Evaluation of Pine Bark, Pine Bark With Wood, and Pine Tree Chips as Components of a Container Plant Growing Media[1]

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Abstract

Three woody landscape species, *Rhododendron indica* 'President Clay', *Ligustrum sinense* 'variegata', and *Ilex crenata* 'compacta', were grown in media prepared from fresh pine bark, pine bark with wood, and pine tree chips. Although media were variable in physical properties, all exhibited very high hydraulic conductivity and low water holding capacity. The capacity of these media materials to hold fertilizer elements was very low. Nitrogen, potassium, and phosphorus were rapidly removed by leaching while calcium and magnesium were retained longer because of the low solubility of dolomitic limestone. Pine bark was the best growth media tested for all plant species. Pine bark with wood was less satisfactory than pine bark and growth was poorest in pine tree chips. More research is needed on the use of the organic amendments with greater amounts of wood before being widely used as organic components of growth media.

Index Words: container growth media, chemical properties, physical properties, woody landscape plants

Introduction

Pine bark is currently a principal organic component of growth media for containerized plant production (3, 4, 5, and 6). Pine bark is obtained with equipment that removes only the bark and cambium from logs or with equipment that removes the bark and some of the wood, producing straight logs or poles (7). Nurserymen consider bark without wood to be the most desirable. Pine bark is hammermilled to obtain a desirable particle size for container-plant production. Whole pine tree chips (needles, twigs, bark and wood) is used by the lumber industry to manufacture hardboard. This material is not currently being used by the nursery industry as a component of container-growth media. The increased use of pine bark as a fuel by the lumber industry has decreased the availability of pine bark. Pine bark with wood and whole pine tree chips may be adequate substitutes.

The objective of this study was to evaluate the use of pine bark with some wood and whole tree chips as the organic component of growth media to produce woody ornamental plants in containers.

Materials and Methods

Fresh pine bark with a considerable amount of wood (PBW), pine tree chips (PC), and milled pine bark (PB) were passed through a soil shredder with a 12.7mm (½ in) screen before mixing with concrete sand in a 4:1 ratio (v/v) in 1980 and 1981. The study was conducted in a 45% shade house and the growth medium was amended with 0.59 kg/m^3 (1 lb/yd^3) of 0N-8.6P-0K (0-20-0), 0.59 kg/m^3 (1 lb/yd^3) of 8N-3.4P-6.6K (8-8-8) and 37 g/m^3 (1 oz/yd^3) of fritted trace elements (FTE 555- W.R. Grace & Co., Allentown, PA). The medium was also amended with 4.75 kg/m^3 (8 lbs/yd^3) of dolomitic limestone in 1980.

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On April 28, 1980, liners of *Rhododendron indica* 'President Clay' and *Ligustrum sinense* 'variegata' with 4 and 2 plants per experimental plot, respectively, were planted in 3 l (#1) containers in a 3 (organic materials) × 2 (fertilizer rates) factorial arrangement in a randomized complete block (RCB) design with 5 replications. Osmocote 18N-3P-8.3K (18-7-10) controlled release fertilizer was incorporated in the media at the rates of 2.97 and 4.46 kg/m^3 (5 and 7.5 lbs/yd^3) for rhododendron and 4.46 and 5.90 kg/m^3 (7.5 and 10 lbs/yd^3) for ligustrum before transplanting. The controlled release fertilizer was also surface applied at the rates of 1.98 and 2.97 kg/m^3 (3.3 and 5.0 lbs/yd^3) for rhododendron and 2.97 and 3.93 kg/m^3 (5.0 and 6.7 lbs/yd^3) for ligustrum on August 8, 1980.

On April 14, 1981, *Rhododendron indica*, 'President Clay', *Ligustrum sinense* 'variegata', and *Ilex crenata* 'compacta' were planted in 3 l (#1) containers in an RCB factorial with 3 (organic materials) × 2 (dolomitic limestone rates) × 2 (iron chelate 330 Fe rates) in 5 replications. Plot size was 3, 3 and 2 container plants with rhododendron, ligustrum and ilex, resp. Dolomitic limestone was added to the growth media before planting at the rates of 2.97 and 4.75 kg/m^3 (5 and 8 lbs/yd^3) with rhododendron and 4.75 and 6.53 kg/m^3 (8 and 11 lbs/yd^3) with ligustrum and ilex. Iron treatment consisted of adding 74 g/m^3 (2 oz/yd^3) of 330 Fe to the media before planting and watering on August 9 with 120 ml (4 oz) per container with a solution of 1.8 grams of 330 Fe per l (0.24 oz/gal) of water.

A controlled release fertilizer, 18N-2.6P-10K (18-6-12), was surface applied to rhododendron immediately after planting at the rate of 2.97 kg/m^3 (5 lbs/yd^3) and on August 9 at the rate of 1.49 kg/m^3 (2.5 lbs/yd^3). Fertilization of ligustrum and ilex with 18N-2.6P-10K (18-6-12) was 4.46 kg/m^3 (7.5 lbs/yd^3) immediately after planting and 2.2 kg/m^3 (3.75 lbs/yd^3) on August 9.

Fresh weight of the shoots was obtained by removing the tops at the surface of the medium. Plant height was taken from the rim of the container. Root quality and foliage color evaluations were taken by two observers and averaged. Experiments each year were terminated on October 31.

Analysis of media were determined prior to planting each year. Subsequent samples were taken 3 and 5 months later in 1980, and 7 months after planting in 1981. Hydraulic conductivity, particle size, pore space and water holding capacity were measured by standard methods (1) from samples taken in 1980. Chemical analyses were made on 2:1 water:media extracts. The analyses performed were pH, electrical conductivity, Ca, Mg, K, Na, P, NO_3-, and NH_4+. The metallic cations were determined by atomic absorption spectrophotometry, P by colorimetry and NO_3- and NH_4+ by specific ion electrodes. In general, the methods used were those given by Black. Organic matter of the growth media less than 2 mm was determined by loss in weight on ignition at 900°C (1940°F) (2).

Results and Discussion

There were slight changes in the physical properties of the media during the growing season. These changes are illustrated by the particle size distributions shown in Table 1. In 2 of the 3 media (PB and PBW) there was a decrease in the quantity of the coarser fractions and an increase in the finest fractions with time. Because of the large size and variable shape of the particles, it was difficult to obtain a representative sample. Therefore, only trends should be inferred from these data. The high content of organic matter in the fine fraction for PB and PBW is significant and accounts for the higher water holding capacity of these materials compared to pine chips. The total pore space (Table 2) of these media was very large (50–74%) with much of this being large pores (45–56%) which were emptied of water during free drainage. The water holding capacity of these materials was low, especially with PC. Values of water holding capacities, as well as other physical measurements, were variable between replicates, presumably because of the difficulty of repetition in packing. Hydraulic conductivity values were somewhat erratic but, in general, decreased with time. These values for hydraulic conductivity (1–5 cm/min) (.39-2 in/min) are extremely high when compared to natural soils where 5 cm/hr (2 in/hr) is considered to be rapid. This is one reason that special management practices must be used in watering and fertilizing container plants as compared to those grown in the field.

Low pH values of water extracts of the various media were obtained on April 18, 1980, with the exception of PBW fertilized with 2.97 kg/m^3 (5 lbs/yd^3) of 18N-3P-8.3K (18-7-10). Generally, pH values were higher at mid season and decreased by the end of the growing season (Table 3). The pH increased initially in response to the neutralization of the acidity by the lime. After depletion of the lime at mid season and leaching of bases the pH declined.

Potassium (K) content of water extracts decreased dramatically by mid season (Table 3). Further decline in K was offset by the surface application of fertilizer on August 8, 1980, with slight increases in K content, especially with PB (Table 3). Similar trends were shown for the other elements (N, P, Ca, Mg) and electrical conductivity. Although all of these analyses indicate a decline in elemental composition during the growing season, it was not possible to relate these values to the nutrient holding capacity of the media. The fertilizer elements (N, P, K) are all water soluble and the retention capacity of these media for these elements is very low, therefore they are rapidly removed with the water. It appears that the primary value of a chemical test is to monitor the change in the solution composition with time and to apply additional fertilizer once a critical value is reached. Chemical data for 1981 showed similar trends and are not included.

Highest fresh weight was obtained with PB with all 3 species. Generally, lowest fresh weight was obtained with

Table 1. Particle size distribution (% by weight) of media prepared from wood products-sand mixture (4/1 volume ratio) and organic matter content of fine fractions at three dates during growing season.

Particle size distribution	4-28-80			8-4-80			9-28-80		
	PB[z]	PBW	PC	PB	PBW	PC	PB	PBW	PC
(cm)									
>1.27	1.2	3.0	5.1	0.2	1.8	5.9	1.3	1.3	3.9
0.63–1.27	10.3	4.0	18.7	5.7	5.4	10.5	6.8	5.8	16.9
0.2–0.63	25.9	18.2	14.9	20.9	19.2	12.7	20.8	21.0	13.1
<0.2	62.4	74.7	62.7	73.1	73.2	71.1	71.0	71.9	66.0
O.M in the <.2 cm fraction	18.3	18.0	7.2	21.8	14.9	6.7	25.1	21.2	6.5

[z]PB = Pine bark; PBW = pine bark with wood; PC = pine tree chips.

Table 2. Selected physical properties of media prepared from wood products-sand mixtures (4/1 volume ratio).

Media[z]	Initial material: Total pore space	Initial material: Water after drainage	Air capacity	Hydraulic conductivity: Initial sample 4-28-80	Hydraulic conductivity: 2nd sample 8-4-80	Hydraulic conductivity: 3rd sample 9-26-80
		% by volume			cm H_2O/min	
PB:Sand	58	13	45	1.6	1.4	1.3
PBW:Sand	74	18	56	4.4	4.3	2.5
PC:Sand	50	4	46	4.9	1.6	2.1

[z]PB = pine bark; PBW = pine bark with wood; PC = pine tree chips.

Table 3. Changes in pH and potassium level of 2 water:1 media extract at three sampling times.

Media	Fertilizer[z]	April 18, 1980 pH	April 18, 1980 K	Aug. 4, 1980 pH	Aug. 4, 1980 K	Oct. 1, 1980 pH	Oct. 1, 1980 K
	kg/m³		mg/100g		mg/100g		mg/100g
Pine bark (PB)	4.46	4.0	60.8	4.8	8.6	3.6	15.0
Pine bark + wood (PBW)	4.46	4.9	36.4	6.3	5.4	3.4	10.0
Pine tree chips (PC)	4.46	5.0	31.8	6.5	5.6	5.1	5.4
Pine bark (PB)	2.97	3.7	39.8	4.4	4.2	4.1	13.4
Pine bark + wood (PBW)	2.97	6.4	21.0	6.1	7.2	5.1	6.8
Pine tree chips (PC)	2.97	4.0	14.8	5.3	2.8	4.5	5.2

[z]Fertilizer incorporated in media was a slow release (18-7-10). Additional fertilizer was surface applied August 8, 1980 equivalent to ⅔ of incorporated rate.

PC and PBW was intermediate (Tables 4 and 5; Fig. 1 and 2). PC caused a reduction in height only with *Ilex crenata* 'compacta' (Table 5). The root quality of *Ligustrum sinense* 'variegata' was not affected by the 3 organic materials. Slight differences in root quality were obtained with *Rhododendron indica* 'President Clay' and *Ilex crenata* 'compacta' in 1981 (Table 5). Taller plants and poor foliage color with *Rhododendron indica* 'President Clay' were obtained at the lower fertilizer rate (Table 6). Lime rate did not result in any differences with the 3 species tested. Iron application only caused a slight decrease in root quality of *Rhododendron indica* 'President Clay' from 7.9 to 7.6.

There was a consistent trend, although not always significant, ranking the three media suitability as an organic component for container growing media in the order: PB > PBW > PC. It was apparent that materials containing large quantities of wood can be used, but the performance is inferior to the PB. This is likely due to the higher leaching rate, lower nutrient retention and water holding capacity. We suggest that PC milled to smaller particle sizes would probably decrease leaching, and increase nutrient retention and water holding capacity and thereby enhance its use as an organic component of container plant growing media. Also, the high wood content increases the need for nitrogen because microorganisms which decompose the wood compete with plants for nitrogen. The less desirable materials will require closer observation and perhaps more frequent irrigation and fertilization. More experimentation is needed on management practices when using woody materials before they can be used with confidence.

Table 4. Effects[z] of media prepared from 3 forest products on the growth of *Rhododendron indica* 'President Clay' and *Ligustrum sinense* 'variegata' in 1980.

Media	Foliage color[y]	Height (cm)	Shoot fresh wt (gm)	Root quality[x]
		Rhododendron 'President Clay'		
Pine bark (PB)	2.7a[z]	33a	91a	5.6a
Pine bark + wood (PBW)	2.0ab	31a	69b	5.3a
Pine tree chips (PC)	1.5b	29a	64b	4.9a
		Ligustrum sinense 'variegata'		
Pine bark (PB)	—	41a	81a	8.6a
Pine bark + wood (PBW)	—	40a	65ab	8.9a
Pine tree chips (PC)	—	39a	57b	7.8a

[z]Means within a column followed by different letters are different at the 5% level of probability according to Duncan's multiple range test.
[y]Foliage color rating: 3 = excellent; 0 = poor.
[x]Root quality rating: 10 = excellent; 0 = poor.

Table 5. Effects of media prepared from 3 forest products on the growth of *Rhododendron indica* 'President Clay,' *Ligustrum sinense* 'variegata', and *Ilex crenata* 'compacta' in 1981.

Media	Height (cm)	Shoot fresh wt (gm)	Root quality[y]
		Rhododendron indica 'President Clay'	
Pine bark (PB)	51.4a[z]	179a	7.2c
Pine bark + wood (PBW)	55.6a	145b	8.5a
Pine tree chips (PC)	50.6a	116c	7.6b
		Ligustrum sinense 'variegata'	
Pine bark (PB)	45.2a	96a	7.2a
Pine bark + wood (PBW)	41.0a	77b	7.2a
Pine tree chips (PC)	40.7a	68b	7.0a
		Ilex crenata 'compacta'	
Pine bark (PB)	48.3a	184a	8.8a
Pine bark + wood (PBW)	48.1a	139b	8.1b
Pine tree chips (PC)	43.5b	111b	7.6c

[z]Means within a column followed by different letters are different at the 5% level of probability according to Duncan's multiple range test.
[y]Root quality: 10 = excellent; 0 = poor.

Significance to the Nursery Industry

The availability of large quantities of organic materials at economical prices for use as components of container plant growing media is of fundamental importance to nurs-

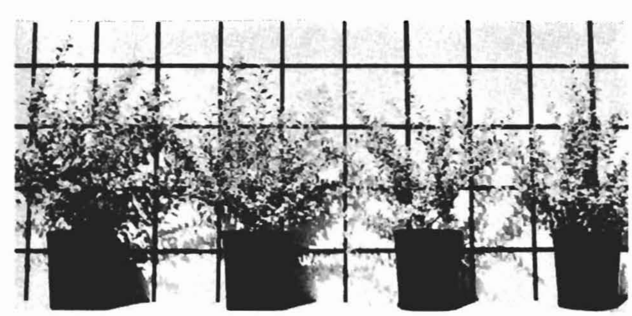

Fig. 1. Growth of *Ligustrum sinense* 'variegata', *Left to right*: in pine bark and sand (4:1, v/v) and in pine tree chips and sand (4:1, v/v), fertilized with 7.42 and 9.83 kg/m³ (12.5 and 16.7 lbs/yd³) of Osmocote 18N-3P-8.3K (18-7-10), resp.

Fig. 2. **Growth of *Rhododendron indica* 'President Clay', *Left to right*: in organic components of pine bark, pine bark with wood and pine tree chips and sand (4:3 v/v) with 4.46, 4.75, and 0 kg/m^3 (7.5, 8 and 0 lbs/yd^3) of 18N-2.6P-10K (18-6-12), dolomitic lime and 330 FE, resp.**

erymen. A decrease in availability and increased costs of pine bark, currently the most widely used organic component of growth media for the container production of woody landscape plants, has occurred due to the use of pine bark as a fuel by the lumber industry, fluctuations in the economy (i.e., the construction industry) and higher freight costs. Therefore, information is needed about possible alternative media materials which are renewable and available at reasonable costs such as pine bark with considerable wood and whole tree pine chips.

In this study best growth was obtained with fresh pine bark as the organic component of growth media and that increasing the wood content of organic components decreased its value for use in growth media. Additional research is needed with management practices to determine the suitability of the more woody materials for use as organic components of growth media.

Table 6. Effects of fertilizer rate on the height and foliage color of *Rhododendron indica* 'President Clay' in 1980.

18-7-10 rate (kg/m^3)	Height (cm)	Foliage color[y]
4.95	33a[z]	1.7b
7.43	28b	2.4a

[z]Means within a column followed by different letters are different at the 5% level of probability according to Duncan's multiple range test.

[y]Foliage color rating: 3 = excellent; 0 = poor.

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