Calcium and Magnesium Nutrition of Containerized *Cotoneaster dammeri* 'Coral Beauty'[1]

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Abstract

Cotoneaster dammeri 'Coral Beauty' C.K. Schneid. were grown in a peat:perlite:sand container medium amended with either 4.8 kg/m^3 (8 lb/yd^3) dolomite, or combinations of $CaSO_4$ and $MgCO_3$ providing medium concentrations of 0.1, 0.5, 0.9, 1.4 or 1.8 kg/m^3 (0.2, 0.9, 1.5, 2.4, 3.0 lb/yd^3) Ca or Mg. Plant growth was greatest in plants grown with dolomite at the end of 4 months. At low [0.1 or 0.5 kg/m^3 (0.2 or 0.9 lb/yd^3)] Ca medium concentrations, growth was reduced as Mg medium concentration increased above 0.5 kg/m^3 (0.9 lb/yd^3). There were smaller adverse effects on dry weight as Ca medium concentration increased above 0.9 kg/m^3 (1.5 lb/yd^3) at low [0.1 or 0.5 kg/m^3 (0.2 or 0.9 lb/yd^3)] Mg. The smallest plants were associated with foliar Ca:Mg ratios less than 1 and, to a lesser extent, greater than 5.

Index words: calcium carbonate, calcium sulphate, magnesium carbonate, dolomite, lime

Significance to the Nursery Industry

Dolomite is used frequently as a medium amendment to supply Ca and Mg in container-grown plants, but since solubilities of $CaCO_3$ and $MgCO_3$ differ, Ca and Mg are not released evenly. An alternative is to amend media with Ca and Mg salts of similar solubility. Our research has shown that the use of dolomite results in growth of Cotoneaster dammeri C.K. Schneid. 'Coral Beauty' which is equal to or better than that achieved with combinations of $CaSO_4$ and $MgCO_3$. Imbalances between leaf Ca and Mg were common at high rates of one nutrient in the presence of low rates of the other. Leaf Ca:Mg ratios less than 1 were associated with greatly diminished growth.

Introduction

Traditionally, dolomitic limestone has been applied to container media at a standard rate to raise pH and to provide both Ca and Mg (2, 8). More recently, this approach has been modified to account for irrigation water quality, medium composition and plant nutrient requirements (1, 8, 10). When irrigation water and media contain little Ca and Mg, premixture of dolomitic limestone at rates between 4.2 and 4.8 kg/m^3 (7 and 8 lb/yd^3) has been recommended (8). In several species, however, rates between 0 and 2 kg/m^3 (0 to 3.4 lb/yd^3) have been shown to stimulate maximum growth of plants grown with little Ca or Mg in the irrigation water (1).

Dolomitic limestone typically contains Ca (as $CaCO_3$) and Mg (as $MgCO_3$) in a ratio of about 2:1. While foliar nutrient concentrations of healthy woody plants in the field often contain a similar 2:1 ratio of Ca:Mg (4), dolomite does not provide Ca and Mg in this ratio throughout the growing season. Since $MgCO_3$ is solubilized much more readily than $CaCO_3$, medium and plant Mg levels in dolomite-amended media tend to be high early in the season but decrease if growth continues beyond 4 months or into a second growing season (9). Heavy applications of dolomite may suppress growth by increasing availability and plant uptake of Ca thus widening the ratio between tissue Ca and Mg concentrations (8), or indirectly by increasing nitrification and the NO3:NH_4 ratio in organic media (1). To avoid these problems, various alternative methods of supplying Ca and Mg in container media have been investigated (8). Strategies based upon using combinations of Ca and Mg salts (i.e. $CaCO_3$ and MgO) with similar, low solubilities in container media have met with limited success due largely to the very slow release of Mg from MgO. Other salts with similar, but higher solubilities ($CaSO_4$ and $MgCO_3$) have been considered inappropriate for container production since both Ca and Mg may be released too quickly to allow season-long plant uptake (5, 8). In some cases, however, growth of plants fertilized with $CaSO_4$ and $MgCO_3$ has exceeded that of those grown in dolomite-amended media (8). The present study was undertaken to evaluate the single season growth response of a vigorous woody plant (*Cotoneaster dammeri* 'Coral Beauty') to various combinations of $CaSO_4$ and $MgCO_3$, and to dolomite in a peat:perlite:sand medium, in the absence of irrigation water Ca or Mg.

Materials and Methods

Cotoneaster dammeri 'Coral Beauty' cuttings were rooted in a peat, perlite (2:1 by vol) medium under fog. A growing medium prepared by mixing coarse sphagnum peat, perlite and sand (2:1:1 by vol.) was amended with Nutricote 16N-4.4P-8.1K (16-10-10) Type 100 [80% of constituent N released over 100 days at a constant temperature of 25°C (77°F], and Micromax micronutrient fertilizer at 5 and 0.5 kg/m^3 (8.3 and 0.8 lb/yd^3), respectively. This medium was divided into 26 batches of equal volume. Dolomite (20.8% Ca, 10.4% Mg) was mixed into 1 batch at 4.8 kg/m^3 (8 lb/yd^3) providing 1.0 kg/m^3 (1.7 lb/yd^3) Ca and 0.5 kg/m^3 (0.9 lb/yd^3) Mg. $CaSO_4$ and $MgCO_3$ were mixed into the remaining batches to provide the medium Ca and Mg concentrations outlined in Table 1. On June 1, 1990, rooted cotoneaster cuttings were planted singly in 3.8 liter (#1) containers containing one of the 26 amended media. Containers were placed outside in a nursery at Kentville, N.S. (latitude 45°N) and were irrigated daily with 350 ml of

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Table 1. Calcium sulphate and magnesium carbonate amendments and equivalent medium calcium and magnesium concentrations for 25 treatments.

$CaSO_4$ (kg/m^3)	Mg CO_3 (kg/m^3) 0.4	1.8	3.2	4.6	6.1
0.3	0.1/0.1[z]	0.5/0.1	0.9/0.1	1.4/0.1	1.8/0.1
1.7	0.1/0.5	0.5/0.5	0.9/0.5	1.4/0.5	1.8/0.5
3.1	0.1/0.9	0.5/0.9	0.9/0.9	1.4/0.9	1.8/0.9
4.5	0.1/1.4	0.5/1.4	0.9/1.4	1.4/1.4	1.8/1.4
5.9	0.1/1.8	0.5/1.8	0.9/1.8	1.4/1.8	1.8/1.8

[z]Ca and Mg (Ca/Mg) concentration in medium (kg/m^3) at start of experiment. To convert kg/m^3 to ℓb/yd^3 multiply kg/m^3 by 1.69.

deionized water supplied via pressure compensated, drip irrigation emitters. On July 3, August 1, September 1 and October 1, 3 replicate containers of each treatment were brought to container capacity by subirrigation and then 200ml (7 fl oz) of deionized water were poured onto media surfaces. The resulting leachate was collected and analyzed at 25°C (77°F) for pH, and then for Ca and Mg concentration using atomic absorption spectrophotometry. The same containers were sampled at each date. On October 1, root and shoot dry weight were determined and leaf samples of 3 plants per treatment, selected at random, were wet ashed and analyzed for Ca, Mg and K as described above.

The experimental design was a randomized complete block with 8 single plant replicates (containers from only 3 blocks were used for leachate analysis). Analysis of variance was applied to all data according to the 5 × 5 factorial classification of Ca and Mg medium amendment treatments, plus a control (dolomite).

Results and Discussion

At the end of the season (October 1), plants grown with dolomite had the greatest root and shoot weights (Table 2). Some combinations of $CaSO_4$ and $MgCO_3$ [e.g. Mg at 0.1 kg/m^3 (0.2 lb/yd^3)] and Ca at 0.5 or 0.9 kg/m^3 (0.9 or 1.5 lb/yd^3); Mg and Ca both at 0.5 kg/m^3)] produced plants with similar root weights and slightly reduced shoot weights, but other combinations significantly reduced both root and shoot weight in comparison with the dolomite control. This is in agreement with previous study (8) involving Pyracantha sp. in which growth of containerized plants supplied with mixtures of $CaSO_4$ and $MgCO_3$ did not differ from those supplied with dolomite provided that rates of Ca and Mg did not exceed 0.5 and 1.0 kg/m^3 (0.9 and 1.7 lb/yd^3), respectively.

High application rates of both Ca and Mg medium were detrimental to final root and shoot weights. At 1.8 kg/m^3 (3.0 lb/yd^3) of Ca and Mg, for example, root weight was depressed by 26% and shoot weight by 12% compared with plants grown at 0.5 and 0.1 kg/m^3 (0.9 and 0.2 lb/yd^3) of Ca and Mg, respectively. Similar effects of high rates of Ca and Mg, supplied from $CaSO_4$ and $MgCO_3$, have been described (9). Chrustic and Wright (1) reported decreased growth of holly and azalea when high rates of Ca and Mg were supplied as dolomite and attributed the effect, in part, to the influence of high pH in reducing NH4 availability. In our work, $CaSO_4$ had no significant effect on medium

Table 2. Root and shoot dry weights of *Cotoneaster dammeri* 'Coral Beauty' in relation to media amended with different rates of calcium and magnesium.

Calcium application rate (kg/m^3)	Magnesium application rate (kg/m^3) 0.1 Root	0.1 Shoot	0.5 Root	0.5 Shoot	0.9 Root	0.9 Shoot	1.4 Root	1.4 Shoot	1.8 Root	1.8 Shoot
	Dry weight (g)									
0.1	13.2	60.0	15.9	66.0	14.9	62.1	11.7	50.6	8.6	34.1
0.5	16.5	69.0	15.8	69.0	15.0	66.5	13.3	56.0	8.2	38.8
0.9	14.7	69.6	14.2	65.3	13.2	66.4	14.9	67.2	11.6	51.3
1.4	11.2	57.3	11.2	58.0	13.6	63.8	12.9	60.8	12.2	56.6
1.8	11.8	62.6	12.5	64.1	15.2	67.9	12.7	58.8	12.4	60.5
	Root	Shoot								
Dolomite (4.8 kg/m^3)	15.4	74.7								

Statistical analysis

Comparison		Root DW	Shoot DW
Calcium	linear	NS[z]	**
	quad.	NS	NS
Magnesium	linear	**	**
	quad.	**	**
Calcium × Magnesium		**	**
Dolomite vs others		*	**
SE[y]		1.1	3.9

[z]NS: Not Significant; *: significant at 5%; **: significant at 1%.

[y]SE: Standard error of the mean for Ca × Mg effect (n = 8, df = 168).

pH through the growing season, but pH increased linearly with rate of Mg supplied from $MgCO_3$ (Tables 3 and 4). At the highest rate of Mg (1.8 kg/m^3), leachate pH was 6.3 or above for much of the season. Under these conditions NH4 availability could be a factor influencing plant growth (1).

Ca and Mg application rates showed significant interactions in their effects on plant growth. Root and shoot weights were more adversely affected by increasing medium Mg concentrations [>0.5 kg/m^3 (0.9 lb/yd^3)] at low Ca [<=0.5 kg/m^3 (0.9 lb/yd^3)], than by the inverse situation (Table 2). For example, root and shoot weights were decreased by averages of 46 and 48%, respectively, as Mg was increased from 0.5 to 1.8 kg/m^3 (0.9 to 3.0 lb/yd^3) at 0.1 kg/m^3 (0.2 lb/yd^3) Ca. The equivalent decreases as Ca was increased from 0.5 to 1.8 kg/m^3 (0.9 to 3.0 lb/yd^3) at 0.1 kg/m^3 (0.2 lb/yd^3) Mg were 28 and 9%, respectively. The detrimental effects on plant growth of increasing Ca supply under conditions of low Mg availability are well documented (8, 10). Our results confirm those effects, but indicate that increasing Mg supply at low Ca is more detrimental.

There were also significant interactions between Ca and Mg application rates in their effects on leaf Ca and Mg (Table 5). Increasing Ca application rate resulted in lower leaf concentrations of Mg and *vice versa*. Plants grown with dolomite showed significantly higher leaf Ca, but lower leaf Mg as compared with the average of all other treatments. Plant weight declined where leaf Mg exceeded leaf Ca (cf. Tables 2 and 5). The smallest plants (those supplied with Ca and Mg medium amendments [of 0.1 and 1.8 kg/m^3 (0.2 and 3.0 lb/yd^3), respectively] also had the lowest leaf Ca:Mg ratio (0.6); the largest plants (those grown with dolomite) had a leaf Ca:Mg ratio of 3.5. Harvest weights declined at very high leaf Ca:Mg ratios [e.g. with 1.8 and 0.1 kg/m^3 (3.0 and 0.2 lb/yd^3)] Ca and Mg amendments, respectively, but the effect was relatively minor. These results are in agreement with Therios and Sakellariadis (6) who reported marked declines in fresh weight accumulation in olive trees as the ratio of leaf Ca:Mg declined below 1, but relatively little effect of ratios as high as 8.2. In olive, the detrimental effects of low Ca:Mg ratios were attributed partly to a reduction in K uptake. Increasing medium Mg amendment did affect leaf K in our study (data not shown), but only to a small degree. K concentrations declined from 0.93% to 0.84% of dry weight as Mg amendment increased from 0.1 to 1.8 kg/m^3 (0.2 to 3.0 lb/yd^3).

Sources of Ca and Mg such as $CaSO_4$, and $MgCO_3$ used either alone or combined with $CaCO_3$ in dolomite are often considered to solubilize too quickly to satisfy plant Ca and Mg requirements during a growing season. In experiments

Table 3. Concentration of calcium and pH of container leachate on 4 sampling dates in relation to calcium application rate.

Calcium application rate (kg/m^3)	Date: Jul 3 Ca (mg/ℓ)	Jul 3 pH	Aug 1 Ca (mg/ℓ)	Aug 1 pH	Sep 1 Ca (mg/ℓ)	Sep 1 pH	Oct 1 Ca (mg/ℓ)	Oct 1 pH
0.1	16.7[z]	5.2	16.9	5.5	2.9	5.7	1.5	5.7
0.5	18.0	5.2	10.7	5.8	2.4	6.2	1.3	6.1
0.9	20.1	5.1	28.1	5.2	5.3	5.7	2.5	5.9
1.4	26.3	4.8	23.5	4.9	5.7	5.5	7.7	5.6
1.8	42.1	4.7	29.9	5.1	13.3	5.4	10.2	5.3
Dolomite (4.8 kg/m^3)	7.1	4.9	14.0	4.5	2.2	5.6	2.3	5.9
Statistical analysis[y]								
	L	NS	L	NS	L	NS	L	NS
SE:	3.5	0.4	3.4	0.7	3.0	0.5	1.4	0.5

[z]Leachate Ca concentration and pH averaged over all Mg application rates.

[y]L: linear effect of Ca application rate (1% level); NS: Not significant; SE: standard error of mean (n = 16, df = 48).

Table 4. Concentration of magnesium and pH of container leachate on 4 sampling dates in relation to magnesium application rate.

Magnesium application rate (kg/m^3)	Date: Jul 3 Mg (mg/ℓ)	Jul 3 pH	Aug 1 Mg (mg/ℓ)	Aug 1 pH	Sep 1 Mg (mg/ℓ)	Sep 1 pH	Oct 1 Ca (mg/ℓ)	Oct 1 pH
0.1	6.7[z]	4.2	1.0	4.3	1.3	5.1	0.9	5.2
0.5	15.8	4.5	30.1	4.4	0.9	5.1	1.9	5.2
0.9	15.1	4.9	43.1	5.0	4.8	5.5	4.6	5.5
1.4	31.7	5.9	90.8	6.4	10.2	6.3	7.5	6.1
1.8	38.1	5.5	93.8	6.3	16.9	6.5	28.0	6.5
Dolomite (4.8 kg/m^3)	2.0	4.9	43.8	4.5	0.9	5.6	0.7	5.9
Statistical analysis[y]								
	L	L	L	L	L	L	L	L
SE:	4.3	0.2	14.7	0.3	2.3	0.4	1.4	0.3

[z]Leachate Mg concentration and pH averaged over all Ca application rates.

[y]L: linear effect of Mg application rate (1% level); SE: standard error of mean (n = 16, df = 48).

Table 5. **End of season leaf concentrations of calcium and magnesium in relation to calcium and magnesium application rates.**

Calcium application rate (kg/m^3)	Magnesium application rate (kg/m^3)									
	0.1		0.5		0.9		1.4		1.8	
	Ca	Mg	Ca	Mg	Ca	Mg	Ca	Mg	Ca	Mg
	Leaf concentration (% DW)									
0.1	0.62	0.32	0.51	0.55	0.52	0.63	0.38	0.65	0.30	0.61
0.5	0.93	0.26	0.90	0.49	0.69	0.57	0.55	0.66	0.42	0.67
0.9	0.98	0.19	1.10	0.44	0.87	0.54	0.76	0.63	0.58	0.63
1.4	1.38	0.19	1.26	0.35	1.02	0.51	0.80	0.62	0.83	0.63
1.8	1.20	0.17	1.32	0.33	1.15	0.50	0.98	0.59	0.77	0.56
	Ca	Mg								
Dolomite (4.8 kg/m^3)	0.98	0.28								

Statistical analysis Comparison	Leaf Ca	Leaf Mg
linear	**[z]	**
quad.	**	NS
Magnesium linear	**	**
quad.	**	**
Calcium × Magnesium	**	**
Dolomite vs others	**	**
SE[y]	0.05	0.02

[z]NS: Not Significant; **: significant at 1% level.

[y]SE: Standard error of the mean for Ca × Mg effect (n = 3, df = 48).

with Wiltonii Juniper, Whitcomb (8) concluded that plants grown with dolomite at 5.4 kg/m^3 (9 lb/yd^3) in the medium showed restricted growth due to Mg deficiency caused by rapid solubilization and loss of Mg from the medium. Results from our study showed that Ca and Mg availability in the $CaSO_4$ and $MgCO_3$ treatments increased linearly with application rate, and was greatest during June and July (as indicated by the July 3 and August 1 leachate analysis; Tables 3 and 4). Thereafter relatively little Ca or Mg was present in leachate from containers at application rates below 1.4 kg/m^3 (2.4 lb/yd^3). Leachate from the dolomite-amended containers also had low Ca concentrations on September 1 and on October 1 although concentrations exceeded those of Mg. Despite the low medium concentrations of Ca and Mg in many treatments towards the end of the season, no deficiency symptoms appeared. Moreover, all leaf concentrations of Ca and Mg in treatments at the end of the season (Table 5) were generally at or above those recorded for vigorous Cotoneaster dammeri in previous studies (3). We conclude that mid to late season Ca and Mg supply is not limiting to growth of cotoneaster over a single season.

In summary, no $CaSO_4/MgCO_3$ amendments resulted in an improvement of cotoneaster growth over that achieved with dolomite incorporated at 4.8 kg/m^3 (8 lb/yd^3). Plant growth was reduced when Mg supply and plant uptake exceeded Ca supply and uptake, but the converse was not as pronounced. These data support the use of dolomite for single season Ca and Mg supply to containerized cotoneaster. Under production conditions, however, concentrations of Ca and Mg in irrigation water must also be taken into account in determining appropriate Ca and Mg source amendments for container media (8). Our results also help in the interpretation of cotoneaster foliar analysis since high leaf Ca:Mg ratios (up to 5) may not significantly diminish growth, whereas low ratios (<1) warrant an immediate increase in Ca supply.

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