Performance of Container-Grown *Loropetalum* Grown in Clean Chip Residual Substrate©

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The idea of using forest residuals is gaining in popularity as a replacement for pine bark (PB) in nursery crop substrates due to reduced availability of PB. Clean chip residual (CCR) is a by-product of in-field forestry harvesting practices. This material, composed of roughly 50% wood, 40% bark, and 10% needles has been shown to produce annual plants and perennials similar in size to plants grown in pine bark. This study evaluated the growth of woody ornamentals grown in CCR or PB over the course of 1 year. Four woody species were tested; *Loropetalum chinensis* f. rubrum, *Lagerstroemia* 'Hopi', *Rhododendron* 'Fashion', and *Buddleja davidii* 'Black Knight'. Data for *Loropetalum* show that plants grown in CCR had similar or greater growth than plants grown in PB. These results indicate that CCR can support the growth of woody ornamentals in a similar fashion to traditional pine bark substrates and is a viable option for the nursery industry.

INTRODUCTION

Safe, effective, and economical growth substrates are an important part of nursery crop culture. Growers have been searching for innovative ways to meet this need since the inception of container-grown crops on a large scale in the 1950s. The first container substrates were composed primarily of field soil which had poor physical properties (Davidson et al., 2000). Then pine bark became available as a forest by-product. For the last 30 years pine bark has been the primary component of nursery crop substrates. Unfortunately, pine bark is becoming increasingly expensive and less available due to in-field harvesting practices, alternative fuel uses, decreased domestic forestry production, and increased foreign importation of logs (Lu, et al., 2006).

A recent trend in substrate research has identified clean chip residual (CCR), a forest in-field harvesting residual material, as a possible replacement for pine bark-based substrates (Boyer et al., 2006a; 2006b; 2007). Clean chip residual is composed of a high percentage of wood-fiber (about 50%) though it also contains about 40% bark and roughly 10% foliage and other material (pine cones, etc.). This high wood-fiber content is a departure from traditional pine bark substrates which contain less than 5% wood fiber. Clean chip residual is obtained from total tree harvester machines which processes small-caliper trees to produce clean chips (for pulp mills)

in the forest. Taken from the in-field site, the CCR can be processed in a hammer mill to desired specifications.

To date, several studies have been conducted to evaluate the growth of nursery crops in high wood-fiber content substrates. Gruda and Schnitzler (2003) reported the use of wood-fiber substrates for vegetable transplant production in Europe. In the U.S.A. Wright and Browder (2005) conducted a short-term greenhouse study with 100% wood-fiber which showed that marigold (*Tagetes*) could be grown successfully with a note that substrate fertility needed to be further evaluated. Fain et al. (2006, 2007) reported WholeTree could be successfully used as a growth substrate for annual vinca. WholeTree is composed of the entire shoot portion of trees, but has a slightly higher (about 80%) wood-fiber content than CCR. Fain also reported that annual vinca grown in WholeTree were similar in size to those grown in a pine bark substrate. Boyer et al. (2006a) demonstrated that *Ageratum* and *Salvia* grown in CCR or combinations of CCR and peat produced similarly sized plants when compared to a traditional pine bark substrate. Later, Boyer et al. (2006b) evaluated perennials (*Buddleja* and *Verbena*) in CCR and reported similar results among all treatments. A further study indicated that use of supplemental nitrogen was not necessary for growth of *Buddleja* (Boyer et al., 2007). No tests have evaluated long-term container-grown woody crops with CCR. The objective of this work was to evaluate fresh CCR as a substrate for production of container-grown woody crops over the course of 1 year.

MATERIALS AND METHODS

The CCR used in this study was obtained from a 10-year-old pine plantation near Evergreen, Alabama. Loblolly pine (*Pinus taeda*) were thinned and processed for clean chips using a total tree harvester. Clean chip residual used in this study was further processed through a horizontal grinder with 4-inch screens. The sample was then run through a hammer mill to pass a 3.2-, 1.9-, 1.3-, or 1.0-cm (1¼-, ¾-, ½- or ⅜-inch) screen. These four CCR sizes were compared to a standard pine bark substrate. Treatments are listed in Table 1.

This study was initiated at Auburn University, Alabama, on 6 June 2006. Each substrate was amended with 8.3 kg·m^{-3} (14 lb/yd^3)18-6-12 (Polyon 9-month), 3.0 kg·m^{-3} (5 lb/yd^3) dolomitic limestone, and 0.9 kg·m^{-3} (1.5 lb/yd^3) Micromax (Scotts Co.). Four woody species, *Loropetalum chinensis* f. rubrum, *Lagerstroemia* 'Hopi', *Rhododendron* 'Fashion', and *B. davidii* 'Black Knight' were transplanted from standard 72-cell flats and grown in 1-gal containers (*Rhododendron* in trade gallon), placed outside in full sun (*Rhododendron* was under 30% shade), and overhead irrigated as needed. Only data for *Loropetalum* is presented here. Plants were arranged by species in a randomized complete block with eight single plant replications. Containers were top-dressed with 4.1 kg·m^{-3} (7 lb/yd^3) 19-6-12 (Polyon 6 month) on 23 Feb. 2007. Pour-through extractions were conducted at 1, 31, 92, 141, 258, and 377 days after planting (DAP) to test media pH and electrical conductivity (EC). Growth indices ([height + width1 + width2] / 3 in cm) were recorded at 55, 92, 141, and 373 DAP. Media shrinkage was recorded at 7, 92, and 373 DAP. Percent root-ball coverage was recorded at 373 DAP. Shoot dry weight and foliar nutrient content were recorded at the conclusion of the study (377 DAP). Initial physical properties and particle size distribution of each substrate were measured.

RESULTS

Air space in all substrates was high (47%–65%; recommended 10%–30%) (Table 1). Container capacity (CC) was low for all substrates (27%–38%; recommended 45%–65%); however, 1/2 inch and 3/8 inch CCR had similar CC to PB. Total porosity was slightly above (90%–92%) recommended ranges (50%–85%) except for PB (84%). Bulk density was low for all substrates (0.11–0.15 g·cm^{-3}; recommended 0.19–0.70 g·cm^{-3}).

As expected, 1¼-inch and 3/4-inch CCR had a higher component of large particles and fewer medium and small particles (data not shown). Substrates composed of 1/2-inch or 3/8-inch CCR were similar to PB with the exception of more extra fine particles in the pine bark.

Substrate pH and EC remained relatively constant over the course of the year (Table 2). At 1 DAP, EC ranged from 1.12 mS·cm^{-1} to 0.94 mS·cm^{-1}. By 377 DAP, EC ranged from 0.28 to 0.46 mS·cm^{-1}. The pH levels at 1 DAP ranged from 5.2 to 5.9, but by 31 DAP had risen to 6.4 for all CCR treatments. Pine bark substrates maintained lower pH levels than CCR throughout the remainder of the study (5.0–6.0).

There were no differences in growth indices of *Loropetalum* at 55 DAP (Table 3); however, by 92 DAP plants grown in 3/4-inch CCR were the largest (31.4 cm), but were not different from plants grown in 1/2-inch (29.3-cm) or 3/8-inch (28.2-cm) CCR. At 141 DAP a similar trend existed with plants grown in 1 1/4-inch CCR the smallest (33.2 cm) along with PB (35.8 cm). At the conclusion of the study (373 DAP), plants grown in PB were the smallest (57.1 cm), but were similar to 1¼-inch CCR (58.0 cm) and 1/2-inch CCR (62.4 cm). While plants grown in PB may have exhibited less

Table 1. Physical properties of pine bark (PB)- and clean chip residual (CCR)-based substrates[z].

Substrates[y]	Air space[x] (% Vol)	Container capacity[w]	Total porosity[v]	Bulk density (g·cm^{-3})[u]
1 1/4-inch CCR	65 a[t]	27 c	92 a	0.11 d
3/4-inch CCR	62 a	29 b	91 a	0.12 c
1/2-inch CCR	52 b	37 a	89 b	0.13 b
3/8-inch CCR	52 b	38 a	90 b	0.13 b
PB	47 c	37 a	84 c	0.15 a
Recommended range[s]	10-30	45-65	50-85	0.19-0.70

[z]Analysis performed using the NCSU porometer.
[y]Treatments were: PB = pine bark, CCR = clean chip residual.
[x]Air space is volume of water drained from the sample / volume of the sample.
[w]Container capacity is (wet weight - oven dry weight) / volume of the sample.
[v]Total porosity is container capacity + air space.
[u]Bulk density after forced-air drying at 105 °C for 48 h (1 g · cm^{-3} = 62.43 lb/ft^3).
[t]Mean separation within column by Waller-Duncan k ratio t tests (α = 0.05, n = 3).
[s]Recommended ranges as reported by Yeager et al., 1997. In: *Best Management Practices Guide for Producing Container-Grown Plants.*

Table 2. Substrate electrical conductivity (EC) and pH (median) for substrate blends in a greenhouse container study.

	1 DAP[y]		31 DAP		92 DAP		141 DAP		258 DAP		377 DAP	
Substrate[z]	**EC[w]**	**pH**	**EC**	**pH**	**EC**	**pH**	**EC**	**pH**	**EC**	**pH**	**EC**	**pH**
1 1/4-inch CCR	1.07 a[v]	5.8	0.42 a	6.3	0.41 a	6.3	0.23 a	6.4	0.15 a	6.4	0.34 a	6.3
3/4-inch CCR	0.94 a	5.9	0.38 a	6.4	0.31 a	6.5	0.22 a	6.4	0.14 a	6.4	0.31 a	6.3
1/2-inch CCR	0.99 a	5.7	0.52 a	6.3	0.33 a	6.4	0.21 a	6.3	0.11 b	6.3	0.34 a	6.1
3/8-inch CCR	1.08 a	5.5	0.45 a	6.4	0.32 a	6.4	0.20 a	6.3	0.11 b	6.3	0.46 a	6.0
PB	1.12 a	5.2	0.52 a	5.0	0.34 a	6.0	0.18 a	5.9	0.11 b	5.8	0.28 a	5.7

[z]Treatments were: PB = pine bark, CCR = clean chip residual.
[y]DAP = days after planting.
[x]EC = mS/cm.
[w]Values within column followed by a different letter are significant using Waller-Duncan k ratio t tests (α =0.05, n = 4).

Table 3. Effects of various substrates on growth of *Loropetalum chinensis* var. *rubrum*.

	Growth indices[z]				Substrate shrinkage (cm)[y]	Rootball coverage (%)	Shoot dry weight
Substrate[x]	55 DAP[w]	92 DAP	141 DAP	373 DAP	373 DAP	373 DAP	377 DAP
1 1/4-inch CCR	20.4 a[v]	25.2 b	33.2 c	58.0 bc	2.9 a	57.5 c	60.3 c
3/4-inch CCR	22.9 a	31.4 a	41.2 a	66.6 a	2.1 b	71.9 b	81.7 abc
1/2-inch CCR	21.3 a	29.3 ab	40.3 ab	62.4 abc	1.9 b	77.5 ab	88.5 ab
3/8-inch CCR	20.0 a	28.2 ab	42.1 a	63.3 ab	2.1 b	83.1 ab	99.7 a
PB	20.0 a	25.0 b	35.8 bc	57.1 c	1.9 b	85.0 a	76.4 bc

[z]Growth indices [(height + width1 + width2)/3] presented in centimeters and shoot dry weight presented in grams.
[y]Measured from the top of the container to the surface of the substrate.
[x]Treatments were: PB = pine bark, CCR = clean chip residual.
[w]DAP = days after planting.
[v]Values within column followed by a different letter are significant using Waller-Duncan k ratio t tests (α =0.05).

Table 4. Tissue nutrient content of *Loropetalum chinensis* var. *rubrum* grown in varous substrates.

	Tissue nutrient content[z]										
Substrates	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)
1 1/4-inch CCR	1.4 a[y]	0.13 a	0.86 a	1.4 b	0.20 a	0.16 a	18 a	50 a	45 a	7 a	27 a
3/4-inch CCR	1.4 a	0.13 a	0.82 ab	1.4 b	0.20 a	0.15 a	19 a	49 a	40 a	10 a	33 a
1/2-inch CCR	1.3 a	0.12 a	0.70 c	1.4 b	0.19 a	0.14 a	19 a	48 a	35 a	10 a	33 a
3/8-inch CCR	1.3 a	0.13 a	0.74 bc	1.6 ab	0.21 a	0.14 a	20 a	59 a	33 a	10 a	31 a
PB	1.3 a	0.12 a	0.75 abc	1.7 a	0.20 a	0.15 a	17 a	48 a	38 a	7 a	31 a
Suffiencieny range[x]	1.43–1.90	0.10–0.13	0.40–0.52	2.0–2.9	0.13–0.15	0.12–0.14	55–126	58–69	15–35	4–6	7–10

[z]Tissue analysis performed on 50 recently mature leaves per plant.
[y]Mean separation within column by Waller-Duncan k ratio t tests ($\alpha = 0.05$, n = 4).
[x]Sufficiency range as published by Mills, H.A., and J. B. Jones. 1996. Plant Analysis Handbook II.

shoot growth, root growth was excellent (85.0% rootball coverage) as was the root growth of plants grown in 1/2 inch (77.5%) and 3/8-inch (83.1%) CCR. Plants grown in 1¼-inch CCR had the least rootball coverage (57.5%). Shoot dry weight at 377 DAP indicated that plants grown in 3/8 inch CCR had the greatest shoot growth (99.7 g) while plants grown in 3/4 inch and 1/2 inch CCR were similar (81.7g, 88.5 g). Plants grown in PB had the least shoot dry weight (76.4 g), but were similar to all other treatments except 3/8-inch CCR which had the greatest shoot dry weight.

There were no differences in substrate shrinkage (cm below the top of the container) at 7 and 92 DAP (data not shown). However, at the conclusion of the study substrates composed of 1¼ inch CCR had more substrate shrinkage (2.9 cm) than all other substrates (1.9 to 2.1 cm) (Table 3).

Tissue nutrient content of *Loropetalum* was similar among treatments for N, P, Mg, S, B, Fe, Mn, Cu, and Zn (Table 4). Potassium content among all treatments was higher (0.40%–0.86%) than the sufficiency range (0.40%–0.52%) (Mills and Jones, 1996), but all CCR treatments were similar to PB. Calcium tissue nutrient content was less in the larger CCR-particle sizes, however, 3/8-inch CCR calcium content was similar to PB.

DISCUSSION

Loropetalum grown in substrates composed of 3/8-, 1/2-, or 3/4-inch screen-size CCR tended to be larger than plants grown in the traditional pine bark substrate, while those grown in the larger screen size (1¼ inch) were the smallest plants in the study. There was also a trend for the smaller particle size media to have the best root growth. Consistency among pH and EC levels suggest that CCR will be a dependable substrate comparable to pine bark. Similarly, nutrient analysis shows that plant response is similar whether plants were grown in pine bark or CCR. These data demonstrate the *Loropetalum* can be successfully grown in CCR.

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