J. Amer. Soc. Hort. Sci. 109(6):774–776. 1984.

Construction of a Milled Pine Bark and Sand Potting Medium from Component Particles II. Medium Synthesis

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Additional index words. reverse engineering, artificial substrate

Abstract. **A standard 1:1 v/v pine bark and sand potting medium was characterized physically by particle size distribution, bulk density (BD), total pore space, porosity at 50 cm H_2O tension and porosity at >50 cm H_2O tension. A potting medium identical to the standard was constructed from component milled pine bark and sand particles. *Phaseolus lunatus* L. 'Jackson Wonder' plants grown in the 2 physically similar media, under a standard cultural program, were essentially identical. Construction of a potting medium from a prescribed screen analysis provides a means to quantify variation which exists within a medium assumed to be uniform.**

The greatest single drawback in greenhouse and nursery production is the lack of standardization, especially in formulation of the growing medium (4). Reproducible growing media are desirable so that standardized cultural practices may be superimposed with consistent results (6).

In experimentation, unless physical and chemical properties of a medium are comparable among replications, one cannot be certain that plant response is due to treatment or to differences in medium properties. Therefore, researchers must examine ways to reproduce physical and chemical properties in media to realize progress towards standardizing growing substrates.

Lawrence and Newell (9) recommended the use of standardized composts for container-grown greenhouse crops. Their aim was to develop a growing medium which was well aerated, had good moisture retaining capacity, was penetrated easily by roots, and was replicable. The resulting John Innes Potting Composts consisted of 7 loam: 3 peatmoss: 1 sand (by volume) amended with fertilizer and lime.

Matkin and Chandler (10) developed 5 soil mixes known as the Univ. of California or U.C. Mixes, which are adaptable to a wide range of crops grown in containers, flats, or greenhouse bench conditions. U.C. Mixes consist primarily of fine sand and peatmoss amended with lime and fertilizers.

Other mixes that attempt to satisfy the requirement of reproducibility include the Einheitserde or Standardized Soil (11) and the Cornell "Peat-Lite" mixes (1). DeWerth and Odom (4) standardized peat and perlite growing media by specifying that perlite be graded by size.

The feasibility of identifying a texturally unknown potting medium by screen analysis and constructing a medium identical to the unknown from component particles was first demonstrated by Pokorny and Delaney (12) working with 100% milled pine bark. However, few plants are grown commercially in a single component potting medium. Most growers utilize a multiple component medium. Building a multiple component medium presents a more complex problem in regard to particle size analysis, since each component used in medium preparation may be retained singly or in an unknown volume blend on each and/or every screen. Successful synthesis of a multiple component medium depends on predicting accurately the volume percentages of components retained on each screen.

The purposes of this research were: 1) to characterize a standard 1:1 (v/v) milled pine bark and sand potting medium physically and, 2) reconstruct a medium which possesses properties comparable to the standard from milled pine bark and sand particles.

Materials and Methods

Air-dried milled pine bark (Table 1) was placed in a 2-liter beaker and settled by tapping lightly on a countertop 10 times. Volume was adjusted to 2 liters. This process was repeated for air-dried sand (Table 1). The bark and sand were mixed in a rotary cement mixer. Ten 250-cc samples then were drawn using a mechanical sample splitter, and each of the 10 air-dried samples was placed, 50 cc at a time, on a Ro-Tap shaker and sieved for 20 min using U.S. Standard sieves with openings of 4.76, 2.38, 2.00, 1.00, 0.84, 0.60, and 0.42 mm (mesh numbers 4, 8, 10, 18, 20, 30, and 40). Fractions retained on each screen and in the receiver pan were collected after each shaking period. After all five 50-cc samples had been sieved, fractions for each screen and receiver pan were weighed.

Table 1. Screen analysis and bulk density of components used in preparing the standard milled pine bark and sand potting medium.

		Screen analysis (% wt)		
U.S. Standard sieve number	Openings (mm)	Milled pine bark	Fine sand	Blend sand
4	4.76	16.5	0	0
8	2.38	34.4	1.0	7.7
10	2.00	7.0	0.8	6.3
18	1.00	17.3	22.9	32.8
20	0.84	4.4	8.0	6.7
30	0.60	6.8	17.5	12.8
40	0.42	4.0	19.4	13.7
Pan	<0.42	9.3	30.4	20.5
Bulk density (g/cc)		0.28	1.58	1.65

Received for publication 1 Dec. 1983. Supported by State and Hatch funds allocated to the Georgia Experiment Stations. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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Table 2. Particle size distribution (% by wt) of a standard and synthesized pine bark and sand 1:1 (v/v) potting medium.

U.S. Standard sieve number	Openings (mm)	Screen analysis (% by wt) Standard medium	Synthesized medium	$S\bar{x}$
4	4.76	1.3[z]	1.3	0.01
8	2.38	9.8	9.8	0.06
10	2.00	7.5	7.5	0.05
18	1.00	32.7	33.1	0.07
20	0.84	6.8	6.6	0.05
30	0.60	12.4	12.3	0.10
40	0.42	12.4	12.5	0.11
Pan	<0.42	17.2	17.1	0.05

[z]Paired means within a row are not significantly different at 5% level (F-test).

Percentage by volume of bark and sand remaining on each screen and in the receiver pan was determined according to the method of Krafka (8). After percent by volume bark and sand on each screen was known, a paired sample for each screen was synthesized from air-dried component particles. Particle fractions were placed in plastic containers and mixed mechanically, end over end, for 20 min to reconstruct the samples.

Screen analysis was redetermined for the standard and its paired sample; thereafter, samples were subjected to the following analyses.

Total porosity, porosity at 50 cm water tension, porosity at greater than 50 cm water tension, and bulk density. Standard and synthesized medium samples were placed in 250-cc metal containers. Fine mesh screen was fastened over one end; the other was sealed with a metal lid. Containers of medium were submerged in deionized water and placed under vacuum (−150 mm Hg) for 72 hr to saturate (12). Saturated samples were weighed and transferred to a porous ceramic pressure plate apparatus (13), and a pressure equivalent to 50 cm H_2O was applied. After equilibrium was attained (about 96 hr), samples were removed, weighed, oven-dried at 80°C, and reweighed. Total porosity, porosity at 50 cm tension, porosity at >50 cm tension, and oven-dried BD were calculated as follows:

$$\underset{(\%\ \text{vol})}{\text{Porosity at 50 cm tension}} = \frac{\text{wt at saturation} - \text{wt at 50 cm } H_2O \text{ tension}}{\text{vol of sample}} \times 100;$$

$$\underset{(\%\ \text{vol})}{\text{Porosity at tension} > 50 \text{ cm } H_2O} = \frac{\text{wt at 50 cm } H_2O \text{ tension} - \text{oven dry wt}}{\text{vol of sample}} \times 100;$$

$$\underset{(\%\ \text{vol})}{\text{Total porosity}} = \text{porosity at 50 cm tension} + \text{porosity at tension} > 50 \text{ cm } H_2O;$$

$$\underset{(\text{g/cc})}{\text{Bulk density}} = \frac{\text{oven dry wt}}{\text{vol of sample}}.$$

Growth Study. Seeds of *Phaseolus lunatus* L. 'Jackson Wonder' were sown in vermiculite and germinated under mist. When true leaves appeared, a terminal cutting was obtained with the basal cut made just above the cotyledonal node. Roots were washed after rooting to remove vermiculite. Twenty plants of similar weight were planted in paired standard and synthesized bark-sand samples and grown under cool-white fluorescent lights (49.3 μmol s^{-1} m^{-2}) with 16 hr daylength. Plants were watered daily (90 ml/250 cc pot); once each week 90 ml of a 20N–8.8P–16.6K solution (200 ppm N) replaced watering.

Plants were harvested after 40 days and dry weight was obtained. Leaf tissue was analyzed for P, K, Ca, and Mg by spectrophotometric methods (7) and for N by modified Kjeldahl method (3).

The experiment was conducted in a randomized complete block design with 10 replications. Treatment effects were delineated by F-test (5).

Results and Discussion

Percent by weight of bark and sand retained on each screen and on the receiver pan did not differ significantly between the standard and synthesized bark-sand medium samples (Table 2). Only pine bark particles were collected on screen 4; therefore, the synthesized samples were constructed on the basis of weight alone and not BD for this screen size.

A high percentage of bark was retained on screens with large openings (mesh no. 8, 10) while most of the sand was retained on screens with small openings (mesh no. 20, 30, and 40).

None of the screens showed a 1:1 (v/v) ratio of bark to sand (Table 3), but rather a 1:3 (v/v) ratio. This latter bark to sand ratio occurred because the BD of sand was considerably greater than bark. Thus, there were fewer bark particles than sand particles retained per volume resulting in the 1:3 (v/v) ratio.

The synthesized bark-sand medium did not differ significantly from the standard on the basis of BD, porosity at 50 cm tension, porosity at >50 cm tension, and total porosity (Table 4). Thus, the 2 potting media (standard and synthesized) essentially were identical for the parameters measured.

There was no significant difference in total dry weight of *Phaseolus lunatus* L. 'Jackson Wonder' between standard and synthesized samples (Table 5). Leaf analysis for N, P, K, Ca, and Mg showed no marked difference in nutrient content between the plants grown in the 2 potting media and subjected to a standard cultural program (Table 6).

Table 3. Average percent pine bark and sand retained on each screen.

U.S. Standard sieve number	Openings (mm)	Standard medium	Synthesized medium
4	4.76	100/0	100/0
8	2.38	75/25	76/24
10	2.00	41/59	42/58
18	1.00	29/61	28/62
20	0.84	24/76	24/76
30	0.60	27/73	29/71
40	0.42	23/77	24/76
Pan	<0.42	31/69	32/68

Table 4. Physical properties of a standard and synthesized pine bark and sand 1:1 (v/v) potting medium.

Physical property	Standard medium	Synthesized medium	$S\bar{x}$
Bulk density (g/cc)	1.15[z]	1.15	0.00
Total porosity (% v)	61.35	60.04	0.43
Porosity at 50 cm tension (% v)	29.87	29.08	0.51
Porosity at pressure >50 cm tension (% v)	31.48	30.95	0.47

[z]Paired means within a row not significantly different at 5% level (F-test).

Table 5. Dry weight (g) of *Phaseolus lunatus* L. 'Jackson Wonder' grown in a standard and synthesized pine bark and sand 1:1 (v/v) potting medium.

Plant part	Standard medium	Synthesized medium	$S\bar{x}$
		Dry wt (g)	
Total	1.66[z]	1.51	0.06
Top	1.37	1.25	0.53
Root	0.29	0.26	0.01

[z]Paired means within a row are not significantly different at 5% level (F-test).

Table 6. N, P, K, Ca, and Mg content of *Phaseolus lunatus* L. 'Jackson Wonder' leaf tissue of plants grown in a standard and synthesized pine bark and sand 1:1 (v/v) potting medium.

Potting medium	Element (%)				
	N	P	K	Ca	Mg
Standard	3.54	0.82	3.36	2.02	0.41
Synthesized	4.09	0.84	3.32	2.06	0.48

These results and those of Pokorny and Delaney (12) support the hypothesis of Brown and Pokorny (2) that screen analysis can be used to characterize and standardize a pine bark and/or pine bark and sand potting mixture. The application of these techniques to variable medium components or to complex blends (3 or more) has not been attempted.

A method now exists for constructing samples with 2 components in which the ingredients are relatively stable, thus reducing variation. This method provides the researcher with a choice between constructing idental samples from a prescription derived from an unknown medium or locating variation between samples drawn from a large population. Assuming a large population to be uniform is a common error (14).

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