Ground Pine Chips as a Substrate for Container-grown Woody Nursery Crops[1]

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Abstract

The objective was to compare pine wood chips (PC) to pine bark (PB) for use as a container substrate for the production of a wide range of woody species. The PC substrate was prepared by grinding coarsely ground [approximately 2.5 cm × 2.4 cm × 0.6 cm (1 in × 1 in × ¼ in)] debarked pine logs (*Pinus taeda* L.) in a hammer mill to pass a 6.35 mm (0.25 in) screen. Plants of several woody taxa were potted on two different dates (April 4 and May 18, 2005) in each of the two substrates in 3.8 liter (1 gal) containers and grown in a glass house or on outdoor beds in Blacksburg, VA, until late August. Shoot dry weight (SDW) of 13 of 18 species in the April planting was not different between PB and PC, with SDW of four species in this planting being higher when grown in PB and one being higher when grown in PC. Shoot dry weight for 6 of 10 species in the May planting was higher in PB compared to PC. Instances of reduced growth with PC compared to PB were attributed to reduced nutrient availability in PC compared to PB. Results suggest that with adjustments to fertility, PC can be a suitable substrate for container production of woody ornamental plants.

Index words: pine bark, nutrition, nursery production, loblolly pine, *Pinus taeda* L., media.

Species used in this study: See Table 1.

Significance to the Nursery Industry

Due to concerns regarding the availability of pine bark, alternative substrates for container nursery production would be desirable. Results indicate that a container substrate composed of ground pine chips offers promise as a substitute for pine bark for a wide range of woody taxa. More research is needed to address fertility issues with pine chips before it can be fully recommended.

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Introduction

Many studies have investigated the use of industrial and agriculture wastes as substitutes for peat moss and pine bark, including animal wastes (12), cotton gin waste (10), wood by-products (7, 2), municipal leaf and sewage sludge (1, 11) rice hulls (3), coconut coir dust (4), and residential refuse (5). Most of these alternative substrate components show promise in that they are non-toxic to plants and can be successfully used to amend conventional substrates. However, regional availability and a limited supply of uniform and consistent quality product reduce their widespread usage. Kenna and Whitcomb (6) demonstrated that *Pyracantha* x 'Mojave' and *Liquidambar formosana* Hance. (Formosan gum) grew as well in a substrate of 3:1:1 (by vol) hardwood

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chips:peat:sand as in a substrate composed of 3:1:1 (by vol) pine bark:peat:sand. A more recent approach to alternative substrates was described by Wright and Browder (15). They demonstrated that Japanese holly (*Ilex crenata* 'Chesapeake'), azalea (*Rhododendron obtusum* 'Karen'), and marigold (*Tagetes erecta* 'Inca Gold') could be grown in 100% ground loblolly pine (*Pinus taeda*) logs, (pine chips, PC), compared to 100% pine bark (PB). Shoot dry weight of azalea and marigold was higher in 100% PB than in 100% PC, and there was no difference in shoot dry weight between the substrates for Japanese holly. Nutrient analysis of the substrate solution indicated that there were no toxic nutrient levels associated with PC, and the pH was also acceptable for plant culture. There was no apparent shrinkage due to decomposition during the two to three month experiment. Therefore, whole loblolly pine logs processed into PC may be a suitable and economical alternative substrate to conventional substrates for the nursery industry. Trees are renewable, reasonably priced, and widespread geographically, allowing a substrate to be produced near growers, thereby reducing costs related to the transportation of raw materials and distribution of the finished substrates. The objectives of this study were to determine if a wide range of woody nursery crops can be produced in PC and what limitations might exist with using PC as a container substrate.

Materials and Methods

April planting. On April 4, 2005, 18 different plant taxa (Table 1) were potted in 3.8 liter (1 gal) plastic containers containing either aged PB (*P. taeda* L.) or fresh PC (*P. taeda* L.). Liners had been propagated during summer 2004 in a 50:50 (v/v) peatmoss perlite substrate in 7.5 cm (3 in) square containers. Pine chips were produced by taking chips from roughly ground debarked pine logs and further grinding them in a hammer mill (Meadows Mills, Inc., North Wilkesboro, NC) to pass through a 6.35 mm (0.25 in) screen. Pine chips were amended with 5% (by vol) 16/30 particle size calcined clay (Oil-Dri Corp., Chicago, IL) and 0.6 kg/m^3 (1 lb/yd^3) $CaSO_4$. Dolomitic lime at a rate of 3.5 kg/m^3 (6 lb/yd^3) was pre-plant incorporated into PB (but not PC) for all taxa except 'Hinodegiri' azalea, 'Kleim's Hardy' gardenia, and 'Compacta' and 'Soft Touch' hollies. Substrate solution pH was higher for PC than PB, a result that has been seen in a number of unpublished studies by these authors. It was for this reason that no limestone was added to PC. Plants were fertilized with 21 g (0.74 oz) of topdressed 15N–3.9P–10K Osmocote Plus (9-month release with micronutrients) (O.M. Scott Horticulture Products, Marysville, OH) per container. Substrate solution was extracted for four reps of four species using the pour-through method (14) on April 19 and analyzed for pH, electrical conductivity (EC), and concentrations of NO_3, NH_4, P, K, Ca, Mg, S, Fe, Cu, Mn, and Zn; ion concentrations were determined by inductively coupled plasma (ICP) analysis. Plants were glasshouse grown on raised benches in Blacksburg, VA, with an average day/night temperature of 26/22C (79/72F) and hand watered as needed. After 10 weeks plants were moved outdoors onto a gravel pad at the Urban Horticulture Center, Blacksburg, VA, and all species irrigated the same as needed with overhead irrigation. Approximately 1.2 cm (0.5 in) of water was applied with each irrigation. On August 8, the most recently matured tissue was collected from four reps of 'Green Giant' arborvitae, 'Hinodegiri' azalea, 'Compacta' holly, 'Yoshino' cryp-

Table 1. Common, scientific, and cultivar names for species in April planting and May planting.

Common name	Scientific name	Cultivar
April		
Arborvitae	*Thuja plicata* D. Don.	'Green Giant'
Azalea	*Rhododendron sp.* L.	'Hinodegiri'
Barberry	*Berberis thunbergii* D.C.	'Crimson Pygmy'
Blue fescue	*Festuca glauca* L.	
Boxwood	*Buxus microphylla* var. *koreana* Nak.	'Wintergreen'
Carissa holly	*Ilex cornuta* Lindl. & Paxt.	'Carissa'
Compacta holly	*Ilex crenata* Thunb.	'Compacta'
Crapemyrtle	*Lagerstroemia indica x fauriei* L.	'Tuscarora'
Cryptomeria	*Cryptomeria japonica* D. Don.	'Yoshino'
Gardenia	*Gardenia jasminoides* Ellis.	'Kleim's Hardy'
Liriope	*Liriope muscari* Lour.	'Variegata'
Nandina	*Nandina domestica* Thunb.	'Firepower'
Pfitzer juniper	*Juniperus chinensis* L.	'Pfitzeriana'
Shore juniper	*Juniperus conferta* Parl.	
Soft Touch holly	*Ilex crenata* Thunb.	'Soft Touch'
Viburnum	*Viburnum dilatatum* Thunb.	'Asian Beauty'
Waxleaf ligustrum	*Ligustrum japonicum* Thunb.	'Texanum'
Weigelia	*Weigelia florida* (Bunge) A. DC.	'Wine and Roses'
May		
Arborvitae	*Thuja occidentalis* L.	'Emerald Green'
Azalea	*Rhododendron sp.* L.	'Hinodegiri'
Barberry	*Berberis thunbergii atropurpurea* D.C.	'Rose Glow'
Blue rug juniper	*Juniperus horizontalis* Moench.	'Wiltonii'
Boxwood	*Buxus microphylla* var. *koreana* Nak.	'Wintergreen'
Carissa holly	*Ilex cornuta* Lindl. & Paxt.	'Carissa'
Compacta holly	*Ilex crenata* Thunb.	'Compacta'
Gold Mound spirea	*Spiraea* x *bumalda* Burv.	'Gold Mound'
Nippon spirea	*Spiraea nipponica* Maxim.	
Weigela	*Weigelia florida* (Bunge) A. DC.	'Wine and Roses'

Table 2. **Growth index and shoot dry weight data for woody taxa grown in pinebark (PB) or pine chips (PC).**

Common name	Growth index[z] PB	Growth index[z] PC	Shoot dry wt (g) PB	Shoot dry wt (g) PC
	April			
Arborvitae	43.4a[y]	43.7a	41.4a	41.7a
Azalea	44.1a	42.3a	49.0b	61.8a
Barberry	38.5a	37.2a	11.6a	12.3a
Blue fescue	43.0a	38.2a	55.0a	49.7a
Boxwood	25.2a	25.2a	22.6a	21.7a
Carissa holly	27.9a	26.8a	36.3a	27.4b
Compacta holly	41.2a	39.3a	58.6a	40.0a
Crape myrtle	69.7a	58.7b	58.8a	59.7a
Cryptomeria	44.3a	48.4a	37.3a	33.2a
Gardenia	36.1a	35.1a	41.7a	35.5a
Liriope	37.5b	41.9a	22.8a	18.2b
Nandina	42.0a	41.8a	70.4a	69.9a
Pfitzer juniper	53.4a	52.6a	53.7a	39.8b
Shore juniper	25.5a	22.6a	28.3a	20.5b
Soft Touch holly	33.0a	33.8a	47.9a	47.9a
Viburnum	56.1a	50.0b	65.5a	59.8a
Waxleaf ligustrum	46.4a	45.0a	72.0a	70.9a
Weigelia	61.0a	55.0a	68.1a	56.7a
	May			
Arborvitae	29.2b	31.3a	51.0a	41.4b
Azalea	40.7a	35.6b	44.5a	29.4b
Barberry	59.8a	52.8a	22.5a	17.6b
Blue rug juniper	45.9a	46.0a	38.2a	36.7a
Boxwood	20.1a	19.3a	10.0a	8.2a
Carissa holly	31.5a	24.6b	43.1a	22.6b
Compacta holly	36.4a	32.2b	38.0a	28.6b
Gold Mound spirea	41.2a	39.4a	41.8a	36.4a
Nippon spirea	45.4a	43.5a	52.3a	37.7b
Weigela	48.5a	46.8a	48.0a	37.6a

[z]Growth index = (height + widest width + perpendicular width) / 3

[y]Lowercase letters denote mean separation (n = 6) between substrates within taxa by LSD, $P = 0.05$.

tomeria, 'Firepower' nandina, and 'Soft Touch' holly, and analyzed for N, P, K, Ca, Mg, S, Fe, Cu, Mn, and Zn concentrations (The Penn State University, Agricultural Analytical Services Laboratory, University Park, PA). On Aug 24 growth measurements were taken to calculate a growth index for each plant (height + widest width + perpendicular width) / 3 and plant dry weight was determined by severing stems at the substrate surface, drying at 65C and weighing.

May planting. An experiment similar to the previous experiment was conducted from May 18 to August 24, 2005, using 10 woody plant species (Table 1). Dolomitic lime at a rate of 3.5 kg/m^3 (6 lb/yd^3) was pre-plant incorporated into PB for all species except 'Hinodegiri' azalea. Clay and $CaS0_4$ were incorporated in PC as above. All substrates were topdressed with 15 g (0.52 oz) of the above Osmocote fertilizer per container except for 'Hinodegiri' azalea which was topdressed with 11 g (0.39 oz). Plants were grown outdoors on a gravel pad and irrigated as above. On August 24 growth indicies and plant dry weight were determined as with the April planting.

The experimental design for the April planting experiment was completely randomized with 6 single container replications per treatment for all species except 'Hinodegiri' azalea, 'Compacta' holly, 'Yoshino' cryptomeria, and 'Firepower' nandina which had 4 single container replications. The experimental design for the May planting experiment was completely randomized with 6 single container replications per treatment. Data were subjected to analysis of variance (ANOVA) using SAS (SAS Institute, Cary, NC, version 9.1.3), and least significant difference (LSD) values were generated by this procedure, $P = 0.05$.

Results and Discussion

For the April planting, the growth index for most taxa (15 out of 18) was not different between PC and PB; crape myrtle and viburnum were larger when grown in PB, and liriope was larger when grown in PC (Table 2). Shoot dry weight was not different between the two substrates for 13 of 18 taxa; carissa holly, liriope, pfitzer juniper, and shore juniper were higher when grown in PB, and azalea was higher when grown in PC (Table 2). For the May planting, growth index for 6 of 10 taxa was not different between PC and PB. 'Hinodegiri' azalea, 'Carissa' holly and 'Compacta' holly were larger when grown in PB, while 'Green Giant' arborvitae was larger when grown in PC. Shoot dry weight was higher for 6 of 10 taxa in PB, with no difference for juniper, boxwood, spiraea, and weigela (Table 2).

When substrate solution concentrations of N, P, and K differed between substrates they were higher in PB compared to PC (Table 3). With the other nutrients there were few differences between PB and PC, with the exception that S concentration, reflective of the additions of $CaSO_4$ to PC, which was higher in PC than PB for three of the four species (Table 3). Copper concentrations and pH were also higher in the

Table 3. **Substrate solution pH and nutrient concentrations for four woody taxa grown in pine bark (PB) or pine chips (PC) (April study).**

Common name	Substrate	pH	NO_3	NH_4	P	K	Ca	Mg	S	Cu	Fe	Mn	Zn
			ppm										
Azalea[y]	PB	3.9b[z]	85.3a	19.0a	15.0a	104.3a	40.5a	27.3a	13.8a	0.003b	1.03a	1.19a	0.24a
	PC	6.2a	7.5b	2.0a	2.0a	46.3b	26.8a	11.5b	16.8a	0.118a	0.31b	0.03b	0.30a
Compacta holly	PB	3.8b	118.3a	32.0a	17.8a	132.3a	54.3a	27.0a	21.0b	0.02b	0.95a	1.81a	0.29a
	PC	6.6a	57.0b	5.0a	3.0b	91.3a	88.0a	40.0a	84.8a	0.27a	0.52a	0.12b	0.30a
Shore juniper	PB	5.1b	116.5a	6.3a	12.5a	112.8a	53.8a	58.0a	17.3b	0.02b	0.40a	0.19a	0.20a
	PC	6.4a	32.3b	3.0b	4.0b	70.8b	56.5a	25.0b	45.8a	0.14a	0.27b	0.05a	0.27a
Weigelia	PB	5.3b	98.0a	26.5a	17.3a	96.3a	41.0b	37.3a	20.8b	0.08b	0.77a	0.23a	0.25a
	PC	6.8a	89.8a	27.8a	11.8a	123.8a	78.3a	44.8a	63.5a	0.23a	0.85a	0.74a	0.48a

[z]Lower case letters denote mean separation (n = 4) between substrates within taxa by LSD, $P = 0.05$.

[y]No lime added to pine bark for azalea and holly.

Table 4. Leaf tissue nutrient concentrations for six woody taxa plants grown in pine bark (PB) or pine chips (PC).

Common name	Substrate	N	P	K	Ca	Mg	S	Fe	Cu	Mn	Zn
		%						ppm			
Arborvitae	PB	2.13a[z]	0.27a	1.27a	0.97a	0.38a	0.16a	49.3a	3.5a	253.3b	29.3a
	PC	1.75b	0.28a	1.05b	0.79b	0.30b	0.13b	42.3a	7.5a	353.5a	30.5a
Azalea	PB	2.41a	0.26a	1.99a	0.53b	0.27b	0.23a	61.3a	3.3a	37.3b	25.8a
	PC	1.50b	0.19b	1.54b	0.88a	0.33a	0.18b	25.8a	2.5a	86.8a	17.8b
Compacta holly	PB	2.95a	0.17a	1.25a	0.44a	0.25b	0.20a	50.5a	4.0b	657.5a	144.0a
	PC	2.66a	0.16a	1.26a	0.48a	0.30a	0.22a	48.0a	10.5a	694.3a	170.0a
Cryptomeria	PB	1.90a	0.30a	1.73a	0.67a	0.44a	0.18b	35.3a	1.0b	22.8a	26.0a
	PC	1.39a	0.22b	1.98a	0.49b	0.19b	0.22a	33.0a	4.3a	23.3a	18.3b
Nandina	PB	1.72a	0.16a	0.71a	0.28a	0.15a	0.12a	39.8a	2.0a	41.8a	18.5a
	PC	1.27a	0.09b	0.76a	0.21a	0.09b	0.08b	38.5a	2.5a	58.5a	14.8a
Soft Touch holly	PB	3.13a	0.21a	1.27a	0.55b	0.29b	0.25b	54.5a	4.8b	889.8a	168.3b
	PC	2.38b	0.13b	1.44a	0.79a	0.42a	0.31a	69.0a	11.5a	796.5a	239.0a

[z]Lower case letters denote mean separation (n = 4) between substrates within taxa by LSD, $P = 0.05$.

substrate solution of PC compared to the substrate solution of PB. Differences in tissue concentrations of N, P, K, were characterized by higher nutrient levels in PB than PC (Table 4). Other tissue nutrient concentrations did not follow any particular pattern with some being higher in PB, some being higher in PC (Cu), and some showing no difference (Table 4).

Shoot dry weight for 4 of the 18 taxa planted in April was higher in PB than PC compared to 6 of the 10 planted in May. The different growth response between the April and May plantings may be due to the lower fertilizer application rate for the May planting (15 gm) compared to the April planting (21 g). For example, in April azalea in PB was smaller than in PC. This difference could be due to too much fertilizer applied for plants growing in PB and adequate amounts for PC. Whereas for the May study the lower application rates may be adequate for PB but too low for PC. The reason more fertilizer may result in less overall difference in growth between with PC and PB may be two-fold. First, PC is more porous and has a lower CEC (15) than PB allowing more nutrients to be leached from PC. The second may relate to increased microbial N-immobilization for PC compared to PB due to a higher C/N ratio of PC vs PB (13). The impact that leaching and N immobilization have on nutrient availability on PC needs further investigation. Copper, in contrast to most of the other cations, was higher in substrate solution and tissue levels with PC than PB. This is probably due to the high affinity of organic matter for Cu and thus the lower substrate solution concentrations of Cu in PB compared to PC (8). In spite of differences in substrate solution nutrient concentrations between PB and PC, there were none that should cause concern in terms of the suitability of PC as a container substrate. As well, tissue nutrient levels were in normal physiological ranges for both PB and PC (9). Lower nutrient concentrations in PC substrate solution compared to PB is of concern and must be addressed before PC can become a viable substrate for woody nursery crops.

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