Alternative Substrates in Production of Trees in 25-Gallon Containers

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Significance to Industry: With a recent threat of diminishing available pine bark (PB) supplies, nursery growers need information about possible amendments or alternatives for their standard substrate mixes. Clean chip residual (CCR) and WholeTree (WT) substrates have been identified as two possible pine-based high wood content alternatives to PB for the production of annuals, perennials and woody ornamentals. This study shows the possibility of using 100% CCR or WT in the production of large container-grown trees (in 25-gal containers). The data suggests that while there are differences in the physical properties of these two alternatives compared to PB, the growth of three tree species (*Magnolia grandiflora* 'D.D. Blanchard', *Quercus shumardii*, and *Acer rubrum* 'Summer Red') was acceptable and generally similar to a PB standard.

Nature of Work: Pine bark (PB) supplies have wavered in availability over the past couple of years due to a downturn in the economy, a shift to in-field harvesting where bark is no longer brought to mills, and an increase in using PB as a biofuel material. Research in alternative potting substrates has continued across the country in an attempt to identify inexpensive, and locally available, substrate options that could offset any lapses in pine bark availability. Two high wood content, pine-based, substrates have been identified as potential amendments or replacements to pine bark in soilless media. WT consists of the entire pine tree harvested from pine plantations, generally at the thinning stage. It contains about 80% wood particles, 15% bark, and 5% needles. Several studies have shown WT to be a viable substrate alternative to peat (4,5,6,7) in the production of greenhouse-grown crops. CCR (approx. 50% wood, 40% bark, and 10% needles) was also evaluated as an alternative to peat in greenhouse substrates (2), as well as an alternative to PB in the production of perennial and woody nursery crops (1,3). CCR and WT were also evaluated together as potential amendments or alternatives to PB in the nursery production of six woody ornamental species in full gallon containers including 'New Gold' lantana (*Lantana camara* 'New Gold' L.), 'Gold Mound' spirea (*Spiraea japonica* 'Gold Mound' L.f.), 'Amaghasa' azalea (*Rhododendron* x 'Amaghasa' L.), tea olive (*Osmanthus fragrans* Lour.), 'Rotundifolia' ligustrum (*Ligustrum japonicum* 'Rotundifolia' Thunb.), and 'Soft Touch' holly (*Ilex crenata* 'Soft Touch' Thunb.) (8). Treatments consisted of 100% PB, WT, and CCR, and then

treatments with either 25, 50, or 75% CCR or WT mixed with PB. Data from the study showed that after 365 days, five of the six species tested showed no difference in growth indices of any treatment compared to the PB standard.

Most of the previous research has evaluated production in 1-gal containers, and for only one growing season. In continuing the search for alternative substrates, this study was developed to evaluate long-term production with two particle sizes each of CCR and WT in 25-gal container production of three common tree species. Container-grown 3-gal liners of 'D.D. Blanchard' magnolia (*Magnolia grandiflora* 'D.D. Blanchard' L.), shumard oaks (*Quercus shumardii* Buckland), and 'Summer Red' maples (*Acer rubrum* 'Summer Red' L.) were potted into 25-gallon containers on April 22 and 24, 2009. Five substrate treatments were evaluated, including two 100% WT treatments [0.64 and 0.95 cm (1/4 in and 3/8 in)], two 100% CCR treatments [1.91 and 2.54 cm (0.75 in and 1 in)] and a 100% PB control. Dolomitic limestone was incorporated into each substrate at 3.0 kg/m^3 (5 lb/yd^3). Fertilizer [17N-2.1P-9.1K (17-5-11) Polyon CRF (11-12 month release) with blended minors (Harrell's Fertilizer, Inc., Lakeland, FL)], at 5.0 kg/m^3 (10 lbs/yd^3), was applied using a modified dibble method, where 75% of the pot was filled with substrate, the plant was placed inside, and 590 grams of fertilizer was poured around the root ball. The rest of the substrate was then placed around the root ball until the pot was filled completely. Trees were watered with spray stakes (Netafilm PC Spray Stakes; Double Spray; 6.6GPH) for 12 minutes twice per day [3.17 cm (1.25 in) total per day] On March 8, 2010 (320 DAP), the trees were fertilized again (dibble method with two holes per pot) with 590 g 17N-2.1P-9.1K (17-5-11) Polyon CRF (11-12 month release) (Harrell's Fertilizer, Inc., Lakeland, FL); this time without any blended minors. Trees were grown for a total of 500 days. Physical properties [air space (AS), container capacity (CC), total porosity (TP), and bulk density (BD)] were determined prior to planting on base substrates (without incorporated lime). Substrate pH and electrical conductivity (EC) were measured throughout the study at 30, 180, 365 and 500 DAP using the pour-through method. Height and caliper were both measured at 14 and 180 DAP, as well as at study termination (500 DAP). Height (cm) was measured from the substrate surface to the apical bud on each plant, while caliper (cm) was measured 15.2 cm (6 in) above the substrate surface. The experiment was a randomized complete block design with 8 replicates for each species tested. Data were analyzed using Tukey's Honestly Significant Difference Test ($p \leq 0.05$) in SAS (SAS® Institute version 9.2, Cary, NC).

Results and Discussion: While all container substrate AS and CC percentages were within the respective recommended ranges (10-30% for AS; 45-65% for CC), there were differences among treatments (Table 1). The 100% PB treatment had significantly less AS (11.6%) than all other treatments, while the 3/8" WT treatment had higher AS (32.1%) than the ¼" WT and both CCR treatments. With only one exception at 86.3% (3/4" CCR), all container substrate TP percentages were also within the recommended range (50-85%).

Except for the 100% PB treatment at 500 DAP (4.4), all pH values were within the BMP recommended range for nursery crops (4.5-6.5) (Table 2) (9). As expected, pH values

generally decreased over time, and were similar at all but one testing date (270 DAP). At 270 DAP, all treatments were similar to the 100% PB standard (5.7) except for the 3/8" WT treatment (6.2). Values for EC followed the same general trend as pH, except that by 500 DAP, the EC of all treatments had increased from an average of 0.13 mS/cm at 270 DAP to an average of 1.3 mS/cm (Table 2). This can be attributed to the addition of dibbled fertilizer that occurred at 320 DAP. There were no differences among treatments at any testing date for EC.

For height and caliper of both 'D.D. Blanchard' magnolia and shumard oaks, there were no differences across any treatment at any testing date (14, 180, and 500 DAP) (data not presented). For 'Summer Red' maple, there were no differences for height or caliper across all treatments at 14 DAP, indicating that the plants were adequately blocked for height at the beginning of the study (Table 3). At 180 DAP, the only treatment that was different in height from the 100% PB control (248.8 cm) was the ¼" WT treatment (201.1 cm). However, by 500 DAP, there were no differences for height across any treatment. Differences in caliper occurred at both 180 and 500 DAP. Both WT treatments (2.8 cm for both ¼" and 3/8" WT) were different from the 100% PB control (3.3 cm) at 180 DAP, but by 500 DAP, the only treatment different from the 100% PB control (3.8 cm) was the ¼" WT treatment (3.4 cm).

While there were differences in physical properties between substrates, there were few differences in growth parameters (height and caliper). This data suggests that WT and CCR may be viable alternatives to PB in the production of large container-grown trees.

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Table 1. Physical properties of five substrates containing pine bark, clean chip residual, and *WholeTree*[z].

Substrate[y]	Air Space[x] (% vol)	Substrate water holding capacity[w] (% vol)	Total Porosity[v] (% vol)	Bulk density ($g \cdot cm^{-3}$)[u]
PB	11.6 c[t]	55.6 bc	67.1 d	0.46 a
1/4" WT	20.6 b	58.5 ab	79.2 c	0.39 c
3/8" WT	32.1 a	51.6 c	83.7 b	0.34 d
3/4" CCR	24.2 b	62.2 a	86.3 a	0.32 e
1" CCR	22.0 b	59.8 ab	81.8 b	0.41 b
Recommended Range[s]	10-30%	45-65%	50-85%	0.19-0.70

[z]Analysis performed using the North Carolina State University porometer (http://www.ncsu.edu/project/hortsublab/diagnostic/porometer/).

[y]PB = pine bark, CCR = clean chip residual, WT = *WholeTree*.

[x]Air space is volume of water drained from the sample / volume of the sample.

[w]Substrate water holding capacity is (wet weight - oven dry weight) / volume of the sample.

[v]Total porosity is substrate water holding capacity + air space.

[u]Bulk density after forced-air drying at 105C (221.0F) for 48 hrs; 1 $g \cdot cm^{-3}$ = 62.4274 $lb \cdot ft^{-3}$.

[t]Means within column followed by the same letter are not significantly different based on Tukey's Studentized Range Test at $\alpha = 0.05$ (n=3).

[s]Recommended ranges as reported by Yeager, et al., 2007. Best Management Practices Guide for Producing Container-Grown Plants.

Table 2. Solution pH and substrate electrical conductivity (EC) for five substrates containing pine bark, clean chip residual, or *WholeTree*[z].

	30 DAP[x]		120 DAP		270 DAP		500 DAP	
Substrate[y]	pH	EC ($mS \cdot cm^{-1}$)[w]	pH	EC ($mS \cdot cm^{-1}$)	pH	EC ($mS \cdot cm^{-1}$)	pH	EC ($mS \cdot cm^{-1}$)
PB	6.2 [v ns]	0.36 [ns]	5.9 [ns]	0.20 [ns]	5.7 b	0.14 [ns]	4.4 [ns]	1.25 [ns]
1/4" WT	6.4	0.41	6.2	0.18	6.1 ab	0.14	5.3	1.38
3/8" WT	6.4	0.34	6.2	0.15	6.2 a	0.12	4.6	1.58
3/4" CCR	6.3	0.30	6.3	0.15	6.1 ab	0.11	4.6	1.02
1" CCR	6.3	0.36	6.1	0.32	5.8 ab	0.12	4.7	1.43

[z]pH and EC of solution determined using pour-through method on 'D.D. Blanchard' magnolia.

[y]PB = pine bark, CCR = clean chip residual, WT = *WholeTree*.

[x]DAP = days after planting.

[w]1 $mS \cdot cm^{-1}$ = 1 $mmho \cdot cm^{-1}$.

[v]Means within column followed by the same letter are not significantly different based on Tukey's Studentized Range (HSD) Test at $\alpha = 0.05$ (n=4).

[ns]Means not significantly different.

Table 3. Effect of five substrates containing pine bark, clean chip residual, or *WholeTree* on height and caliper[z] of 'Summer Red' maple.

	Height			*Caliper*		
Substrate[y]	14 DAP	180 DAP	500 DAP	14 DAP	180 DAP	500 DAP
PB	175.6 [ns, w]	248.8 a	274.6 [ns]	1.8 [ns]	3.3 a	3.8 a
1/4" WT	169.9	201.1 b	270.7	1.8	2.8 b	3.4 b
3/8" WT	173.0	214.8 ab	263.8	1.7	2.8 b	3.5 ab
3/4" CCR	167.0	217.3 ab	257.3	1.9	3.0 ab	3.6 ab
1" CCR	169.4	214.8 ab	276.9	1.7	3.0 ab	3.6 ab

[z]Height and caliper measured in cm.

[y]PB = pine bark, CCR = clean chip residual, WT = *WholeTree*.

[x]DAP = days after planting.

[w]Means within column followed by the same letter are not significantly different based on Tukey's Studentized Range Test at $\alpha = 0.05$ (n = 8).

[ns]Means not significantly different.