

# Landscape Establishment of Woody Ornamentals Grown in Alternative Wood-Based Container Substrates<sup>1</sup>

S. Christopher Marble<sup>2</sup>, Glenn B. Fain<sup>3</sup>, Charles H. Gilliam<sup>4</sup>, G. Brett Runion<sup>5</sup>,  
Stephen A. Prior<sup>6</sup>, H. Allen Torbert<sup>7</sup>, and Daniel E. Wells<sup>8</sup>

Department of Horticulture  
Auburn University, Auburn, AL 36849

## Abstract

Due to concerns over future pine bark (PB) availability for container plant production, recent research has focused on evaluating suitable alternatives. For alternatives to be considered suitable substrate replacements, they must not only have desirable characteristics as a container substrate (e.g., adequate drainage, inert, pathogen free, etc.), but must also cause no negative fertility effects (e.g., nitrogen immobilization) following planting in the landscape. The study objective was to evaluate the landscape performance of three woody ornamentals grown in PB and in two alternative wood-based substrates, namely WholeTree (WT) and Clean Chip Residual (CCR). Crapemyrtle (*Lagerstroemia indica* × *faurei* 'Acoma'), magnolia (*Magnolia grandiflora* 'D.D. Blanchard'), and shumard oak (*Quercus shumardii*) were container grown in PB, WT, or CCR for an entire growing season prior to being planted into the landscape. Plants were grown in the landscape for two growing seasons. Data suggest that all species exhibited similar landscape performance when grown in WT or CCR compared to the PB standard. Therefore, the use of WT and CCR as alternative wood-based substrates for crapemyrtle, magnolia, and oak production may be acceptable from a landscape establishment standpoint.

**Index words:** alternative substrate, Clean Chip Residual, WholeTree, ornamental trees, landscape.

**Species used in this study:** Acoma crapemyrtle (*Lagerstroemia indica* × *faurei* 'Acoma'); magnolia (*Magnolia grandiflora* 'D.D. Blanchard'); shumard oak (*Quercus shumardii*).

## Significance to the Nursery Industry

There is concern that supplies of pine bark (PB), the industry standard for container plant production, may become limited creating a need for alternative substrates. Alternative substrates have been used to grow containerized ornamentals; however, before widespread adoption of these materials can take place, landscape performance of plants produced in these substrates needs to be established. This study evaluated the landscape performance of three commonly grown woody ornamentals (crapemyrtle, magnolia, and oak) following container production in alternative wood-based substrates [WholeTree (WT) and Clean Chip Residual (CCR)]. Results showed that all species performed similarly following planting into the landscape when grown in WT or CCR compared to the PB industry standard.

## Introduction

Pinebark (PB) is the most common nursery substrate used for horticulture container crop production in the Southeastern United States. In recent years, PB supplies for horticultural production have begun to decline due to reduced domestic forestry production and increased use of PB as a fuel (19). In many areas in the Southeastern United States, PB suppliers are unable to fill orders for container nursery producers with limited supplies leading to possible price increases. Therefore, it is important to develop alternative substrates for use in container production of horticultural crops.

Container substrates comprised primarily of wood and wood based products have been heavily investigated in recent years. Use of wood fiber substrates have been successful in production of vegetables (15), annuals and perennials (5, 9, 11, 25), and woody ornamentals (6, 8, 16, 23, 24).

Potential lies in the use of WholeTree (WT) and Clean Chip Residual (CCR) as alternatives to PB. WholeTree substrate consists of entire pine trees harvested from plantations at the thinning stage (~ 10–15 yrs) and hammer milled through specific screen sizes depending on crop needs (10). WholeTree is composed of the entire shoot portion of the pine tree (wood, limbs, needles, cones) and contains approximately 80% wood fiber (11). Clean Chip Residual is also a by-product of the forestry industry. Mobile equipment is now being used for in-field tree harvesting operations that process pine trees into 'clean chips' for pulp mills. The remaining material, CCR, is then sold as boiler fuel or spread across the harvest area. Clean Chip Residual contains approximately 50% wood, 40% bark, and 10% needles (5).

Research suggests WT and CCR can be used successfully to produce a wide variety of container grown landscape plants (5, 6, 8, 9, 10, 11); however, no studies have focused on the post-transplant landscape performance and survival of woody plants grown in either substrate. Previous research has shown plants grown in a wood fiber substrate may require additional nitrogen (N) applications to have similar growth to

<sup>1</sup>Received for publication September 14, 2011; in revised form November 4, 2011. Financial support for this research was provided in part by the USDA-ARS Floriculture Nursery Research Initiative and The Horticulture Research Institute, 1200 G Street NW., Ste. 800, Washington DC 20005. The authors would also like to acknowledge B.G. Dorman for technical assistance.

<sup>2</sup>Graduate Research Assistant, marblsc@auburn.edu.

<sup>3</sup>Assistant Professor, gbf0002@auburn.edu.

<sup>4</sup>Professor, gillicl@auburn.edu.

<sup>5</sup>Plant Pathologist, USDA-ARS National Soil Dynamics Laboratory, Auburn, AL 36832. brett.runion@ars.usda.gov.

<sup>6</sup>Plant Physiologist, USDA-ARS National Soil Dynamics Laboratory, Auburn, AL 36832. steve.prior@ars.usda.gov.

<sup>7</sup>Soil Scientist and Research Leader, USDA-ARS National Soil Dynamics Laboratory, Auburn, AL 36832. allen.torbert@ars.usda.gov.

<sup>8</sup>Graduate Student, Louisiana State University, School of Plant, Environmental, and Soil Sciences, Baton Rouge, LA 70803. dwell11@tigers.lsu.edu.

plants grown in PB or peat moss (12, 16, 25). Further, wood particles incorporated into the soil or when used as a landscape mulch have also been shown to cause N immobilization (4, 18, 21, 27). A review of the literature identified only one study in which landscape performance of plants previously grown in an alternative wood fiber substrate was evaluated (26). However, in this case, annual bedding plants were evaluated for survival and growth, and as annual bedding plants were evaluated, these studies only lasted several months. The annual bedding plants investigated were: begonia (*Begonia* × *semperflorens-cultorum*) 'Cocktail Vodka' and 'Cocktail Whiskey'; coleus (*Solenostemon scutellarioides*) 'Kingswood Torch'; impatiens (*Impatiens walleriana*) 'Dazzler White'; marigold (*Tagetes erecta*) 'Bonanza Yellow' and 'Inca Gold'; petunia (*Petunia* × *hybrida*) 'Wave Purple'; salvia (*Salvia splendens*) 'Red Hot Sally'; and vinca (*Catharanthus roseus*) 'Cooler Pink'. All species had been previously grown in a pine tree substrate (PTS) made from *Pinus taeda* or PB prior to being planted into the landscape at three different fertilizer rates. Results indicated that, while N immobilization occurred with no N addition, growth and performance of annuals in the landscape were similar for PTS and PB under fertilized conditions.

Although bedding plants have shown acceptable landscape performance following container production in a high wood fiber substrate, no research has yet focused on landscape performance of woody plants which have a much longer lifespan in the landscape. Nitrogen deficiency from incorporation of wood particles from container substrates with high wood content (i.e., WT, CCR) could be problematic for the landscape industry if growers shift to using alternative substrates for container plant production. Therefore, our objective was to evaluate the performance of three woody ornamentals (crapemyrtle, magnolia, and oak) originally grown in WT, CCR, or PB following planting into the landscape.

## Materials and Methods

On March 25, 2008, three species of woody ornamentals including crapemyrtle (*Lagerstroemia indica* × *faurei* 'Acoma'), magnolia (*Magnolia grandiflora* 'D.D. Blanchard'), and oak (*Quercus shumardii*) were transplanted from 7.62 cm (3 in) 10.16 cm (4 in) and 3.8 liter (#1) liners, respectively, into 11.4 liter (#3) containers containing WT, CCR, or PB. The CCR was obtained from a 10-year-old loblolly pine (*Pinus taeda* L.) plantation in Atmore, AL, that was being thinned using a total tree harvester (Peterson DDC-5000-G Portable Chip Plant, Peterson Pacific Corp., Eugene, OR). Following harvest, trees were processed through a horizontal grinder with a 10.2 cm (4 in) screen (Peterson 4700B heavy duty grinder, Peterson Pacific Corp., Eugene, OR) to produce the CCR. The CCR was delivered to Auburn University's E.V. Smith Research Station in Tallahassee, AL, on March 29, 2007, and was stored in an uncovered pile exposed to ambient climate (not aerated or turned) for about one year (363 days). The CCR was then further processed through a swinging hammer mill (No. 30; C.S. Bell, Tifton, OH) to pass through a 1.27 cm (1/2 in) screen on March 11, 2008. The WT was obtained from a pine plantation (~10 yr) in Georgetown, GA, with pine trees harvested at ground level and the entire shoot portion chipped (Chipper Model 725H; PowerTek, Lebanon, IN). The WT was delivered to the E.V. Smith Research Station on January 18, 2007, aged (432 days) in a similar manner to CCR, and then further processed using

the swinging hammer mill described above to pass through a 0.64 cm (1/4 in) screen on March 3, 2008. Aged pine bark (PB) was obtained from Pineywoods Mulch Co. (Alexander City, AL) of unknown age.

Each substrate treatment was mixed with sand on a 6:1 (v:v) basis. Each substrate was pre-plant incorporated with 18N-2.6P-9.9K (18-6-12) Polyon® (Harrell's Fertilizer Inc. Sylacauga, AL) (8 to 9 month formulation) at 18.3 kg·m<sup>-3</sup> (14 lb·yd<sup>-3</sup>, or approximately 84 grams of product per tree), 3.0 kg·m<sup>-3</sup> (5 lb·yd<sup>-3</sup>) dolomitic limestone, and 0.9 kg·m<sup>-3</sup> (1.5 lb·yd<sup>-3</sup>) Micromax® (The Scotts Co., Maryville, OH). All amendments were incorporated into each substrate treatment on the day of potting. Following transplanting, plants were placed outdoors on a gravel container pad and overhead irrigated twice daily [1.27 cm (0.5 in) in total]. Plants were arranged by species in a randomized complete block design with 20 single pot replications per treatment. Plants were grown in containers for nine months. In December 2008, six plants from each substrate treatment were chosen to be planted out into the field by selecting plants with a similar growth index [(plant height + plant width1 + plant width2) / 3] based on Tukey's Mean Separation Test ( $P \leq 0.05$ ) (SAS® Institute version 9.1, Cary, NC). Plants were transplanted by species into a clay-loam soil (pH 6.2) at the Old Agronomy Farm, Auburn University, AL. Oaks were planted into two rows with 3.7 m (12 ft) in between rows and each plant was spaced 2.4 m (8 ft) apart. Crapemyrtles and magnolias were planted into three rows (three separate rows for each species) spaced 3 m (10 ft) apart with 1.5 m (5 ft) in between each plant. Plants within each species were arranged in a randomized block design with pairs of plots for each substrate randomized within each of three blocks. Plants were watered in by hand following transplanting and received only rainfall thereafter. All plants were mulched at the time of transplanting with pine straw [5 cm (2 in) thickness] and again on June 30, 2010. Plants were fertilized on June 25, 2009, by broadcasting Polyon® (Harrell's Fertilizer Inc. Sylacauga, AL) (8 to 9 month formulation) 13N-5.6P-10.9K (13-13-13) at a rate of 454 g (1 lb) of product per 93 m<sup>2</sup> (1000 ft<sup>2</sup>). Weed control was conducted by hand-weeding and applying directed applications of RoundUp Pro® (Monsanto Co., St. Louis, MO) herbicide at a 2% spray solution.

Caliper measurements were taken on November 1, 2010, by measuring trunk circumference at 15.3 cm (6 in) above the soil line; plant height was also measured at this time. Landscape marketability ratings were taken on November 1, 2010, on a scale of 0 to 5 [0 = completely non-marketable (chlorotic or yellow foliage, sparse canopy); 3 = acceptable for landscape planting (green foliage, good canopy); 5 = very marketable (dark green foliage, dense, lush canopy)]. On November 3, 2010, all plants were destructively harvested. Plant shoots were cut at 15.3 cm (6 in) above the soil line. Roots were extracted by connecting a clamp to the stump just below the soil surface, connecting the clamp to a hydraulic cylinder mounted on the front of a small tractor, and raising the cylinder mount until the taproot and lateral roots were loosened from the soil (22). Coarse roots were removed with the hydraulic cylinder with additional loose roots collected by hand. It is likely that the extraction method did not recover all fine fibrous roots for each tree; however, as the same technique was used for all three species in all plots, the relative amount of roots removed should be comparable. Following destructive harvest, shoots and roots were dried in a forced air

**Table 1.** Height and caliper of crapemyrtle (*Lagerstroemia indica* × *faueri* ‘Acoma’), magnolia (*Magnolia grandiflora* ‘D.D. Blanchard’) and oak (*Quercus shumardii*) following landscape outplanting.

Treatment <sup>a</sup>	Height (cm) <sup>b</sup>			Caliper (mm) <sup>c</sup>		
	Crapemyrtle	Magnolia	Oak	Crapemyrtle	Magnolia	Oak
PB	118.0a <sup>w</sup>	162.0a	203.4a	67.9a	56.2a	64.2a
CCR	122.0a	152.2a	235.5a	65.1a	52.6a	65.2a
WT	121.3a	151.0a	217.5a	61.8a	61.0a	67.3a

<sup>a</sup>Height measurements (cm) taken by measuring trees from soil line to top of the tree, approximately 2 years after outplanting.

<sup>b</sup>Caliper measurements (mm) taken by measuring trunk circumference at 15.3 cm (6 in) from soil line, approximately 2 years after outplanting.

<sup>c</sup>Treatments: PB = pinebark, CCR = Clean Chip Residual, WT = WholeTree.

<sup>w</sup>Means separated based on Tukey’s Studentized Range Test ( $P \leq 0.05$ ). Means within a column followed by the same letter are not significantly different from each other.

**Table 2.** Shoot and root dry weights<sup>a</sup> of crapemyrtle (*Lagerstroemia indica* × *faueri* ‘Acoma’), magnolia (*Magnolia grandiflora* ‘D.D. Blanchard’) and oak (*Quercus shumardii*) following landscape outplanting.

Treatment <sup>a</sup>	Shoot weight (g)			Root weight (g)		
	Crapemyrtle	Magnolia	Oak	Crapemyrtle	Magnolia	Oak
PB	2784.2ab <sup>x</sup>	1751.4a	1748.6a	1093.6a	910.7a	1575.7a
CCR	3051.4a	1496.4a	1673.7a	1127.6a	836.0a	1433.5a
WT	2563.5b	1689.3a	1605.9a	949.3a	972.1a	1738.8a

<sup>a</sup>Plants harvested for dry weights on November 3, 2010, approximately two years after transplanting.

<sup>b</sup>Treatments: PB = pinebark, CCR = Clean Chip Residual, WT = WholeTree.

<sup>x</sup>Means separated based on Tukey’s Studentized Range Test ( $P \leq 0.05$ ). Means within a column followed by the same letter are not significantly different from each other.

oven 55C (131F) for 14 days at which time dry weights (DW) were recorded. Data were subjected to analysis of variance (ANOVA) with means separation by Tukey’s Studentized Range Test ( $P \leq 0.05$ ) using the Proc GLM feature of SAS (SAS® Institute version 9.1, Cary, NC).

## Results and Discussion

Height and caliper measurements show that no differences in plant growth occurred regardless of substrate used during container production in any of the three species evaluated (Table 1). While height and caliper measurements were similar among treatments in each species, differences were observed when comparing shoot DW of crapemyrtle (Table 2). Crapemyrtles previously grown in CCR had higher shoot DW than plants previously grown in WT. However, both alternative substrates (WT and CCR) had similar shoot DW to the PB standard. Magnolia and oak shoot DW revealed no difference among treatments. Root DW indicates that each species had similar root growth regardless of substrate treatment (Table 2).

Regardless of container substrate used during plant production, all three species evaluated performed similarly in terms of growth following planting in the landscape. In addition, visual marketability ratings taken before harvest indicate that all plants would be considered marketable in a home or commercial landscape setting (Table 3).

Previous work has demonstrated that when wood by-products are used as container substrate, N immobilization may occur, requiring additional fertilizer applications for optimal plant growth (4, 14, 16, 21, 25). Soil N content (along

with plant visual ratings and growth) has also been shown to decrease as organic mulch depth increased (3). Others have shown that decomposing mulch material is readily available to soil microorganisms (1, 20), thereby reducing plant available N as soil microorganisms outcompete plants for nutrients. It should be noted that fresh wood-based materials were used in many of the above cases. However, it has been shown that using fully composted or aged materials may reduce N

**Table 3.** Marketability ratings of crapemyrtle (*Lagerstroemia indica* × *faueri* ‘Acoma’), magnolia (*Magnolia grandiflora* ‘D.D. Blanchard’), and oak (*Quercus shumardii*) at two years after landscape outplanting.

Treatment <sup>a</sup>	Marketability ratings <sup>b</sup>		
	Crapemyrtle	Magnolia	Oak
PB	5.0a <sup>x</sup>	5.0a	4.2a
CCR	5.0a	5.0a	4.6a
WT	5.0a	5.0a	4.5a

<sup>a</sup>Marketability ratings were taken on November 1, 2010, on a scale of 0 to 5 [0 = completely non-marketable (chlorotic, yellow foliage, sparse canopy); 3 = acceptable for landscape planting (green foliage, good canopy); 5 = very marketable (dark green foliage, dense, lush canopy)].

<sup>b</sup>Treatments: PB = pinebark; CCR = Clean Chip Residual; WT = WholeTree.

<sup>x</sup>Means separated based on Tukey’s Studentized Range Test ( $P \leq 0.05$ ). Means within a column followed by the same letter are not significantly different from each other.

immobilization and alleviate the need for additional N fertilizer applications in containers (7). Further, aged materials are considered a more desirable container substrate due to smaller particle size and better water holding capacity (2, 17). Previous work by Gaches (13) showed that growth and flowering of petunias (*Petunia* × *hybrida* 'Dreams White') and marigolds (*Tagetes patula* 'Little Hero Yellow') was greater when grown in aged WT substrate when compared to fresh WT. Substrates in the current study were aged before use; it is possible this may have alleviated any potential N immobilization since all plants displayed similar growth.

As container nursery growers continue to seek alternatives to PB, suitable substrates must not only provide acceptable growth during container production, but must also demonstrate no negative effects (e.g., N immobilization) following transplanting. The woody ornamental species evaluated in this study performed similarly in a landscape setting with the same amount of fertilizer after previously being grown in properly aged alternative wood-based WT or CCR substrates, compared to the industry standard PB. Whether fresh material of WT or CCR can be used with similar results requires further research.

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