What To Do When Pine Bark Runs Short: Physical Properties of Pine Bark Alternatives

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Significance to Industry: When selecting a substrate amendment, particle size and particle size distribution should be considered and used in determining the volume of amendment to add to the pine bark (PB) base. Both the physical size and shape of the amendment's particles will impact how it will blend with PB determining the air and water relations of the blended substrate. Additionally, the porosity and chemistry of the particles will alter the moisture availability and nutrient retention of the blended substrate.

In this work, all amendments resulted in PB-based substrates with physical properties within the range recommended by the Best Management Practices Guide (Yeager, et al., 2007). However, plant available water and stability over time under production conditions varied with substrate amendment. Time in production did not alter the total porosity, available water, or unavailable water of builders sand, clay, and slate amended substrates meaning that these physical properties were stable and remained constant over the 17 months; however, container capacity and the small particle factions increased in theses substrates over time. Pine bark-based substrates amended with mortar and builders sands had the greatest CC and lowest AS while the slate amended and PB substrates had the lowest CC and greatest AS. However, data on plant growth in all these substrates needs to be evaluated before production recommendations can be established.

Nature of Work: The Southeastern nursery industry relies almost exclusively on PB as a substrate to grow nursery plants in pots. Pine bark is desirable because it is light in weight, well-drained, pathogen-free and disease suppressive. Changes in forestry practices and new markets for forestry products have threatened the availability of this vital component in nursery plant production. A survey by Lu, et al. (2006) found a decline in PB availability across the southeast and elsewhere with associated increased cost due to less domestic forestry production, imported logs without adhering bark, increase rate of 'in-forest' wood harvesting that leaves bark behind on the forest floor, and increase use of PB as a fuel source. Consequently, less than 5% of the forest product inventory of PB is available for horticultural use.

Alternative substrates and substrate components with desirable horticultural characteristics have been investigated to mitigate the potential impact of diminished PB supplies for containerized plant production industry. Many alternative substrate components show promise in that they are non-toxic to plants and can be successfully used as an amendment with PB stretching our PB supplies and creating acceptable growing substrates. However, cost, regional availability, and insufficient research have reduced the widespread use of these alternatives. Research based recommendations offered to growers for utilizing alternative substrate components would create options for a nursery to select the cheapest, most convenient resources.

The goal of this project is to provide the nursery industry in the southeast with regionally available, alternative potting substrates that will keep the industry competitive and continue demand for their products in the competitive nursery industry. To meet this goal, comparison of several PB-based, blended substrates were evaluated for their appropriateness in supplying the water availability and aeration required to support containerized plant growth and substrate stability in containers over time.

Containers were filled with either 100% PB or a blended substrate (v/v) of 8:1 PB : expanded slate (slate) (PermaTill, Carolina Stalite Company, Salisbury, NC 28145-1037; 8:1 PB : calcined attapulgite clay (clay) (OilDri LVM, Oil-Dri Corporation of America, Chicago, IL 60611-4213); 8:1 PB : washed builder sand (builders) (Caudle Sand and Rock, Raleigh, NC 27603-2339); 8:1 PB : mortar sand (mortar) (Caudle Sand and Rock, Raleigh, NC 27603-2339); or 8:1 PB : Lilesville granite (granite) (Hawksridge Farms, Inc. Hickory, North Carolina 28603-3349) for a total of six substrates. Table 1 shows the particle size range and physical characteristics of each amendment.

Fallow containers of each substrate were filled and irrigated as were containers with plants grown in these substrates. Physical properties [total porosity (TP) (% vol.), air space (AS) (% vol.), container capacity (CC) (% vol.), available water (AW) (% vol.), unavailable water (UW) (% vol.), and bulk density (BD) (g/cc)] and particle size distributions [sieve screens: 6.3 mm (XL), 2 mm (L), 0.71 (M), 0.50 mm (S), 0.25 mm (XS), 0.106 mm (XXS) and < 0.106 (pan)] were determined from substrate in these fallow containers following the procedures described by (Fonteno, et al., 1995) 6 weeks and 17 months after potting. No plant growth data will be presented.

The fallow containers were arranged in a randomized complete block design (RCBD) with two sample times, six substrates, and three replications. All variables were tested for differences using analysis of variance procedures and lsd means separation procedures where appropriate (SAS, 2001). When a non-significant sample time x substrate interaction was in effect, only main effects of sample time and substrate were presented. When a significant sample time x substrate effect was present data were reanalyzed by each main effect.

Results and Discussion: The sample time x substrate interaction was non-significant for CC, AS, and AW as well as for the XL, L, M, S, and XXS particle sizes in the substrates (data not shown). Sample time did not alter AS or AW but did affect CC, and the XL, L, M, S, and XXS particle distributions (Table 2). Container capacity increased with time as did the M, S, and XXS particles while the XL and L particle fractions decreased with time presumably due to decomposition. Pine bark-based substrates amended with mortar and builders sands had the greatest CC and lowest AS while the slate amended and PB substrates had the lowest CC and greatest AS. Mortar and builders sand amended substrates also had low fractions of XL, L, and M particle sizes and high fractions of S and XXS. The large percentage of smaller particle sizes created a greater number of small pores in these PB-based substrates which held water and increased CC. Additionally, mortar and builders sands resulted in the greatest percentage of AW of all these PB-based substrates. Clay resulted in a substrate with a CC similar to builders sand and AS and AW similar to granite, slate, and PB. Granite resulted in the similar CC and AW but lower AS than slate.

The sample time x substrate interaction was significant for TP, UW, and BD as well as for the SX and pan particle size distributions (data not shown). Sample time did not affect TP and UW of the builders sand, clay, and slate amended substrates meaning that these physical properties were stable and remained constant over the 17 months (Table 3). In contrast, TP increased for granite and TP and UW increased for mortar sand. BD decreased with time for all the substrates except clay. The fraction of XS sized particles increased with the builders sand and PB but were not affected in any of the other substrates. An increase in the very smallest particles (those collected in the pan) was seen in only the clay and the PB substrates. PB had the greatest TP and UW at 6 weeks while at 17 months clay and mortar sand had the greatest TP and UW, respectively (Table 4). The slate, builders sand, and granite consistently over time had the lowest UW.

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Table 1. Particle size range and particle characteristics of pine bark and substrate amendments.

Amendment	Particle size (inches)	Particle shape
2008		
PB	6.3 – 0.106 mm (0.248 – 0.004 in)	flat, slightly porous
clay	0.71 – 0.106 mm) (0.028 – 0.004 in)	round, slightly porous
slate	6.3 – 2.0 mm (0.248 – 0.079 in)	round, angular, highly porous
builders sand	2.0 – 0.106 mm (0.079 – 0.004 in)	round, non-porous
mortar sand	0.71 – 0.106 mm (0.028 – 0.004 in)	round, non-porous
granite	6.3 – 0.71 mm (0.248 – 0.028 in)	round, non-porous

Table 2. Effect of sample time and substrate on physical properties and particle size of substrates. A non-significant sample time x substrate interaction is in effect.

Sample time	CC (%)	AS (%)	AW (%)	XL (g)	L (g)	M (g)	S (g)	XXS (g)
6 weeks	59.0[z]	--[y]	--	14.3	40.9	25.9	7.1	2.9
17 months	61.2	--	--	11.9	35.0	27.9	9.9	3.7
Substrate								
mortar sand	64.5 a[x]	15.1 c	33.4 a	11.1 cd	23.7 c	29.7 b	15.3 a	4.1 a
builder sand	62.6 ab	15.3 c	33.4 a	9.8 cd	25.6 c	31.8 b	12.7 b	4.4 a
clay	61.6 b	22.2 ab	30.1 b	8.7 d	37.1 b	35.4 a	6.6 c	2.7 bc
granite	57.0 c	19.3 b	28.6 b	13.3 bc	59.0 a	16.0 e	4.1 d	2.3 c
slate	56.6 c	23.8 a	27.3 bc	20.4 a	41.2 b	22.4 d	5.9 c	3.3 b
PB	58.4 c	24.7 a	25.32 c	15.5 b	41.2 b	26.2 c	6.5 c	3.1 b

[z]Significant analysis of variance at $P \leq 0.05$ or $P \leq 0.01$, respectively. Data are means of 3 observations

[y]Non-significant analysis of variance.

[x]Means followed by different letters within a column are significantly different from each other based on lsd means separation procedures.

Table 3. Effect of sample time within each substrate on selected physical properties and particle sizes. A significant sample time x substrate interaction is in effect.

	Sample time	6 weeks means	17 months means
		Builder sand	
TP (%)	NS[z]	--	--
UW (%)	NS	--	--
BD (g/cc)	*	0.49[y]	0.44
XS (g)	*	12.1	17.9
Pan (g)	NS	--	--
		Granite	
TP (%)	**	74.6	77.9
UW (%)	NS	--	--
BD (g/cc)	*	0.48	0.47
XS (g)	NS	--	--
Pan (g)	NS	--	--
		Mortar sand	
TP (%)	*	76.3	83.0
UW (%)	**	27.3	35.0
BD (g/cc)	*	0.48	0.43
XS (g)	NS	--	--
Pan (g)	NS	--	--
		Clay	
TP (%)	NS	--	--
UW (%)	NS	--	--
BD (g/cc)	NS	--	--
XS (g)	NS	--	--
Pan (g)	**	1.13	0.57
		PB	
TP (%)	NS	--	--
UW (%)	NS	--	--
BD (g/cc)	*	0.26	0.24
XS (g)	*	4.9	9.4
Pan (g)	*	1.0	1.43
		Slate	
TP (%)	NS	--	--
UW (%)	NS	--	--
BD (g/cc)	**	0.40	0.45
XS (g)	NS	--	--
Pan (g)	NS	--	--

[z]Analysis of variance *, ** Nonsignificant or significant at $P \leq 0.05$ or $P \leq 0.01$, respectively.
[y]Data are means of 3 observations.

Table 4. Effect substrate within each sample time on selected physical properties and particle sizes. A significant sample time x substrate interaction is in effect.

Sample time	TP (%)	UW (%)	BD (g/cc)	XS (g)	Pan (g)
6 weeks	**[z]	**	**	**	**
Means (6 wks)					
PB	84.0 a[y]	34.3 a	0.26 d	4.9 b	1.0 e
clay	83.5 a	31.6 b	0.30 c	5.5 b	1.1 de
slate	77.8 b	29.0 c	0.40 b	5.5 b	1.7 a
mortar sand	76.3 bc	27.3 d	0.48 a	11.6 a	1.4 bc
builders sand	75.5 c	29.4 c	0.49 a	12.1 a	1.5 b
granite	74.6 c	28.4 cd	0.49 a	4.2 b	1.3 cd
17 months	*[z]	**	**	**	**
Means (17 months)					
PB	82.2 ab[y]	32.0 b	0.24 e	9.4 b	1.4 ab
clay	84.0 a	31.2 bc	0.27 d	8.1 b	0.6 c
slate	82.9 ab	29.4 cd	0.34 c	7.5 bc	1.8 a
mortar sand	83.0 ab	35.0 a	0.43 b	17.4 a	1.4 ab
builders sand	80.1 bc	29.1 d	0.45 b	17.9 a	1.2 b
granite	77.9 c	28.3 d	0.47 a	4.9 c	1.2 b

[z]Significant analysis of variance at $P \leq 0.05$ or $P \leq 0.01$, respectively.

[y]Data are means of 3 observations. Means followed by different letters within a column are significantly different from each other based on lsd means separation procedures.