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Effect of mycorrhiza on growth criteria and phosphorus nutrition of lettuce (*Lactuca sativa* L.) under different phosphorus application rates

S. Fatih Ergin, Füsun Gülser *

Yüzüncü Yıl University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition, Van, Turkey

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Abstract

In this study, effect of mycorrhiza on growth criteria and phosphorus nutrition of lettuce (*Lactuca sativa* L.) under different phosphorus fertilization rates were investigated. Phosphorus were added into growing media as 0, 50, 100 and 200 mg P_2O_5/kg with and without mycorrhiza applications. Phosphorus applications significantly increased yield criteria of lettuce according to the control treatment statistically. Mycorrhiza application also significantly increased plant diameter, plant dry weight and phosphor uptake by plant. The highest phosphorus uptakes by plants were determined in 200 mg P_2O_5/kg treatments as 88.8 mg P/pot with mycorrhiza and 83.1 mg P/pot without mycorrhiza application. In the control at 0 doses of phosphorus with mycorrhiza treatment, phosphorus uptake (69.9 mg P/pot), edible weight (84.36 g), dry weight (8.64 g) and leaf number (28) of lettuce were higher than that (47.7 mg P/pot, 59.33 g, 6.75 g and 20, respectively) in the control without mycorrhiza application. It was determined that mycorrhiza had positive effect on growth criteria and phosphorus nutrition by lettuce plant, and this effect decreased at higher phosphorus application rates.

Keywords: Mycorrhiza, phosphorus, lettuce, plant growth criteria.

Introduction

Mycorrhiza, is one of the most common symbiotic life styles in soils, occurs between plant roots and soil fungus. Arbuscular mycorrhiza within endomikorizal life style promotes plant growth in marginal soil conditions especially having critical nutrient levels (Marschner, 1995).

Mycorrhizal funguses are the basic members of soil microflora in many ecosystems and have important roles in natural ecosystems and plantations. They have important functions on nutrient uptake by plants such as; P, N, K, Ca, Zn, Cu, Mn, Fe, regulate plant-water relations and plant protection from disease and pathogens. As a result, plants having healthy and strong root system make soils more resist to erosion with improving soil structure (Brundett et al. 1996; Gülser, 2004, 2006). Arbuscular mycorrhizal funguses uptake unavailable forms of plant nutrients, especially phosphorus, from soil by micelles and supply them to plants with having symbiotic life (Papastylianou, 1993). Fitriatin et al. (2014) reported that applications of phosphorus solubilizing microbe significantly improved yield of maize on Ultisol, but had no real effect towards potential-P, available-P, phosphatase and P uptake of plants. Application of a mix inoculant of phosphorus

* Corresponding author.
Yüzüncü Yıl University, Faculty of Agriculture, Department of Soil Science and Plant Nutrition 65080 Van, Turkey
Tel.: +90 432 2251024 E-mail address: gulserf@yahoo.com
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solubilizing microbe and phosphorus solubilizing fungi gave better effects on available-P in soil and yield of maize. Asghari and Cavagnaro (2014) studied on mycorrhizal colonization using mycorrhizal and non mycorrhizal plants, arbuscular mycorrhizal external hyphae development, plant growth, nutrient uptake and NO_3, NH_4 and available P in soil and leachate. They reported that mycorrhizal fungi highly colonized roots of arbuscular mycorrhizal plant (exotic grass *Phalaris aquatica*) and significantly increased plant growth and nutrient uptake. Columns having *Phalaris aquatica* had higher levels of arbuscular mycorrhizal external hyphae, lower levels of NO_3, NH_4 and available P in soil and leachate than non mycorrhizal plant columns.

The most researchers focused on vesicular-arbuscular mycorrhiza because of their additive effects on phosphorus uptake. Smith et al (1992) reported that vesicular-arbuscular mycorrhiza living symbiotically in more than 90% of vegetation in nature plays determinative role in phosphorus uptake by plants.

Besides their limited sources and expensive cost, excessive use of chemical fertilizers can damage soil microorganisms and cause soil pollution. Alternative approaches for chemical fertilizer use in recent years are thought due to increasing environmental pollution and decreasing phosphate rock sources. In this study, effect of mycorrhiza on growth criteria and phosphorus nutrition of lettuce (*Lactuca sativa* L.) under different phosphorus fertilization rates were investigated.

Material and Methods

This study was carried out in the greenhouse of Horticultural Department of Agricultural Faculty at Yüzüncü Yıl University, Van –Turkey. Some soil physical and chemical properties of soil were determined as follow; texture by hydrometer method (Day, 1965), available phosphorus by Olsen method, pH in 1:1 soil: water suspension by pH meter, salt content of the same suspension by EC meter, lime by Scheibler calcimeter, organic matter by modified Walkley-Black method, total nitrogen by Kjeldahl method, exchangeable potassium, calcium and magnesium by extraction of soil with 1 N neutral ammonium acetate (Kacar, 1994). The results of soil analyses belong to growing media used in this study were given in Table1. According to the results, growing media was slightly alkaline in pH, non saline, moderate in lime content, low in organic matter, total nitrogen and phosphorus contents and adequate in potassium, calcium and magnesium contents.

Table 1. Some physical and chemical properties of growing media.

Texture	Sandy clay loam	Total N, %	0.07
pH(1:1)	8.03	Available P, ppm	6.98
Salt,%	0.057	Exchangeable K, cmol/kg	1.23
Lime ($CaCO_3$),%	14.04	Exchangeable Ca, cmol/kg	24.00
Organic Matter, %	0.92	Exchangeable Mg, cmol/kg	1.84

A mixture of soil:sand:manure in 1:1:1 ratio was used as growing media. The experiment was carried out according to factorial experimental design in randomized plots with two mycorrhiza (with (M+) and without (M-) mycorrhiza) and four phosphorus (0, 50, 100 and 200 mg P_2O_5/kg) treatments. The four doses of triple super phosphate (0, 50, 100 and 200 mg P_2O_5/kg) and a basic fertilizer of 200 mg N/kg as ammonium sulphate form was added into pots. Yedikule cultivar was used as a plant material. The irrigation was made by using distilled water. The experiment was ended after four months after seed sowing. The plant diameter, leaf number, crown fresh weight and dry weight were determined according to standard methods in harvested plants. The phosphorus contents of plant samples were analyzed according to vanadomolibdo phosphoric acid method reported by Kacar (1994).

The experimental data were analyzed by SPSS statistic program and means significantly different each other were shown with LSD test.

Results and Discussion

The effects of mycorrhiza and phosphorus applications on some yield criteria and phosphorus uptake in lettuce were given in Table 2. The mycorrhiza applications have significant effects on plant diameter, dry weight and phosphorus uptake. The phosphorus applications also significantly affected on dry weight and phosphorus uptake. The phosphorus uptake was also significantly influenced by mycorrhiza x phosphorus interaction.

Mycorrhiza application into growing media generally increased plant diameter compared with growing media without mycorrhiza application (Table 3). Mean of plant diameter (19.7 cm) in mycorrhiza added (M+) media was significantly higher than that (18.2 cm) in mycorrhiza nonadded (M-) media. There is no significant effect of mycorrhiza application on leaf number at different phosphorus rates. The mean values of leaf numbers were significantly affected by different phosphorus application rates. The lowest and the highest mean values of leaf number were obtained as 24 and 31 at 0 and 50 mgP/pot application rates, respectively (Table 3).

Table 2. According to variance analysis, F values for effect of mycorrhiza and phosphorus application on yield criteria and phosphorus uptake by lettuce.

Variation Sources	df	Plant diameter	Leaf number	Fresh weight	Dry weight	Phosphorus uptake
Mycorrhiza (M)	1	4.76**	2.47	3.22	8.17**	8.84**
Phosphorus (P)	3	0.84	2.78	1.75	4.31**	36.06**
MxP	3	2.10	2.84	9.14**	31.04**	28.10**

** significant at P<0.01 level.

Table 3. Effects of mycorrhiza (M) on plant diameter and leaf number at different phosphorus rates.

Phosphorus	Plant diameter (cm)			Leaf number		
(mg P/kg)	with M+	without M-	Mean	with M+	without M-	Mean
0	19.6	17.3	18.5	28	20	24 b
50	21.6	18.0	19.8	35	27	31 a
100	18.3	19.0	18.5	27	30	29 ab
200	19.3	18.3	18.8	27	28	28 ab
Mean	19.7 a*	18.2 b		29	27	

* There are significant differences between the means shown with different letters at P<0.01 level.

The mycorrhiza applications increased crown or fresh plant weight at the control treatment (Table 4). The interaction between mycorrhiza and phosphorus significantly affected fresh plant weight (Table 2). The lowest and the highest fresh plant weight means were obtained in media without mycorrhiza application as 59.33 g/pot for control and 96.23 g/pot for 200 mg P application (Table 4). The increasing phosphorus doses upper than 50 mg/kg decreased fresh plant weight in mycorrhiza added media. On the other hand, low phosphorus doses (0 and 50 mg/kg) increased plant dry weight in mycorrhiza added growing media. However, at the higher P application rates (100 and 200 mg P/kg), fresh plant weights for mycorrhiza application decreased. The highest plant dry weight mean was obtained as 9.91 g/pot in mycorrhiza and 50 mg/kg phosphorus added media. Fitriatin et al. (2014) reported that increasing doses of P fertilizer can inhibit the activity of phosphatase. Phosphate fertilizer with 50% recommendations dose gave better effects on potential-P in soil and maize yields.

Table 4. Effects of mycorrhiza (M) on fresh and dry plant weights at different phosphorus rates.

Phosphorus	Fresh weight (g/pot)			Dry weight (g/pot)		
(mg P/kg)	with M+	without M-	Mean	with M+	without M-	Mean
0	84.36	59.33	71.85	8.64	6.75	7.69 b*
50	93.93	62.73	78.33	9.91	6.87	8.39 a
100	77.50	81.86	79.68	7.32	8.82	8.07 ab
200	74.13	96.23	85.18	8.09	9.21	8.66 a
Mean	82.48	75.04		8.49 a*	7.91 b	

*There are significant differences between the means shown with different letters at P<0.01 level.

The plant dry weight mean (8.49 g/pot) in mycorrhiza application was significantly higher than that (7.91 g/pot) in nonmycorrhiza added media. Some researchers studied on different plants such as; Welling et al. (1991) in pea, Şimşek et al. (1998) in tomato, pepper and eggplant, Çetiner et al. (1999) in sweet corn, and obtained the similar results. Mycorrhiza applications increased plant dry weight in low phosphorus doses (0 and 50 mg P/kg). These increases were occurred at high phosphorus rates of nonmycorrhiza added media.

The increasing phosphorus rates increased phosphorus uptake by lettuce (Table 5). The lowest and the highest phosphorus uptakes were obtained as 47.66 mg/kg and 88.78 mg/kg for nonmycorrhiza added media with 0 and 200 mg/kg phosphorus application rates, respectively. Also, the lowest and the highest phosphorus uptake means were obtained as 58.81 mg/kg and 85.93 mg/kg in 0 and 200 mg/kg phosphorus applications, respectively. While mycorrhiza application increased phosphorus uptake by plant in low phosphorus rates, phosphorus uptake by plant decreased in higher phosphorus rates (Table 5). Ortaş et al. (2004) reported that some plants develop the adaptation mechanism to benefit from soil phosphorus in phosphorus deficient soils. Several researchers (Li et al. 1996, Ortaş et al. 1996, Bago and Azcon-Aquilar 1997) reported that plant roots having symbiotic life with mycorrhiza play role in increasing of phosphorus uptake due to their ability in regulation of soil pH. Waterer and Coltman (1989) reported that mycorrhiza inoculation increased total fresh weight and phosphorus content of stem of onion by phosphorus applications in low doses.

Table 5. Effects of mycorrhiza (M) on phosphorus uptake by plant at different phosphorus rates.

Phosphorus (mg P/kg)	Phosphorus uptake (mg P/pot)		
	with M+	without M-	Mean
0	69.95	47.66	58.81 c*
50	82.89	61.23	72.06 b
100	64.61	80.98	72.80 b
200	83.09	88.78	85.92 a
Mean	75.14 a*	69.66 b	

*There are significant differences between the means shown with different letters at P<0.01 level.

Conclusion

As a result, it was determined that mycorrhiza application had positive effect on yield criteria and phosphorus uptake of lettuce in lower phosphorus application rates. This positive effect decreased in high doses of phosphorus application rates probably due to decreasing phosphatase activity in soil.

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