Response And Dependence Of Haricot Bean To Inoculation With Arbuscular Mycorrhiza

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Abstract. The mycorrhizal dependence and response of haricot bean (*Phaseolus vulgaris* L.) to arbuscular mycorhizal (AM) fungus (*Glomus deserticola*) were studied at various concentrations of triple superhosphate. The results showed a decline in mycorrhizal dependence and responsiveness in haricot bean with an increase in phosphate added to the soil. Furthermore, a difference was found between the mycorrhizal responsiveness and mycorrhizal dependence in plants inoculated with the AM fungus.

Key Words: Mycorrhizal dependence; *Phaseolus vulgaris;* Phosphorus; Arbuscular mycorrhiza.

Introduction

Phaaseolus vulgaris L. (haricot bean) is a pulse legume grown in soils ranging from light sand to heavy clay. It is well known that legume plants benefit from associations with mycorrhizal fungi (Pena *et al.* 1988).

Plant species and cultivars within a host plant genus are known to vary in their responses to arbuscular mycorrhizal (AM) fungal colonization (Plenchette *et al.*, 1983; Pope *et al.*, 1988; Al-Garni *et al.*, 1997). These differences are often attributed to the poor ability to take up soil phosphorus (P) in the absence of AM fungi (Baylis 1972; 1975; Hayman 1983). Many attempts have been made to determine the mycorrhizal dependence of several plant species (Azcon and Ocampo 1981; Hetrick 1988; Saif 1987).

Mycorrhizal dependence (MD) is defined as the degree to which a plant is dependent on the mycorrhiza to produce maximum growth or yield at a given soil fertility level (Gerdmann, 1975) i.e. MD = (Mycorrhizal dry wt - Nonmycorrhizal dry wt.) $(\text{Mycorrhizal dry wt})^{-1}$ X 100.

A study of the AM fungal dependency of host species is vital because the extent to which a host plant will respond to AM fungal infection (AM fungal responsiveness), may be a function of its AM fungal dependency and this may be of

Table 1. Influence of soil phosphorus concentrations and inoculation with *G. deserticola* on total dry weight, mycorrhizal colonization and Mycorrhizal dependence.

	Soil P solution (ppm)			
Treatments	5	25	50	100
	Total dry weight (mg)			
Inoculated	599±60*	611±60	914±44*	1211±79
Uninoculated	198±58	475±76	794±58	1292±84
Mycorrhizal Colonization	83%	77%	66%	51%
Mycorrhizal Dependence[1]	66.94%	22.25%	13.13%	-6.69%

*Asterisk denotes significance according to student *t-test* (P=0.5) ± S.E. (Standard error).
1). Mycorrhizal dependence was calculated according to the field relative mycorrhizal dependency as per the following equation:
Relative mycorrhizal dependency = (Dry weight of mycorrhial plants – Dry weight of nonmycorrhizal plants) ÷ Dry weight of mycorrhizal plants X 100

great value in predicting host response to AM fungal inoculation (Habte and Manunath 1991).

The objective of this study was to assess the mycorrhizal dependence of haricot bean in soil fertilized with different P levels.

Materials and Methods

The soil used in this study was a subsurface sample (5-15 cm) of 1 part clay to 2 part sand mixture with pH of 8.1 and phosphorus (P) content of 5 ppm (Olsen *et al.* 1954). The subsoil sample was selected because of its low P content (5 ppm).

Three P concentrations of 25, 50 and 100 ppm were established by adding triple superphosphate to the autoclaved soil. The soil was then distributed into 12.5 cm plastic pots at the rate of 1 kg per pot. Each P concentration constituted 15 pots.

Mycorrhizal inoculation of soil in the pots was carried out by mixing the contents of each pot with 10g of mycorrhizal propagules *Glomus deserticola* Trappe, Bloss & Menge. The fungal material consisted of sandy soil, spores, hyphae and infected root segments. Inoculated controls received 10g of sterilized sand and washings of the crude inoculum after autoclaving.

Seeds of haricot bean (*Phaseolus vulgaris* L.) were surface disinfected with 80% alcohol for 1 min. followed by 2% sodium hypochlorite for 10 min. and washing several times with sterile water. Seeds were then pre-germinated in sterile disposable Petri dishes and planted in pots,

Table 2. Influence of soil phosphorus concentration and inoculation with arbuscular mycorrhiza on ion uptake.

P Levels		Minerals (Ion uptake)			
		Phosphorus	Potassium	Copper	Zinc
		P (%)	K (%)	Cu ($ug^{-1}g$)	Zn ($ug^{-1}g$)
5 ppm	I	0.17*	1.87*	6.71*	42.51*
	NI	0.13*	1.8	8.79	32.97
25 ppm	I	0.30*	1.79	4.17	39.58
	NI	0.28*	2.06*	15.49*	46.46*
50 ppm	I	0.32	1.97	6.28	37.66
	NI	0.38	1.94	4.13	28.93
100 ppm	I	0.39	2.00	9.09*	29.55
	NI	0.40	2.13	6.57	28.93

*Asterisk denotes significance according to Student *t-test* between each pair of treatments (P=0.5)
I: Inoculated, NI: not inoculated.

one healthy pre-germinated seed per pot. The pots were placed in a greenhouse that provided approximately 12h photoperiod, 1500 lux and 28 °C.

Plants were harvested 11 weeks after planting and the total dry weight was determined after root and shoot were dried separately at 70 °C for 48 h. The proportion of roots colonized with the AM fungus *Glomus deserticola* was determined in 1-cm root segment after cleaning with 10% potassium hydroxide and staining with acid trypan blue in lactophenol (Phillips and Hayman, 1970).

The P content of the plant was determined by the molybdate blue method (Murphy and Riley 1962). The Cu and Zn contents of the shoot were determined by atomic absorption sepctroscopy and K content of shoots by atomic emission spectroscopy (Hue and Evans 1985). The Cu, K and Zn were measured to detect the role of the fungus on uptake of these nutrients by the *P. vulgaris* in substrate soil fertilized with an array of P levels.

Relative mycorrhizal dependency was expressed as the difference between dry matter yields of inoculated and noninoculated plant and presented as a percentage of total dry matter yield of inoculated plants (Plenchette *et al.*, 1983). Means were compared using paired *t-tests* following analysis of variance.

Results and Discussion

The total matter yield of haricot beans increased with P increasing for both mycorrhizal and nonmycorrhizal plants, but the mycorrhizal colonization tended to increase the dry matter yield even at 5 ppm level (Table 1).

The P amendments to the soil had a negative effect on AM fungal colonization level and thereby decrease the level of mycorrhizal colonization (Table 1). The P absorption by the plant was not influenced by its higher concentration in the soil tested. At low P concentration (5 ppm), P uptake by mycorrhizal haricot bean was significantly higher than that of nonmycorrhizal haricot bean (Table 2). The uptake of P, K, Cu and Zn by mycorrhizal plants declined from a maximum in the 5 P treatment (Table 2). Generally, the effect of mycorrhizal inoculation on ionic absorption has shown a deminishing tendency with further increase in P concentration.

Improved P uptake enhanced the yield of the mycorrhizal haricot bean plants. Similar observations were made on soybean plants by Pacovsky and Fuller, (1986). It is interesting to note that such increase has not led to an increase in the dry matter weight of the haricot bean. However, *P. vulgaris* was highly dependent on mycorrhizal inoculation when the P concentration was low (5 ppm) where it demonstrated dependence of 67%. As the mycorrhizal infection percentage decreased with increasing P, haricot bean seems to demonstrate decreasing mycorrhizal dependency.

There was an increase in biomass production in haricot bean with an increase in P level and the effect was more pronounced in the mycorrhizal plants at 5 to 50 ppm. The beneficial effect of mycorrhizal colonization on host species can be explained in terms of improved P uptake. Similar observation has been made on soybean plant by Pacovsky and Fuller, (1986). It is interesting that haricot bean was highly dependent on mycorrhizal inoculation at low (5 ppm) P concentration, demonstrating a dependence of 67%. As the mycorrhizal colonization percentage decreased with an increase in P, haricot bean seemed to exert a negative effect on mycorrhizal dependency. As previously reported by Habte and Manjunath, (1987; 1991), the mycorrhizal colonization percentage was negatively correlated with added P.

In common with the observations of Habte and Manjunath, (1987) and Gerdemann, (1975) the mycorrhizal colonization percentage proved to be negatively proportional to added P concentration. A soil P level of 5 ppm appears to be associated with both maximum mycorrhizal dependency and colonization percentages.

The present results have also indicated differences between "mycorrhizal responsiveness" and "mycorrhizal dependence". These results support the earlier hypothesis of Linderman and Hendrix, (1982) who have urged against the use of a single P concentration for differentiating "AM fungal dependence" from "AM fungal responsiveness."

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استجابة واعتمادية نبات الفاصوليا للتلقيح بفطريات الجذور الشجرية

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ملخص :

تمت دراسة استجابة واعتماية نبات الفاصوليا للتلقيح بفطرة الجذور الشجرية (قلومص ديزيرتيكولا) عند تراكيز مختلفة من ثلاثي سيوبر الفوسفات . هذا ، وقد أوضحت الدراسة تدني في استجابة واعتمادية نبات الفاصوليا وذلك عند زيادة تركيز عنصر الفسفور المضاف للتربة . كما أوضحت النتائج أن ثمة اختلاف بين الإستجابة والاعتمادية في نبات الفاصوليا الملقح بفطرة الجذور الشجرية .