Woody Shrub Production With Alternative Substrates: Aged vs. Fresh©

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INTRODUCTION

Recent research has identified two potential materials to meet nursery grower's needs: Clean Chip Residual (CCR) and WholeTree (WT). Both of these alternative substrates contain higher wood content than pine bark alone. The CCR is a product composed of approximately 50% wood, 40% bark, and 10% needles (Boyer et al., 2008a). It is created when transportable in-field harvesters are used to process pines into "clean chips" that can be used by pulp mills. One study evaluating CCR as an alternative substrate in annual species production (Boyer et al., 2008b) reported that two out of three species tested had similar growth when compared to standard PB substrates. Another study evaluating perennial species production in CCR (Boyer et al., 2008a) determined that there were few differences in growth at the conclusion of the study for most species. In 2009, Boyer et al. also reported that CCR as an alternative nursery crop substrate for container-grown ornamentals was acceptable for use at several screen sizes 3.2, 1.9, 1.3, 1.0 cm (1 1/4, 3/4, 1/2, 3/8 in.) (Boyer et al., 2009). In general, studies indicate that plants grown in CCR are comparable to those grown in a traditional PB substrate.

WholeTree is different from CCR in that it consists of the entire pine tree harvested from pine plantations at the thinning stage, therefore having a higher wood content than CCR (Fain et al., 2008). Just as with CCR, several studies have been conducted to assess the value of WT as a comparable substrate to traditional PB (Fain et al., 2006). A study evaluating annual vinca grown in WT showed plant growth similar to growth of plants grown in PB (Fain and Gilliam, 2006). Another study by Fain et al. (2006) evaluating WT in production of herbaceous greenhouse crops indicated mixed results. In general, plants grown in WT substrates were smaller than plants in other blends, but plants increased in size with increasing peat moss percentage.

Most of the studies thus far have used fresh WT and CCR. However, PB is often aged for several months before use in nursery crop production. Many growers prefer to have aged PB and have asked if additional benefits could occur with aging WT or CCR. The objective of this study was to compare growth of several woody nursery crops in fresh and aged CCR and WT.

MATERIALS AND METHODS

Five substrates were evaluated in this study, including a traditional PB substrate, along with aged and fresh samples of both CCR and WT. Fresh CCR (42 days old at planting) was obtained from a forestry operation at an 11–12 year old pine plantation in Flomaton, Alabama. Aged CCR (451 days old at planting) was acquired from an operation in Atmore, Alabama. Fresh WT (32 days old at planting) came from a 15-year old plantation in Lumpkin, Georgia, and aged WT (431 days old at planting) was obtained from Georgetown, Georgia. Before the study was initiated, each substrate was processed further to pass through varied screen sizes in a #30 Swinging hammer-mill (#30, C.S. Bell Co., Ohio). Fresh CCR and aged WT were both processed through a 1.0-cm (3/8-in.) screen. Aged CCR particles were processed through a 1.3-cm (0.5-in.) inch screen, and fresh WT was processed through a 0.6-cm (1/4-in.) screen. All substrates were mixed 6 : 1 (v/v) with sand.

Treatments were amended prior to planting with 8.3 $kg \cdot m^{-3}$ (14 lb/yd^3) Polyon (Harrell's Fertilizer, Inc., Lakeland, Florida) controlled-release fertilizer (9 months), 2.97 $kg \cdot m^{-3}$ (5 lb/yd^3) dolomitic limestone, and 0.9 $kg \cdot m^{-3}$ (1.5 lb/yd^3) Micromax (The Scotts Company, Marysville, Ohio).

Ten species were evaluated, including: *Ilex crenata* 'Soft Touch', *Juniperus horizontalis* 'Wiltonii', *Spiraea cantoniensis* 'Reeves', *Ternstroemia japonica* 'Conthery', *Loropetalum chinense* 'Ruby', *Gardenia jasminoides* 'August Beauty', *Lantana camara* 'Lucky Yellow Improved', *Rosa* 'Radrazz', Knock Out® rose, *Rhaphiolepis indica*, and *Nandina domestica* 'Firepower'. All species were potted in #1 containers.

Substrates were mixed on 24 March 2008, and planted the following day, on 25 March 2008. Plants were placed on a full-sun nursery pad, except for nandina, which was under a 30% shade structure. All plants were irrigated using overhead irrigation. The experimental design was a randomized complete block design with 20 single pot replications per treatment. Each species was treated as its own separate experiment.

Leachates were collected to determine pH and electrical conductivity (EC) values using the pour-through method at 7, 15, 30, and 180 DAP. Other data, including plant growth indices [(height + width + width)/3] (at 90 and 180 DAP), and substrate shrinkage (at 15 and 180 DAP) was determined throughout the study. Root growth was also rated at termination (180 DAP) on a scale from 1–5, where 1 was no visible roots on the outer root ball, and 5 was 100% coverage of root ball surface. Studies were conducted at the Paterson Greenhouse Complex on the Auburn University campus.

RESULTS

With few exceptions, pH values reported were within the BMP recommended pH range (4.5–6.5) (Yeager et al., 2007) (Table 1). In general, 100% PB substrate had the lowest pH values throughout the test. Fresh WT had the highest pH value of 6.8 (30 DAP), however it was statistically similar to all other treatments. For the most part, both CCR treatments, fresh and aged, were similar to pH levels in 100% PB.

Fresh and aged CCR had statistically similar values for EC at all testing dates (Table 1). Fresh and aged WT were similar at both 7 and 15 DAP, although at 30 DAP, the EC value for fresh WT (0.38 $dS \cdot m^{-1}$) was lower than that of aged WT (0.58 $dS \cdot m^{-1}$). With relatively few exceptions, all values reported were similar to that of a traditional PB substrate, indicating that similar nutritional amendments would be needed for these new alternatives.

Growth indices [(height + width1 + width2)/3] were recorded for each species (in cm) at 90 and 180 DAP (Table 2). By 180 DAP; there were no statistical differences in any of the substrates for nandina, rose, and spiraea. With raphiolepsis and loropetalum at 180 DAP, plants in aged CCR were the largest. Plants grown in aged WT also did well, as 5 of the 10 species tested were statistically as large, or larger than, those grown in PB substrate at 180 DAP. For the most part, plants grown in fresh WT were statistically the same as those grown in aged WT. Only once at 180 DAP was this not the case. For ternstroemia at 180 DAP, plants in aged WT were statistically larger than those in fresh WT. The same trend occurs in the comparison of fresh and aged CCR in both raphiolepsis and loropetalum at 180 DAP, where plants grown in aged CCR were larger than those in fresh CCR.

Shrinkage of substrates (in cm) was measured on holly at 15 and 180 DAP. The differences between shrinkage amounts at 180 DAP and 15 DAP were also calculated and analyzed. Substrate of 100% PB had the least amount of shrinkage (0.87 cm) throughout the study, indicating that over time, it held up better, and didn't compact as much as the others (Table not included because of space limitations). Shrinkage of fresh CCR (1.9 cm) was similar to shrinkage of aged CCR (1.6 cm). Aged WT (1.5 cm) had less shrinkage that Fresh WT (2.8 cm).

Plants grown in aged CCR had among the highest root ratings in 9 of 10 species (Table 3). Traditional 100% PB had the highest statistical ratings on 8 of the 10 species. Aged treatments

Table 1. Effect of substrate on pH[z] and electrical conductivity[z] (EC) in *Ternstroemia.*

Substrate	7 DAP[y]		15 DAP		30 DAP		180 DAP	
	pH	EC[x]	pH	EC	pH	EC	pH	EC
100% PB[w]	5.9 b[t]	0.45 a	6.0 b	0.30 b	6.5 a	0.52 ab	5.9 b	0.30 a
Fresh CCR[v]	6.4 ab	0.44 a	6.6 a	0.33 ab	6.4 a	0.46 ab	5.8 b	0.29 a
Aged CCR	6.3 ab	0.65 a	6.5 a	0.48 a	6.5 a	0.54 a	6.3 a	0.28 ab
Fresh WT[u]	6.0 ab	0.55 a	6.5 a	0.43 ab	6.8 a	0.38 b	6.4 a	0.29 a
Aged WT	6.5 a	0.54 a	6.6 a	0.41 ab	6.7 a	0.58 a	6.3 a	0.26 b

[z]pH and EC of solution determined using pour-through method.

Abbreviations: [y]DAP = Days after planting, [x]EC = Electrical Conductivity (dS/m), [w]PB = Pine Bark, [v]CCR = Clean Chip Residual, [u]WT = WholeTree.

[t]Means separated in columns by Duncan's Multiple Range Test at P = 0.05.

Table 2. Substrate effect on growth indices[z] for *Ilex crenata* 'Soft Touch', *Juniperus horizontalis* 'Wiltonii', *Spiraea cantoniensis* 'Reeves', *Ternstroemia japonica* 'Conthery', *Loropetalum chinense* 'Ruby', *Gardenia jasminoides* 'August Beauty', *Lantana camara* 'Lucky Yellow Improved', *Rosa* "Radrazz', Knock Out® rose', *Rhaphiolepis indica*, and *Nandina domestica* 'Firepower'.

	Growth Indices									
	Ternstroemia		*Nandina*		*Gardenia*		*Rhaphiolepis*		*Juniperus*	
Substrate	90 DAP[y]	180 DAP	90 DAP	180 DAP	90 DAP	180 DAP	90 DAP	180 DAP	**90 DAP**	**180 DAP**
100% Pb[x]	28.6 ab[u]	40.2 a	35.3 a	47.2 a	30.1 a	56.5 a	28.9 a	40.9 b	**25.2 a**	**43.0 a**
Fresh CCR[w]	28.6 ab	36.6 bc	31.5 bc	46.1 a	29.8 a	51.0 bc	28.5 a	39.9 b	**20.3 b**	**37.2 bc**
Aged CCR	28.6 ab	38.6 ab	32.5 abc	45.7 a	30.0 a	53.2 b	32.0 a	45.3 a	**22.3 ab**	**40.9 b**
Fresh WT[v]	28.6 ab	35.0 c	30.0 c	44.7 a	28.6 a	49.9 c	30.5 a	43.2 ab	**25.0 a**	**44.6 c**
Aged WT	28.6 ab	38.1 ab	33.9 ab	45.0 a	27.8 a	50.1 c	29.8 a	43.2 ab	**24.6 ab**	**40.4 bc**
	Lantana		*Loropetalum*		*Rosa*		*Spiraea*		*Ilex*	
Substrate	90 DAP	180 DAP	90 DAP	180 DAP	90 DAP	180 DAP	90 DAP	180 DAP	90 DAP	180 DAP
100% Pb[x]	52.8 a	96.8 a	33.4 ab	57.4 b	37.7 a	59.2 a	60.1 a	82.6 a	15.2 a	28.3 a
Fresh CCR[w]	41.9 b	82.3 b	22.4 c	57.0 b	35.6 ab	56.6 a	52.8 b	83.1 a	12.6 b	25.6 b
Aged CCR	44.5 b	83.1 b	34.1 ab	64.2 a	37.3 a	58.1 a	59.7 a	80.5 a	13.1 b	26.2 b
Fresh WT[v]	37.3 c	80.1 b	31.1 bc	56.0 b	34.2 b	57.5 a	55.4 ab	84.2 a	12.9 b	24.4 b
Aged WT	45.1 b	81.8 b	35.2 a	58.2 b	36.7 ab	57.4 a	60.2 a	84.5 a	13.2 b	25.5 b

[z]Growth indices reported as (height + width1 + width 2) ÷ 3.

Abbreviations: [y]DAP = Days after transplanting, [x]PB = Pine Bark, [w]CCR = Clean Chip Residual, [v]WT = WholeTree.

[u]Means separated in columns by Duncan's Multiple Range Test at P = 0.05.

Table 3. Root ratings of root growth due to effect from substrates[z] for *Ilex crenata* 'Soft Touch', *Juniperus horizontalis* 'Wiltonii', *Spiraea cantoniensis* 'Reeves', *Ternstroemia japonica* 'Conthery', *Loropetalum chinense* 'Ruby', *Gardenia jasminoides* 'August Beauty', *Lantana camara* 'Lucky Yellow Improved', *Rosa* "Radrazz', Knock Out® rose', *Rhaphiolepis indica*, and *Nandina domestica* 'Firepower'.

	Root rating[y]									
Substrate	*Ternstroemia*	*Nandina*	*Gardenia*	*Rhaphiolepis*	*Juniperus*	*Lantana*	*Loropetalum*	*Rosa*	*Spiraea*	*Ilex*
100% PB[x]	2.4 b[u]	4.7 a	4.9 a	3.0 a	3.4 a	4.8 ab	4.0 ab	3.3 b	5.0 a	2.9 a
Fresh CCR[w]	3.3 a	3.6 b	4.6 ab	2.8 a	2.9 ab	4.5 b	3.5 bc	3.2 b	4.9 a	2.9 a
Aged CCR	3.4 a	3.4 b	4.7 ab	3.3 a	3.1 ab	5.0 a	4.1 a	3.9 a	5.0 a	3.0 a
Fresh WT[v]	3.5 a	3.1 b	4.4 bc	3.4 a	2.7 b	4.7 b	3.3 c	3.1 b	5.0 a	2.6 a
Aged WT	3.5 a	3.7 b	4.1 c	3.2 a	2.8 b	4.8 ab	3.4 c	3.3 b	5.0 a	2.9 a

[z]Ratings taken at study termination (180 days after planting).

[y]Rating scale ranges from 1–5, where 1 = 0-20% root coverage of the root ball and 5 = 100% coverage.

Abbreviations: [x]PB = Pine Bark, [w]CCR = Clean Chip Residual, [v]WT = WholeTree.

[u]Means separated in columns by Duncan's Multiple Range Test at $P = 0.05$.

of both CCR and WT tended to have higher root ratings than their fresh counterparts. While aged CCR had 9 out of 10 species in the highest statistical category, fresh CCR had only 6 out of the 10. Aged WT had only 5 out of the 10 species in the highest statistical category, however it still had more than fresh WT, which only had 3 of the 10 in the highest statistical category.

DISCUSSION

Before beginning this experiment, existing research showed that fresh CCR and WT products could be used as comparable, sustainable alternatives to PB substrates. Many nursery producers prefer aged PB for use in nursery production. Data in this experiment shows that the same may also be true for CCR and WT, depending on the species being grown. Throughout the study, data showed that aged CCR or WT could produce larger, healthier plants, that in some cases may look better than plants grown in 100% PB. This is good news to industry professionals, since this data shows that CCR and WT substrates can be stored without having a negative impact on plant health and growth.

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