Water Quality and Calcium plus Magnesium Fertilization Effects on Container-Grown Gardenia and Japanese Holly[1]

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Abstract

Combinations of calcium carbonate with magnesium oxide were found to be superior to dolomite as calcium and magnesium fertilizers for container production of gardenia (*Gardenia jasminoides* 'Radicans') and Japanese holly (*Ilex crenata* 'Convexa'). When growth and quality measurements were analyzed, a number of significant water quality by fertilizer interactions were found for both species. In contrast, when responses to water quality and to different rate combinations of calcium carbonate and magnesium oxide (no dolomite) were analyzed, only the visual grade of gardenias showed a significant water quality by fertilizer interaction. Since calcium and magnesium are common constituents of irrigation waters, it is suggested that commercial container nurseries test different rate combinations of calcium carbonate and magnesium oxide for their own water supply and plant species of importance.

Index words: Calcium carbonate, magnesium oxide, dolomite, *Ilex crenata* 'Convexa,' Japanese holly, *Gardenia jasminoides* 'Radicans,' dwarf gardenia

Introduction

Dissolved minerals in irrigation water, especially calcium and magnesium, can affect growth and quality of plants grown in containers (1, 2, 6). Chemical salts dissolved in irrigation water can change the nutritional status of the container growth-media and may accumulate in the media to toxic levels (1, 2, 6). Whitcomb et al. (6, 7) found that optimum growth of geranium and gardenia was observed when concentrations of calcium and magnesium in the irrigation water were inversely correlated with rates of dolomite used. Tayrien and Whitcomb (5) also found a water quality effect on the growth of nandina and noted that calcium carbonate and magnesium oxide were superior sources of calcium and magnesium compared to dolomite. Toxicity problems, resulting from dissolved minerals in irrigation water, can also influence plant growth and quality. Two of the three water sources used in our study had substantial amounts of Cl, Na, and HCO_3 (Table 1, see Tap and HBC). Sodium can readily combine with Cl and HCO_3 to markedly increase the soluble salt content of container media (1, 2, 3, 6). Excessive levels of Cl and Na can produce symptoms of marginal necrosis and tipburn of older leaves (3, 4). Therefore, it was expected that in our study water quality effects on plant growth and quality would include toxicity problems.

The purpose of this study was to compare calcium carbonate and magnesium oxide against dolomite as fer-

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Table 1. Chemical evaluation of irrigation water used on container grown nursery crops[z].

Test	Unit of Measurement	Deionized	Tap	HBC
Bicarbonate	mg/kg	37.00	262.00	494.00
Boron	mg/kg	0.03	0.11	0.35
Calcium	mg/kg	0.00	42.00	32.00
Carbonate	mg/kg	0.00	0.00	0.00
Chloride	mg/kg	11.00	50.00	50.00
Magnesium	mg/kg	1.00	16.00	40.00
Nitrate	mg/kg	0.00	0.00	0.00
Potassium	mg/kg	0.00	4.00	3.00
Sodium	mg/kg	3.00	27.00	54.00
Sulfate	mg/kg	0.00	16.00	15.00
pH	——	6.50	7.90	8.30
Electric Conductivity	mmho/cm	0.06	0.40	0.60
Total Dissolved Solids	mg/kg	38.00	269.00	397.00
Sodium	%	11.90	17.40	22.30
Adjusted Sodium Adsorption Ratio		0.00	1.60	2.70

[z]Samples analyzed by Servi-Tech, Inc., Dodge City, Kansas on January 22, 1985.

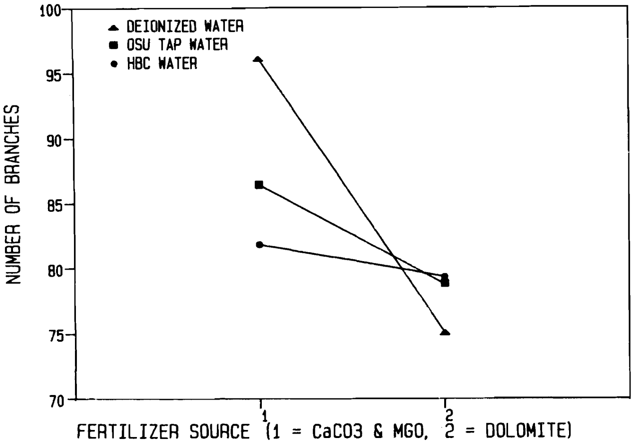

Fig. 1. Mean branch count of dwarf gardenia for each water quality at each fertilizer source. Lines connecting means indicate the effect of fertilizer source on plant visual grade for a specific water quality. The interaction indicated by this graph is significant at the 5% level.

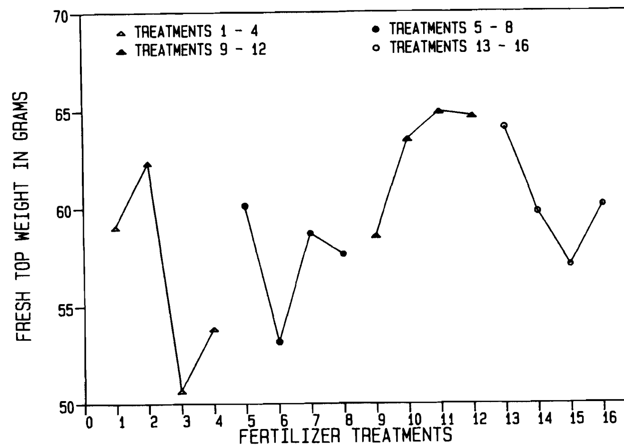

Fig. 2. Mean fresh top weights of dwarf gardenia from all 16 fertilizer treatment combinations (see Table 1). Each group of four, connected by lines, represents four levels of MgO at one level of $CaCO_3$. The interaction indicated by this graph is significant at the 5% level.

tilizers to provide calcium and magnesium to container grown plants. Since calcium and magnesium are minerals commonly found in irrigation water, the influence of different water qualities on the effectiveness of these fertilizers also was examined.

Materials and Methods

Japanese holly, *Ilex crenata* 'Convexa,' and dwarf gardenia, *Gardenia jasminoides* 'Radicans' were planted as rooted cuttings on January 11 and January 18, 1985, respectively. Standard 15 cm (6 in) pots were used with a soilless media of pine bark, peat, and sand (2-1-1 by vol). The media was amended with 18N-2.6P-9.9K (18-6-12) Osmocote at 7.12 kg/m (12 lb/yd) and Micromax (Sierra Chemical Co., Milpitas, CA) at 0.9 kg/m (1.5 lb/yd).

The study was conducted at the Oklahoma State University Nursery Research Station, Stillwater, in a quonset style greenhouse having an air-inflated double layered polyethylene covering. The experiment was divided into two (according to species) randomized complete block designs with six replications per treatment. Plants were randomly placed in blocks that were parallel to the poly-tube heating system which ran under benches next to the side of the greenhouse. Treatments included three water qualities (Table 1), 16 combinations of $CaCO_3$ and MgO (Table 2), plus two levels of dolomite (2.374 kg/m (4 lb/yd) and 4.748 kg/m (8 lb/yd)). Deionized water (DI) was produced from running tap water through organic and cation removal Barnsted cartridge filters. Lake water, treated at Oklahoma State University, was the source of tap water (TW). High bicarbonate water (HBC) was a 1:1 mixture of tap water and water from a local commercial nursery. Water sources were stored in the greenhouse in one 110 and two 200 gallon polyolefin agri-tanks. Water requirements were visually checked daily and water was applied, as needed, with a plastic beaker with no water contacting the foliage.

Data taken after six months of growth included; branch count, visual grade, fresh top weight, and fresh root weight. This data was analyzed as two separate (according to species) 3 x 18 factorials (3 levels of water quality x 18 levels of fertilizers). Because of this design, interactions were based on a differential number of means which formed the water quality main effect (16 for $CaCO_3$ and MgO combinations and 2 for dolomite rates). The 18 fertilizers were also partitioned to show the 4 x 4 factorial arrangement of calcium carbonate and magnesium oxide.

Table 2. Calcium carbonate plus magnesium oxide combinations used in this study[z].

CaCO3	MgO (kg/m)			
(kg/m)	0.0	0.178	0.356	0.534
0.0	1[y]	2	3	4
0.237[x]	5	6	7	8
0.475	9	10	11	12
0.712	13	14	15	16

[z]Each treatment was used in factorial combination with three water qualities for each of the two species.

[y]Treatment combinations 1 -> 16; i.e., rate 6 = 0.237 kg/m $CaCo_3$ + 0.178 kg/m MgO.

[x]To convert kg/m to lb/yd, divide kg/m by 0.593, i.e., 0.237 kg/m divided by 0.593 equals 0.4 lb/yd.

Results and Discussion

Significantly greater growth and quality for gardenia and Japanese holly resulted when deionized water was used for irrigation instead of tap water or HBC water (Table 3). For Japanese holly, tap water was also superior to HBC water for three out of the four plant growth measurements (Table 3). The high bicarbonates and sodium of HBC water were probable causes for poor growth and quality of HBC irrigated plants. For example, tip burn of lower leaves, a symptom characteristic of sodium damage, was found on 57% of Japanese holly plants irrigated with HBC water, but only 4% of plants irrigated with tap water and 0% irrigated with deionized water had such damage.

Significant water quality by fertilizer interactions occurred with gardenia and Japanese holly (Table 3). For both plant species, growth and quality were restricted when combinations of deionized water and dolomite were used. The water quality by fertilizer interactions occurred when combinations of tap or HBC water with dolomite either did not decrease plant responses to the same degree as deionized water or caused an opposite response. Gardenia branch count serves as an example of such an interaction (Fig. 1).

Both test plants had significantly greater fresh top weight and better visual quality with calcium carbonate and magnesium oxide combinations than with dolomite. Gardenia branch count and Japanese holly fresh root weight also showed superior responses with calcium carbonate and magnesium oxide combinations (Table 4).

The most cost effective calcium carbonate rates were the lowest rates that produced responses which were not significantly less than the treatment that gave maximum plant growth and best visual quality. The most cost-effective rate for gardenia was 0.475 kg m^{-3} (0.8 lb/yd^3) and for Japanese holly was 0.237 kg m^{-3} (0.4 lb/yd^3) (Table 5). Since plants irrigated with HBC and Tap waters received some magnesium directly from the water, addition of magnesium oxide caused no significant main effect on growth and visual quality (data not shown). However, when all water and fertilizer combinations were considered, the combination of magnesium oxide with calcium carbonate was generally superior to dolomite (Table 3).

Plant responses that indicated the effects of rate combinations of calcium carbonate and magnesium oxide were analyzed against water quality. The results of that analysis indicated only visual grade for gardenias had a significant water quality by fertilizer interaction (data not shown). However, several interactions between different rate combinations of calcium carbonate and magnesium oxide were found. A significant interaction at the 5% level (F test) is illustrated in Figure 2. Each group of four means, connected by lines, represents plant response to four levels of MgO at one level of $CaCO_3$. If the lines were all parallel then the pattern of response would be the same and no interaction would result. Although the interaction was significant in Figure 2, there was no significant treatment effect regarding differences between fresh weight means.

Significance to the Nursery Industry

These results indicate calcium carbonate and magnesium oxide are better sources of calcium and magnesium than dolomite. The results also indicated that water quality can have a significant effect on growth and plant quality.

No recommendation for rates of calcium carbonate or magnesium oxide can be made from the results of this study. There was no consistency in the response patterns between the different types of data (top weight, visual grade, etc.) and thus no clear single treatment combination or combinations would be considered as superior.

We recommend that each nursery have its irrigation water tested on a regular or timely basis. Based on the calcium and magnesium content of the irrigation water, select different rate combinations of calcium carbonate

Table 3. Effects of water quality on the growth and plant visual quality of dwarf gardenia and Japanese holly.

Species	H_2O Source	Fresh top wt. (g)	Visual Grade	Branch Count	Fresh root wt. (g)
Gardenia	deionized	62.77a[z]	*7.62a	*93.70a	*20.97a
	tap	58.30b	6.95b	85.52b	17.21b
	HBC	54.87b	6.82b	81.56b	17.18b
Japanese Holly	deionized	49.56a	*7.35a	21.50a	23.13a
	tap	41.95b	6.19b	20.47b	20.81b
	HBC	31.86c	4.40c	19.59b	16.45c

[z]For each species, means within columns followed by the same letter or letters are not significantly different at the 5% level as determined by Duncan's multiple range test.

*Water quality by fertilizer interaction, F test, 5% level.

Table 4. Effects of different fertilizers on the growth and quality of gardenia and Japanese Holly.

Species	Fertilizer[z]	Fresh top wt. (g)	Visual Grade	Branch Count	Fresh root wt. (g)
Gardenia	C & M	59.27a[y]	7.21a	88.08a	18.64a
	Dolo.	53.68b	6.48b	77.71b	16.95a
Japanese Holly	C & M	41.78a	6.11a	20.67a	20.43a
	Dolo.	35.84b	4.98b	19.37a	17.75b

[z]C & M equals all $CaCO_3$ & MgO rate combinations while Dolo. equals all dolomite rates.

[y]For each species, means within columns followed by the same letter are not significantly different at the 5% level as determined by an F test for fertilizer main effects.

Table 5. Effects of calcium carbonate on growth and quality of gardenia and Japanese Holly.

Species	Rate[z] (kg/m^3)	Fresh top wt. (g)	Visual[y] Grade	Branch Count	Fresh root wt. (g)
Gardenia	0	56.52b	6.83b	84.13b	16.79c
	0.237	57.39b	7.13ab	83.90b	17.64bc
	0.475	69.92a	7.47a	93.10a	20.69a
	0.712	60.26ab	7.42a	91.31a	19.44ab
Japanese Holly	0	41.51a	5.94b	19.92a	19.61a
	0.237	42.10a	6.19ab	20.38a	20.13a
	0.475	43.21a	6.47a	21.53a	21.83a
	0.712	40.32a	5.82b	20.85a	20.14a

[z]Rate expressed as kg/m^3 of calcium from calcium carbonate.

[y]For each species, means within columns followed by the same letter or letters are not significantly different at the 5% level as determined by Duncan's multiple range test.

and magnesium oxide and test those combinations against that water supply. These tests should be made for each major plant species being grown, as respsonse to $CaCO_3$ and MgO will vary.

Literature Cited

1. Furuta, T. 1978. Environmental plant production and marketing. Cox Publishing Co., Arcadia, CA.

2. Gauch, H.G. 1972. Inorganic plant nutrition. Dowden-Hutchinson and Ross, Stroudsberg, PA.

3. Harris, R.W. 1983. Arboriculture: Care of trees, shrubs, and vines in the landscape. Prentice-Hall, Inc., Englewood Cliffs, NJ.

4. Luttge, U. and N. Higinbotham. 1979. Transport in plants. Springer-Verlag, New York, NY.

5. Tayrien, R.C. and C.E. Whitcomb. 1984. An evaluation of calcium and magnesium sources and water quality on container grown nandina. Okla. State Univ. Res. Report P-855:41-43.

6. Whitcomb, C.E. 1984. Plant production in containers. Lacebark Publications, Stillwater, OK.

7. Whitcomb, C.E., B. Appleton, and C. Gray. 1983. Effects of water quality on plant growth. Okla. State Univ. Res. Report P-843: 52-54.

Sensitivity and Time of Application of Fusilade 2000 to Azaleas[1]

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Abstract

Application of Fusilade 2000 (fluazifop-P-butyl) (R-butyl ± 2-[4-[5- (trifluoromethyl)-2-pyridinyl] oxyl] phenoxy] propanoic acid) on September 3 reduced flowering of 'Hino-Crimson' azalea by 60% and 25% compared to those treated on August 1 and nontreated control plants. Off-Shoot-O (methyl esters of C6-C12 fatty acids) treated plants responded similarly. 'Hino-Crimson' azaleas treated with Fusilade 2000 on July 2 and August 1 had greater flower numbers the following spring than comparable plants treated with Off-Shoot-O. Only azaleas sensitive to Fusilade 2000 respond as such. Sensitive azalea cultivars tested include: 'Hino-Crimson,' 'Hinodegiri,' 'Sherwood Red,' 'Girard's Scarlet' and 'Girard's Rose.'

Index words: postemergence herbicides, phytotoxicity, weed control, ornamentals, growth regulator, chemical pinching

Introduction

Fusilade 4E has been shown to be injurious to several azalea cultivars (1, 2, 3, 4). This injury is characterized by death of terminal shoots, when Fusilade 4E is applied at the recommended rate for annual grass control. Recent work (3) has shown that phytotoxicity associated with application of 0.28 kg/ha ai of Fusilade 4E on 'Hino-Crimson' azalea resulted in activity similar to chemical pinching. Flowering the following spring was greater with the plants treated with Fusilade 4E compared to nontreated plants (3).

While Fusilade (4E and 2000) is injurious to several

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