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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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.

Table 1. Efficacy of oxalic acid treatments for removing irrigation water residues from foliage of selected ornamentals. Median rating values shown with range in parentheses.

Species	Treatment							
	3%		5%		7%		Untreated	
	rinsed	no rinse	rinsed	no rinse	rinsed	no rinse	rinsed	no rinse
Chamaedorea seifrizii	0[z] (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	1 (1-1)	1 (1-1)
Dracaena marginata	1 (1-1)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	1 (1-1)	1 (1-1)
Ficus benjamina	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	1 (1-1)	1 (1-1)
Jasminum multiflorum	0 (0-1)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	1 (1-1)	1 (1-1)
Philodendron selloum	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	1 (1-1)	1 (1-1)
Phoenix reclinata	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	1 (1-1)	1 (1-1)
Spathiphyllum 'Mauna Loa'	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	1 (1-1)	1 (1-1)
Viburnum suspensum	0 (0-0)	1 (1-1)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	1 (1-1)	1 (1-1)

[z] = efficacious, 1 = no efficacy.

multiflorum (Burm. F.) Andr., *Philodendron selloum* C. Koch., *Phoenix reclinata* Jacq., and *Viburnum suspensum* Lindl. and 4 plants of *Spathiphyllum* Schott. 'Mauna Loa' were treated with each of these solutions. Application was done with an 8 liter capacity compressed air hydraulic sprayer. Half of the plants in each treatment group were rinsed thoroughly with pure water immediately following application of the acid. Any delay in rinsing resulted in oxalate crystal formation on the surface of leaves which was unsightly and difficult to remove. Plants were evaluated subjectively for efficacy of the treatments, presence of oxalate residues, and for phytotoxicity one week following treatment.

Viburnum and *Jasminum*, which showed phytotoxic responses to oxalic acid treatment, were treated with 3% oxalic acid, but with surfactant at concentrations of 2.5, 5, and 10 ml/liter in a later experiment to determine if efficacy could be maintained while reducing phytotoxicity and oxalate residues. Five plants per treatment were used in this experiment and all plants were rinsed with pure water immediately after application of the acid.

Results and Discussion

Oxalic acid was highly effective in removing mineral deposits from foliage of all species tested at concentrations of 3%, 5%, and 7%, although a few plants of *Dracaena*, *Viburnum*, and *Jasminum* treated with 3% oxalic acid still had some deposits following treatment (Table 1). Treatment with water alone was completely ineffective in removing these deposits.

Oxalate crystal residues remained on the foliage of

Table 2. Residue of oxalic acid remaining after treatment of selected ornamentals. Median rating values shown with range in parentheses.

Species	Treatment							
	3%		5%		7%		Untreated	
	rinsed	no rinse	rinsed	no rinse	rinsed	no rinse	rinsed	no rinse
Chamaedorea seifrizii	0[z] (0-0)	1 (0-1)	0 (0-1)	1 (1-1)	0 (0-0)	1 (0-1)	0 (0-0)	0 (0-0)
Dracaena marginata	1 (1-1)	1 (1-2)	1 (1-1)	1 (0-1)	1 (1-1)	1 (0-2)	0 (0-0)	0 (0-0)
Ficus benjamina	1 (1-1)	2 (2-2)	1 (1-1)	2 (2-2)	1 (1-1)	2 (2-2)	0 (0-0)	0 (0-0)
Jasminum multiflorum	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-1)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Philodendron selloum	0 (0-0)	0 (0-1)	0 (0-0)	0 (0-1)	0 (0-0)	0 (0-1)	0 (0-0)	0 (0-0)
Phoenix reclinata	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Spathiphyllum 'Mauna Loa'	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Viburnum suspensum	2 (1-2)	2 (2-2)	2 (1-2)	2 (1-2)	2 (1-2)	2 (2-2)	0 (0-0)	0 (0-0)

[z] = no residue, 1 = slight residue, 2 = considerable residue.

Table 3. Phytotoxicity of oxalic acid treatment on selected ornamentals. Median rating values shown with range in parentheses.

Species	Treatment							
	3%		5%		7%		Untreated	
	rinsed	no rinse	rinsed	no rinse	rinsed	no rinse	rinsed	no rinse
Chamaedorea seifrizii	0[z] (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Dracaena marginata	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Ficus benjamina	1 (1-1)	2 (2-3)	1 (1-1)	3 (2-3)	0 (0-1)	3 (3-3)	0 (0-0)	0 (0-0)
Jasminum multiflorum	1 (0-1)	2 (1-2)	1 (1-2)	2 (1-2)	0 (0-1)	1 (1-2)	0 (0-0)	0 (0-0)
Philodendron selloum	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Phoenix reclinata	0 (0-0)	0 (0-0)	0 (0-0)	1 (1-1)	0 (0-0)	0 (0-1)	0 (0-0)	0 (0-0)
Spathiphyllum 'Mauna Loa'	0 (0-1)	0 (0-0)	0 (0-1)	0 (0-0)	1 (1-2)	1 (1-1)	0 (0-0)	0 (0-0)
Viburnum suspensum	1 (1-2)	1 (1-2)	1 (0-2)	2 (1-2)	1 (0-1)	2 (2-2)	0 (0-0)	0 (0-0)

[z]0=no injury, 1=slight injury, 2=moderate injury, 3=severe injury, 4=dead.

Table 4. Effect of surfactant concentration on efficacy, oxalate residue, and phytotoxicity of 3% oxalic acid treatment of *Viburnum* and *Jasminum*. Median rating values shown with range in parentheses.

	Treatment							
	2.5 ml/liter		5.0 ml/liter		10.0 ml/liter		Untreated	
	Jasminum	*Viburnum*	*Jasminum*	*Viburnum*	*Jasminum*	*Viburnum*	*Jasminum*	*Viburnum*
Efficacy	0[z] (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	1 (1-1)	1 (1-1)
Oxalate residue	0[y] (0-0)	2 (1-2)	0 (0-0)	2 (1-2)	0 (0-0)	2 (1-2)	0 (0-0)	0 (0-0)
Phytotoxicity	0[x] (0-0)	1 (0-1)	0 (0-0)	0 (0-1)	0 (0-0)	1 (0-1)	0 (0-0)	0 (0-0)

[z]0=efficacious, 1=no efficacy.
[y]0=no residue, 1=slight residue, 2=considerable residue.
[x]0=no injury, 1=slight injury, 2=moderate injury, 3=severe injury, 4=dead.

Chamaedorea, Dracaena, Ficus, and *Viburnum,* especially if they were not rinsed (Table 2). These residues were particularly severe on *Viburnum,* which has a rather rough leaf surface and on *Ficus* which has a thick waxy leaf, but were not generally observed on *Jasminum, Philodendron, Phoenix,* and *Spathiphyllum.*

Phytotoxicity was observed on *Ficus* (moderate to severe), *Jasminum* (slight to moderate), and *Viburnum* (slight to moderate) (Table 3). In *Jasminum* and *Viburnum,* tender new growth showed irregular necrotic blotches, whereas foliage of all ages showed necrosis on *Ficus. Chamaedorea, Dracaena,* and *Philodendron* were not damaged by any treatments, even without rinsing. *Phoenix* showed slight damage at high concentrations without rinses and some *Spathiphyllum* had minor damage, particularly at the 7% rate.

When *Viburnum* and *Jasminum* were sprayed with 3% oxalic acid and surfactant at rates of 2.5, 5, and 10 ml/liter, efficacy was acceptable at all surfactant rates (Table 4). Oxalate residues on *Viburnum* were not reduced by increasing surfactant concentration and phytotoxicity was not reduced on either species at high surfactant rates.

In conclusion, oxalic acid, in combination with a surfactant, is an effective agent for removal of mineral deposits from foliage of ornamentals. Oxalic acid concentrations of 5% and 7% were both highly effective, however 3% solutions were usually adequate. Concentrations higher than 3% increased the likelihood of phytotoxicity occurring and probably are not necessary in most cases. Increasing surfactant concentration did not increase efficacy nor reduce phytotoxicity or oxalate crystal residues on plants where this is a problem. Spraying foliage of *Chamaedorea* and *Phoenix* palms, *Dracaena,* and *Philodendron* with a 3% oxalic acid plus 5 ml/liter Atplus 411F® can be effective and safe, provided the plants are thoroughly rinsed before the acid crystalizes or dries on the foliage. Anyone contemplating using this material should experiment with a few plants to test for phytotoxicity prior to using it on a large group of plants. Lastly, treatment of stained foliage with oxalic acid should not be viewed as a long term solution for water quality problems. Growers faced with severe water quality problems are advised to use non-overhead irrigation systems or find a better water source.

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