Physical Properties of Pine Bark and Hardwood Bark Media and Their Effects with 4 Fertilizers on Growth of *Ilex* x 'Nellie R. Stevens' Holly[1]

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Abstract

Pine bark (PB) and composted hardwood bark (HWB) were combined into 5 media. Particle size distribution, total porosity, air space, moisture retention characteristics, and bulk density were determined for each medium. Four commercial fertilizers were applied and substrate nitrogen levels, pH, % foliar nitrogen and top dry weight were determined for *Ilex* x 'Nellie R. Stevens' holly. Pine bark had approximately 84% of the particles between 4.75 and 1.0 mm (0.19 and 0.04 in). As HWB was added in 25% increments (by vol) the percent weight of particles in this range decreased. HWB increased bulk density, but did not significantly change total porosity. Hardwood bark and the 1:3 PB:HWB (v/v) medium held more water than other media. Nursery Special raised pH in all media treatments. Plants treated with SulfurKote tended to have the highest foliar nitrogen content. The Sierrablen in PB and SulfurKote in 3 PB:1 HWB and 1 PB:1 HWB (v/v) and HWB produced the greatest top dry weight.

Index words: total porosity, bulk density, air space, moisture retention, pH, particle size distribution, foliar analysis, substrate nitrogen

Introduction

A wide variety of materials are used as potting media components in nursery production. However, pine and hardwood barks are the predominant components in many areas of the U.S. (1,2,8,9). The composition of pine bark and hardwood bark are considerably different and this results in large differences in their physical and chemical characteristics as well as their management for use in potting mixes (1,5,6,10,11,12). Both barks are available in much of the southeastern U.S. Large quantities of pine bark are shipped to the northeastern and midwestern parts of the U.S. where hardwood bark is available locally. Blending the two barks is feasible to extend quantities of pine bark, but due to great differences in pH and physical properties, problems may be encountered. Very limited information is available on medium preparation and management to growers or commercial media producers who might otherwise prepare potting mixes of the two components (2).

Many slow release and soluble fertilizers are available for use in nursery production and general recommendations concerning use and rates of application are provided by the manufacturers. Fertilizer application and pH control of blended bark media may vary considerably as the volume of pine bark and hardwood bark are changed.

This study was conducted to classify particle size distribution, air space, moisture retention characteristics, pH, and total substrate nitrogen levels of 5 bark media fertilized with 4 commercial fertilizers and to determine the growth response and percent foliar nitrogen levels achieved by *Ilex* X 'Nellie R. Stevens' holly in response to the physical and chemical properties of the potting media and fertilizer applications.

Materials and Methods

Five combinations of aged pine bark and composted hardwood bark were evaluated. The hardwood bark was composted by procedures reported by Hoitink (10). Hardwood bark and pine bark were passed through a 12.7 mm (1/2 in) and 6.4 mm (1/4 in) mesh hardware cloth respectively to eliminate coarse particles. Pine bark was amended with 4.8 kg/m^3 (8 lb/yd^3) gypsum ($CaSO_4$), and 1.2 kg/m^3 (2 lb/yd^3) epsom salts ($MgSO_4$) before blending. At potting, nutritional amendments and fertilizers were applied to 5 container substrates consisting of pine bark and hardwood bark at 100:0, 75:25, 50:50, 25:75, or 0:100 percent (by vol) combinations.

Fertilizer treatments were applied in accordance to manufacturer's recommendations with additional phosphate and minor element supplementation as follows:

1) Sierrablen and amendments—17N-3.0P-8.3K (17-7-10) + iron, incorporated at 8.92 kg/m^3 (15 lbs/yd^3); Micromax 0.89 kg/m^3 (1.5 lbs/yd^3); and single superphosphate 0.0N-8.6P-0.0K (0-20-0) 3.6 kg/m^3 (6 lbs/yd^3). Approximately 4.9 g (0.17 oz) N was applied per container.

2) Prostart + Nursery Special and amendments—

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Prostart 13.0N-2.6P-5.0K (13-6-6) was used as an initial fertilizer with minor elements incorporated at 5.9 kg/m³ (10 lbs/yd³) and Nursery Special 12.0N-2.6P-5.0K (12-6-6) was applied to the medium surface at 6.0 g/l (0.21 oz) per container per 4 week interval. Approximately 6.1 g N (0.21 oz N) per container, were applied through 5 applications.

3) Osmocote and amendments—17N-3.0P-10.0K (17-7-12) incorporated at 8.33 kg/m³ (14 lbs/yd³); Micromax 0.89 kg/m³ (1.5 lbs/yd³) and single superphosphate 3.6 kg/m³ (6 lbs/yd³). Approximately 4.6 g N (0.16 oz) per container was applied.

4. Prostart + SulfurKote and amendments—Prostart 13.0N-2.6P-5.0K (13-6-6) was incorporated at 5.9 kg/m³ (10 lbs/yd³). SulfurKote 24.0N-1.7P-8.3K (24-4-10) was applied to the medium surface 4 weeks after potting and at 12 week intervals for a total of 2 applications os SulfurKote at 6.0 (0.3 oz) per container. Approximately 5.4 g (0.19 oz) N was applied per container.

Particle size distribution was obtained by screening four 100 g (3.5 oz) air dried samples of each medium for 5 min at 160 shakes per min with a Ro-Tap shaker and U.S. standard sieves with openings of 6.4, 4.75, 2.99, 1.99, 0.60, 0.25, and 0.106 mm (0.25, 0.19, 0.12, 0.08, 0.02, 0.01, and 0.004 in). The percent total weight was calculated for the particles remaining on each screen and the receiver pan.

Moisture retention curves were established for each medium from samples taken from pots at the end of the study using procedures and materials as outlined by Fonteno et al. (7) and Bilderback, et al. (3). Eight samples were first moistened and materials were packed into three cylinders (r + 3.8 cm (1.5 in); h + 7.6 cm (3.0 in) mounted end to end with the bottom cylinder resting in a plastic petri dish. The cylinders were filled by placing 100 cc (6.1 in³) of sample in the cylinder 5 cm (2 in) from the table and tapping once. This procedure was repeated until all 3 cylinders were filled. The upper and lower cylinders were then removed and only the center cylinder was used for moisture determinations.

Stepwise applications of selected positive pressures were applied and the corresponding moisture release recorded. The air space and moisture content at container capacity (drainage) was calculated for each medium using cubic regression models from the individual moisture characteristic curves (Fig. 2). The container volume was calculated at 2 cm (0.8 in) increments to the height of the medium and the % moisture content calculated from the model was multiplied by the corresponding volume and summed to give the moisture content at container capacity. Air space at container capacity was calculated by subtracting the % moisture content at container capacity from the total porosity (Table 2).

On May 13, 1980 rooted and branched *Ilex* x "Nellie R. Stevens' holly plants were potted in 2.9 l (3 qt) containers. The containers were placed in full sun and arranged in a split plot design with 4 replications and 3 plants per plot at the Horticultural Crops Research Sta-

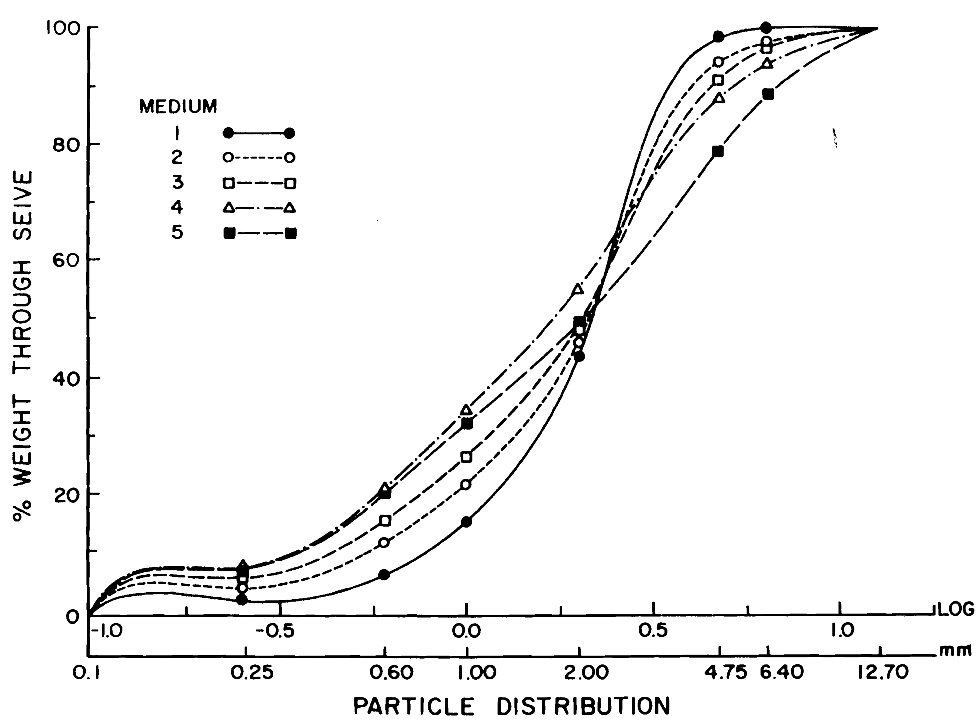

Fig. 1. Summation curves of particle size distribution of pine bark, hardwood bark and 3:1, 1:1 and 1:3 (by volume) blended media.
1 • = pine bark
2 O = 3 pine bark:1 hardwood bark
3 □ = 1 pine bark:1 hardwood bark
4 Δ = 1 pine bark:3 hardwood bark
5 ■ = hardwood bark

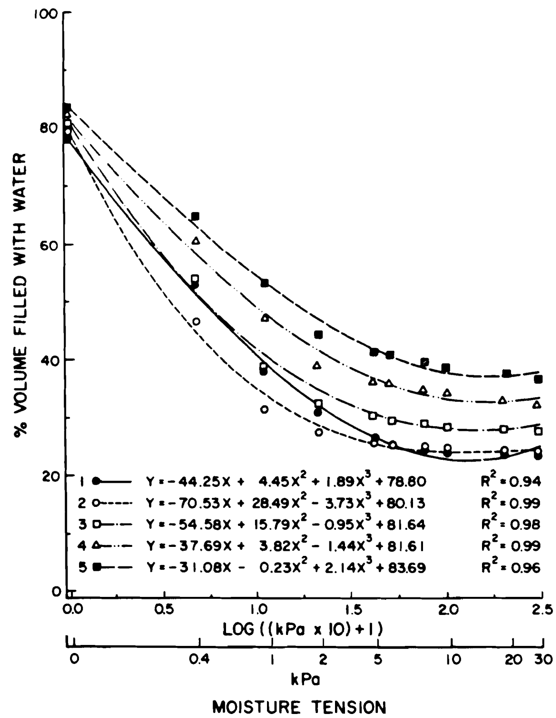

Fig. 2. Moisture retention curves for pine bark, hardwood bark and 3:1, 1:1 and 1:3 (by volume) blended media.
1 • = pine bark
2 O = 3 pine bark:1 hardwood bark
3 □ = 1 pine bark:1 hardwood bark
4 Δ = 1 pine bark:3 hardwood bark
5 ■ = hardwood bark

tion, Castle Hayne, NC. Overhead irrigation was applied daily during the summer months, until November 6 when the study was terminated. Plants and media from 3 containers per replication were combined and averaged to determine top dry weight, % foliar nitrogen content, substrate nitrogen content, and pH. Foliar nitrogen content was determined by collecting the top most fully expanded leaves at the termination of the study. Media extraction for total nitrogen and pH was by saturated paste extract (13). Foliar N and substrate N determinations were done by modified Microkjeldahl procedures (4).

Results and Discussion

Particle Size Distribution. The particle size distribution is expressed in a summation curve (Fig. 1). In the 100% pine bark medium more particles passed through the larger sieves (6.4 and 4.7 mm; 0.25 and 0.19 in) than any medium containing hardwood bark (Fig. 1). As the volume of hardwood bark increased, the % weight of coarse particles (between 6.4 and 4.7 mm) increased, and the percent weight of fine particles (below 0.60 mm = 0.02 in) also increased. Approximately 84% of the particles in pine bark were between 4.75 and 1.00 mm (0.19 and 0.04 in). As hardwood bark was added in 25% volume increments the percent weight of particles in this range decreased to 72%, 65%, 53%, and 47%, respectively.

Air and moisture characteristics. Bulk density was different for every medium and increased as the volume of HWB increased (Table 1). The addition of HWB to PB did not significantly increase total porosity (Table 1). Hardwood bark and the 1 PB:3 HWB (v/v) bark medium held more water throughout the range of pressure applied (0 to 30 kPa, 4.3 lb/in^2) (Fig. 2). Spomer (12) reported that <25% of the water held at saturation by fresh hardwood bark is released between 0 and -15 bar (permanent wilting point = -15 bar = 1500 kPa = 220 lbs/in^2) and is unavailable for plant growth or survival. In this study, composted HWB retained 36.6% (by volume) water at 30 kPa (-0.3 bar), which is approximately 44% of the water held at saturation (Table 1). Approximately 56% of the water held at saturation would be available from 0 to 30 kPa from the HWB. Therefore, it would appear that HWB used in our study would supply approximately twice the volume of water to plants that Spomer reported. A similar comparison with PB shows that 31% of the water held at 0 kPa (TP) is still present at 30 kPa or approximately 69% of the water held at saturation would be available to plants between 0 and 30 kPa.

In Table 2, the volume of air and water for each medium within a 2.9 l (3 qt) container at container capacity were predicted from the moisture characteristic regression model (Fig. 2) and the container volume model. The hardwood bark had the least air space but greatest volume of water within the container at container capacity, although as previously mentioned,

Table 1. Total porosity (0 kPa), moisture held at 30 kPa, and bulk density of 5 bark media.

Medium (by vol)	0 kPa (% vol)	30 kPa (% vol)	BD (g/cc)
Pine Bark	78.3 b[z]	24.0 d	.19 e
Pine Bark + Hardwood Bark (3:1)	79.7 ab	24.2 d	.22 d
Pine Bark + Hardwood Bark (1:1)	81.9 ab	28.0 c	.23 c
Pine Bark + Hardwood Bark (1:3)	81.1 ab	32.5 b	.26 b
Hardwood Bark	83.2 a	36.6 a	.27 a

[z]Mean separation within a column followed by the same letter or letters are not significantly different at the 5% level using the Waller-Duncan k-ratio t-test (k-ratio = 200).

Table 2. Air space and water volume (ml) and percent volume of five bark media in 2.9 l containers at container capacity (drainage)[z].

Medium	Air space		Water	
(v/v)	ml	%	ml	%
Pine Bark	658	32	948	47
Pine Bark + Hardwood Bark (3:1)	805	40	828	41
Pine Bark + Hardwood Bark (1:1)	699	34	965	47
Pine Bark + Hardwood Bark (1:3)	562	28	1101	54
Hardwood Bark	502	25	1203	59

[z]Data predicted from the moisture characteristic regression model (Fig. 2) and the container model. Container media volume = 2038 cc.

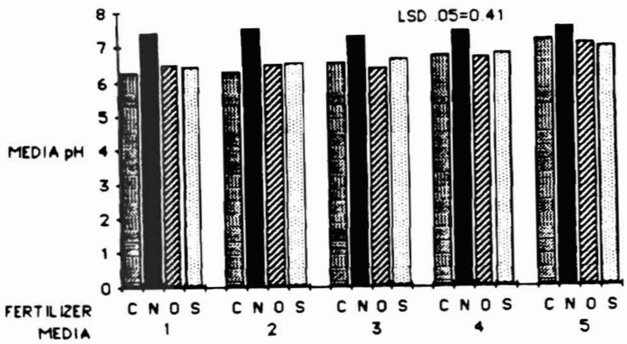

Fig. 3. **Effect of Sierrablen (C), Nursery Special (N), Osmocote (O), and SulfurKote (S) fertilizers on pH of pine bark (1), 3:1 pine bark:hardwood bark (v/v) (2), 1:1 pine bark:hardwood bark (v/v) (3), 1:3 pink bark:hardwood bark (v/v) (4) and hardwood bark (5) media.**

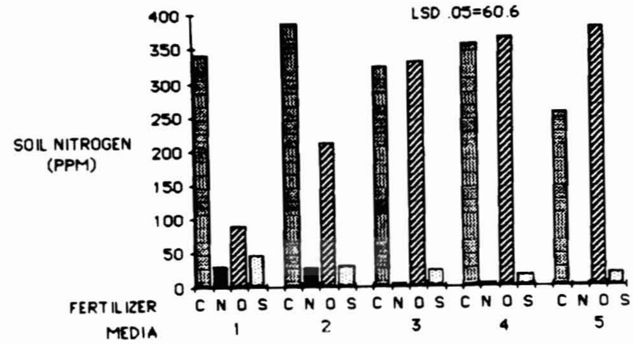

Fig. 4. **Effect of Sierrablen (C), Nursery Special (N), Osmocote (O), and SulfurKote (S) fertilizers on soil nitrogen of pine bark (1), 3:1 pine bark:hardwood bark (v/v) (2), 1:1 pine bark: hardwood bark (v/v) (3), 1:3 pine bark:hardwood bark (v/v) (4), and hardwood bark (5) media.**

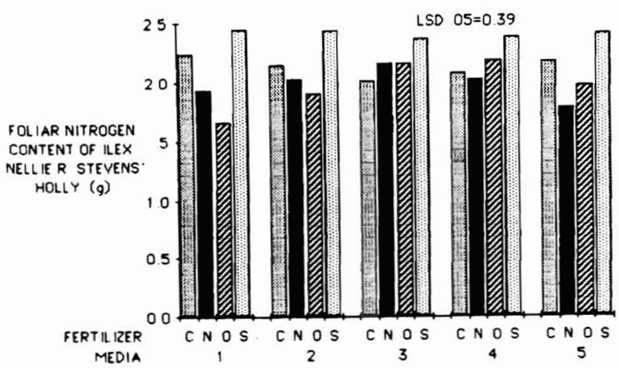

Fig. 5. **Effect of Sierrablen (C), Nursery Special (N), Osmocote (O), and SulfurKote (S) fertilizers on foliar nitrogen content *Ilex* 'Nellie R. Stevens' holly in media composed of pine bark (1), 3:1 pine bark:hardwood bark (v/v) (2), 1:1 pine bark:hardwood bark (v/v) (3), 1:3 pine bark:hardwood bark (v/v) (4), and hardwood bark (5) media.**

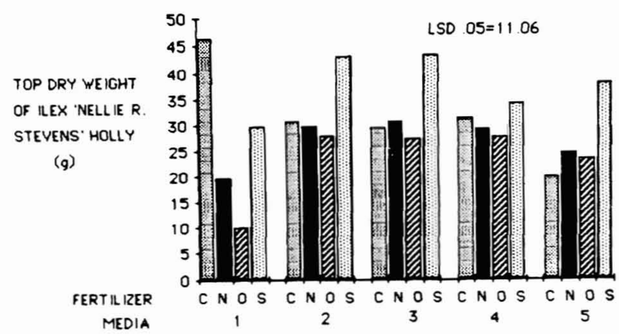

Fig. 6. **Effect of Sierrablen (C), Nursery Special (N), Osmocote (O), and SulfurKote (S) fertilizers on top dry weight of *Ilex* 'Nellie R. Stevens' holly in media composed of pine bark (1), 3:1 pine bark:hardwood bark (v/v) (2), 1:1 pine bark:hard-wood bark (v/v) (3), 1:3 pine bark:hardwood bark (v/v) (4), and hardwood bark (5) media.**

much of this water may not be available for plant growth. The PB medium held 658 ml (22.4 oz) or 32% air space and 948 ml (32.2 oz) or 47% water at container capacity. When PB and HWB were of equal volume, the water held was slightly increased and more air space was created. These data would therefore indicate that a 1:1 PB:HWB (by volume) medium might provide better physical properties than either bark alone.

The pH of the medium was affected by fertilizer (Fig. 3). Nursery Special (N) raised pH and produced the highest pH in all media treatments. The Nursery Special treatments were all similar in pH (7.3-7.5) regardless of the medium. As the volume of HWB increased, pH also tended to increase, and fertilizer treatments in HWB were higher in pH than the respective treatment in PB (except Nursery Special).

Large differences occurred in the soil N levels between fertilizers (Fig. 4). The experiment was terminated at approximately the end of the effective application period for Nursery Special (N) and SulfurKote (S) treatments, but Osmocote (O) and Sierrablen (C) treatments were still within their effective release periods. Osmocote soil N levels increased dramatically as the volume of HWB increased and may have been related to higher volume of water held in HWB. Sierrablen N levels were somewhat more uniform but declined in HWB.

Foliar nitrogen levels (Fig. 5) appeared to bear little resemblance to soil N levels for respective fertilizer treatments. SulfurKote (S) tended to have the highest foliar N levels. Media did not affect foliar N levels. Foliar N levels were similar for all treatments within a medium except Osmocote (O) in PB was less than SulfurKote (S) in PB.

The Sierrablen (C) in PB and SulfurKote (S) in 3:1, 1:1 PB:HWB and HWB produced the greatest top dry weight of 'Nellie R. Stevens' holly (Fig. 6). Top dry weight for SulfurKote (S) treatments were similar for all media, except PB. Osmocote (O) and Nursery Special (N) top dry weights were similar in each medium. Sierrablen (C) proved to give the most diverse response in top dry weight, but was similar in the blended media treatments.

Blending pine bark and hardwood bark produces pH, physical properties and plant growth acceptable for container production. A 1:1 (by volume) blend of pine bark and hardwood bark stabilized at a pH of approximately 6.2 without the addition of lime. The moisture and air relationships of the blended media were intermediate between pine bark and hardwood bark and generally retained more air space than hardwood bark and held more water than pine bark. Bulk density increased with addition of hardwood bark. Plant growth was more affected by fertilizer than medium, however, top dry weight tended to be greater for *Ilex* 'Nellie R. Stevens' in the blended media as evidenced by greatest plant growth in SulfurKote treatments 3:1 and 1:1 PB:HWB and Osmocote yielding greatest plant growth in blended media vs. PB or HWB alone.

Significance to the Nursery Industry

The results of this study are useful to nurserymen who have sources of composted hardwood bark and pine bark. Blending pine bark and hardwood bark could prove to be more economical by extending quantities of pine bark if pine bark supplies must be shipped. The blended media may actually provide better physical properties for growing container plants than either bark alone. Addition of hardwood bark to pine bark increased bulk density which helps offset the usual addition of sand, and increased the volume of water held in the container. Air space is greater in blended media than hardwood bark alone. Application of 4 commercial fertilizers had varying effects on media and plant response but pH, soil N and foliar N were as acceptable or superior in blended media as pine bark or hardwood bark alone. Most importantly, plants grown in blended media were as large or larger than plants grown in either pine bark or hardwood bark.

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