Nursery Crop Science
College of Agriculture and Life Sciences • NC State University

A Comparison of Physical Properties of Double Processed Pine Bark to Other Selected Propagation Substrates nd Their Effects on Rooting Response of Three Ornamentals[1]

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Abstract

The influence of particle size and physical property characteristics on rooting responses of *Rhododendron* sp. Sunglow azalea, *Photinia x* fraseri and *Illicium parviflorum* was investigated. Double Processed Pine Bark (DPPB) had a more uniform distribution of particles collected on sieves between 6.3 and 0.5 mm than other substrates studied. The DPPB particle size range was most similar to other single component pine bark substrates, but had fewer particles <0.4 mm than 12.8 mm (1/2 inch) or 6.4 mm (1/4 inch) pine bark substrate The effect of the uniform particle size distribution was that resultant physical properties yielded the greatest total porosity and volume of water held after drainage of the substrates studied. Pine bark:sand (equal volumes) had the least total porosity and air space and the greatest bulk density. Regression and correlation analyses indicated that there were no relationships between percent volume of air space or container capacity of propagation substrates and any of the rooting responses measured for any of the three species propagated. Analysis of variance and mean separation statistical analyses indicated that there were no differences in rooting percentage among substrates tested except for *Illicium parviflorum* which had lower rooting percentage in the Fafard 3 substrate. Root ball diameters were not different for *Photinia x fraseri* , however Sunglow azalea produced the smallest root ball diameters in peat:sand, Metro-Mix 360 and Fafard 3. *Illicium parviflorum* had largest root ball diameters and greatest root dry weight when rooted in DPPB and 6.4 mm (1/4 inch) pine bark and least root dry weight in peat:sand (equal volumes) and Metro-Mix 360, while other substrates were intermediate for root dry weight.. *Photinia x* frazeri cuttings had the greatest number of roots in perlite:peat (80:20 by vol) and the least number of roots in Fafard 3 while other substrates were intermediate for root number.

Index words: Air space, container capacity, available water, unavailable water content

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Species used in this study: Sunglow Azalea (*Rhododendron* L. Sunglow), Fraser Photinia (*Photinia x fraseri* Dress.), and Small Anise-tree *(Illicium parviflorum).*

Significance to the Nursery Industry

In this study, Double Processed Pine Bark produced as favorable rooting responses as any of the substrates tested for all three ornamental crops propagated and was superior to commercially available substrate for *Illicium parviflorum* for two of the rooting responses measured. Although results were nearly identical to rooting responses of two component substrate, DPPB would not require equipment and time required to uniformly blend two component substrates. Rooting responses of ornamentals in DPPB and 1/4 and 1/2 inch pine bark were similar, however the DPPB was more uniform in particle size distribution and texture and would appear to have an advantage of greater uniformity from one crop to another.

Introduction

Professional propagators use a wide variety of techniques and materials to vegetatively propagate nursery crops. Many of these techniques dictate unique characteristics for propagation substrate if cuttings are successfully rooted. Cuttings are often watered in by over head application of water to establish contact between stems and the substrate and to avoid large air pockets which could lead to desiccation of the cuttings. However, irrigating cuttings can also create a water logged substrate unless the substrate has well drained characteristics. Intermittent mist is often used by commercial nurserymen to maintain a vapor around the foliage of cuttings and reduce desiccation. Intermittent mist can create a water logging effect in the substrate if droplets are large and infiltrate into the substrate.

For these reasons, nurserymen use a variety of substrate for propagation of nursery stock. Several commercial substrate are available, however many commercial substrate contain peat moss as a predominant component and may remain too moist for some propagation uses. Other propagators use single component propagation substrates such as pine bark, but single component pine bark substrates often are too coarse in texture and may contain air pockets or inadequate amounts of moisture for adsorption of newly formed roots. Therefore some nurserymen choose to prepare rooting substrate by mixing components to achieve mixtures with suitable air and drainage characteristics that remain moist but not water logged during the period of time that roots are initiated. Propagation mixtures of predominantly coarse perlite with less volume of peat have become popular because they maintain high volumes of air space yet have acceptable moisture holding characteristics. However, mixing components uniformly requires equipment that many propagators may not have accessible.

Propagation of woody ornamentals has been studied extensively, however information on air and water relationships of propagation substrate and their effects upon rooting response is somewhat limited. Reisch (1967) concluded that the particular substrate components were not of primary importance in rooting response, but the resultant physical properties and the management of the substrate were the major areas of concern. Texture and brittleness of the roots have been attributed to the particle size distribution of the substrate (Chadwick, 1933; Long, 1932). However, the particle size distribution has been thought to be secondary to available moisture levels, with a fine-textured substrate holding more moisture and producing finer roots than a coarse-textured substrate (Reisch, 1967).

There are no distinct physical property standards for propagation substrate and propagation components and resultant physical properties of various components may be very different.
Physical properties of a substrate include such parameters as total porosity, bulk density, particle size distribution, air space, water holding capacity, available water content and unavailable water content. Of these, aeration and moisture content appear to be the two properties of major concern in a propagation substrate (Reisch, 1967). Acceptable volumes for air space within a propagation substrate have been suggested at levels of 15% (Puustjarvi, 1969; 20% (Arnold, 1983; Guttormen, 1974; Hoitink and Poole, 1979; and Matkin, 1965), and 40 and 45% (Puustjarvi, 1969 and Whitcomb, 1979). Tilt and Bilderback (1987) evaluated physical properties of 11 propagation substrate which ranged in air space between 12 and 40% and had water holding capacities after drainage of 35 to 55%. Variation of rooting response occurred in their study for leyland cypress and Nellie R. Stephens holly but differences could not be attributed to physical properties of the various substrate. They concluded that if a threshold of air space volume exists, it was < 12% by volume for the species they studied.

Double Processed Pine Bark (DPPB) is a screened and finely ground hammermilled pine bark with minimal amounts of wood or cambium. After screening and hammermilling, the DPPB appears to have a uniform texture with less variation in particle size than if aged and screened as most pine bark sources. The appearance and texture of DPPB suggest that it could be used as a propagation substrate and would not require preparation by mixing with other components.
To determine the usefulness of this product in propagation, a study was designed to physically characterize DPPB and compare DPPB with seven other substrates commonly used for propagation of nursery crops.

The objective of this experiment was to investigate the effect of particle size distribution and the resultant physical properties of eight propagation substrate on rooting response of three ornamental species.

Materials and Methods

The eight substrate selected for comparison are listed in Table 1. Double Processed Pine Bark (DPPB) was acquired after it was screened and hammermilled. The 1/4 and 1/2 pine bark substrate were acquired from inventory windrows which had been turned three times over an eight month period and passed through 6.3 and 12.7 mm screens, respectively. Pine bark: peat (PB:Pt) (9:1 by vol.) was composed of the 1/2 screened pine bark blended with sphagnum peat moss. The other substrate were as follows: coarse horticultural perlite: sphagnum peat moss (Per Pt) (8:2 by vol.), Sphagnum peat moss: coarse builder s sand (Pt S) (1:1 by vol.), Metro-Mix 360 (MM 360) (Grace/Sierra, Travelers Rest, S.C.), and Fafard #3 (FF3) (Anderson, S.C.).

Softwood cuttings of *Rhododendron* sp. Sunglow , *Photinia* x Fraseri and *Illicium parviflorum* were prepared by administering a light wound of two equidistant vertical incisions on the basal portion of the stem to a depth reaching secondary xylem, each wound being approximately 3.0 cm (1.2 in) long. The basal 3.0 cm stems of Sunglow azalea were then dipped for 10 seconds into a 1500 ppm IBA in alcohol liquid solution (C-Mone, Coor Farm Supply, Smithfield, N.C.), allowed to air dry and inserted randomly into the appropriate replication and substrate treatments. Illicium and photinia were treated similarly except that a 3000 and 10,000 ppm IBA quick dip respectively, was used.

The experimental design was a randomized split plot design. Propagation trays with forty cells (2 $^{1/8}$ x 2 $^{1/8}$ x 2 $^{7/8}$ in for each cell) were filled with all eight substrate randomized within columns in each tray. Five cells in a column were filled with each substrate. Each tray contained only one species and total of 9 trays were used for each species. The experiment was conducted in a greenhouse maintained at day/night temperatures of 30 and 20 C (86 and 68 F). Intermittent mist operated 3 sec every 5 min from 8:00 a.m. to 6:00 p.m. daily. Sunglow azalea was evaluated for rooting response four weeks after propagating. Illicium and photinia were evaluated for rooting response after 15 weeks. Data included percent rooting and root ball diameter for azalea, root weight was also determined for illicium and photinia and root number was determine for photinia in addition to the other rooting response data. Cuttings were considered rooted if emerged roots >1.0 mm were present. Standard analysis of variance procedures were utilized to determine significant differences at the $p=0.05$ level.

The particle size distributions of each of the eight substrate were obtained at the beginning of the study by sieving three air-dried samples of each substrate through U.S. standard sieves using a Ro-tap shaker (10 min at 160 rpm). The weight of the material on each screen and the receiver pan was measured and expressed as a percentage of the total weight (Table 1).

To determine air and water retention characteristics, five replications of eight substrate were packed in cylindrical aluminum rings, 347.5 cm^3 (21.2 in^3) in volume (7.6 cm dia, 7.6 cm ht) (3 in dia, 3 in ht), using procedures of Bilderback et al. (1982). Additional substrate was used to determine water retention at 1.5 MPa, using procedures of Milks et al. (1989). Total porosity, water holding capacity and air space for each substrate, were determined by procedures of Fonteno and Bilderback (1991) using aluminum cylinders attached to a porous plate base. Each unit (cylinder with attached base plate) was placed in a Buchner funnel, saturated and allowed to drain. Wet weights of the samples were recorded. Samples were place in a forced-air drying oven at 110 C for 24 hours and dry weight recorded. Container capacity (CC) (% volume) was defined as (wet weight - dry weight) / volume. Air space (AS) was the volume of water drained from the sample/ volume of sample. Total porosity (TP) was CC + AS. An estimate of unavailable water (UW) was defined as the amount of water held at 1.5 MPa. Available water was determined for each sample as CC - UW using pressure plate extraction and procedures of Milks et al. (1989).

Results and Discussion The particle size distribution of the DPPB confirmed initial observations of uniform texture. Approximately the same percent dry weight of particles were collected on sieves with openings of 6.3, 4.0, 2.8, 2.0, 1.4,1.0, 0.7 and 0.5 mm. The DPPB substrate also had fewer fine particles from 0.36 to < 0.0 mm indicating that there is less

variation in particle size range between large and small particles than the other substrate samples. The DPPB particle size range was most similar to the other single component pine bark substrate, but had fewer fine particles (16% by wt.) < 0.36mm than the 12.8 (1/2"PB) with 20.1% or 6.4 mm (1/4 inch) pine bark with 21.6% fine particles by wt. The five substrate with two or more components reflected the particle sizes of the individual components. For example, the PB Pt substrate was nearly identical to the 1/2"PB substrate for particles collected on 4.0, 2.8, and 2.0 sieves. The Pt S substrate had the greatest number of particles by weight collected on sieves between 1.0 and 0.25mm, which is approximately the range of most particles in washed builders sand. The MM360 had the most particles below 0.36mm and 0.0 mm (36.41%). The uniformity of particle sizes in the DPPB substrate apparently reduced the amount of "nesting" or physical shrinkage
between particles which occurs when large differences in particles allow fine particles to fit between large particles. This characteristic is supported by physical property data (Table 2). The DPPB had the greatest total porosity and container capacity of the substrate studied, yet held as much air space as the 1/4"PB. The PS had far less total porosity and extremely low air space due to the shrinkage between peat and sand particles and due to the bulk density of the resultant mix.

The extreme amount of shrinkage is indicated by the relatively high available water content that is held around and between particles. The Per Pt substrate was the best drained substrate with 27% air space, only 46% moisture content at container capacity and 18.5% available water content.

Analysis of variance and mean separation statistical analyses indicated that there were no differences in rooting percentage among substrate tested except for *Illicium parviflorum* which had lower rooting percentage in the Fafard 3 substrate. Root ball diameters were not different for *Photinia x fraseri* , however Sunglow azalea produced the smallest root ball diameters in peat:sand, Metro-Mix 360 and Fafard 3. *Illicium parviflorum* had largest root ball diameters and greatest root dry weight when rooted in DPPB and 6.4 mm (1/4 inch) pine bark and least root dry weight in peat:sand (equal volumes) and Metro-Mix 360, while other substrate were intersubstratete for root dry weight.. *Photinia x* frazeri cuttings had the greatest number of roots in perlite:peat (80:20 by vol) and the least number of roots in Fafard 3 while other substrate were intersubstratete for root number.

Regression and correlation analyses indicated that there were no relationships between percent volume of air space or container capacity of propagation substrate and any of the rooting responses measured for any of the three species propagated. This indicates that in this study, substrates were not maintained in too wet or too dry conditions for these factors to limit rooting or other rooting responses. However, the peat:sand (equal volumes) substrate would seem to have very limited air space and could become water logged under some propagation and liner production conditions. Conversely, the perlite:peat (80:20 by volume) substrate would appear to have potential to become dry quickly. Air space percent volumes between 10 and 15 % and container capacity between 66 and 73 % in the 7.6 cm (3 inch) sample cores seems appropriate for a wide range of propagation conditions and represents the intersubstratete values of most of the substrates measured in this study.

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Table 1. Particle size distribution of eight propagation Substrates.[z]

SIEVE OPENING (mm)	SUBSTRATE[y] (% weight of sample collected on each screen)							
	DPPB	6.4 PB	12.7 PB	PB Pt	Per Pt	Pt S	MM360	FF3
6.40	9.00	0.10	5.38	7.93	1.46	0.44	0.22	4.69
4.00	10.66	1.58	11.86	11.89	13.62	1.13	0.67	13.23
2.80	10.88	12.34	12.34	12.12	27.73	3.33	1.30	12.81
2.00	11.45	14.89	11.86	11.40	21.57	7.05	4.50	12.95
1.40	10.73	13.31	10.57	9.98	12.38	9.42	11.78	11.19
1.00	10.10	11.89	9.24	8.82	5.81	12.16	16.85	9.22
0.71	10.99	12.71	9.61	9.15	4.26	16.17	16.65	8.35
0.50	10.15	11.59	9.04	8.62	2.49	17.04	11.63	6.96
0.36	6.99	8.95	7.47	7.03	2.28	14.38	8.69	5.72
0.25	3.95	5.46	5.11	5.06	1.81	10.31	8.00	4.63
0.18	2.10	3.09	3.08	3.21	1.45	5.64	6.89	3.37
0.11	1.63	2.23	2.35	2.48	1.30	2.58	6.05	3.09
0.00	1.37	1.86	2.09	2.31	3.82	1.15	6.78	3.79
%particles < 0.5 mm (by weight)	16.04	21.59	20.10	20.09	10.66	34.06	36.41	20.60

[z]Each value represents the mean of five air-dried samples.
[y]Propagation substrates are as follows: Double Processed Pine Bark, 6.4 mm Screened Aged Pine Bark, 12.7 mm Screened Aged Pine Bark, Pine Bark:Sphagnum Peat moss (90:10), Perlite:Sphagnum Peat moss (80:20), Sphagnum Peat moss:Sand (50:50), Metro Mix 360, and Fafard #3.

Table 2.Physical properties of eight propagation substrates.[z]

Substrate[y]	Total Porosity	Air Space	Container Capacity (% Volume)	Available Water	Unavailable Water	Bulk Density (g/cc)
DPPB	84.05	10.81	73.24	38.88	34.36	0.18
6.4 PB	80.59	10.85	69.74	37.00	32.74	0.19
12.7 PB	78.90	12.62	66.28	32.07	34.21	0.20
PB Pt (90:10)	78.55	10.36	68.19	36.39	31.80	0.19
Per Pt (80:20)	73.68	27.01	46.63	18.56	28.08	0.15
Pt S (50:50)	58.55	2.30	56.25	42.41	13.84	0.95
MM360	82.27	10.11	72.15	47.90	24.25	0.16
FF3	77.27	15.42	61.86	38.51	23.35	0.15
Normal Ranges	50.0-85.0	10.0-30.0	45.0-65.0 (% volume)	25.0-35.0	25.0-35.0	0.19.0.52.0 (g/cc)

[z]All analyses performed using standard soil sampling cylinders (7.6 cm ID, 7.6 cm h)
Air Space and Container Capacity affected by height of container.

[z]All analyses performed using standard aluminum soil sampling cylinders (7.6 cm ID, 7.6 cm h)

[y]Propagation substrates are as follows: Double Processed Pine Bark, 6.4 mm Screened Aged Pine Bark, 12.7 mm Screened Aged Pine Bark, Pine Bark: Sphagnum Peat moss (90:10), Perlite: Sphagnum Peat moss(80:20), Sphagnum Peat moss:Sand (50:50), Metro Mix 360 and Fafard #3.

Table 3. Rooting responses of *Illicium parviflorum* propagated in eight substrates.[z]

Substrate[y]	Rooting Response		
	Percent Rooting	Root Weight (g)	Root ball Diameter (mm)
DPPB	98.0a	0.26a	17.8a
6.4 PB	100.0a	0.26a	17.8a
12.7 PB	100.0a	0.23abc	15.7b
PB Pt (90:10)	100.0a	0.22abc	15.9b
Per Pt (80:20)	96.0a	0.25ab	15.6b
Pt S (50:50)	98.0a	0.18c	15.6b
MM360	100.0a	0.18c	13.9c
FF3	84.0b	0.20bc	15.4bc

[z]Mean separation within a column followed by the same letter or letters are not significantly different using the Waller-Duncan k-ratio t-test at k-ratio=100. Rooting percentage represents the mean of 40 cuttings other data represents values from cutting which rooted.
[y]Propagation media are as follows: Double Processed Pine Bark, 1/4" Screened Aged Pine Bark, 1/2" Screened Aged Pine Bark, Pine Bark:Peat (90:10), Perlite:Peat (80:20), Peat:Sand (50:50), Metro Mix 360 and Fafard #3.