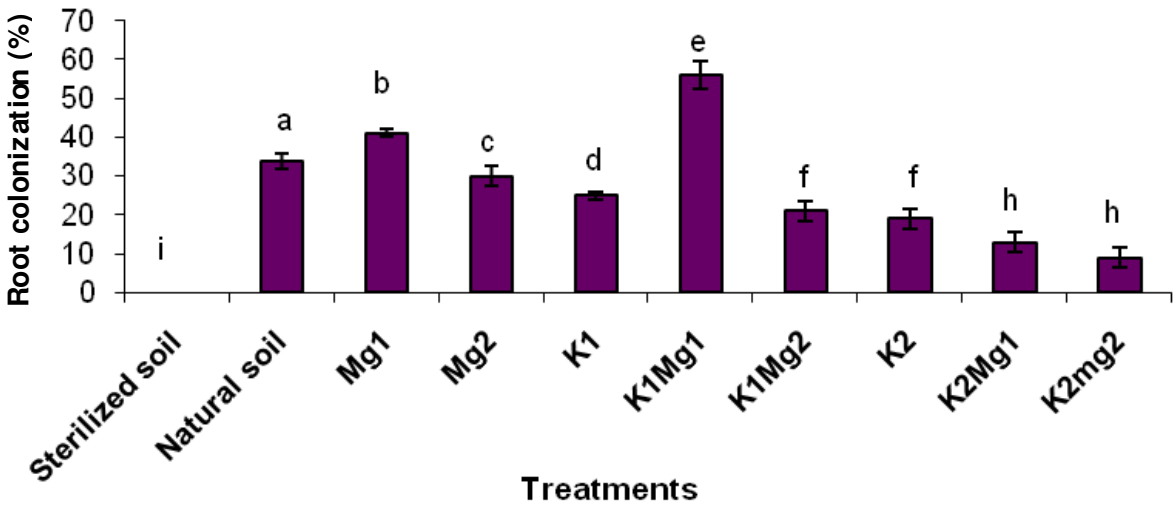

Figure 1. Effect of different potassium and magnesium levels on mycorrhizal colonization of maize. K_1: 0.92 meq/l; K_2: 1.23 meq/l; Mg_1: 7.2 meq/l; Mg_2 9.6 meq/l. Different letters on the columns represent statistically significant differences between the data sets (P≤0/05).

senescence which may have disrupted the mycorrhizal association.

When K and Mg are both present at suitable concentrations in the soil, the highest colonization rate of mycorrhiza in maize roots occurred (Figure 1). The stimulatory interaction of K and Mg on mycorrhizal colonization in host plant has been reported by Ebrahimzade (2001). However, when concentrations of these ions are not adjusted, as shown in treatments with high concentrations of these cations (Figure 1), then mycorrhizal colonization is expectedly decreased. The fact that mycorrhizae contribute to the well being of host plants and in turn improve agricultural yield and ecological turnover rate in ecosystems, attending to physiological aspects of soil nutrient contents, for example, K and Mg, of the rhizosphere in a regulated skim seems necessary (Zare-Maivan, 1993, 2004).

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