Bare Root Shade Tree Whip Production in Containers[1]

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Abstract

A production system for producing bare root shade tree whips in containers is described. First year growth, transplant survival and re-growth of eight taxa were studied. Red oak (*Quercus rubra* L.) seedlings grown in 2:2:1, 2:1:2 or 3:1:1 sand:Comtil (composted municipal sewage sludge):Isolite (by vol) bare root media had first year height growth (100 cm, approximately 40 in) similar to seedlings grown in a 3:0.5:0.5:1 pine bark:peat moss:Comtil:sand medium (by vol). In a 2:2:1 sand:Comtil:Isolite (by vol) medium, red oak seedling height growth was greatest when 60 g (2.1 oz) slow release fertilizer was applied per container. Red oak seedlings were easily bare-rooted by hand shaking the sand:Comtil:Isolite media from the root systems. The root systems of all the taxa were fibrous and had many intact root tips. Red oak seedlings could be successfully transplanted in fall or spring. Six of the eight taxa studied, all except blackgum (*Nyssa sylvatica* Marsh.) and chinkapin oak (*Q. muehlenbergii* Engelm.), could be successfully over-wintered bare root in refrigerated storage. When spring transplanted to containers, survival averaged over 90%; second season height growth increased over 60 cm (24 in).

Index words: feritigation, slow release fertilizer, container media, composted municipal sewage sludge, Isolite, pine bark.

Species used in this study: American chestnut (*Castanea dentata* (Marsh. Borkh)); Carolina Silverbell (*Halesia carolina* L.); Sweetbay Magnolia (*Magnolia virginiana* L.); Blackgum (*Nyssa sylvatica* Marsh.); Swamp White Oak (*Quercus bicolor* Willd.); Chinkapin Oak (*Q. muehlenbergii* Engelm.); Northern Red Oak (*Q. rubra* L.); Shumard Oak (*Q. shumardii* Buckl.).

Significance to the Nursery Industry

A method for producing bare root whips in copper-treated containers is described. Several media were found to be suitable for bare root whip production: 3:1:1, 2:2:1 or 2:1:2 sand:composted municipal sewage sludge:Isolite (by vol). These media could be easily separated from the root systems of eight taxa. Whips grown in copper-treated containers had fibrous root systems with many intact root tips. Bare root whips had high transplant survival and re-growth potential. This production method has the potential for commercial production of difficult-to-transplant (coarse-rooted) species; it combines the advantages of high transplant survival of container stock with the ease of handling of bare root stock.

Introduction

Finish stock producers transplant bare root whips to be harvested later as larger caliper shade trees. Bare root whips are field produced and harvested by digging and shaking the soil from the root systems. Significant root loss occurs during the production cycle from harvesting operations, desiccation during handling, storage and shipping, and root pruning before transplanting. Root pruning prior to planting facilitates planting and promotes development of a dense root system for subsequent harvest, but root loss results in transplant shock, a period of slow growth and adjustment to the new environment after transplanting (7). Transplant shock is severe enough in some species to eliminate them from commercial production.

Typically, difficult-to-transplant species have coarse root systems. Coarse-rooted species when dug bare root have few intact root tips (10) so that root regeneration must be via new root initiation (9). This is a slow process relative to elongation of existing roots (1, 4). Over 40 days many elapse between budbreak and first new root regeneration (4). Despite possible high mortality due to transplant shock, bare root whips are the most common type of liner because of the handling and shipping convenience. The nursery industry would benefit from a bare root whip production method that combines the benefits of container production (little root loss at harvest, increased root system density, and intact root tips) with the easy of handling of bare root whips.

The Ohio Production System [OPS (11)] can be used to produce shade tree whips in containers. Whips produced under OPS conditions have high survival and regrowth potential (13) attributed to increased root system density and numerous intact root tips (1, 2, 12, 14). However, the OPS uses a pine bark medium, which is difficult to remove from root systems.

This study was conducted for three reasons. First, to study the effect of slow release fertilizer type and rate on red oak growth in media suitable for containerized bare root whip production. Second, to study the effect of over-wintering method and transplanting date on container-grown red oak whip survival and growth. Third, to determine the first year growth rate, transplant survival and re-growth potential of eight woody plant taxa produced in the containerized bare root whip system.

Materials and Methods

Common procedures. Procedures common to all experiments are: fruits were picked from trees in mid-September of each year, placed in plastic bags and stratified at 3C (45F) until sown in February.

Whips were produced by transplanting seedlings to Spinout-treated (Griffin Corp, Valdosta, GA) square plastic containers (250 XL Classic Nursery Supplies, Fairless Hills, PA) by mid-March, growing in a heated greenhouse until mid-May, transferring them outdoors to 70% shade for one week and repotting into Spinout-treated No. 3 round black plastic containers (Classic 1200 SC, Nursery Supplies, Fairless Hills, PA) by June 6 (11). Metro Mix 360 (O.M.

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Scotts and Son, Marysville, OH) was used as the germination and greenhouse growing medium. Seedling heights were measured three times during the growing season: in June, August and October.

Fertilizer types and application rates were: 25 mg/liter N from Peter's 15N–2.6P–10K (15–16–17, The Scott's Co., Marysville, OH) water soluble fertilizer applied daily with 3.8 liters (one gal) of water between June 1 and September 30. Slow release fertilizers used were Woodace 21N–1.8P–8.3K (21–4–10, Vigoro Industries, Winterhaven, FL) and Sierra 17N–2.6P–10.0K + minors (17–6–12, The Scott's Co., Marysville, OH) top dressed at 15, 30 and 60 g (0.5, 1.1, 2.1 oz) per container. Slow release fertilizers were applied directly under the trickle irrigation emitter. All plants received 3.8 liters (one gal) daily irrigation from 1.9 liter (0.5 gal) per hour trickle emitters.

Experiment 1992–1: Effect of slow release fertilizer type, rate and container media on red oak whip growth. During the first week in June, red oak seedlings were transplanted into either a 3:0.5:0.5:1 (pine bark:sand:Canadian peat moss:composted municipal sewage sludge [Comtil, City of Columbus, OH], by vol) or 2:1:2 (sand:Comtil:Isolite [GC2, Sumitomo Corp. of America, Denver, CO], by vol) medium. Isolite was added to increase the nutrient and water holding capacity of the sand-based media. Within each medium, 20 plants were treated with either 17–6–10 + minors or 21–4–10 slow release fertilizers at three rates, 15, 30 or 60 g (0.5, 1.1, and 2.1 oz) per container. The plants were placed in a randomized complete block design with two 10-plant replications, a total of 240 plants. No water soluble fertilizer was used.

Experiment 1992–2: Effect of container media on red oak seedling growth. Another group of red oak seedlings were potted in either the pine bark medium or into one of three sand:Comtil:Isolite media. The sand-based media were 2:1:2, 2:2:1, or 3:1:1 (sand:Comtil:Isolite, by vol). These plants were treated with 15 g (0.5 oz) of 21-4-10 Woodace slow release fertilizer per container and fertigated with 25 mg/liter N. Plants were placed in a randomized complete block design with two 20-plant replications per medium, a total of 80 plants.

Experiment 1992–3: Over winter storage method, transplanting date, survival and regrowth of container-grown red oak bare root whips. The red oak whips from Experiment 1992–1 were used in the transplant study. Whips within the bare root medium types were combined over fertilizer types and rates, and randomly assigned to one of the bare root over-wintering and transplanting treatment combinations.

In October 1992, 60 red oak whips, 30 whips each from the bare root medium and pine bark medium, were selected for fall transplanting into a field plot at the Horticulture Farm, Columbus, OH. The soil type was a Crosby silt loam. A randomized complete block design with three 10-plant replications was used with a 1.1 m (4 ft) within row and 4 m (12 ft) between row spacing. Whips grown in the bare root medium were removed from the containers and bare rooted by shaking the medium from the root systems. The whips had naturally defoliated before being bare rooted. Whips grown in the pine bark medium were planted as described above, but the container medium was undisturbed.

Ninety additional whips were selected for over-wintering in either a polyhouse or in refrigerated storage. Thirty whips grown in the pine bark and 30 grown in the bare root medium were placed in a polyhouse covered with a single layer of 70% milky poly in early December. Thirty additional whips grown in the bare root medium were prepared for refrigerated storage by hand shaking the medium from the root systems. These whips were over-wintered in a refrigerated walk-in cooler set a 3C (45F). The whips were laid horizontally on the floor, moist peat moss placed on the root systems and the whips covered with plastic. The root systems and peat moss were hand watered during storage.

In early April 1993, all over-wintered whips were transplanted into the same field plot as the fall transplanted whips. The transplanting/over-wintering treatment combinations are listed in Table 3.

In early June of each year all plants received 0.029 kg N/m (6lb N/1000 ft^{-2}). Sod was established between the rows in Fall 1993 and a 1.2 m (4 ft) wide weed-free strip maintained within each row by a combination of pre-emergent herbicide applications and mechanical cultivation.

Pre-planned single degree of freedom contrasts were made to determine the effects of: planting stock type (bare root vs. container, treatments 1 and 2 vs. 3 and 4), bare root over-wintering method (polyhouse vs. refrigerated storage, treatment 4 vs. 5) and transplanting time (fall vs. spring, treatments 1 and 3 vs. 2 and 4). Data from the 1992 experiments were analyzed using the Oneway ANOVA and Contrast procedures within SPSS/PC+ V2.0 (6).

Experiment 1993–1: Growth of eight taxa in pine bark or sand:Comtil:Isolite (by vol) growing media. Seeds of *Magnolia virginiana*, *Quercus bicolor*, *Q. muehlenbergii*, and *Q. shumardii* were obtained from Sheffield's Seed, Locke, NY, in Fall 1992 and handled similarly to the red oak seed. Seedling were produced as described previously. *Halesia carolina* microcuttings were rooted and plantlets produced according to Brand and Lineberger (3).

Twenty seedlings or plantlets of each species were potted into either the pine bark medium or into the 2:2:1 sand:Comtil:Isolite medium. All seedlings received two 15-g (0.5 oz) applications of 21–4–10 Woodace slow release fertilizer (in early June and late July) and 3.8 liters of 25 mg N/liter water soluble fertilizer daily. Two 10-plant replications were used per species and container medium.

Experiment 1993–2: Species trial for containerized bare root whips transplanted to larger containers. Whips smaller than 50 cm (18 in) produced in Experiment 1993–1 were graded out and the remaining whips were used in this over-wintering/transplanting study. In early December 1993, whips grown in the pine bark medium were placed in an polyhouse and over-wintered as described for Experiment 1992–3. Whips grown in the bare root medium were removed from the containers, bare rooted by hand shaking and placed in refrigerated storage as described of Experiment 1992–3.

In late May 1994, whips grown in the pine bark and bare root medium were potted into No. 10 round black plastic containers (Classic No. 10, Nursery Supplies, Fairless Hills, PA) using a 3:3:1 rice hull (Dock Site, Warsaw, IL):Comtil:sand (by vol) medium. Whips were fertigated from June to September with 25 mg N/liter from water soluble

Table 1. Red oak growth in copper treated containers in two media under different slow release fertilizer types and rates.

Medium[z]	Slow release fertilizer	Rate (g)	Height (cm) October 6
Pine bark	17–6–12 + minors[y]	15	70b[x]
		30	65b
		60	98a
	21–4–10	15	66b
		30	63b
		60	92a
Sand:Comtil:Isolite	17–6–12 + minors	15	71b
		30	88a
		60	69b
	21–4–10	15	86b
		30	81b
		60	102a

[z]Pine bark medium was 3:0.5:0.5:1 pine bark:composted municipal sewage sludge (Comtil):Canadian peat moss:sand (by vol); the bare root medium was sand:Comtil:Isolite 2:1:2 (by vol).

[y]Fertilizer treatments were: Sierra 17–6–12 + minors or Woodace 21–4–10 at 15, 30 or 60 g per container.

[x]Means within a medium type followed by different letters are significantly different from each other at the $\alpha = 0.05$ level, using Student-Newman-Keuls test.

Table 2. Height of red oak grown in three media (sand:Comtil:Isolite) suitable for containerized bare root whip production.

Medium	Height (cm)		
	June	August	October
Pine bark	26	80	104
Sand:Comtil:Isolite			
2:1:2[z]	27	74	99
2:2:1	31	91	109
3:1:1	26	65	88
P>F-value	0.099	0.319	0.588

[z]Indicates ratios (by vol) of sand:composted municipal sewage sludge (Comtil):Isolite. The pine bark medium was 3:0.5:0.5:1 (by vol) pine bark:Comtil:peat moss:sand.

fertilizer. First and second year plant heights were measured in October 1993 and 1994, respectively. Data for the 1993 experiments were analyzed using the Oneway procedure within SPSS/PC+ V2.0 (6).

Results and Discussion

Experiment 1992–1. Statistically significant differences in red oak height growth did not occur until October; seedling heights averaged 25 cm (10 in) in June and 67 cm (26 in) in August. In the pine bark medium, the tallest seedlings were produced at the 60 g fertilizer rate for both slow release fertilizer types (Table 1). In the 2:1:1 sand:Comtil:Isolite medium, the tallest seedlings were produced at the 60 g application of 21–4–10 Woodace fertilizer rate (Table 1). There were no statistical differences in height growth between the slow release fertilizer types: Sierra 17–6–12 + minors or Woodace 21–4–10 (P = 0.56).

Experiment 1992–2. There were no differences in red oak height growth attributed to medium type at any measurement period (Table 2). By October seedling heights ranged from 88 to 109 cm (35 to 43 in).

Experiment 1992–3. Survival of transplanted red oak whips was high; regardless of transplanting time or overwintering method, only one whip died. There were no statistical differences in height growth until 1994 (Table 3). By 1994, the tallest red oaks were initially grown in the pine bark medium and spring planted. The shortest red oaks were initially grown in the pine bark medium and fall transplanted. There were no differences in 1993 or 1994 red oak height between planting stock types (bare root vs. container, 139 vs. 128 cm for 1993, and 177 vs. 176 for 1994), over-wintering methods (polyhouse vs. refrigerated storage, 137 vs. 144 for 1993, and 173 vs. 181 for 1994) or between transplanting times (fall vs. spring, 141 vs. 138 for 1993, and 170 vs. 185 for 1994).

Red oaks grown in the sand:Comtil:Isolite media could be easily bare rooted by hand shaking; the medium easily separated from the root systems. In contrast, the pine bark medium could not be easily separated from the root systems by hand shaking.

Red oak grown in the sand:Comtil:Isolite media had fibrous root systems. There were many one-to-three mm (1/16 to 3/16 in) diameter lateral roots with intact root tips and

Table 3. Red oak growth following fall (1992) or spring (1993) transplanting to field plots. Prior to transplanting, plants were grown in copper-treated containers using a pine bark or sand:Comtil:Isolite bare root medium.

Medium[z]	Transplant time	Over-wintering treatment[y]	Treatment no.	Height (cm)		
				1992	1993	1994
Pine bark	Fall	Field	1	86a[x]	121a	160b
	Spring	Polyhouse	2	93a	135a	192a
Sand:Comtil:Isolite	Fall	Field	3	101a	140a	180ab
	Spring	Polyhouse	4	100a	137a	173ab
	Spring	Refrigerated storage	5	100a	144b	181ab

[z]The pine bark medium was a 3:0.5:0.5:1 pine bark:composted municipal sewage sludge (Comtil):Canadian peat moss (by vol), sand:Comtil:Isolite medium was 2:1:2 (by vol).

[y]Over wintering treatments were: field, fall transplanting; polyhouse, container plants were placed in polyhouse with single layer 70% milky poly covering; refrigerated storage, plants grown in sand:Comtil:Isolite medium were bare-rooted and stored at 3C until planted in spring.

[x]Means within a column followed by different letters are statistically different from each other at the $\alpha = 0.05$.

Table 4. Growth of eight taxa in pine bark or 2:2:1 (by vol) Sand:Comtil:Isolite medium.

Species	Medium	Height (cm)	
		June 9	October 7
Castanea dentata	Pine bark	11.0a	54.5a
	Bare root[z]	9.6a	30.0b
Halesia carolina	Pine bark	21.1b	67.3a
	Bare root	13.2a	63.2a
Magnolia virginiana	Pine bark	9.9a	94.3a
	Bare root	8.8a	98.8a
Quercus bicolor	Pine bark	21.7a	71.8a
	Bare root	19.8a	62.8a
Quercus muehlenbergii	Pine bark	11.2a	105.5a
	Bare root	9.5a	88.5a
Quercus shumardii (Dallas, TX)	Pine bark	28.8a	165.8a
	Bare root	23.4a	154.0b
Quercus shumardii (LA)	Pine bark	16.4a	126.3a
	Bare root	14.2a	111.5a

[z]Pine bark medium was 3:0.5:0.5:1 (by vol) pine:sand:Canadian peat moss:composted municipal sewage sludge (Comtil):sand, the bare root medium was 2:2:1 (by vol) sand:Comtil:Isolite.

[y]Means within a column and species followed by different letters are statistically different from each other at the $\alpha = 0.05$ level, using the Student-Newman-Keuls test.

few circling roots. The high quality root systems resulted from a combination of well aerated media and Spinout-treated containers. Copper-treated containers have increased root system density in other studies (2, 5, 8).

Experiment 1993–1. In October, American chestnut and the Dallas,TX, Shumard oak source were taller when grown in the pine bark medium than in a 2:2:1 sand:Comtil:Isolite medium (Table 4). For the other five species, there were no differences in height growth attributed to media type.

The sand:Comtil:Isolite medium readily separated from the root systems of the seven taxa grown in Experiment 1993–1. Similar to the red oak whips, these seven taxa could be bare rooted by hand shaking the plants three to five times. In contrast, removing the pine bark medium was difficult. All root systems were fibrous with many intact root tips.

Experiment 1993–2. Survival of blackgum and chinkapin oak whips grown in the pine bark medium and over-wintered in containers in a polyhouse was greater than that of whips grown in the sand:Comtil:Isolite medium, bare rooted and over-wintered in refrigerated storage (Table 5). For the other species, survival averaged over 90% regardless of over-wintering method.

At transplanting, the whips grown in the pine bark medium and over-wintered in the polyhouse had completed their first growth flush, while bare root whips over-wintered in refrigerated storage were dormant. These differences in time of budbreak are reflected in the June 1994 height data; whips over-wintered in containers in the polyhouse were significantly taller than bare root whips over-wintered in refrigerated storage (Table 5). The differences in June height growth were maintained for the remainder of the growing season (Table 5).

The eight taxa grown in these studies had rapid first year height growth. With two exceptions, growth in the bare root media was similar to growth in the pine bark medium. These studies also showed that six of the eight taxa could be grown in copper-treated containers, bare rooted, over-wintered in refrigerated storage and successfully transplanted to larger containers or nursery fields. Transplanted bare root whips had high survival and regrowth potential.

Copper-treated containers are essential to containerized bare root whip production. Copper-treated containers increase root system density and reduce root malformation (1, 4). Reduced root malformation means less corrective root pruning is needed at transplanting, thus reducing loss of root tips, root surface area and root storage compounds such as carbohydrates and mineral nutrients. Reduced root pruning means that the planting stock has many rapidly regenerating intact root tips at planting.

These studies showed that the high survival and regrowth potential characteristics of container-grown stock can be combined with the shipping and handling ease of bare root planting stock. Container-grown bare root whips are a viable production alternative to field-grown bare root planting stock.

Additional potential advantages offered by containerized bare root whip production are: increased mechanization

Table 5. Survival and growth in 1994 of five species initially grown in containers in 1993. In December 1993, plants grown in a pine bark medium were placed in an unheated polyhouse for over wintering. Plants grown in a 2:2:1 sand:Comtil:Isolite (by vol.) medium were bare-rooted and stored in a walk-in cooler until May 1994. In May 1994, all plants were repotted into 10 gallon containers.

Species	Over-wintering method	No. of plants	Survival (%)	Height (cm)		
				October 1993	June 1994	October 1994
Halesia carolina	Bare root	28	93	54.8b[z]	97.3b	149.8b
	Container	18	90	66.9a	149.7a	209.7a
Magnolia virginiana	Bare root	10	90	106.7a	123.9b	143.9b
	Container	19	100	103.4a	167.9a	198.4a
Nyssa sylvatica	Bare root	29	31	109.3a	NA[y]	142.7b
	Container	33	100	81.6b	128.0b	189.4a
Quercus bicolor	Bare root	71	92	64.2a	104.3b	121.5b
	Container	20	100	68.5a	140.3a	172.3a
Quercus muehlendbergii	Bare root	9	50	72.0a	95.0a	135.0a
	Container	37	45	80.0a	121.2a	167.7a
Quercus shumardii	Bare root	36	100	146.3a	185.0b	215.8b
	Container	50	100	135.9a	205.0a	247.6a

[z]Means within a column and species followed by different letters are significantly different from each other at $\alpha = 0.05$ level using Student-Newman-Keuls test.

[y]NA = not available.

during harvest and increased number of species that can be produced bare root. Further, because of reduced weight and bulk, container-produced bare root whips can be shipped greater distances than similar sized container-grown stock. Therefore, containerized bare root whip production is not limited to regional markets.

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Cyclic Irrigation and Media Affect Container Leachate and Ageratum Growth[1]

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Abstract

Two experiments were conducted with container-grown *Ageratum houstonianum* Mill. 'Blue Puffs' to compare cyclic and continuous irrigations. In experiment 1, leachate volumes were reduced about 54% with 0.4 cm (0.16 in) cyclic irrigation treatments applied with either a 30 min or 2 hr resting phase compared to continuous irrigation of 0.4 cm (0.15 in). Total N leached was about 47% less with the cyclic treatments compared to continuous irrigation. In experiment 2, container leachate volumes and N leached were higher from a pine bark:sand medium, while plants were smaller compared to a pine bark:peat medium. Growth index and root distribution were similar with cyclic and continuous irrigation.

Index words: water quality, interval irrigation, intermittent irrigation, pulse irrigation.

Species used in this study: ageratum (*Ageratum houstonianum* Mill. 'Blue Puffs').

Significance to the Nursery Industry

There are increasing demands to improve the quality of runoff water in container nursery production areas. These experiments demonstrate the influence of media and irrigation practices on container leachate volume and subsequent NO_3-N + NH_4-N loss. Media with greater water holding capacities and higher CEC can improve water quality of container leachate by reducing leachate volume and NO_3-N leached. These data also demonstrate cyclic irrigation can reduce container leachate volumes and leachable forms of N as compared to current irrigation practices, while producing plants of similar size and quality. Cyclic irrigation could become a practical alternative in addressing future environmental regulation. This concept could be incorporated into irrigation management without substantial investment using equipment currently available at many container nurseries.

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Introduction

Nurseries in the southeastern United States utilize large volumes of water to meet irrigation demands of container-grown plants in pine bark-based media (4, 15). Overhead