Effects of Dolomitic Lime on Growth and Nutrient Uptake of *Buddleia davidii* 'Royal Red' Grown in Pine Bark[1]

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Abstract

Buddleia davidii Franch. 'Royal Red' was grown in pine bark amended with 0.0, 2.4, 4.7 or 9.5 kg/m³ (0.0, 4.0, 8.0, or 16.0 lbs/yd³) dolomitic lime. Growth characteristics responded quadratically to dolomitic lime with those plants receiving 2.4 kg/m³ having the greatest shoot and root dry weights and inflorescence numbers. Plants grown in 4.7 kg/m³ had the greatest shoot lengths. Concentrations of Ca and Mg in leaves of plants grown in containers without dolomitic lime amendment were below that recommended for normal growth of *B. davidii*. Leaf concentrations of N, S and Mn showed quadratic responses to dolomitic lime additions. Media pH and concentrations of NO_3, Al, B, Mn and P also showed quadratic responses. Media Zn concentrations showed a linear response. Although all dolomitic lime amendments tested improved growth of *Buddleia davidii* 'Royal Red', the incorporation of 2.4 kg/m³ produced maximum growth and inflorescence quantity.

Index words: butterfly bush, dolomitic lime, nutrition, *Buddleia davidii*.

Significance to the Nursery Industry

Nursery stock, such as *Buddleia davidii* Franch., is frequently grown in a pine bark medium amended with dolomitic lime. Studies were undertaken to determine whether additions of dolomitic lime were beneficial to the growth of *B. davidii* and to determine how container medium and leaf nutrient content were affected by additions of dolomitic lime. It was determined that a dolomitic lime amendment of 2.4 kg/m³ results in optimal growth. By adding a threshold level of dolomitic lime, and avoiding excess, producers can optimize growth and dolomitic lime usage.

Introduction

Buddleia davidii, butterfly bush, is an ornamental shrub prized for its rapid growth rate and fragrant inflorescences as well as for its ability to grow under conditions unfavorable for the growth of many other ornamental plants (12). The ability of *Buddleia* to grow in waste areas high in lime such as roadsides (20), bombed out buildings (2), and abandoned chalk mines (9), is well documented and is partially attributed to a tolerance for high Ca concentrations (17, 21).

The addition of dolomitic lime, usually between 1.8 and 8 kg/m³ (3.0 and 13.5 lbs/yd³), to pine bark is a common practice in container nursery production (16, 19, 23). Dolomitic lime increases concentrations of Ca and Mg as well as the pH of the growing medium to levels more suitable for nutrient uptake (13, 14). The usual pH range of unamended pine bark is 3.5 to 4.8 (19), which is below that considered optimal for uptake of many elements including Ca and Mg (18). Plants respond to pine bark based media amended with dolomitic lime in a variety of ways, both positive and negative, depending on the amount added and the plant specificity (16). The addition of dolomitic lime to a medium has been shown to result in suboptimal growth for a variety of crops (1, 3, 10, 11, 22, 25) and increased growth in others (1, 4, 8, 11, 15).

The range of Ca and Mg concentrations in *B. davidii* leaf tissue that correlate with normal growth are 7,500 to 20,400 ppm and 1,700 to 4,400 ppm, respectively (14). These values are similar to or greater than values established for plants, listed above, which exhibit increased growth with dolomitic lime additions.

Observations indicate that *Buddleia davidii* tolerates, and may benefit from, conditions of high lime (2, 9, 20), but its requirements for dolomitic lime under nursery production conditions have not been quantified. This study examines the effects of increasing levels of dolomitic lime on the growth and nutrient uptake of *B. davidii* 'Royal Red'.

Materials and Methods

Forty *Buddleia davidii* 'Royal Red' plants, rooted from single node cuttings and grown into 7.5 × 7.5 × 10 cm (3 × 3 × 4 in) cells, were selected for uniformity, divided into four groups of ten, and transplanted on August 15, 1996, one each, into 3.8 liter (1 gal) containers filled with pine bark amended with 0.0, 2.4, 4.7, or 9.5 kg/m³ (0.0, 4.0, 8.0, or 16.0 lbs/yd) dolomitic lime. Media analyses of the four treatments were conducted immediately after amending with dolomitic lime and prior to potting. These analyses revealed a range in pH and nutrient concentrations (Table 1). Plants were grown on a gravel pad in Athens, GA, for the duration of the experiment. Containers were arranged in a randomized complete block design and top-dressed with 18g Nutricote Total 17N–3.0P–6.7K (17–7–8) plus micronutrients (Plantco Inc., Ontario, Canada) immediately after transplanting. Plants were

Table 1. Nutrient concentration and pH of pine bark media amended with 0, 2.4, 4.7 and 9.5 kg/m³ (0.0, 4.0, 8.0 and 16.0 lbs/yd³) dolomitic lime before transplanting and fertilization.

Lime amendment	Nutrients (ppm)				
	pH	P	K	Ca	Mg
0.0 kg/m³	4.4	0.25	9.16	0.52	0.01
2.4 kg/m³	5.6	0.12	21.04	7.21	5.35
4.7 kg/m³	6.1	<0.10	23.85	10.54	7.82
9.5 kg/m³	6.4	<0.10	31.04	22.13	14.36

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watered as needed and no pesticides were applied during this study.

On October 15, 1996, after 60 days of growth, maximum shoot length, measured from the pine bark media to the tip of the longest shoot, and inflorescence number per plant (open and senescent flowers) were determined. Immediately after measurements were taken, plants were destructively sampled and dried. Shoot and root dry weights were determined after drying plants at 70C (158F) for 5 days. Leaf nutrient levels of five plants, chosen randomly, from each of the four treatments were determined by sampling fully expanded mature leaves after drying and weighing. Nutrient concentrations and pH of the pine bark media were determined by randomly sampling five containers separately out of each of the four treatments immediately after removal of plants. Nutrient analyses for both leaves and media were performed by Benton Labs (Athens, GA) using a Jarrell-Ash ICAP 9000 (Jarrell-Ash, Hookset, NH).

Growth and nutrient data were analyzed for significant linear and quadratic trends using proc ANOVA on SAS (SAS Institute, Cary, NC).

Results and Discussion

After 60 days all plants were marketable as one-gallon container-grown *Buddleia davidii* 'Royal Red'. Dry weights of shoots and roots as well as inflorescence number showed quadratic responses to dolomitic lime additions with greatest weights and inflorescence numbers present in those plants grown in 2.4 kg/m³ (Table 2). Plants grown without dolomitic lime had the lowest weights of all treatments. Shoot length also showed a quadratic trend with those plants receiving 4.7 kg/m³ attaining the greatest length. Shoot:root dry weight ratios showed no significant trends among treatments.

The difference in growth between plants grown with dolomitic lime and plants grown without dolomitic lime indicates that adding dolomitic lime to pine bark is beneficial for the growth of *Buddleia davidii* 'Royal Red'. Additions of dolomitic lime greater than 2.4 kg/m³ proved to be extraneous as they did not increase growth and reduced inflorescence number.

Leaf nutrient analyses showed quadratic increases in both Ca and Mg as dolomitic lime concentration increased (Table 3). Concentrations of Ca and Mg at 0.0 kg/m³ were below that recommended by Mills and Jones for normal growth (14), indicating that a deficiency of either or both resulted in decreased growth. With the exception of Mn, which was present in supraoptimal levels (14) in all treatments, concentrations of other elements (besides Ca and Mg) were within the range required for normal growth. Concentrations of N, S and Mn were greater in those treatments showing lower dry weights, including 0.0 kg/m³ and 9.5 kg/m³ (Table 4). It is hypothesized that greater growth of plants in those treatments receiving 2.4 kg/m³ and 4.7 kg/m³ may have diluted concentrations of these elements.

Analyses of pine bark media at the end of the experiment showed an increase in pH (Table 5), as well as quadratic increases in Ca and Mg (Table 3) with increasing dolomitic lime rates. Concentrations of NO_3, Al, B, Mn, and P in the media decreased quadratically with increasing lime while Zn concentration increased linearly (Table 5). The levels of Ca and Mg in unamended pine bark before the application of fertilizer (Table 1) were below that reported to be required in the root zone for normal growth of *Ilex crenata* 'Helleri' which requires a media solution concentration of 5–10 ppm Ca and Mg (24), and *I. crenata* 'Convexa' which requires 1 ppm Ca (5). Calcium levels in the media were above that required by *Prunus persica* (L.) Batsch grown in nutrient solution (0.3 ppm Ca) (6), while Mg levels were lower than those required by *P. persica* (0.5 ppm Mg) (7). By the end of the experiment, watering and fertilizing increased concentrations of Ca and Mg in the 0.0 kg/m³ treatment to levels satisfactory for all of the above plants with the exception of *I. crenata* 'Helleri'.

Table 2. Influence of dolomitic lime rate on average shoot length, inflorescence number, shoot and root weights and shoot:root ratio of *Buddleia davidii* Franch. 'Royal Red' 60 days after transplanting and fertilization.

Lime amendment	Shoot length (in)	Inflorescence number	Shoot dry weight (g)	Root dry weight (g)	Shoot:root ratio
0.0 kg/m³	16.2	5.6	8.06	1.37	6.20
2.4 kg/m³	20.8	9.8	19.18	4.35	4.77
4.7 kg/m³	21.0	8.6	17.26	3.36	5.34
9.5 kg/m³	20.7	6.7	14.64	3.13	5.06
Significance					
linear	0.01	0.01	0.01	0.01	0.11
quadratic	0.01	0.01	0.01	0.01	NS

Table 3. Calcium and magnesium levels in leaves of *Buddleia davidii* Franch. 'Royal Red' and pine bark media 60 days after transplanting and fertilizing.

Lime amendment	Media (ppm)		Leaf (ppm)	
	Ca	Mg	Ca	Mg
0.0 kg/m³	3.08	0.63	3622.6	1524.5
2.4 kg/m³	6.54	5.20	8797.5	3614.0
4.7 kg/m³	8.84	7.42	10306.6	4256.3
9.5 kg/m³	12.79	9.99	11788.6	4417.0
Significance				
linear	0.01	0.01	0.01	0.01
quadratic	0.01	0.01	0.01	0.01

Table 4. Effect of dolomitic lime rate on leaf nutrient concentration in *Buddleia davidii* Franch. 'Royal Red' 60 days after transplanting and fertilizing[z].

Lime amendment	Nutrients N (%)	S (%)	Mn (ppm)
0.0 kg/m³	3.94	0.410	273.5
2.4 kg/m³	2.89	0.304	161.6
4.7 kg/m³	3.16	0.342	157.1
9.5 kg/m³	3.65	0.372	176.7
Significance			
linear	0.01	0.01	0.01
quadratic	0.01	0.01	0.01

[z]Only elements showing significant linear or quadratic trends are shown.

Table 5. Effect of dolomitic lime rate on media pH and nutrient concentrations 60 days after transplanting and fertilizing *Buddleia davidii* Franch. 'Royal Red'[z].

Lime amendment	pH	Nutrients (ppm)					
		NO_3	Al	B	Mn	P	Zn
0.0 kg/m³	3.9	9.82	0.627	0.235	0.187	2.18	0.024
2.4 kg/m³	5.3	4.51	0.273	0.114	0.013	1.31	0.039
4.7 kg/m³	6.1	2.50	0.202	0.054	0.033	0.90	0.149
9.5 kg/m³	6.7	5.51	0.125	0.033	0.078	0.98	0.098
Significance							
linear	0.01	0.01	0.01	0.01	0.01	0.01	0.03
quadratic	0.01	0.01	0.01	0.01	0.01	0.04	NS

[z]Only elements showing significant linear or quadratic trends are shown.

Low leaf tissue concentrations of Ca and Mg (Table 3) in plants grown without dolomitic lime indicate that Ca and Mg are not readily available to these plants due to low concentrations of Ca and Mg, a low pH, or both, in the unamended pine bark medium (1, 18, 24).

Our results agree with other research (1, 8, 24), which concluded that dolomitic lime additions increase the growth of some plants by increasing the amount of Ca and Mg available for uptake. Results from this research also agree with Starr and Wright (24), who concluded that there is an optimal quantity of dolomitic lime in a growing medium for the promotion of growth and that, although luxury Ca and Mg occur, supraoptimal levels do not promote additional growth and may even decrease growth.

Threshold levels of Ca and Mg were needed to maximize growth in *Buddleia davidii* 'Royal Red'. Observations of *Buddleia davidii* growing in chalk mines and in mortar joints reflect a tolerance to high lime and high pH conditions. However, increasing the concentration of dolomitic lime above 2.4 kg/m³ to increase foliar concentrations of Ca and Mg did not result in increased growth. We speculate that dolomitic lime concentrations lower than 2.4 kg/m³ would provide sufficient Ca and Mg for normal growth.

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