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4. Laiche, A.J., Jr. 1988. Effects of rate and repeat application of flurprimidol on *Photinia* x *fraseri* and *Ilex crenata* 'Compacta'. J. Environ. Hort. 6:114–118.

5. Norcini, J.G. 1991. Growth and water status of pruned and unpruned woody landscape plants treated with Sumagic (uniconazole), Cutless (flurprimidol), or Atrimmec (dikegulac). J. Environ. Hort. 9:231–235.

6. Sachs, R.M., H. Heild, and J. DeBie. 1975. Dikegulac: a promising new foliar-applied growth regulator for woody species. HortScience 10:367–369.

7. Steffens, G.L. 1988. Gibberellin biosynthesis inhibitors: comparing growth-retarding effectiveness on apple. J. Plant Growth Regul. 7:27–36.

8. Vaigro-Wolff, A.L. and M.R. Warmund. 1987. Suppression of growth and plant moisture stress of forsythia with flurprimidol and XE-1019. HortScience 22:884.

9. Woodson, W.R. and T.J. Raiford. 1986. Induction of lateral branching in Chinese hibiscus with mefluidide. HortScience 21:71–73.

Effect of Cupric Hydroxide-treated Containers on Bougainvillea Propagation and Growth after Transplanting[1]

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Abstract

Cupric hydroxide (100g $Cu(OH)_2$/liter; 13.3 oz/gal) in a latex paint was sprayed to the interior of propagation cups to evaluate the effects on rooting of *Bougainvillea glabra* Choisy 'Sanderiana' cuttings and their growth after transplanting. Forty-two-day-old rooted cuttings propagated in $Cu(OH)_2$-treated cups had a compact rootball with no root circling and tended to have more primary roots. From 91 to 144 days after transplanting 42-day-old rooted cuttings into non-treated 3.8 liter (1 gal) containers, transplants from the $Cu(OH)_2$-treated cups had a greater growth index, principally due to increased height, than transplants from non-treated cups. However, the $Cu(OH)_2$ treatment did not significantly affect shoot or root fresh and dry weights 144 days after transplanting.

Index words: Spin Out, $Cu(OH)_2$, propagation, *Bougainvillea glabra*, nursery production.

Significance to the Nursery Industry

Root systems of bougainvillea typically circle the interior of the container outside the rootball when propagated by cuttings. These roots are brittle and easily broken off or injured during transplanting. However, application of cupric hydroxide to the interior of the container resulted in a root system that remained within the rooting substrate thereby reducing the possibility of injury to the root system, and hence transplant shock. When rooted liners were transplanted to 3.8 liter (1 gal) containers, those liners rooted in $Cu(OH)_2$-treated containers resulted in larger plants 91 days after transplanting compared to those liners rooted in non-treated containers within 91 days. Faster growing plants would allow for earlier upcanning, earlier sale of a certain sized plant, or result in a larger plant by a certain date.

[1]Received for publication March 15, 1996; in revised form July 15, 1996. Florida Agricultural Expt. Station Journal Series No. R-04441. We gratefully acknowledge Griffin Corporation for the donation of Spin Out. The authors would like to thank Dr. Frank G. Martin for assistance with interpretation of the statistical analyses.

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Introduction

Bougainvillea propagated by stem cuttings form very delicate and brittle root systems (6) that typically circle the interior of the propagation container and emerge from drainage holes. Hence, roots of bougainvillea liners are easily broken off or injured during transplanting thereby increasing transplant shock. Cupric hydroxide ($Cu(OH)_2$) has been used as a chemical root pruning agent (3, 4, 9) that is applied to the interior surface of containers, inhibiting growth of the root apical meristems near the interior surface. For most species tested, $Cu(OH)_2$ reduced or eliminated roots that circled the interior of containers (8), while root systems grown in $Cu(OH)_2$-treated containers were distributed more evenly within the substrate and had an increased uptake of several nutrients (5).

In a previous study, the only statistically significant quantitative rooting response of 'Barbara Karst' bougainvillea [*Bougainvillea* x *buttiana (Bougainvillea glabra* Choisy x *Bougainvillea peruviana* Humb. & Bonpl.) 'Barbara Karst'] cuttings propagated in $Cu(OH)_2$-treated containers was a reduction in root fresh weight (1). However, cuttings rooted in $Cu(OH)_2$-treated containers had no root circling and had a more compact, branched root system compared to cuttings rooted in non-treated containers. Although there was a reduction in root fresh weight of these cuttings, growth after transplanting was not investigated. In a study on tomato seed-

Table 1. Effect of $Cu(OH)_2$-treated propagation containers on rooting of *Bougainvillea glabra* 'Sanderiana' and growth after transplanting into non-treated 3.8 liter (1 gal) containers.

	Control	$Cu(OH)_2$	Pr > |t|
Cuttings[z]			
No. primary roots	13.8	18.6	0.12
Root fresh weight (mg)	428.0	600.0	0.35
Root dry weight (mg)	43.0	56.0	0.40
Harvested transplants[y]			
Shoot fresh weight (g)	85.0	94.0	0.50
Shoot dry weight (g)	24.8	27.5	0.54
Root fresh weight (g)	34.2	36.2	0.75
Root dry weight (g)	5.0	5.4	0.65

[z]Rooting parameters recorded 42 days after cuttings were stuck; n = 10.
[y]144 days after transplanting; n = 10.

lings, total root dry weight was reduced by $Cu(OH)_2$-treated flats (7). However, after transplanting, total root dry weight and shoot dry weight gains were greater for seedlings from $Cu(OH)_2$-treated flats compared to seedlings from non-treated flats. In another study, azalea liners grown for 5½ months in $Cu(OH)_2$-treated containers were transplanted to the field and grown for eight months. Although there was no effect on root dry weight, roots from $Cu(OH)_2$-treated containers had grown into the surrounding soil and roots from non-treated containers had not (2).

The objective of this study was to determine the effects of $Cu(OH)_2$-treated containers on the root system of *Bougainvillea glabra* 'Sanderiana' cuttings and their subsequent growth when transplanted into non-treated 3.8 liter (1 gal) containers.

Materials and Methods

Cupric hydroxide in gray latex paint (100 g $Cu(OH)_2$/liter (13.3 oz/gal); Spin Out, Griffin Corp., Valdosta, GA) was sprayed on the interior of 20 of 40 propagation cups (0.12 liter; 5.3 × 5.3 × 7.5 cm (2.1 × 2.1 × 3.0 in); a 6 × 14 mm (0.24 × 0.55 in) hole on each of four sides). All cups were filled with a substrate composed of equal parts Canadian sphagnum peat and coarse perlite (1:1 by vol). *Bougainvillea glabra* 'Sanderiana' herbaceous cuttings (10–13 cm; 3.9–5.1 in) were taken on April 9, 1994. Cuttings were scored at the base (1.3 cm; 0.5 in) on opposite sides, dipped (3 sec) in 6000 mg/liter (0.6%) 1*H*-indole-3-butyric acid (K-IBA; Sigma Co., St. Louis, MO) and placed in the propagation cups. The cups were arranged in a completely random design on a heating pad (21C; 70F) in a greenhouse (20% light exclusion) and they received intermittent mist (9 sec/2.5 min) from 0730 to 1930 HR. Additionally, a total of 54 sec of mist was applied at 2230, 0130, and 0430 HR.

On May 17, 1994 (42 days after the cuttings were struck), half of the cuttings of each treatment (i.e., 10 per treatment) were randomly chosen and transplanted into non-treated 3.8 liter (1 gal) cylindrical, black plastic containers. The substrate consisted of pine bark: Canadian peat: sand (3:1:1; by vol) amended with 5.9 kg/cu m (9.9 lb/cu yd) Osmocote 18N–2.6P–10K (18–6–12; 8–9 month formulation at 21C (70F), The Scotts Co., Marysville, OH), 2.2 kg/cu m (3.7 lb/cu yd) triple superphosphate, and 1.4 kg/cu m (2.4 lb/ cu yd) Micromax 12S-0.1B-0.5Cu-12Fe-2.5Mn-0.05Mo-12Zn (The Scotts Co.). A topdressing of another 12 g (0.4 oz) 18N–2.6P–10K (18–6–12) Osmocote was applied after transplanting. Containers were placed on a black plastic container bed in full sun in a completely random design. Overhead irrigation was 1.3 cm (0.5 in) daily. Height and two widths (greatest width and perpendicular to the greatest width) were recorded and a growth index was calculated on 0, 45, 91, 118, and 144 days after transplanting. Shoots and roots were harvested for fresh and dry (dried at 70C (158F) for 48 hr) weight determinations 144 days after transplanting.

The other half of the cuttings were used for root system evaluation on May 21, 1994. Qualitative observations were made of the root systems before and after the substrate was washed off the roots. Number of primary roots and root fresh and dry weights (dried at 70C (158F for 48 hr) were also determined.

Rooted cutting and transplant harvest data were subjected to analysis of variance (GLM), and mean separations were performed by t-test using SAS (SAS Institute, Cary, NC).

Table 2. Plant growth of *Bougainvillea glabra* 'Sanderiana' after transplanting to 3.8 liter (1 gal) containers.[z]

	Post-transplant period (days)				Pr > F			
					Linear		Quadratic	
Treatment	**45**	**91**	**118**	**144**	**Mean**	**Trt**	**Mean**	**Trt**
	Growth index (cm)[y]							
Control	17.8	37.4	41.6	45.8	0.0001	0.0231	0.0001	0.0021
$Cu(OH)_2$	17.6	45.1	49.9	51.6				
	Height (cm)							
Control	17.7	25.7	28.4	31.2	0.0001	0.0528	0.0001	0.0062
$Cu(OH)_2$	18.3	33.8	39.5	39.7				

[z]There was no treatment effect on plant width; average plant widths on 45, 91, 188, and 144 days after transplanting were 17.5, 52.8, 57.5, and 62 cm, respectively.
[y]Growth index = (height + ((greatest width + width perpendicular to greatest width) / 2)) / 2.

Transplant growth was subjected to repeated measures analysis of variance with analysis of variance performed on the linear, quadratic, and cubic orthogonal polynomial contrasts. The hypotheses tested were 1) Is there a polynomial relationship of degree n (n = 1, 2, 3) averaged over treatments (Mean)? (see Table 2), and 2) If so, is this relationship the same for both treatments (Trt)? (see Table 2).

Results and Discussion

Bougainvillea glabra 'Sanderiana' cuttings grown in $Cu(OH)_2$-treated containers had a well branched, compact root system completely within the substrate with no root circling compared to cuttings from non-treated cups which had roots circling at the interface of the substrate and the inside of the container. Although there were no significant treatment effects in the 42-day-old rooted cuttings, cuttings from $Cu(OH)_2$-treated cups tended to have more primary roots (Table 1). A similar trend was evident on two-month-old 'Barbara Karst' bougainvillea cuttings propagated in the same size containers as in this study with and without $Cu(OH)_2$ (1).

Plants propagated in $Cu(OH)_2$-treated cups were larger than plants propagated in non-treated cups 91, 118, and 144 days after transplanting into non-treated 3.8 liter (1 gal) containers (Table 2). The analyses of variance, for height and growth index, suggest different quadratic relationships in time for the control and $Cu(OH)_2$. Plant height was the principal component that caused significant treatment differences in the growth indices. There was no treatment effect on plant width.

As noted earlier, tomato seedlings transplanted from $Cu(OH)_2$-treated flats had higher shoot and root dry weights compared to those from non-treated flats (7). However, there were no treatment differences in the mean shoot and root fresh or dry weights of cuttings transplanted in this study (Table 1). There was no foliar phytotoxicity observed on the 'Sanderiana' bougainvillea from the $Cu(OH)_2$ treatment.

In summary, applying 100 g $Cu(OH)_2$/liter (13.3 oz/gal) in latex paint to the interior surfaces of cups used to propagate *Bougainvillea glabra* 'Sanderiana' completely eliminated root circling compared to cuttings rooted in non-treated cups. Root circling in bougainvillea cuttings predisposes the root system to damage during transplanting. Cuttings damaged during transplantation could result in a less vigorous plant and/or plant death. Transplanting 'Sanderiana' bougainvillea from $Cu(OH)_2$-treated cups to non-treated 3.8 liter (1 gal) containers resulted in larger plants with no difference in shoot or root mass. These faster growing plants would permit earlier upcanning and result in a marketable plant in a shorter period of time. Studies should continue to determine effects on flowering, as Svenson and Johnston (10) reported increased flowering from transplanted $Cu(OH)_2$-treated cuttings of four species.

Literature Cited

1. Aldrich, J.H. and J.G. Norcini. 1994. Copper hydroxide-treated pots improve the root system of bougainvillea cuttings. HortScience 29:556(Abstract).

2. Appleton, B.L. and A. Salzman. 1993. Root modification of container-grown azaleas using Spin Out™. Proc. Southern Nurserymens Assoc. Res. Conf. 38:73–75.

3. Arnold, M.A. 1992. Timing, acclimation period, and cupric hydroxide concentration alter growth responses of the Ohio production system. J. Environ. Hort. 10:114–117.

4. Arnold, M.A., D.L. Airhart, and W.E. Davis. 1993. Cupric hydroxide-treated containers affect growth and flowering of annual and perennial bedding plants. J. Environ. Hort. 11:106–110.

5. Arnold, M.A. and D.K. Struve. 1993. Root distribution and mineral uptake of coarse-rooted trees grown in cupric hydroxide-treated containers. HortScience 28:988–992.

6. Iredell, J. 1990. Propagation. p.78–86 *In*: The bougainvillea growers handbook. Simon and Schuster Australia, Brookvale NSW, Australia.

7. Latimer, J.G. and S.A. Baden. 1993. Spin Out™ enhances subsequent growth of tomato, but not pepper, transplants. Proc. Southern Nurserymens Assoc. Res. Conf. 38:121–123.

8. Struve, D.K., M.A. Arnold, R. Beeson, Jr., J.M. Ruter, S. Svenson, and W.T. Witte. 1994. The copper connection. Amer. Nurseryman 179:52–54, 56–61.

9. Svenson, S.E. and T.K. Broschat. 1992. Copper hydroxide controls root circling in container-grown West Indies mahogany and carpentaria palm. Proc. Fla. State Hort. Soc. 105:219–220.

10. Svenson, S.E. and D.L. Johnston. 1995. Rooting cuttings in cupric hydroxide-treated pots affects root length and number of flowers after transplanting. HortScience 30:247–248.