

## Effects of VA-mycorrhizal fungi on growth and nutrient uptake of cuttings of *Rosa multiflora* in two container media with three levels of fertilizer application\*

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### Abstract

Rooted cuttings of *Rosa multiflora* 'Brooks 56' were grown in a medium of 1 mineral soil:1 sand (v/v) or 4 bark:1 sand (v/v) inoculated with the VA-mycorrhizal (VAM) fungi *Glomus mosseae* (Nicol. and Gerd.) Gerd. and Trappe and *G. fasciculatum* (Thaxt. sensu Gerd.) Gerd. and Trappe or left as noninoculated controls. The slow release fertilizer osmocote was applied at rates of either 0, 1.2, or 4.2 kg/m<sup>3</sup> (18N-6P-12K) and incorporated into the container medium. After 180 days plants were evaluated for growth, development and chemical leaf analysis. Greatest growth responses occurred after the highest fertilizer application of 4.2 kg/m<sup>3</sup>, and the poorest one after 0 kg/m<sup>3</sup>. Combination bark:sand medium was superior to mineral soil:sand medium for growth of mycorrhizal plants. At 0 kg/m<sup>3</sup>, mycorrhizal plants in bark:sand medium had longer shoots than other treatments. At 1.2 kg/m<sup>3</sup>, VAM plants compared to nonmycorrhizal plants in bark:sand medium had greater effect on growth parameters. At the highest fertilizer application of 4.2 kg/m<sup>3</sup>, greatest growth responses occurred with VAM plants in bark:sand medium. Mycorrhizal plants compared to nonmycorrhizal plants in bark:sand medium had greater K and Zn uptake at 0 kg/m<sup>3</sup>, and greater K, Ca, S, Mn and Zn uptake at 1.2 kg/m<sup>3</sup>.

### Introduction

New techniques are needed to increase yield of Texas field rose bushes produced in a 2-year cycle. Insufficient rainfall reduces the success rate of rooting of hardwood cuttings and their subsequent T-budding during the following spring. Therefore, under present practices, many growers harvest less than 65% of cuttings planted (Davies *et al.* 1980).

Mycorrhizal fungi have been shown to increase plant uptake of water and mineral nutrients (Maronek *et al.* 1982; Strong and Davies, 1982; Sweatt and Davies, 1984). Since growers do not irrigate (dry land farming) and rose production fields are low in phosphorus (4-6 ppm) and other

nutrients (Paterson and Earhart, 1985), there is a potential for commercial application of vesicular-arbuscular mycorrhizal (VAM) fungi in field bush production systems. In addition, *Rosa multiflora* 'Brooks 56', the principal Texas rootstock, is naturally colonized by *Glomus sps* and *Gigaspora sps* in commercial production fields (Davies *et al.* 1987). The objectives of this research were to determine the relationship of endomycorrhizal fungi, fertility and container medium on plant growth, development and nutrition of roses.

### Materials and methods

Inoculum of mycorrhizal fungi *Glomus fasciculatum* (Thaxt. sensu Gerd.) Gerd. and Trappe and

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*Glomus mosseae* (Nicol. and Gerd.) Gerd. and Trappe were cultured in containers as previously described (Strong and Davies, 1982). Hardwood cuttings of *Rosa multiflora* 'Brooks 56' were rooted under intermittent mist in a glasshouse.

A randomized, complete block design was utilized to determine the influence of 0, 1.2, and 4.2 kg/m<sup>3</sup> 18N-6P-12K slow release fertilizer on two container media (4 composted bark:1 sand, or 1 Lilbert fine sand loam:1 sand v/v) on mycorrhizal and nonmycorrhizal *Rosa multiflora* 'Brooks 56' rootstock. The Lilbert fine sand loam was obtained at a commercial rose production field in Smith County, Texas. All media were steam sterilized before treatment initiation. Trace elements in fritted form (W.R. Grace Co.) were added at 74 g/m<sup>3</sup> to medium. The 12 treatments consisted of 1 plant/replication and 20 replications/treatment. Rooted cuttings were grown in 15 cm clay pots under the above fertility and medium regimes. Sixty grams of soil-root-mycelium inoculum of each VAM isolate (120 g total) or 120 g of the mycorrhizal-free control were added to steam sterilized medium in each container.

Plants were established in a glasshouse with a maximum irradiance of 800  $\mu\text{mol s}^{-1} \text{m}^{-2}$  (400 to 700 nm), and grown at night temperature of 18° ± 2°C, and ambient day temperatures of 20°C minimum. After 180 days, plants were evaluated for shoot and root fresh and dry weight, stem length and number of elongated axillary buds. Percentage of mycorrhizal colonization was assessed using the techniques of Ambler and Young (1977) and Phillips and Hayman (1970). Colonized plants had 60–85% mycorrhizal roots and non-inoculated control plants had 0–4% mycorrhizal roots. Tissue nutrient analysis of total N and P was analyzed using block digestion, autoanalysis technology (Wall and Gehrke, 1975). Tissue analysis of P, K, Ca, and microelements (Fe, Zn, Mn, Cu, B) was done on an inductively coupled plasma atomic

emission spectrometer (3510ICP). The media were analyzed for pH, soluble salts, macro and microelements before experiment initiation (Table 1).

## Results

Greatest growth occurred at the highest fertility of 4.2 kg/m<sup>3</sup>, and 0 kg/m<sup>3</sup> had poorest growth (Table 2). Combination bark:sand medium was generally superior to mineral soil:sand medium for growth of mycorrhizal plants. At 0 kg/m<sup>3</sup> there were no treatment differences in shoot and root fresh and dry weights, however mycorrhizal plants in bark:sand medium had greater shoot length (Table 2). At 1.2 kg/m<sup>3</sup>, VAM plants in bark:sand medium had greatest effect on all growth parameters, except the length of the longest shoot and number of new lateral breaks (Table 2). At the highest fertility rate of 4.2 kg/m<sup>3</sup>, greatest growth responses occurred with mycorrhizal plants in bark:sand medium (Table 2). There was also a higher shoot-root ratio and greater number of lateral shoot breaks with increasing fertility levels (Table 2).

Mycorrhizal plants grown in bark:sand medium took up more K and Zn at 0 kg/m<sup>3</sup> than non-colonized roses grown in the same medium, and in the loam:sand medium VAM plants had greater Zn uptake (Table 3). Comparing the 2 media at 0 kg/m<sup>3</sup>, plants grown in the loam:sand medium had greater Mn and B uptake regardless of mycorrhizal treatment, even though initial medium levels were comparable (Table 3).

Mycorrhizal plants in bark:sand medium had greater K, Ca, S, Mn and Zn uptake at 1.2 kg/m<sup>3</sup> than non-inoculated plants (Table 3). At the higher fertility level of 4.2 kg/m<sup>3</sup> there was no mycorrhizal effect on nutrient uptake, however, plants in bark:sand media had less K and Mn than in loam:sand media (Table 3).

Table 1. Soil analysis of two growth media before nutrient incorporation

Growth medium	pH	Soluble salts (millimhos/cm)	NO <sub>3</sub> <sup>-</sup>	P	K	Ca	Mg	Mn	Fe	B	Zn
1 loam:1 sand	6.8	0.21	43	0.5	19	30	5	0.02	0.85	0.02	0.09
4 bark:1 sand	7.0	0.13	8	0.2	14	16	2	0.01	0.28	0.02	0.01

<sup>1</sup> Units in ppm.

Table 2. The influence of mycorrhizal fungi and container media on growth and development of *Rosa multiflora* at 0, 1.2, 4.2 kg m<sup>-3</sup> osmotic fertilizer application.

Osmocote (kg/m <sup>3</sup> )	Media	Mycor- rhizae	Shoot		Shoot		Shoot		Number of breaks	Shoot		Root		Shoot to root ratio (dry wt.)
			fresh Wt. (g)	dry Wt. (g)	fresh Wt. (g)	dry Wt. (g)	fresh wt. minus dry wt. (g)	dry wt. (g)		longest shoot (cm)	2nd longest shoot (cm)	fresh wt. minus dry wt. (g)	dry wt. (g)	
0	loam-sand	No	3.03a <sup>c</sup>	1.12a	10.54a	1.56a	24.3b	4.6b	1.9a	1.91a	8.98a	0.7:1		
	bark-sand	No	2.99a	1.09a	8.16b	1.00b	22.6b	6.9b	1.8a	1.89a	7.16b	1.1:1		
	loam-sand	Yes	3.62a	1.31a	7.73b	1.24ab	27.9ab	6.7b	2.0a	2.31a	6.49b	1.1:1		
	bark-sand	Yes	4.13a	1.49a	6.88b	1.21ab	33.6a	14.1a	1.9a	2.63a	5.67b	1.2:1		
1.2	loam-sand	No	16.57b	5.59bc	9.19d	2.12c	72.2a	26.2b	3.5a	10.99b	7.08d	2.6:1		
	bark-sand	No	17.02b	5.89b	20.16b	2.92b	84.2a	37.4b	3.6a	11.13b	17.42b	2.0:1		
	loam-sand	Yes	13.90b	4.58c	13.91c	2.49bc	82.3a	35.4b	3.0a	9.32b	11.42c	1.8:1		
	bark-sand	Yes	23.93a	8.46a	27.29a	3.86a	88.1a	61.7a	2.6a	15.48a	23.42a	2.2:1		
4.2	loam-sand	No	28.93b	9.02b	12.51b	2.43b	89.4ab	63.7ab	4.3b	19.91b	10.08b	3.8:1		
	bark-sand	No	32.78b	10.30b	12.49b	2.23b	84.5b	64.7ab	4.6b	22.47ab	10.26b	4.6:1		
	loam-sand	Yes	29.53b	8.60b	13.74b	2.29b	83.4b	58.0b	5.6b	20.93b	11.45b	3.8:1		
	bark-sand	Yes	37.68a	13.11a	35.63a	6.72a	98.8a	71.3a	7.1a	24.57a	28.91a	2.0:1		

<sup>c</sup> Mean separation within columns by Duncan's multiple range test, 5% level.

Table 3. Nutrient uptake of *Rosa multiflora* 'Brooks 56' inoculated with selected mycorrhizal fungi at 3 fertility levels (osmocote 18N-6P-12K) and 2 growth media

Osmocote (kg/m <sup>3</sup> )	Media	Mycorrhizae	N <sup>a</sup>	P	K	Ca	Mg	S	Mn <sup>a</sup>	B <sup>a</sup>	Zn <sup>a</sup>	Fe <sup>a</sup>
0	loam:sand	No	1.5a <sup>c</sup>	0.1a	1.5a	1.2a	0.3a	0.6a	166a	116a	49c	92a
	bark:sand	No	1.4a	0.1a	1.3b	1.1a	0.2a	0.6a	77b	64b	48c	80a
	loam:sand	Yes	1.5a	0.2a	1.5a	1.3a	0.3a	0.6a	151a	105a	62b	79a
	bark:sand	Yes	1.4a	0.2a	1.5a	1.2a	0.3a	0.6a	72b	60b	89a	84a
1.2	loam:sand	No	2.1a	0.2a	1.7ab	1.2b	0.2a	0.6ab	153a	79ab	46bc	124a
	bark:sand	No	1.8a	0.1a	1.3c	1.1b	0.2a	0.4c	76c	48c	34c	83b
	loam:sand	Yes	1.7a	0.2a	1.5bc	1.2b	0.2a	0.5b	133ab	88a	64ab	103ab
	bark:sand	Yes	1.7a	0.2a	1.8a	1.5a	0.3a	0.7a	119b	57bc	80a	107ab
4.2	loam:sand	No	2.8a	0.2a	2.0a	1.1a	0.2a	0.6a	166a	60a	49a	111a
	bark:sand	No	2.6a	0.2a	1.6b	1.0a	0.2a	0.5a	102b	60a	51a	143a
	loam:sand	Yes	2.7a	0.2a	2.1a	1.2a	0.2a	0.6a	150a	67a	54a	124a
	bark:sand	Yes	2.3a	0.2a	1.7b	1.2a	0.2a	0.6a	108b	55a	68a	191a

<sup>a</sup> Mean separation within columns by Duncan's multiple range test, 5% level.

<sup>b</sup> Analysis based on % dry wt of leaf tissue.

<sup>c</sup> Analysis based on ppm on dry wt of leaf tissue.

## Discussion

The slow release fertilizer Osmocote at 4.2 kg/m<sup>3</sup> 18N-6P-12K is the manufacturer's recommended level for an 8-9 month growth period, while 1.2 kg/m<sup>3</sup> is 29% of the recommended rate. Growth responses of VAM roses grown in the bark:sand medium at 1.2 kg/m<sup>3</sup> were comparable to all medium treatments at the highest fertility level (Table 2). This would indicate that mycorrhizae may be useful under conditions of minimal maintenance, or where low fertility is dictated by economics as previously reported with other species (Maronek *et al.* 1982; Strong and Davies, 1982). Even at higher fertility rates, mycorrhizal roses in bark:sand medium grew better than non-colonized plants.

Increasing fertility greatly enhanced all growth parameters. Bark:sand was a superior medium compared to the Lilbert fine sandy loam:sand mix due to improved air porosity, less compaction and higher organic matter. Only recently have selected physical and chemical characteristics of media been reported that provide optimum growth responses for a mycorrhizal symbiont on an ornamental host plant (Johnson and Hummel, 1986).

Mycorrhizae had greatest effect on rose nutrient uptake at the intermediate fertility level. This has also been reported with other plant species (Johnson *et al.* 1980; Maronek *et al.* 1982). There

was increased K and Zn uptake in mycorrhizal roses in bark:sand medium at 0 and 1.2 kg/m<sup>3</sup>; however, there was no difference in P or N between mycorrhizal vs. noncolonized plants. Lack of difference in tissue levels of N in mycorrhizal vs. nonmycorrhizal seedlings, may be due to faster growth rates diluting N concentration per unit of dry weight at higher fertility regimes (Johnson *et al.* 1980), or to minimal influence of VAM on N uptake in roses.

Improved growth and development has been reported in other plant species colonized by mycorrhizal fungi (Johnson and Hummel, 1986; Johnson *et al.* 1980; Maronek *et al.* 1982; Sweatt and Davies, 1984). Thus under current field rose bush production systems, mycorrhizae may be useful under conditions of low maintenance and minimal water and fertility inputs. Furthermore, an increasing number of producers are looking at containerized production systems of roses, which would allow incorporation of VAM under either containerized or field production systems.

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