Fig. 3. Variety evaluation planting at the Fort Lauderdale ARC, with date, coconut, and Manila palms shown.

captured per trap in the date palms and 11.2 (0-59) per trap in coconut palms. The difference between these averages was not significant even at the 0.3 level of probability (ANOVA).

The second-most common auchenorrhynchous insect in traps was *Idioderma virescens* Van Duzee (Membracidae). However, there were very few of these. A total of 7 were in traps on coconut palms, and 9 in traps in date palms. There was a total of less than 10 specimens of Cicadellidae in too poor condition for identification, and in 1 date palm 18 *Umbonia crassipes* (Amyot and Serville) (Membracidae) were captured.

Date Palm Variety Evaluation Planting. We have rarely observed *Myndus crudus* on the date palms in the variety planting although hundreds of this species per day are routinely collected from coconut palms in the same grove. When actual counts of the total numbers of *M. crudus* were made on 6 different days, the average *M. crudus* per palm was as follows: coconut varieties: 'Jamaica Tall' 22, 'Golden Malayan Dwarf' 26, 'Green Malayan Dwarf' 38, 'Yellow Malayan Dwarf' 25; true date palms: 0.1 or less on each variety. There was an average of 0.8 *Cedusa inflata* (Ball) per coconut palm, and none of this species on true date palm. The palms in the grove were examined about twice a week in connection with other experiments, and we have observed very few auchenorrhychous insects on these palms other than *M. crudus* and *C. inflata.*

Cases of coconut LY and lethal declines of other palms were observed in all of the areas sampled in this study. Together with the evidence that MLO-associated lethal declines of palms in southeastern Florida are co-identical with coconut LY (9) and the evidence that *M. crudus* is a vector of LY to Manila palm (4), the prevalence of this insect on mature date palms in areas affected by these diseases (this study) makes it suspect as a vector of LY of date palms.

It may be that the apparent unattractiveness of the young date palms to auchenorrhynchous insects was related to age or size, or the high degree of attractiveness of the nearby coconut palms. Mature true date palms are highly susceptible to LY (2). Experiments are being initiated to determine whether *M. crudus* will feed on young date palms and transmit MLO's to them. If this could be accomplished in transmission cages, it could lead to a method of searching for LY resistance that would bring earlier results than testing by field plantings.

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GROWTH STIMULATION OF CITRUS, ORNAMENTAL, AND VEGETABLE CROPS BY SELECT MYCORRHIZAL FUNGI[1]

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Additional index words. symbiotic, hyperparasitism, percent root colonization.

Abstract. **Mycorrhizal plants, including citrus, tomato, peach, chrysanthemum, and podocarpus showed increased vegetative and reproductive growth in a greenhouse study. Citrus rootstock (cv. 'sour orange') shoot height and total dry weight and tomato (cv. 'Walter') fruit yields were increased 200-300%. Peach (breeding line 3-123N) shoot height was improved 25-75%, chrysanthemum bloomed earlier and the number of flowers was increased up to 100%, and podocarpus shoot height was increased slightly. Inoculations with** Glomus etunicatus, G. fasciculatus, **and** G. mosseae **provided, the greatest growth improvement to the majority of crop species, however,** G. epigaeus, G. macrocarpus, G. microcarpus, **and** Gigaspora margarita **were beneficial to plant growth on certain hosts. All crops benefitted from at least one mycorrhizal fungal species, but maximum growth response resulted from specific plant-fungus combinations.**

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Agricultural and horticultural crops have been shown to benefit from vesicular-arbuscular (VA) mycorrhizae (VAM) on a world-wide basis (9, 15). The potential application of VAM to the agricultural and horticultural industries is great (17). Since the fungi involved in this symbiotic host root:fungus association can differ in the degree to which they benefit host growth (14), it is necessary to screen a broad spectrum of VA mycorrhizal fungi (VAMF) to determine the most promising combination for maximum growth response for a particular crop. The relative host growth benefits, especially improved plant phosphorus nutrition, may vary with soil type (14), host cultivar (12), fungal susceptibility to hyperparasitism (8), and a number of other factors.

In spite of numerous reports characterizing specific combinations of mycorrhizal fungal species:crop species, there is a lack of information relating comparative effects of various species on the growth of one or more crops in Florida or elsewhere. Abbott et al. (1, 2) found that of four isolates of VAMF, two isolates of *Glomus monosporus* and one of *G. mosseae* increased the dry weight and phosphorus content in the tops of subterranean clover (*Trifolium subterraneum* L. cv. 'Seaton Park') over plants inoculated with *G. fasciculatus* or uninoculated plants. Growth effects of seven different *Endogone* (*Glomus* sensu Gerdemann & Trappe) strains on onion (*Allium cepa* L.) and bahiagrass (*Paspalum notatum* Fluegge) varied greatly with the strain used (13, 14). The tested strains resulted in a 2-15-fold growth increase in onions, and a 2-10-fold increase in bahiagrass growth.

Citrus, tomato, peach, podocarpus, and chrysanthemum are important economically in Florida and with the exception of chrysanthemum, all have been shown to form mycorrhizae with at least one VA mycorrhizal fungus species (3, 6, 7, 10, 11). However, these crops have not been evaluated in combination with a selection of VAMF for maximum growth response in treated or untreated soil. The purpose of this study was to screen seven VA mycorrhizal fungal species (representing two genera) on these five crops in order to ascertain which combinations maximized plant growth in steamed soil.

Materials and Methods

The two herbaceous and three woody plant species selected for inoculation with VAMF included 14-day-old seedlings of tomato (*Lycopersicon esculentum* Mill. cv. 'Walter'), 14-day-old rooted cuttings of chrysanthemum (*Chrysanthemum morifolium* (Ramat.) Hemsl.), 30-day-old seedlings of citrus rootstock (*Citrus aurantium* L. cv. 'sour orange'), 60-day-old seedlings of peach rootstock (*Prunus persica* (L.) Batsch, breeding line 3-123N), and 60-day-rooted cuttings of podocarpus (*Podocarpus macrophyllum* (Thunb.) D. Don.). Prior to inoculation, citrus, peach, and tomato were grown in flats containing field soil which had been steamed (10 psi, 90 C for 4 hr on two consecutive days). Rooted cuttings of podocarpus and chrysanthemum were grown in flats containing a mixture of nonsterile peat:sand: vermiculite (1:1:1, v/v).

Spores of *Gigaspora margarita* Becker & Hall (Gainesville isolate), *Glomus fasciculatus* (Thaxter sensu Gerdemann) Gerdemann & Trappe (isolate of J. Menge, Univ. of California, Riverside), *G. epigaeus* Daniels & Trappe (isolate of B. Daniels, Kansas State Univ., KA), *G. etunicatus* Becker & Gerdemann (Gainesville isolate), and *G. microcarpus* (Tul: & Tul.) Gerdemann & Trappe were obtained from pot cultures maintained at Abbott Laboratories, Chicago, IL, while spores of *G. mosseae* (Nicol. & Gerd.) Gerdemann & Trappe (Gainesville isolate), and *G. macrocarpus* var. *macrocarpus* Tul. & Tul. (Nicol. & Gerd.) Gerdemann & Trappe (Gainesville isolate) were taken from pot cultures maintained at the Univ. of Florida, Gainesville. Each of the fungal species, with a few exceptions, was evaluated with each of the five hosts. Approximately 500 spores in a spore:water mixture were added to 2 kg of steamed topsoil (0-15-cm depth) of a Lakeland fine sand (P=69 ppm, pH=5.7) in a 15-cm-diameter plastic pot. Spores were distributed throughout the soil in the pot by alternating five aliquots of spores with five layers of soil. Plants were transferred into the pots immediately after infesting the soil.

Plants were maintained on a low nutrient regime with each pot receiving 50 ml of half-strength Hoagland's solution minus phosphorus at weekly intervals the first 60 days and full strength solution minus phosphorus thereafter. There were five replicates of each treatment per evaluation date with four evaluation dates at 45, 60, 90, and 120 days after inoculation. At each date plant height, stem diameter, root and shoot dry weights, and flower or fruit yields were determined. Additionally, spore populations of the VAMF were enumerated along with the percentage host root colonization by the VAMF using a modification of the Phillips and Hayman (16) technique. Results from data recorded at the final evaluation date are presented.

Results

Tomato. Mycorrhizal plants, particularly those plants inoculated with *G. fasciculatus*, flowered and set fruit earlier (data not shown), and had greater average fruit weight per plant than non-mycorrhizal plants (Fig. 1). Plants inoculated with *G. fasciculatus, G. mosseae,* and *G. etunicatus* produced a yield of from 200-300% greater than the controls (Fig. 1). There were no correlations between shoot or root dry weights, plant heights, shoot:root ratios, spore production, root colonization, and yield obtained with the various mycorrhizal fungi on the plants (Table 1).

Chrysanthemum. Flower bloom and plant senescence, particularly in *G. fasciculatus*-inoculated plants, occurred at an earlier date in mycorrhizal than in non-mycorrhizal plants (data not shown). Plants from treatments with *G. fasciculatus, G. macrocarpus, G. etunicatus,* and *G. mosseae* produced a significantly greater (P = 0.05) number of flowers than the remaining treatments (Fig. 2). However, these same treatments were found to have smaller flower diameters than the remaining treatments. An apparent threshold of at

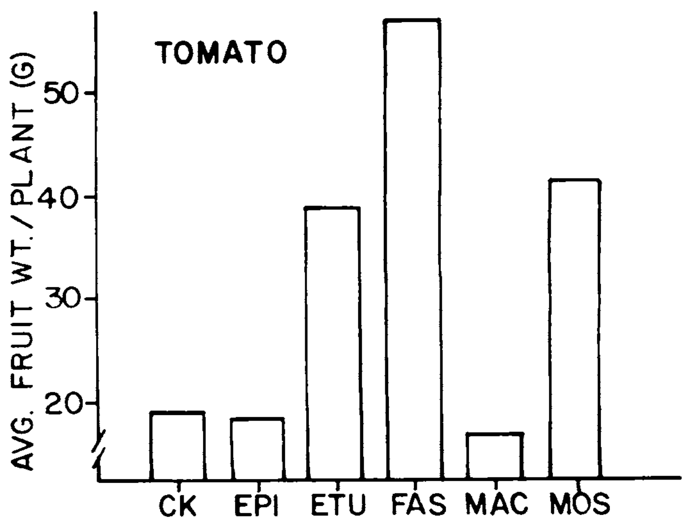

Fig. 1. Yield of tomato (cv. 'Walter') 120 days after inoculation with various VA mycorrhizal fungi. The X— axis abbreviations are: CK=Control, EPI=*G. epigaeus*, ETU=*G. etunicatus*, FAS=*G. fasciculatus*, MAC=*G. macrocarpus*, and MOS=*G. mosseae*.

Table 1. Response of tomato, chrysanthemum, citrus, peach, and podocarpus for several vegetative and yield parameters in relation to percent root colonization 120 days after inoculation with various vesicular-arbuscular mycorrhizal fungi.[z]

Treatment	% Root colonization	Plant height (cm)	Shoot dry weight (g)
Tomato			
Control	0.6 e	87.0 a	10.9 a
G. epigaeus	8.0 d	79.4 ab	10.2 ab
G. etunicatus	31.0 c	76.2 ab	8.3 bc
G. fasciculatus	67.0 a	57.9 c	8.2 bc
G. macrocarpus	46.0 b	67.4 bc	7.8 cd
G. mosseae	39.0 bc	75.6 ab	8.1 bc
Chrysanthemum			
Control	0.0 c	87.0 a	7.7 a
G. epigaeus	2.6 c	79.4 b	7.1 abc
G. etunicatus	17.2 b	76.2 b	5.7 c
G. fasciculatus	32.0 a	77.9 b	6.9 abc
G. macrocarpus	36.0 a	67.4 c	7.2 ab
G. mosseae	34.0 a	75.6 b	6.5 abc
Citrus			
Control	0.0 d	8.2 d	
G. epigaeus	30.0 b	13.5 b	
G. etunicatus	16.7 bc	12.7 bc	
G. fasciculatus	0.0 d	9.0 d	NT[y]
G. macrocarpus	6.7 cd	8.5 d	
G. microcarpus	5.0 cd	9.7 cd	
G. mosseae	56.7 a	24.4 a	
Peach			
Control	0.0 b	40.3 d	
G. epigaeus	20.0 ab	50.1 cd	
G. etunicatus	7.5 ab	73.6 a	
G. fasciculatus	1.1 b	64.6 ab	NT
G. macrocarpus	23.3 ab	67.9 a	
G. margarita	33.3 a	61.5 abc	
G. mosseae	3.3 b	57.4 bc	
Podocarpus			
Control	6.7 a	17.0 ab	
G. epigaeus	16.7 a	19.6 a	
G. etunicatus	0.0 a	11.4 cd	
G. fasciculatus	1.7 a	16.4 abc	NT
G. macrocarpus	20.0 a	12.0 bcd	
G. margarita	0.0 a	10.2 d	
G. mosseae	16.7 a	15.0 abcd	

[z]The data represent means of five replicates per treatment. Mean separation among averages by Duncan's multiple range test, 5% level.
[y]Data not collected at 120 days.

least 17% root colonization by the respective mycorrhizal fungi was associated with an increased flower production of up to 100% (Table 1).

Citrus. The relative ranking order of mycorrhizal fungal species providing the greatest growth benefits to sour orange

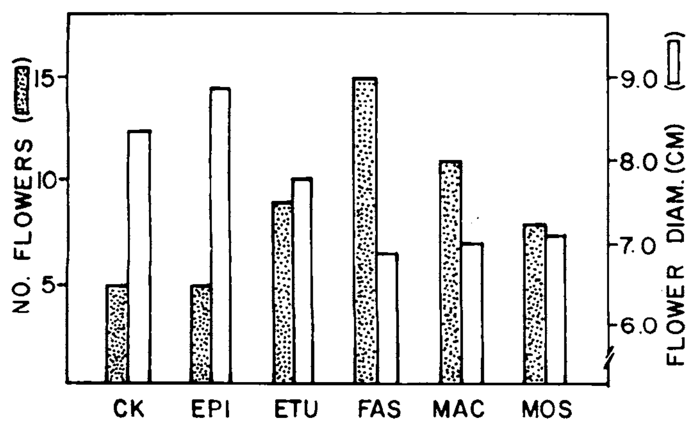

Fig. 2. Yield and size of chrysanthemum flowers 120 days after inoculation with various VA mycorrhizal fungi. The X— axis abbreviations are: CK=Control, EPI=*G. epigaeus*, ETU=*G. etunicatus*, FAS=*G. fasciculatus*, MAC=*G. macrocarpus*, and MOS=*G. mosseae*.

citrus rootstock (Fig. 3) differed from the rankings on tomato and chrysanthemum (Fig. 1 and 2). Inoculations with *G. mosseae*, *G. epigaeus*, and *G. etunicatus* resulted in increases in plant heights of 100, 50, and 50%, *respectively*, that of the controls (Table 1). Plant growth response to the mycorrhizal fungal species was associated with the level of root colonization for *G. mosseae*-, *G. epigaeus*-, and *G. etunicatus*-inoculated plants.

Peach. Mycorrhizal plants were 25-75% greater in plant height than the control plants (Fig. 4). All fungal species with the exception of *G. epigaeus* were associated with a minimum increase of over 40% in plant height. The percent root colonization was not correlated with the growth response (Table 1), i.e., *G. fasciculatus* and *G. etunicatus* possessed colonization values of 1.1 and 7.5%, yet associative plant heights were greater ($P=0.05$) than controls.

Podocarpus. Except for *G. epigaeus*, podocarpus did not respond to mycorrhizae. However, in that some mycorrhizal fungal contamination was noted in the controls (Table 1), the results are difficult to interpret. The possibility of a suppression of podocarpus growth by the fungal species tested cannot be ruled out since the controls had significantly greater shoot height than all other treatments except *G. epigaeus*.

Discussion

Most crop species evaluated in this study benefitted from one or more species of VAMF. Peach was the only plant having a positive growth response to all of the tested species of VAMF, while podocarpus responded appreciably to only one fungal species, with a possible negative response to the species tested. Peach and podocarpus have fine and coarse root systems, respectively. Baylis (4) hypothesized that plants with coarse root systems and limited root hair development are more likely to be dependent on VAM for maximum growth, yet results in this study cannot be explained by this hypothesis. The third woody host, citrus, responded to VAM proportionate to the degree of fungal root colonization. Menge et al. (12) considered sour orange rootstock to be highly dependent on VAM produced by *G. fasciculatus* in comparison with six other citrus rootstock cultivars. Although root hairs were not considered as a factor in the results from their report, the nature of the root system is complementary with Baylis' theory (4). The slow growth rate of podocarpus and hence reduced requirement for phosphorus and other nutrients may explain the lack of dependency on VAM (5). The yields of the two herbaceous hosts, tomato and chrysanthemum were increased significantly by as many as 50% of the fungal species tested. The fibrous nature of the root systems of these plants is suggestive that their growth responses are governed by additional factors such as efficiency of phosphorus absorption (12), soil type (14), mycorrhizal fungal species (13), and other variables. Although both chrysanthemum and tomato plants had less vigor than commercially-grown plants of comparable age, the yield increase in several of the mycorrhizal treatments indicated that on a low nutrient regime mycorrhizal fungi could replace substantially the benefit obtained from additional fertilizer.

Glomus etunicatus and *G. fasciculatus* resulted in the maximum growth response on four of the five crops. *Glomus mosseae* and *G. epigaeus* produced positive growth responses on three, and *G. macrocarpus* on two of the crop species, with all three providing the greatest response on the woody species. *Glomus microcarpus* did not afford citrus (the only crop on which it was evaluated) any growth improvement, while *G. margarita* increased vegetative growth of peach by 50%. Since no one mycorrhizal fungal species could account

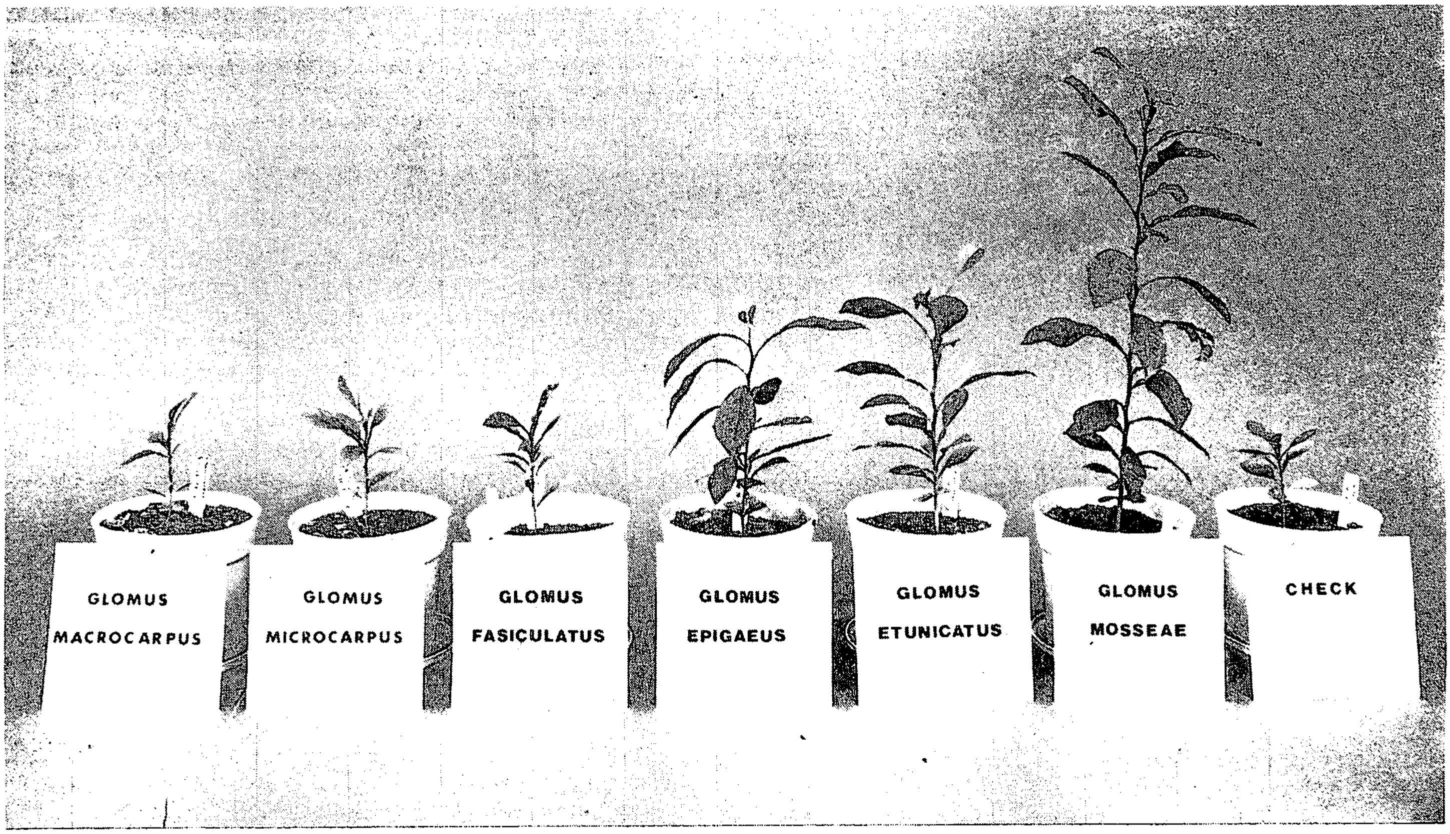

Fig. 3. Growth of citrus rootstock (cv. 'sour orange') 120 days after inoculation with various VA mycorrhizal fungi.

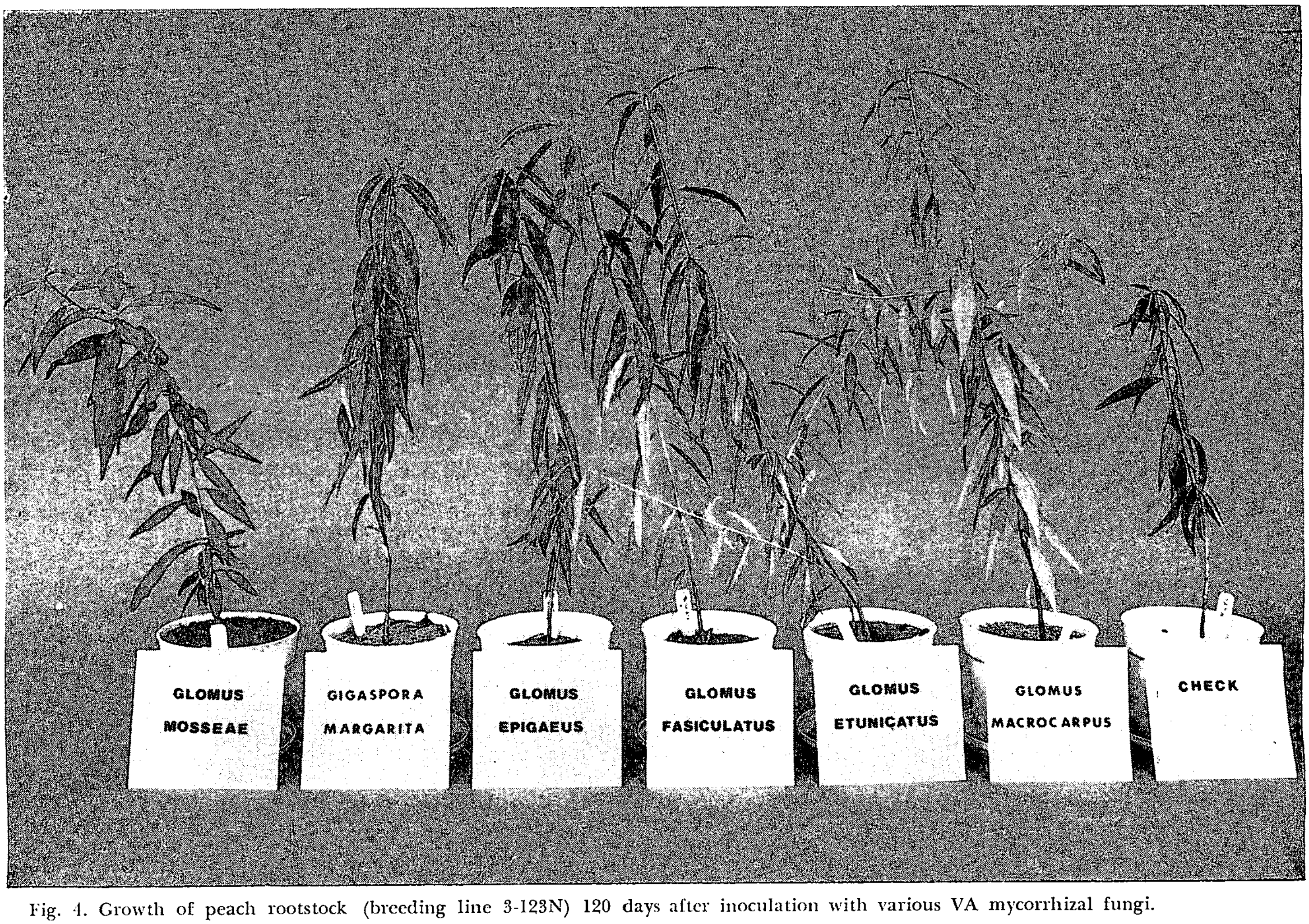

Fig. 4. Growth of peach rootstock (breeding line 3-123N) 120 days after inoculation with various VA mycorrhizal fungi.

for the maximum growth response for the majority of growth parameters in this study, these results are supportive of other reports in the literature; mycorrhizal plant interactions vary in each plant species. However, two of the fungal species, *G. etunicatus* and *G. fasciculatus* were in the top three in plant response on four of the five crops evaluated. In general, *G. etunicatus* performed the best on the woody crops and *G. fasciculatus* the best on the herbaceous crops. Future research involved in screening mycorrhizal fungal species for maximum plant response should include these two species.

The growth and development of the host, specifically the earliness in flowering and fruit set, and advanced senescence in chrysanthemum and tomato are indicative of hormonal effects. Thus, the mechanism by which mycorrhizae benefit the plant, and the variation in plant response as a result of the fungal species being tested may be explained by a combination of factors including improvement of phosphorus nutrition and change in hormonal balances either in the roots or shoots.

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REMOVAL OF IRRIGATION WATER RESIDUES FROM FOLIAGE OF ORNAMENTAL PLANTS[1]

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Additional index words. Oxalic acid.

Abstract. **Irrigation water-induced residues on the foliage of container-grown ornamental plants were treated with commercial grade oxalic acid with surfactant. Three concentrations of oxalic acid, 3%, 5%, and 7% plus a surfactant were applied to 10 plants each of 8 species of ornamentals to test for efficacy, oxalate residue, and phytotoxicity. Half of these plants received a water rinse following oxalic acid application to remove unsightly and potentially phytotoxic oxalate crystals from the foliage. Oxalic acid at concentrations of 5% and 7% with a surfactant at .25% or .5% was highly effective in removing iron residues from foliage. Rinsing following application of oxalic acid was helpful in reducing phytotoxicity.**

Mineral residues on the foliage of ornamental plants can be unsightly. Irrigation water containing high levels of calcium and iron leave insoluble tan colored deposits on foliage when overhead sprinklers are used. Commercial growers who use such water frequently find their plants covered with these mineral residues resulting in reduced profitability due to decreased consumer appeal. Homeowners using such water for irrigation of turf and other ornamental plants in the landscape may experience similar discoloring of not only the plants, but also masonry and any other objects regularly coming in contact with the water. It would be desirable to be able to chemically remove these residues from the foliage of nursery plants prior to sale and from ornamental plants already in landscape.

Oxalic acid is an effective rust remover occurring naturally in leaves of many plants in the Araceae, Oxalidaceae, Chenopodiaceae, and other plant families as the calcium salt or the free acid (1). For this reason it was thought that this organic acid might be less phytotoxic than stronger mineral acids. Oxalic acid was evaluated in this experiment as a potential agent for removal of irrigation water residues from foliage of ornamentals.

Materials and Methods

Commercial grade oxalic acid was mixed with water at concentrations of 3%, 5%, and 7% (by weight). A surfactant, Atplus 411F® was added to each solution at the rate of 2.5 ml/liter. Applications of each solution plus a control solution of pure water were applied to 8 species of tropical plants. Ten plants each of *Chamaedorea seifrizii* Burret., *Dracaena marginata* Lam., *Ficus benjamina* L., *Jasminum*

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Use of a trade name does not constitute a guarantee of the product by the University of Florida and does not imply its approval to the exclusion of other products that may also be suitable.