EFFECTS OF CUPRIC HYDROXIDE-TREATED CONTAINERS ON GROWTH OF FOUR SOUTHWESTERN DESERT LANDSCAPE TREES

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Abstract. Seedling liners of four southwestern desert landscape trees, *Acacia smallii, Acacia stenophylla, Cercidium praecox*, and *Prosopis chilensis*, were potted into black polyethylene containers either painted on the inner wall with a latex paint containing cupric hydroxide [$Cu(OH)_2$] or unpainted. Tree seedlings were then grown for five months in an outdoor container production nursery and evaluated for effects of $Cu(OH)_2$-treated containers on tree growth. No foliar copper toxicity symptoms were observed on any species during the study. In comparison with unpainted containers, Cu-treated containers increased root branching frequency, reduced shoot extension, and lowered the number of primary shoot lateral branches of sweet acacia and shoestring acacia. Cu-treated containers also decreased height of shoestring acacia. Chilean mesquite grew taller and larger with increased shoot and root dry weights in Cu-treated containers in comparison with those in unpainted containers. However, effects of Cu-treated containers on growth of Chilean mesquite were not related to any changes in root branching frequency. Growth of palo brea and root-to-shoot ratios of all four tree species were not affected by Cu-treated containers.

In the southwestern United States, nearly all landscape trees are nursery grown in containers. While benefits of containerization are well known, root systems of trees in containers often become deformed, as expressed through girdling, kinking, or matting of roots at the container wall-rooting medium interface. Problems with container root system deformation may be reduced or even eliminated by chemomorphosis (9). Painting interior surfaces of containers with a latex paint containing cupric hydroxide [$Cu(OH)_2$] is a type of chemomorphosis that reduces root system deformation of plants in containers by chemical root pruning as root tips contact the inner container wall and experience mild copper toxicity (1,2). While this type of chemomorphosis might reduce root system deformation, effects of Cu-treated containers on plant growth have been variable (3,5,6,7,8,9,10), and there have been no published reports on effects of Cu-treated containers on growth of southwestern desert landscape trees. Thus, our purpose was to investigate effects of $Cu(OH)_2$-treated containers on growth of four southwestern desert landscape trees.

Materials and Methods

We potted 10-month old seedling liners of four southwestern desert landscape trees [*Acacia smallii* (sweet acacia), *Acacia stenophylla* (shoestring acacia), *Cercidium praecox* (palo brea), and *Prosopis chilensis* (Chilean mesquite)] on June 1, 1993 from 3-liter polyethylene containers into 19-liter black polyethylene containers filled a 70% ponderosa pine forest mulch, 15% sand, and 15% silt (by vol.) rooting substrate that was amended with controlled release fertilizer (20 N - 3.9 P - 7.5 K) at the rate of 3.0 kg/m^3 plus micronutrients at the rate of 0.9 kg/m^3. Just prior to potting, we painted the inner wall of one-half of all containers with a latex paint containing $Cu(OH)_2$ formulated as Spin Out® (Griffin Corp, Valdosta, GA). Remaining containers were left unpainted as a control. Tree seedlings were then grown in an outdoor container production nursery at a spacing distance of 0.5 m for five months. During this time, all trees were irrigated to container capacity daily with a spray-stake micro-irrigation system and fertigated every two weeks with a soluble fertilizer (20 N - 8.7 P - 16.6 K) at 200 ppm N.

Tree height and number and length of primary shoot lateral branches were measured at the start of the experiment and at harvest. After five months of growth in the nursery, all trees were harvested by severing shoots from the root ball at the rooting substrate surface. We next carefully separated the rooting substrate from each root system by floating the root ball in water. Then, five of the most developed, primary lateral root branch sections were excised at 30, second-order branching points away from a root terminal meristem for analysis of root branching frequency. For each first-order lateral root branch section, we counted the total number of terminal meristems and measured the length with the aid of a digital root imaging system (AgVision, Decagon Devices, Pullman, Wash.). Specific root branching was then calculated as the ratio of root length to the number of terminal meristems.

Finally, shoots and roots of all trees were placed into an oven dryer for 72 hr at 65°C and dry weights were recorded. The experiment was a four species by two cupric hydroxide painted-container factorial arranged in a completely randomized design with five single tree replications. General linear models were used to test for significant responses of the variables.

Results and Discussion

All measured variables were significantly affected by an interaction of species with $Cu(OH)_2$ treatments so data are presented by species after statistical analysis. No foliar copper toxicity symptoms were observed on any species during the study, similar to reports of others (2,10). Also, no evidence of root circling or matting at the rooting substrate-container wall interface was found for any species grown in Cu-treated containers except palo brea, which showed only minor evidence of root circling. All trees in unpainted containers had roots which circled around the rooting substrate-container wall interface and matted at the bottom of the container.

Copper hydroxide-treated containers suppressed shoot growth of both acacia species. Shoot extension and the number of primary shoot lateral branches of sweet acacia and shoestring acacia were less in Cu-treated containers than for those in unpainted containers (Table 1). Final height of shoestring acacia, a species with an strong excurrent growth habit especially when young, was also less in Cu-treated containers than for those in unpainted containers. This was consistent with reduced height growth of bald cypress, another species with an excurrent growth habit, grown in Cu-treated containers (9). In contrast, final height of sweet acacia, a species with a decurrent growth habit, was not affected by Cu-treated containers. Specific root branching of both acacia species was decreased in response to Cu-treated containers compared with those in unpainted containers (Table 2). Reduced specific root branching indicated that Cu-treated containers increased the frequency of acacia root branching and subsequent number of new root tips as roots came in contact with the copper-painted container wall, and was in agreement with an earlier report on increased root branching by apple and green ash in response to Cu-painted containers (4).

Chilean mesquite grew taller and larger with increased shoot and root dry weights in Cu-treated containers in comparison with those in unpainted containers (Tables 1 & 2) and was similar to a report by Ruter (9) on the stimulatory effects of Cu-painted containers on growth of river birch. Stimulated growth of Chilean mesquite by Cu-treated containers was not related to changes in root branching, although Cu-treated containers controlled root circling and matting of Chilean mesquite. Growth and specific root branching of palo brea were not affected by Cu-treated containers (Tables 1 & 2). This was likely due to species specific high experimental error which resulted from seed propagation, currently the standard way of propagating palo brea in the southwestern nursery industry. In addition, the shoot-to-root ratios of all four tree species were not affected by Cu-treated containers which contrasts with the report of increased shoot to root ratio of green ash and red oak in response to Cu-treated containers (2).

In conclusion, we found that the growth responses of four southwestern desert landscape trees to Cu-treated containers varied among species. These findings are consistent with growth responses among temperate tree species.

Acknowledgments. We thank Mr. Allan Dunstan and Desierto Verde Nursery, Tempe, AZ, for their assistance with this project.

Table 1. Height growth, shoot extension (SE), and changes in the number of primary shoot lateral branches[z] of four southwestern landscape trees as affected by $Cu(OH)_2$ treatments of inner container walls.

Tree species $Cu(OH)_2$	Height (m)	Shoot extension (m)	No. of primary lateral branches
Acacia smallii			
+	1.28a	5.72b	17b
-	1.39a	9.42a	29a
Acacia stenophylla			
+	1.80b	5.13b	9.8b
-	2.20a	6.69a	16.6a
Cercidium praecox			
+	1.49a	4.97a	12a
-	1.49a	4.76a	9a
Prosopis chilensis			
+	1.70a	6.00a	11a
-	1.48b	2.50b	5b

[z] *Values are treatment means, n=5.* Means in columns within species followed by the same letter are not significantly different at $P \leq 0.05$ using Fisher's LSD test.

Table 2. Shoot and root dry weight, shoot-to-root ratio, and specific root branching[z] of four southwestern landscape trees as affected by $Cu(OH)_2$ treatments of inner container walls.

Tree species	Dry weight (g)		Shoot to root	Specific root branching
$Cu(OH)_2$	Shoot	Root	ratio	[root length (m)/no. apical meristems]
Acacia smallii				
+	125.1a	66.2a	2.0a	0.017b
-	165.7a	61.6a	2.3a	0.030a
Acacia stenophylla				
+	230.5a	87.8a	3.8a	0.012b
-	217.6a	67.4a	2.7a	0.042a
Cercidium praeco				
+	246.7a	63.7a	4.0a	0.026a
-	248.3a	64.5a	3.8a	0.053a
Prosopis chilensis				
+	203.6a	127.7a	2.1a	0.023a
-	151.7b	70.4b	1.8a	0.033a

[z] Values are treatment means, n = 5. Means in columns within species followed by the same letter are not significantly different at $P \leq 0.05$ using Fisher's LSD test.

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