Effect of Mycorrhiza on Plant Growth

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Various ornamental, micropropagated plants, and fruit tree seedlings were inoculated with mixed indigenous arbuscular mycorrhizal (AM) fungal cultures in a marginal wasteland, nutrient-deficient soil. Inoculated *Petunia* ×*hybrida* showed three-fold increase in the reproductive growth over uninoculated plants while that of *Callistephus chinensis* was two fold in comparison to the uninoculated controls. Micropropagated *Syngonium podophyllum* and *Dracaena* sp. showed maximum response when inoculated at weaning stage. Both the AM fungal inoculum and stage of inoculation influenced shoot P uptake and plant growth. At present, inoculation of some indigenous fruit trees with various AM cultures is being attempted and their growth and development monitored.

INTRODUCTION

Arbuscular mycorrhiza (AM) fungi are obligate biotrophs, forming a symbiotic relationship with roots of higher plants. The major effects of AM fungal inoculation include enhanced growth, saving on phosphate requirement, increased survival rate, increased resistance to water stress, increased flower production and vase life of cut flowers, higher enzymatic activities, and greater resistance to root disease (Chang, 1994). Applications of AM fungal technology include a wide variety of plants ranging from field crops, including pasture forage legumes, wheat, vegetable and ornamental plants, fruit trees, and micropropagated plants. The major objectives of this study were to produce highly infective and effective AM fungal inocula for field application, and to test this inoculum with various micropropagated, ornamental, and fruit tree plants.

MATERIAL AND METHODS

Arbuscular Mycorrhiza Fungal Inoculum. A mixed indigenous culture (Mi) containing native populations of *Glomus, Gigaspora,* and *Scutellospora* spp. was used as the inoculum.

Preparation of Growth Substrate. The substrate was prepared by mixing soil (pH, 8.2; EC, 0.2; organic C, 0.22%; Olsens P, 0.53 ppm) and compost (pH, 7.2; EC, 0.91; organic C, 4.72%; Olsens P, 25 ppm) in the ratio of 1 : 1 or 2 : 1.

Experiment 1. The treatments consisted of three host species (*Allium cepa*, *A. sativum,* and *Solanum tuberosum*) cultivated in the 1 : 1 and 2 : 1 mixture substrates, respectively, each inoculated or uninoculated with AM fungi (3 × 2 × 2 factorial structure). The compost amended soil mixtures were used to form raised beds (30 cm wide × 224 cm long × 16 cm high). Seedlings of onion (*A. cepa*), raised from surface-sterilized seedlings were transplanted to respective treatment beds. Ten seedlings were transplanted 10 cm apart in each bed. Inoculum was applied at the

rate of 2000 infective propagules per plant. Sprouted cloves of garlic (*A. sativum*) and single potato (*S. tuberosum*) tubers were planted directly in furrows in the experimental beds 10 cm apart.

The crops were harvested at Week 16. The bulbs and tubers were removed from each bed and weighed separately. The P content in the shoot was determined using methods described by Jackson (1973). A subsample of root segments was taken for analysis of mycorrhizal colonization (Biermann and Linderman, 1981).

Experiment II. Micropropagated plantlets of *Syngonium podophyllum* and *Dracaena* sp. were obtained either in the weaning stage on agar rooting media or as 7-day-old hardened plants. The experiment was a completely randomized factorial design with a $2 \times 2 \times 2 \times 2$ structure consisting of each species taken from two growth stages (weaning stage or hardened plants), inoculated or uninoculated at two fertility levels. The plants were transplanted into polybags (1.25 kg of substrate), kept in a mist chamber (RH 75%; 24°C) for 4 weeks, and observed for survival percentage. After 4 weeks the plants were taken out and transplanted into large earthen pots (3.5 kg substrate per pot) and kept in a greenhouse (30 ± 2°C, RH 60%). The measurements included shoot dry biomass, shoot P, AM fungal colonization, and soil infectivity at harvest.

Experiment III. Surface sterilized seeds of *P. ×hybrida* 'Blue Bird', *Callistephus chinensis* 'Dwarf Chrysanthemum', and *Impatiens balsamina* were germinated in moist sand in sterile petri dishes at 30°C in darkness for 48 h. Five kilograms soil containing inoculum mixture was transferred to earthen pots (17 cm diameter). Inoculation of substrate with AM fungi was achieved by thoroughly mixing 2000 infective propagules per pot. Control plants were given 5 kg of pot mixture without inoculum. The experiment was a completely randomized design with 3×2 structure containing three ornamental plants, inoculated or uninoculated. Counts of number of flowers were taken at an interval of 10 days for all six replicates in each treatment up to 120 days. Shoot P, AM fungal colonization and soil infectivity was measured as described earlier.

Table 1: Influence of arbuscular mycorrhiza (AM) fungal inoculation on three ornamental species.

Hosts	AM inoculation	AM colonization (%)	Shoot P (g kg^{-1})	Shoot dry weight (g)	Flower initiation (DAT)
Petunia ×hybrida	+	68	4.5 a	0.84 a	29
	-	4	3.1 b	0.64 b	41
Impatiens balsamina	+	54	2.8 a	0.72 a	50
	-	-	2.5 b	0.62 b	53
Callistephus chinensis	+	51	2.7 a	0.34 a	27
	-		2.0 b	0.27 b	49

Table 2: Influence of AM fungal inoculation at nonrooted (Nr) or hardened (Hs) stage of two micropropagated plants.

Inoculation stage	Fertility levels	AM inoculation	*Syngonium*			*Dracaena*		
			Shoot P (µg)	% AM colonization	Shoot D.W. (g)	Shoot P (µg)	% AM colonization	Shoot D.W. (g)
Nr	Hf	+	2.3 a	20	21.6 a	2.1 a	14	22.8 a
		-	1.9 b	4	18.2 b	1.9 ab	1.5	22.0 a
	Lf	+	1.9 bc	32	18.6 b	1.9 ab	35	19.8 a
		-	1.4 de	2	16.3 c	1.4 cde	2	19.1 bc
Hd	Hf	+	1.6 bcd	17	15.3 d	1.7 abc	20	22.9 a
		-	1.5 cde	2	15.0 d	1.3 de	-	23.0 a
	Lf	+	1.7 bcd	30	15.4 d	1.3 de	20	19.0 a
		-	1.2 e	4	14.1 d	1.3 e	-	18.0 a
LSD			0.3		0.72	0.37		1.4

Abbreviations: Hf, high fertility; Lf, low fertility.

Experiment IV. Three species of indigenous fruit trees (*Vangueria infausta*, *Strychnos cocculoides,* and *Thespesia garckeana* [syn. *Azanza garckeana*]) have been inoculated with various mixed and pure inocula and are being monitored for their response in terms of the root colonization and growth parameters.

Statistical Analysis. The recorded data on all the parameters observed for each treatment were analyzed using analysis of variance (ANOVA) with Duncan's multiple range test at 5% significant level. The data were also analyzed for standard deviation within the treatments using Costat software (Cohort, Berkeley, California, USA).

RESULTS AND DISCUSSION

The result of the present study clearly demonstrates the effectiveness of AM fungus in increasing productivity and plant establishment. Inoculation with AM fungi resulted in a significant ($P \leq 0.05$) increase in yield over uninoculated plants, particularly at low fertility (Experiment I). At low fertility, inoculation with AM fungi produced 71%, 31%, and 48% increase in yield over uninoculated plants in onion, garlic, and potato, respectively, as compared to 12%, 19%, and 10% increase in yields of the respective plants at high fertility (Table 1). The extent of positive growth response in our experiment is in agreement with the results reported by others. Furlan and Bernier-Cardou (1989) reported a 41% increase in yield by AM fungus inoculation in onion.

Arbuscular mycorrhiza fungal inoculations at either the nonrooted (Nr) or hardened (Hs) stages resulted in an increase in survival rate (Experiment II). The survival was 74% in *S. podophyllum* inoculated at Nr stage as compared to 60% in uninoculated plants. In contrast, the hardened plants showed 78% and 75% survival in the inoculated and uninoculated plants, respectively. Arbuscular mycorrhiza inoculation in *Dracaena* sp. did not result in increased survival rate. The effect of AM fungal inoculation was more evident at weaning stage than at hardened stage. Arbuscular mycorrhiza fungi promote renewed shoot apical growth of micropropagated plants, and inoculation at the weaning stage produces plants with a more effective root system for uptake of P and other nutrients (Berta et al. 1990).

Flower initiation time (days after transplantation, DAT) in AM-fungal-inoculated plants was significantly shorter as compared to uninoculated plants (Experiment III). The three host plant species showed significantly higher number of flowers in the inoculated plants. At harvest, AM-inoculated plants resulted in an increase of 190% and 75% in *P. ×hybrida* and *C. chinensis*, respectively, in flower number as compared to the non-inoculated plants (Table 1). The P concentration of shoots was significantly (P 0.05) higher in all the inoculated plants though the effect of inoculation on P uptake varied with fertility and host species. The various hosts tested responded differently in terms of the percent root colonization (Table 2). Thus AM fungus enhanced the growth, nutrient uptake, and flower production in the respective ornamental hosts tested.

CONCLUSION

The study demonstrated that the AM fungi could establish a symbiotic association with the host plants tested, which could ensure maximum survival, growth, and productivity of plants. However, the involvement of other physiological process in mycorrhizal and P treated plants and effect of potting mixes used in horticultural systems cannot be excluded.

LITERATURE CITED

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