PHYSICAL PROPERTIES OF DOUBLE-PROCESSED PINE BARK: EFFECTS ON ROOTING

T.E. Bilderback and M.R. Lorscheider
Department of Horticultural Science
North Carolina State University
Raleigh, N.C. 27695-7609 USA

Abstract

Double Processed Pine Bark (DPPB) is a screened and finely ground hammermilled pine bark with minimal amounts of wood or cambium. The appearance and texture of DPPB suggested that it could be used as a propagation medium 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 compared with seven other substrates commonly used for propagation of nursery crops. 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 other pine bark substrates . The effect of the uniform particle size distribution was that the resultant physical properties yielded the greatest total porosity and volume of water held after drainage. Pine bark:sand (equal volumes) had the least total porosity and air space and the greatest bulk density. Regression and correlation analyses indicated no relationship between percent volume of air space or container capacity with rooting responses measured for any of the three species propagated. Analysis of variance and mean separation analyses indicated differences in rooting responses for *Illicium parviflorum* which had lower rooting percentage in the Fafard 3 medium. Root mass diameters for 'Sunglow' azalea were smallest in peat:sand, Metro-Mix 360 and Fafard 3. *Illicium parviflorum* had largest root mass diameter 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. *Photinia x* 'fraseri' cuttings had the greatest number of roots in perlite:peat (80:20 by vol) and the least number of roots in Fafard 3.

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

1. 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 substrates 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 water logged conditions 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 if droplets are large and infiltrate into the substrate.

For these reasons professional propagators use a variety of substrates for propagation of nursery stock. Many commercial substrates are available, however most commercial products contain sphagnum 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 are often too coarse in texture and may contain air pockets or inadequate amounts of moisture for adsorption of newly formed roots. Therefore some propagators choose to prepare rooting substrates 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 sphagnum peat moss 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 media and their effects upon rooting response is somewhat limited. Reisch (1967) concluded that the particular medium components were not of primary importance in rooting response, but the resultant physical properties and the management of the medium 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 substrates 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 Puustjarvi (1969). Tilt and Bilderback (1987) evaluated physical properties of 11 propagation substrates 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 media. 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 medium 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 substrates on rooting response of three ornamental species.

2. Materials and Methods

2.1 Experimental procedures

The eight substrates selected for comparison are listed in Table 1. Double Processed Pine Bark (DPPB) was acquired after it was screened and hammermilled (Summit Corporation Louisburg, N.C.). The 6.4 mm and 12.7 mm pine bark substrates 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:sphagnum peat moss (PB:P) (9:1 by vol.) was composed of the 12.8 mm screened pine bark blended with sphagnum peat moss. The other media were as follows: coarse horticultural perlite:sphagnum peat moss (PP) (8:2 by vol.), Sphagnum peat moss:coarse builder's sand (PS) (1:1 by vol.), Metro-Mix 360 (MM 360) (Scotts and Company, Marysville, OH), and Fafard #3 (FF3) (Fafard, Anderson, S.C.).

The experimental design was a randomized split plot design. Propagation trays with forty cells (5.20 x 5.20 x 5.80 cm for each cell) were filled with all eight substrates 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. 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 measured for illicium and photinia and root number was determined 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.

2.2 Cutting preparation

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 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.

2.3 Physical property analysis

The particle size distributions of each of the eight substrates were obtained at the beginning of the study by sieving three air-dried samples of each substrate through 12 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 substrates were packed in cylindrical aluminum rings, 347.5 cm^3 in volume (7.6 cm dia, 7.6 cm 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 placed 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).

3. Results

3.1 Particle size distribution and physical properties

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 0.4 to < 0.1 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 substrates, but had fewer fine particles < 0.4 mm than the 12.7 or 6.4 mm pine bark. The five substrates with two or more components reflected the particle sizes of the individual components. For example, the PBP substrate was nearly identical to the 12.7 mm PB substrate for particles collected on 4.0, 2.8, and 2.0 sieves. The PS substrate had the greatest number of particles by weight collected on sieves between 2.0 and 0.3 mm, which is approximately the range of most particles in washed builders sand. The MM360 had the most particles below 0.4 mm. 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 substrates studied, yet held as much air space as the 6.4 mm PB. The PS had less total porosity and low air space due to the shrinkage between sphagnum peat moss and sand particles and due to the bulk density of the resultant mix. The PP substrate was the best drained substrate with 27% air space, only 46% moisture content at container capacity and 18.5% available water content.

3.2 Plant growth responses

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 (Table 3). Illicium had largest root ball diameters and greatest root dry weight when rooted in DPPB and 6.4 mm pine bark and least root dry weight in sphagnum peat moss:sand (equal volumes) and Metro-Mix 360. Other substrates were intermediate for root dry weight. *Photinia* x fraseri rooted 97 to 100% in all substrates and was not significant for percent rooting, root weight, or root ball diameter (data not shown). Photinia cuttings had the greatest number (25 roots / cutting average) in perlite:sphagnum peat moss (80:20 by vol) and the least number of roots in Fafard 3 (12 roots / cutting average) while other substrates were intermediate for root number (data not shown). 'Sunglow' azalea rooting percentage ranged from 93 to 100% but was not different among substrates (data not shown). The only significant parameter tested for azalea was root ball diameters which were smaller at 6.7 , 6.0 and 6.0 mm respectively in sphagnum peat moss:sand, Metro-Mix 360 and Fafard 3 and larger at 11.0, 11.3, 10.2 , 11.9 and 11.3 mm respectively in DPPB, 6.2 mm pine bark, 12.7 mm pine bark, PBP, and PP substrates.

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. 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 parameters measured. However, the sphagnum peat moss:sand (equal volumes) substrate would seem to have limited air space and could become water logged under some propagation and liner production conditions. Conversely, the perlite:sphagnum peat moss (80:20 by volume) substrate would appear to have potential to become dry quickly. Air space volumes between 10 and 15 % and container capacity between 66 and 73% in the 7.6 cm sample cores seems appropriate for a wide range of propagation conditions and represents the intermediate values of most of the substrates measured in this study.

4. Conclusions

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 substrates for *Illicium parviflorum* . Although results were nearly identical to rooting responses of two component substrates, DPPB would not require equipment and time required to uniformly blend two components. Rooting response in DPPB, 6.4 and 12.7 mm 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.

References

Arnold, B.R. 1973. Some thoughts on physical properties of substrates with special reference to aeration. Acta Hort. 31:149-160.

Bilderback, T. E., W. C. Fonteno, and D. R. Johnson. 1982. Physical properties of media composed of peanut hulls, pine bark, and peat moss and their effects on azalea growth. J. Amer. Soc. Hort. Sci. 107: 522-525.

Chadwick, L.C. 1933. Studies in plant propagation. Cornell Univ. , Agr. Expt. Sta. Bul. 571, p.51.

Guttormen, G. 1974. Effects of root medium and watering on transpiration, growth and development of glasshouse crops: I. Effects of compression at varying water levels on physical state of root media and on transpiration and growth of tomatoes. Plant & Soil 40:65-81.

Hoitink, H.A.J. and H.A. Poole. 1979. Mass production of composted tree barks for container media. Ohio Florists Assn. Bul. 599:3-4.

Long, J.C. 1932. The influence of rooting media on the character of roots produced by cuttings. Proc. Amer. Soc. Hort. Sci. 29:352-355.

Matkin, O.A. 1965. Physical properties of propagating media. Plant Prop. 11:18.

Milks, Robert R., William C. Fonteno, and Roy A. Larson. 1989. Hydrology of horticultural substrates: II. Predicting physical properties of media in containers. J. Amer. Soc. Hort. Sci. 114:53-56.

Puustjarvi, V. 1969. Water air relationships in peat culture. Peat Plant News: 2:43-53.

Reisch, K.W. 1967. Rooting media. Proc. Intl. Plant Prop. Soc.117:356-361.

Tilt, K. M. and T. E. Bilderback. 1987. Physical properties of propagation media and their effects on the rooting response at three woody ornamental species. HortScience 22:245-247.

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

SIEVE OPENING (mm)	SUBSTRATE (% weight of sample collected on each screen)							
	DPPB	6.4 PB	12.7 PB	PBP	PP	PS	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
pan	1.37	1.86	2.09	2.31	3.82	1.15	6.78	3.79

[z]Each value represents the mean of five air-dried samples.

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

Substrate	Total Porosity	Air Space	Container Capacity	Available Water	Unavailable Water	Bulk Density (g/cc)
				(% Volume)		
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
PBP (90:10)	78.55	10.36	68.19	36.39	31.80	0.19
PP (80:20)	73.68	27.01	46.63	18.56	28.08	0.15
PS (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

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

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

Substrate	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
PBP (90:10)	100.0a	0.22abc	15.9b
PP (80:20)	96.0a	0.25ab	15.6b
PS (50:50)	98.0a	0.18c	15.6b
MM360	100.0a	0.18c	13.9c
FF3	84.0b	0.20bc	15.4bc

[z]Means within a column followed by the same letter or letters are not significantly different at $p < 0.05$. Percent rooting represents the mean of 40 cuttings other data represents values from cuttings which rooted.