Styrene-Lined and Copper-Coated Containers Affect Production of *Cornus florida*[1]

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Abstract

Response of dogwood cultivars (*Cornus florida* 'Barton's White' and 'Weaver's White') to styrene lining and copper hydroxide coating of 10.3 liter (#3) black plastic containers was evaluated in 1993 and 1994. After the first growing season, dogwoods were either left in their original containers or repotted into untreated 23.3 liter (#7) containers. Copper hydroxide reduced root circling of both cultivars in containers; however, root dry weight of plants grown in copper-treated containers was reduced during the first season. Copper-treated containers resulted in less growth in height when plants were left in their original container during the second growing season and less trunk diameter growth of plants repotted into 23.3 liter (#7) containers. In the absence of copper, more surface root coverage and less surface root dieback occurred with plants grown in styrene-lined containers. Both cultivars grown the second season in their original styrene-lined containers had greater height increase than those in unlined containers. After being repotted into 23.3 liter (#7) containers, both cultivars originally grown in styrene-lined containers had greater trunk diameter growth than those in unlined containers.

Index words: dogwood, container production, copper hydroxide, root regeneration, woody landscape plants.

Species used in this study: 'Barton's White' dogwood (*Cornus florida* L. 'Barton's White'); 'Weaver's White' dogwood (*Cornus florida* 'Weaver's White').

Significance to the Nursery Industry

Lining containers with styrene can increase root and shoot growth and reduce surface root dieback of 'Weaver's White' and 'Barton's White' dogwoods during production. This technique has the potential to shorten production cycles of dogwoods. Copper coating of containers was effective in reducing root circling of both dogwood cultivars tested. Although shoot growth may be adversely affected by copper coating of containers, the effect is not likely to be economically significant. In addition, copper treatment may have no effect or reduce root dry weights during the first year of production and not affect dry weights of newly generated roots outside the original rootball in the year following repotting.

Introduction

Two negative factors associated with container production of nursery crops are high root-zone temperatures and root circling along the substrate-container interface. Temperatures can reach 50C (122F) in nursery containers in the southeastern United States, due to direct solar radiation striking the container sidewalls (8). Although plant species differ in their tolerance to elevated root-zone temperature, temperatures in excess of 40C (104F) may lead to root injury or death (9, 12, 22). Heat stress of roots may also lead to a reduction in shoot growth (14) and higher transpiration rates (15).

Many approaches to reducing supraoptimal temperatures in containers have been studied. Assorted container colors and styles have proven relatively effective in reducing root-zone temperatures (8, 20). Ingram and Johnson (11) demonstrated greater root growth for plants grown in a north-south orientation in a triangular placement. Laiche (13) also reported lower summer temperatures and improved shoot growth when growing plants at a reduced spacing. Pot-in-pot production has reduced temperatures within containers and resulted in greater root dry weight and a more uniformly distributed root system, however, benefits in shoot growth are uncertain (16). A reductions of 8C (14.4F) in substrate temperature has been recorded during the summer in the Southeast using styrene lining in containers (7). Styrene sheeting placed directly into the container has also been reported to improve plant growth (1).

Root malformation and circling in containers are common for trees with vigorously growing root systems or plants that are disproportionately large for the container (17). These conditions may lead to a less fibrous root system (2), a reduction in plant growth (4), or the formation of girdling roots (19) which contribute to poor root regeneration and slow transplant establishment in the landscape. When plant roots become densely matted, corrective root pruning is often done at transplanting. Unfortunately, root pruning removes a substantial amount of root mass, which has been shown to reduce shoot growth and root regeneration (3). Copper compounds sprayed on the interior surface of containers control root malformation and circling (3, 5, 6). Several studies have shown that copper-treated containers inhibit root-tip growth, thus altering root morphology and distribution within the container (5). As a result, root malformation and circling are reduced, permitting increased root regeneration following transplanting (3).

Cornus florida, flowering dogwood, are naturally found in partial shade in well drained, organic soils with roots maintained in a cool, moist environment. When dogwoods are grown in containers on beds exposed to full sun in the Southeast, root-zone temperature becomes an important factor. Several growers have expressed difficulty in producing container-grown dogwoods, presumably due to high substrate temperatures. To our knowledge, no published studies have examined the response of *Cornus florida* when grown in sty-

[1]Received for publication February 3, 1997; in revised form May 5, 1997. Supported in part by **The Horticultural Research Institute, 1250 I Street, N.W., Suite 500, Washington, DC**; Griffin Corporation, Valdosta, GA; J. Frank Schmidt & Sons, Boring, OR; and Dart Container Corporation, Leola, PA.

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rene-lined and/or copper-treated containers. Therefore, the objective of our study was to evaluate two dogwood cultivars from different geographical provenances to determine the effects of styrene-lined and copper-coated containers on root and shoot growth during production.

Materials and Methods

A 2 × 2 × 2 factorial experiment which included all combinations of the two cultivars, +/– styrene lining and +/– copper coating was established on March 13, 1993. Compressed 2.6 mm (0.1 in) styrene sheeting (Dart Container Corp., Leola, PA) was cut and inserted into 10.3 liter (#3) injection-molded containers covering the sidewalls but not the container bottom. The sheeting is a generic material that is heated and molded by numerous manufacturers of styrene products. Copper was applied as 100 g $Cu(OH)_2$/liter (3.32 oz/qt) in a latex base (Spin-out, Griffin Corp., Valdosta, GA) with a paint sprayer (Wagner Spray Tech Corp., Minneapolis, MN) to the containers' interior surfaces or directly to the styrene, which was later inserted into the container. Copper hydroxide was also applied to the bottom of containers receiving both styrene and copper treatments. Uniform 20 cm (8 in) liners of *Cornus florida* 'Weaver's White', a vigorous early bloomer in south Alabama, and 'Barton's White', a Tennessee selection that blooms about a week later, were planted into containers of a pinebark:sand (4:1 by vol) substrate amended per m^3 (yd^3) with 8.3 kg (14 lbs) of Osmocote 17N–3P–10K (17–7–12) (Scotts Co., Marysville, OH), 0.9 kg (1.5 lbs) of Micromax (Scotts Co.) and 3.0 kg (5 lbs) of dolomitic limestone. Plants were placed 0.6 m (2 ft) within rows and 0.9 m (3 ft) between rows on a gravel container bed in full sun. Overhead irrigation was applied as needed. Treatments were arranged in a completely randomized design with 16 single-plant replications.

Plant height and trunk diameter 7.6 cm (3 in) above the substrate surface were measured in July and November 1993. Also in November, percent root coverage and percentage of necrotic roots at the substrate-container interface were estimated independently by two observers. Root deflection after contacting the container sidewall or styrene surface was rated according to Arnold and Struve (4): 0 indicating > 2.5 cm (1 in) root elongation; 1 indicating 0.6 cm (0.2 in) < root elongation < 2.5 cm (1 in), and 2 indicating < 0.6 cm (0.2 in) elongation. In December 1993, root dry weight was determined by isolating and drying roots from a wedge-shaped section 5.1 cm (2 in) wide and 5.1 cm (2 in) deep and the height of the rootball. Cuts were made in a north-south orientation with a saber saw using a 7.6 cm (3 in) wood cutting blade. Four single-plant replications of each treatment were sampled. After subsamples of these four replications from each treatment were taken, plants were repotted into their original containers to determine residual effects of copper on root suppression and copper and styrene's effect on growth of plants held for a second growing season in the same containers. Plant height, trunk diameter, and percent surface root coverage of the rootball were assessed in July and November 1994.

In December 1993, six replications of each treatment were repotted into 23.3 liter (#7) injection-molded, non-treated black containers in the substrate previously described. Rootballs were not disturbed at transplanting to determine unbiased treatment effects on root regeneration outside the original rootball. Plants were completely randomized on the container bed, 0.9 m (3 ft) within rows and 1.2 m (4 ft) between rows, and watered once in the morning and afternoon as needed. Height and trunk diameter were measured on the six replications, and surface root coverage and dry weight of roots beyond the original rootball were obtained for three replications in May 1994. Height and trunk diameter for the remaining three replications were recorded in July and November 1994. Surface root coverage at the substrate-container interface and root dry weight of regenerated roots outside the original rootball were also determined at final measurement in November 1994 for the remaining three replications. All data were subjected to an analysis of variance using SAS (18).

Results and Discussion

Plants grown in 10.3 liter (#3) containers during 1993. Dogwoods grown in styrene-lined containers had similar height, trunk diameter and root dry weight as those in non-styrene containers (data not shown). Percent surface root coverage, which was affected by a styrene × copper interaction, was greater ($P \leq 0.05$) for plants in styrene-lined containers (82% vs 64%), but only in the absence of copper. In the absence of copper, extensive surface-root dieback occurred for plants in non-styrene containers (40%), while plants in containers with styrene had much less root-dieback (20%). Since some root-dieback was present for plants in styrene-lined containers, critical high temperatures may have been reached or drying of the container substrate between irrigations may have occurred.

Plant height in copper-treated containers averaged 89.0 cm (35 in) as compared to 94.7 cm (37.3 in) for plants in containers not treated with copper in July 1993, with no differences thereafter. Copper did not affect trunk diameter growth at either sampling in 1993 (data not shown). Copper-treated containers effectively controlled surface root development (6.2%, +Cu vs 53.0%, –Cu), and root deflection (1.6, +Cu vs 0.1, –Cu). These results support previous studies showing copper inhibition of surface root development (5, 6). Root dry weight samples were greater ($P \leq 0.05$) in containers not treated with copper (1.7 g) than in copper-treated containers (1.1 g). A similar reduction in root dry weight from copper application has been reported for other species (6). During the first growing season, 'Barton's White' and 'Weaver's White' had similar growth in height and trunk diameter (data not shown). Unlike shoot growth, root dry weight was greater ($P \leq 0.05$) for 'Barton's White' (2.1 g) than for 'Weaver's White' (1.5 g) at the end of the season.

Plants grown in 10.3 liter (#3) containers during 1994. At the end of the second growing season, plants grown in containers not treated with copper were taller (130.1 cm (51.2 in)) than those grown in copper-treated containers (113.0 cm (44.5 in)). Again, studies have shown copper to have both positive and negative effects on plant height (6, 16). Between November 1993 and July 1994, plants grown in styrene-lined containers had more growth in height (18.4 cm (7.2 in)) than those in non-lined containers (11.6 cm (4.6 in)), possibly due to lower root-zone temperatures (7). Ingram (10) reported three times greater shoot growth of *Cornus florida* in white poly bags where lower root-zone temperatures were recorded compared to plants grown in conventional black containers. Neither copper nor styrene had an effect on trunk diameter growth in 1994 or shoot dry weight in November 1994 (data

Table 1. Percentage of surface root coverage at the substrate-container interface in 10.3 liter (#3) containers, July 1994[z].

Copper	Styrene-lining	
	+	–
+	19.5bA[y]	18.5bA
–	67.4aA	43.8aB

[z]During 1994, 4 replications per treatment were left in their original containers.

[y]Mean separation within columns (lower case) and rows (upper case) by ANOVA, $P \leq 0.05$.

Table 3. Percentage of surface root coverage at the substrate-container interface in 23.3 liter (#7) containers, November 1994[z].

Copper	Styrene-lining	
	+	–
+	38.3bA[y]	40.0bA
–	81.0aA	61.0aB

[z]In December 1993, 6 replications per treatment were repotted into 23.3 liter (#7) containers.

[y]Mean separation within columns (lower case) and rows (upper case) by ANOVA, $P = 0.05$.

not shown). Percent surface root coverage was affected by a styrene × copper interaction (Table 1). Plants grown in containers with or without styrene had less surface root coverage in copper-treated containers than those in nontreated containers. These data show the long-term effects of copper treatment on root development; containers were treated at potting (March 1993) and effects were still apparent two growing seasons later (November 1994). Plants grown in containers not treated with copper had a higher percent root coverage in the presence of styrene. However, styrene lining had no effect on percent root coverage when plants were grown in copper-treated containers, possibly because of copper inhibition of surface root development. Increase in height was over three times greater for 'Barton's White' (Table 2) than for 'Weaver's White' at the end of the growing season. 'Barton's White' also had greater trunk diameter growth at this time. These results may reflect differences in growth habit of the two cultivars. 'Barton White' grew upright with little branching, while 'Weaver's White' branched readily and appeared shrub-like. Percent surface root coverage also was higher for 'Barton's White' (43.5%) than for 'Weaver's White' (22.5%).

Plants repotted into 23.3 liter (#7) containers. In May 1994, trunk diameter was affected by both styrene and copper treatments. Dogwood previously grown in styrene-lined containers had greater ($P \leq 0.05$) trunk diameter (1.7 cm (0.7 in)) than those grown in containers not lined with styrene (1.4 cm (0.5 in)). Plants previously grown in containers not treated with copper had greater trunk diameter (1.7 cm (0.7 in)) than those previously grown in copper-treated containers (1.5 cm (0.6 in)). A copper × styrene interaction occurred for change in trunk diameter between November 1993 and May 1994 for plants transplanted into 23.3 liter containers. For plants grown in the absence of copper, change in trunk diameter was greater ($P \leq 0.05$) in styrene-lined containers (1.0 cm (0.4 in)) than in non-styrene containers (0.6 cm (0.2 in)), but similar in the presence of copper (data not shown). Trunk diameter growth was greater in plants from containers not treated with copper than in those treated with copper both in the presence (1.0 cm (0.4 in) vs 0.2 cm (0.08 in)) and absence (0.6 cm (0.2 in) vs 0.2 cm (0.08)) of styrene. Change in trunk diameter between November 1993 and July 1994 also was less for dogwoods previously grown in copper-treated containers (0.9 cm (0.4 in)) than those grown in containers without copper (1.4 cm (0.6 in)).

Percent surface root coverage in May 1994, and root dry weight outside the original rootball in May and November 1994, were not affected by either styrene or copper treatment (data not shown), perhaps due to the short time period from repotting to measuring or the small sample size (n = 3). By the end of the growing season, surface root coverage was affected by a styrene × copper interaction (Table 3). Regardless of styrene treatment, plants previously grown in containers with copper had less surface root coverage than those in non-copper treated containers. Styrene lining had no influence on surface root coverage in the presence of copper; however, in the absence of copper, there was more surface root growth for plants previously grown in styrene-lined containers than for plants grown in containers without styrene. Throughout the experiment, both cultivars appeared to be under stress when grown in the absence of styrene lining, as evidenced by a lack of root development and earlier wilting. Lower substrate temperatures in styrene-lined containers (7) resulting in more viable surface roots may explain why plants responded with greater root growth following repotting. Neither copper nor styrene affected height of either cultivar. Unlike plants left in 10.3 liter (#3) containers, repotted 'Weaver's White' had greater growth in height, but not trunk diameter, after the second growing season than 'Barton's White' (Table 2). One effect ($P \leq 0.01$) of repotting plants into larger containers was almost 30% greater growth in height than when left in their original containers.

Table 2. Increase in trunk diameter and height of 'Barton's White' and 'Weaver's White' dogwoods, November 1993 to November 1994.

Cultivar	10.3 liter pots	23.3 liter pots[z]
	Trunk diameter (cm)	
BW[y]	0.9a[x]	1.0a
WW	0.4b	0.9a
	Height (cm)	
BW	21.3a	27.0b
WW	6.5b	44.8a

[z]In December 1993, 6 replications per treatment were repotted into 23.3 liter (#7) containers.

[y]BW: 'Barton's White'; WW: 'Weaver's White'.

[x]Mean separation of main effects within columns by ANOVA, $P \leq 0.05$.

Treating containers with copper effectively reduced root circling at the substrate-container interface. However, plants grown in containers treated with copper had less root dry weight during the first year's production and less growth in height during the second season compared to those grown the first season in non-copper treated containers. Both cultivars repotted into 23.3 liter (#7) containers had less trunk diameter growth and a lower percent surface root coverage when previously grown in containers treated with copper than in containers not treated with copper. These results with copper generally are consisted with prior research showing copper treatments are effective in reducing root circling and have inconsistent effects on shoot growth (6). Of interest is that the copper treatment reduced root dry weights during the first year of production and had no effect on dry weights of newly generated roots outside the original rootball following repotting. These results are inconsistent with prior research showing enhanced root growth during and following production in copper-treated containers (3, 21).

Dogwoods grown in styrene-lined containers had a greater percent surface root coverage and less root dieback during the first and second growing seasons in 10.3 liter (#3) containers, in addition to greater growth in height during the second season. Plants originally grown in styrene-lined containers had more trunk diameter growth and a higher percent surface root coverage after being repotted into 23.3 liter (#7) containers than those grown in non-lined containers. While substrate temperatures were not monitored in this study, the reduction in supraoptimal substrate temperatures by styrene lining (7), and the concomitant beneficial effects on plant growth from such a reduction have been previously reported (9, 14, 15). These results demonstrate potential beneficial effects of styrene-lining to dogwood, a species sensitive to supraoptimal substrate temperatures.

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