Research Reports

Chemical or Air Root-Pruning Containers Improve Carambola, Longan, and Mango Seedling Root Morphology and Initial Root Growth after Transplanting[1]

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Abstract

Carambola (*Averrhoa carambola* L.), longan (*Dimocarpus longan* Lour.), and mango (*Mangifera indica* L.) nursery transplants were produced in copper-treated, air-root-pruning (only carambola and mango), or untreated conventional plastic containers during 1990 and 1991. Copper treatments did not influence root growth of carambola or mango; but increased total root growth during container production, the proportion of roots in the upper half of the root system, and new root growth after transplanting for longan. Air-root-pruning containers increased the proportion of roots in the upper half of the rootball and new root growth of carambola and mango following transplanting. Copper-treated containers for longan and air-root-pruning containers for carambola and mango effectively stopped root extension growth at the container wall-medium interface.

Index words: cupric carbonate, root malformation, container production.

Species used in this study: carambola (*Averrhoa carambola* L.), longan (*Dimocarpus longan* Lour.), mango (*Mangifera indica* L.).

Significance to the Nursery Industry

Chemical- or air-root-pruning methods for controlling root system morphology in container production nurseries are not new, but effectiveness of these methods has not been previously tested for carambola, longan, or mango nursery stock. Roots were more fibrous and more evenly distributed vertically within the container medium for longan grown in copper-treated containers and for carambola and mango in air-root-pruning containers. Moreover, initial root growth of plants after transplanting was increased above that of plants in conventional containers by copper and air-pruning methods. If it can be shown that these root modifications will increase post-transplant growth and mechanical stability, the carambola, longan, and mango nursery stock produced in copper or air-root-pruning containers could command a higher market price. Various species exhibit a dose response to copper compounds, and each new species should be tested with a range of compounds to determine the effective range for chemical-root-pruning.

Introduction

Container nursery production of woody perennial plants has many advantages compared with other forms of nursery production, but typically results in root deformation. Container-grown root systems take on the unnatural shape of the container instead of radiating from the collar in a shal-

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low, horizontal plane beneath the surface of the ground. The container-grown specimen may retain this root system shaped like the production container long after transplanting to the field (5). Root system malformation from container production leads to increased mortality or poor initial transplant growth, mechanical instability of the transplant, and other undesirable symptoms (4, 7, 9). Instability of transplants has been attributed to the clustering of root tips at the container bottom during nursery production, then the subsequent lack of lateral roots near the soil surface after transplant establishment in the field (4).

Several strategies for reducing or eliminating root system malformation and improving transplant performance of container-grown plants have been adopted. Two of the more successful strategies are coating interior walls of containers with copper compounds to induce chemical-root-pruning and designing containers to direct root growth toward holes along the container sides and/or bottom which induce air-root-pruning (1).

Carambola, longan, and mango are popular commercial and home fruit trees throughout the tropics or sub-tropics (6). Most commercial transplants are produced in container nurseries, and root system malformation is a recognized, widespread problem in the industry. One post-transplant problem with these species is general lack of vigor with trees which exhibit malformed root systems from container production. Inspection of these less vigorous transplants frequently reveals that they are not anchored well, in many cases even after years of growth (personal observation).

The objective of this study was to determine if production of carambola, longan, and mango transplants in chemical- or air-root-pruning containers would improve root system morphology and initial root growth following transplanting.

Materials and Methods

The interior walls and bottom of conventional 2.6 liter (#1) nursery containers were coated with exterior white latex paint containing 0, 50, 100, or 200 g $CuCO_3$ per liter (0, 6.67, 13.33, or 26.67 oz per gal). Additionally, containers with the same dimensions and volume as the #1 containers were made from RootBuilder® panels (Lacebark, Inc., Stillwater, OK) in order to provide air-root-pruning. All containers and another set of non-treated 2.6 liter (#1) containers were filled with potting medium consisting of peat, sand, perlite, and shredded pine bark chips in equal parts (by vol).

'Golden Star' carambola seeds were planted in the six container types on January 1, 1990, and 'Turpentine' mango seeds were likewise planted on May 18, 1990. Longan seeds were planted on January 1, 1990, in the four painted container treatments and the non-treated control containers. Longan was not included for comparison in the air-root-pruning containers. There were 12 replications in each of the plantings.

The containers were placed in three groups (by species) on raised benches, and each group was arranged in a completely randomized design. Five g (0.18 oz) of granular 12N–2.6P–6.6K (12–6–8) plus micronutrients fertilizer was surface applied to each container every 8 weeks, and daily watering was by rainfall or overhead spinner emitters. The plants were grown under 50% light exclusion.

Six plants from each species and treatment were removed from the benches on February 1, 1991, to determine plant growth during production in the containers. Canopy height was measured, then the roots were carefully washed clean of media. To quantify the degree of root growth that clustered at the container bottoms, we cut through the root systems in a horizontal plane positioned at the vertical midpoint. This provided an upper and lower half of each root system. All root tissue was dried to constant mass at 60C (140F).

The remaining six plants from each species and treatment were removed from the containers with the original root ball intact and transplanted into 10.4 liter (#3) nursery containers containing silica sand. These plants were returned to the nursery and maintained as previously described. The sand was carefully washed from each plant on April 23, 1991, and the new roots which extended into the sand substrate were removed and dried to a constant mass at 60C (140F). After this procedure on two replications of the carambola plants, it was apparent that little root growth had occurred for this species in the short time after transplanting. As a result, the remaining four replications in each treatment were returned to the nursery setting. The procedure was repeated on these remaining plants on August 1, 1991.

A standard t-test was used to determine the difference in response variables between non-treated 2.6 liter (#1) containers and those painted with latex paint containing no $CuCO_3$. Results of this test were not significant for all three species. Thereafter, the response variables were subjected to regression analysis with $CuCO_3$ in the range of 0 to 200 g per liter (0 to 26.67 oz per gal) defined as the independent variable. A standard t-test was used to determine the difference of response variables between non-treated 2.6 liter (#1) containers and the containers designed for air-root-pruning capabilities.

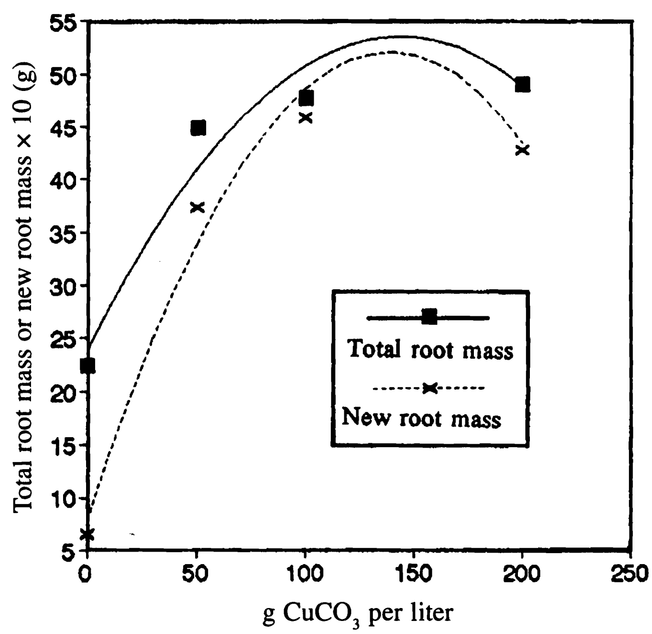

Fig. 1. **Total root mass and initial root growth (× 10) following transplanting of longan nursery transplants grown in conventional #1 containers or containers with interior walls painted with latex paint containing 0 to 200 g $CuCO_3$ per liter (0 and 26.67 oz per gal). Response curves are described by the following equations: total root mass: $y = 23.80 + 0.41x - 0.0015x^2$, $r^2 = 0.94$; new root growth: $y = 7.7 + 0.64x - 0.0023x^2$, $r^2 = 0.98$.**

Table 1. **Total root mass, the upper:lower ratio of root mass, and initial root growth following transplanting of carambola and mango nursery transplants grown in conventional 2.6 liter (#1) containers or containers of equal dimensions with air-pruning capabilities (n = 6).**

Species	Container	Total root mass (g)	Upper:lower ratio	Initial root growth (g)
Carambola	Conventional	60.8	0.37	2.35[z]
	Air-pruning	75.5	0.67*	4.30*
Mango	Conventional	21.5	1.10	1.73
	Air-pruning	21.3	1.48*	2.61*

[z]n = 4 for initial root growth of carambola.

*Means within species are significantly different from each other based on t-test, $P \leq 0.05$.

Results and Discussion

Treatment with $CuCO_3$ effectively controlled root system malformation in longan plants and visibly increased fibrous roots, especially in the upper half of the container. Total root growth of plants while in container production and initial root growth following transplanting were increased by all concentrations of $CuCO_3$ compared to the non-treated containers (Fig. 1). Plants grown with 50 g $CuCO_3$ per liter 6.67 oz per gal) exhibited a 2-fold increase in total root mass and a 5.7-fold increase in new root growth above that of plants in non-treated containers. The upper:lower ratio of root mass increased in a linear response ($P \leq 0.05$) to $CuCO_3$ concentration between 0 and 200 g $CuCO_3$ per liter (0 and 26.67 oz per gal). This ratio was increased from 0.89 for plants receiving 0 g $CuCO_3$ per liter to 1.69 for plants receiving 200 g $CuCO_3$ per liter (26.67 oz per gal). Chemical treatments also increased canopy height in a pattern which paralleled that of total root growth. Height of the control plants was 74 cm (29 in), and of the plants in treated containers ranged from 94 to 99 cm (38 to 39 in).

Chemical treatments within the range of 0 to 200 g $CuCO_3$ per liter (0 to 26.67 oz per gal) did not influence root or canopy growth of carambola or mango plants (data not shown). Root system malformation and circling along the container bottom was evident for all plants of these species in non-treated containers or in containers treated with copper.

Air-root-pruning containers effectively controlled root malformation of carambola and mango plants. Longan plants were not tested. Total root growth during nursery production was not influenced by the container design. Alternatively, the upper:lower ratio of root mass and initial root growth following transplanting were increased by containers designed for air-root-pruning above that for conventional containers (Table 1). Air-root-pruning containers also produced a more fibrous root system than conventional containers. Canopy height was unaffected by the container design, and averaged 144 cm (57 in) for carambola trees and 86 cm (34 in) for mango trees.

These results corroborate earlier studies which indicate the effectiveness of copper compounds applied to the inside walls of conventional containers is dose- and species-dependent (2, 8, 10). A higher dose level of $CuCO_3$ may have controlled carambola and mango root system malformation more effectively and led to a positive root response. For instance, the mass of new root growth after transplanting was arithmetically but not significantly increased 50% for mango and 60% for carambola by treatment with 200 g $CuCO_3$ per liter (26.67 oz per gal) when compared with non-coated containers. A dose response to copper is to be expected considering the mechanism by which copper compounds prune roots. Root growth is inhibited by copper compounds via mild toxicity that is confined to the root tips which contact the interior container wall on which the compound is located (3). As with all other phytotoxic compounds, there is much genetic variation in tolerance of and response to the compound.

The response of longan to $CuCO_3$ and carambola and mango to air-pruning was classic in that more higher order lateral roots were formed in response to repeated pruning of tips as they met the medium-container wall interface (3). Whether or not this response is accompanied by an increase in total root mass, the resulting transplant is better able to develop a root system which more closely resembles a natural, unobstructed root system.

Literature Cited

1. Appleton, B.L. 1993. Nursery production alternatives for reduction or elimination of circling tree roots. J. Arboriculture. 19:383–388.

2. 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.

3. Arnold, M.A. and D.K. Struve. 1989. Cupric carbonate controls green ash root morphology and root growth. HortScience 24:114–117.

4. Burdett, A.N. 1978. Control of root morphogenesis for improved mechanical stability in container-grown lodgepole pine. Can. J. For. Res. 8:483–486.

5. Costello, L. and J.L. Paul. 1975. Moisture relations in transplanted container plants. HortScience 10:371–372.

6. Morton, J.F. 1987. Fruits of Warm Climates. Media, Inc., Greensboro, NC.

7. Nichols, T.J. and A.A. Alm. 1983. Root development of container-treated, nursery-grown, and naturally regenerated pine seedlings. Can. J. For. Res. 13:239–245.

8. Svenson, S.E., D.L. Johnston, and B.L. Coy. 1995. Shoot and root responses of eight subtropical species grown in cupric hydroxide-treated containers. HortScience 30:249–251.

9. Watson, G.W., S. Clark, and K. Johnson. 1990. Formation of girdling roots. J. Arboriculture 16:197–202.

10. Wenny, D.L., Y. Liu, R.K. Dumroese, and H.L. Osborne. 1988. First year field growth of chemically root pruned containerized seedlings. New Forests 2:111–118.