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Physical Properties of Media Composed of Peanut Hulls, Pine Bark, and Peatmoss and their Effects on Azalea Growth[1]

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Abstract. **Equal volumes of peanut hulls, pine bark, and sphagnum peatmoss were combined into 5 media. Particle size distribution, total porosity, air space, easily available water, water buffering capacity, and bulk density were determined for each medium. Top dry weight, root dry weight, and percent growth of *Rhododendron indicum* (L.) Sweet cv. George L. Taber were measured 14 weeks after potting in 1-liter containers. Peanut hulls increased particle size, total porosity, and air space, and decreased easily available water, water buffering capacity, and bulk density of media. Peatmoss generally reduced total porosity and air space and increased easily available water, water buffering capacity, and bulk density regardless of other component combinations. Top dry weight, root dry weight, and percent growth were greater in peanut hull-containing media. Addition of peatmoss to the container media tended to produce less growth.**

When the cost of sphagnum peatmoss sharply increased in the 1960s, the nursery industry sought less costly substitutes for container media. Bark was a low-cost renewable resource and when milled and screened could be used as a medium ingredient for growing container ornamentals (2). Recently, rising prices have caused wood byproducts, such as bark, to be utilized as fuel sources (4, 5). Due to competition and rising costs, nurserymen are in need of other components to use in potting media.

Although substitutes such as peanut hulls are being used by growers in the Southeast, little information is available on performance in potting media. Larson and McIntyre (10) found that plant growth and flowering of pot mums in a 2 soil:1 peatmoss:1 peanut hull medium (v/v/v) were equal to those grown in a 1 soil:1 peatmoss medium (v/v) with no unusual cultural adjustments. The pH ranged from 6.1 to 6.8 with addition of 5.9, 11.7, or 17.6 kg of dolomitic limestone per m^3. No differences in pot mum growth were seen between pasteurized and unpasteurized treatments.

The physical and chemical properties and management required for peanut hulls used in nursery potting media are still unknown. This study was conducted to classify particle size distribution, air space, moisture retention, and plant growth response of 'George L. Taber', a Formosa-type azalea, to peanut hulls and combinations of peanut hulls, pine bark, and peatmoss used as potting media.

Materials and Methods

Five combinations of aged peanut hulls, aged pine bark, and Canadian sphagnum peatmoss were evaluated (Table 1). Peanut hulls were milled and passed through a 12.7-mm screen and pine bark was passed through 6.4-mm mesh hardware cloth.

In all treatments, 3.6 kg superphosphate (0N-16.6P-0K), 3.0 kg $CaSO_4$, and 0.1 kg fritted trace element FTE 503, (Frit Industries, P.O. Box 1325, Ozark, AL 36360), were added per m^3 of medium prior to pasteurizing. After potting azaleas into 1-liter containers, all treatments were top-dressed with 2.4 g Osmocote (14N-6.1P-11.6K) per container. Plants were placed in a greenhouse and arranged in a randomized complete block design with 4 replications and 4 plants per plot. Night temperature was 16°C and day temperatures ranged from 17° to 27°. Initial pH ranged from 3.5 to 4.9, thus all media were drenched with 105 ml of lime water solution (24.0 g/liter hydrated lime) per container. A final pH range of 4.9 to 5.3 was achieved. All media were hand-watered.

To obtain particle size distribution of a medium, four 100-g air-dried samples were sieved for 3 min at 160 shakes per min with a Ro-Tap Shaker and U.S. Standard Sieves with openings of 6.4, 4.75, 1.00, 0.60, 0.25, and 0.106 mm. The particle fractions retained on each sieve and the amount that passed through the smallest sieve and retained on the receiver pan were weighed.

A useful method to compare particle size distribution of various media is a summation curve (6). By plotting the percent weight of sample which passes through a specific mesh screen against the logarithm of the mesh size (sieve opening), a characteristic curve can be generated for that sample (Fig. 1). There are 2 major advantages to this technique: 1) the curve allows convenient comparisons of particle sized not specifically screened and 2) different media screened with different sized sieves can be plotted on the same graph. This then facilitates direct comparison of media without standardization of sieve sizes.

In order to determine the water-holding characteristics of these materials, the samples were first moistened to a moisture content corresponding to pF 1.5–2.0 by eye estimation. The materials

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Table 1. Particle size distribution of 5 synthesized potting media.

Particle size (mm)	Particle size distribution (% wt)				
	PH[z]	PH + PB[y]	PH + P[x]	PH + PB + P[w]	PB + P[v]
> 6.4	17.1	4.8	15.4	8.9	3.0
6.4–4.75	18.9	8.3	13.8	8.3	3.0
4.75–1.0	51.6	67.8	40.3	55.0	59.0
1.0–0.60	7.4	9.8	13.5	12.0	15.5
0.60–0.25	4.7	6.0	12.4	10.0	13.1
0.25–0.106	0.3	1.6	3.6	3.9	4.3
< 0.106	0	1.9	1.1	1.6	2.0

[z] PH = Aged (1 year) peanut hulls (< 12.7 mm).

[y] PH + PB = Aged peanut hulls and pine bark (< 6.4 mm) (1:1 by volume).

[x] PH + P = Aged peanut hulls and Canadian sphagnum peatmoss (1:1 by volume).

[w] PH + PB + P = Aged peanut hulls, pine bark, and Canadian sphagnum peatmoss (1:1:1 by volume).

[v] PB + P = Pine bark and Canadian sphagnum peatmoss (1:1 by volume).

were then packed into three 345.5-ml cylinders (r = 3.8, h = 7.6 cm) mounted end-to-end with the bottom cylinder resting in a plastic Petri dish. The cylinders were then filled by placing 100 cc of sample in the cylinder, raising the cylinders 5 cm 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.

Total porosity (TP), air space (AS), easily available water (EAW), and water-buffering capacity (WBC) were determined for each medium using a porous pressure plate apparatus and procedures as reported by Fonteno, et al. (8). Total porosity (TP) was defined as the moisture content at zero pressure. Air space (AS) was defined as the volume percent difference between total porosity (TP) and moisture content at 10 cm pressure. Easily available water (EAW) was the quantity of water released between pressures of 10 cm and 50 cm. Water-buffering capacity (WBC) was the amount of water released between 50 cm and 100 cm pressure and was considered a measure of water reserve. Bulk densities were determined using oven dried (105°C for 24 hr) medium samples.

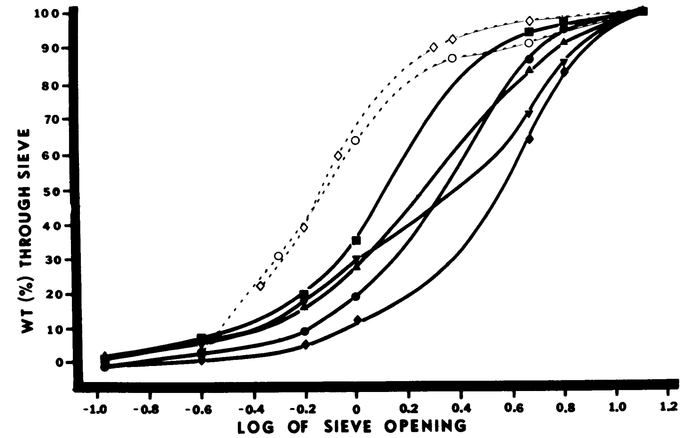

Fig. 1. Summation curve of particle size distribution of 7 media.

◆ = Peanut hulls
● = Peanut hulls + pine bark
▼ = Peanut hulls + peat
▲ = Peanut hulls + pine bark + peat
■ = Pine bark + peat
◇ = Pine bark + sand reported by Brown and Pokorny (2)
○ = Pine bark + peat + sand reported by Fonteno, Cassel, and Larson (8)

After 14 weeks, 'George L. Taber' azalea plants from rooted and branched cuttings were cut at the soil line. Roots were hand-washed free of the medium and top and root dry weight were determined after drying at 70°C for 48 hr. A percent growth increase was calculated as the difference between the mean of total plant dry weight of 16 plants at the time of potting and the sum of top dry weight and root dry weight 14 weeks later, divided by total plant dry weight means at the end of the study.

Results and Discussion

Particle size distribution. Peanut hulls contributed to the very large (> 4.75 mm) particles of 4 media (Table 1). About 50% of all particles were between 4.75 and 1.0 mm. Media containing peatmoss had a greater percent of fine particles (1.0 to 0.106 mm). The PH medium (aged peanut hulls) had no particles < 0.106 mm while the other 4 media showed about the same percentages < 0.106 mm.

When particle size was expressed in a summation curve (Fig. 1), PH had about 65% passing through the 4.75-mm (log = 0.68) screen but only 12% passed through the 1.0-mm (log = 0) screen. This indicated that about 53% of the PH sample had particle sizes between 4.75 and 1.0 mm. Also, the curve for PH tended to flatten out toward the origin, indicating very little collection between 0.6 and 0.1 mm (log = 0.2 + 0 − 1.0). All the peanut hull combinations tended to have large particles (> 1.0 mm) and very few fine particles (< 0.25 mm, log = −0.6). Comparisons were made between the media in this study and those reported by Brown, et al. and Fonteno, et al. (Fig. 1). Even though different screen sizes were used for particle size analyses, direct comparisons among all media can be made. Both the PB + S and the PB + P + S media showed fewer particles > 2.0 mm (log = 0.3) than the other media. Both PB + S and PB + P + S media had over 20% of the particles below 0.42 mm (log = −0.38) while the other media ranged from 4 to 11%. Therefore, the peanut hull-containing media provides greater aeration but less water-holding capacity.

The data in Table 2 and Fig. 2 are discussed in terms postulated by de Boodt and Verdonck (7). The proposed acceptable ranges of TP, AS, EAW, and WBC defined by de Boodt and Verdonck were subsequently used by Fonteno et al. (8), Bunt (3), Prasad (11), and Goh and Haynes (9). These terms may not be entirely accurate in relating plant response to media for the following reasons: first, a major assumption is that water availability is predominantly limited by moisture tension. This excludes effects of unsaturated hydraulic conductivity. Roots also pull water from surrounding pores as well as the pores they occupy. Also, the rate of water movement in a porous medium at a particular site is governed by the unsaturated hydraulic conductivity at that site. However, hydraulic conductivity is more limiting in soils where roots are prevented from filling or penetrating a particular site (1). In porous media where roots are unrestricted and generally fill the container, the role of hydraulic conductivity should be diminished. Second, different plant species may have differing abilities to obtain water from a medium. Consequently, water that is "easily available" for one plant may not be as easily available to another. Third, in a media with widely ranging

Table 2. Total porosity (TP), air space (AS), easily available water (EAW), water-buffering capacity (WBC), and bulk density (BD) of 5 container media.

Media[z]	TP (% vol)	AS (% vol)	EAW (% vol)	WBC (% vol)	BD (g/cm^3)
PH	84.9a[y]	72.9a	3.7c	0.3c	0.11c
PH + PB	70.3b	43.8b	10.7b	0.7c	0.18a
PH + P	84.2a	41.3b	19.6a	5.0a	0.09d
PH + PB + P	75.1ab	39.0ab	15.8ab	1.9bc	0.14b
PB + P	74.0ab	30.0c	20.1a	2.7ab	0.14b
Proposed acceptable ranges[x]	85	20–30	20–30	4–10	—

[z] See Table 1 for medium composition.

[y] Mean separation within columns by Duncan's multiple range test, 5% level.

[x] From de Boodt and Verdonck (7).

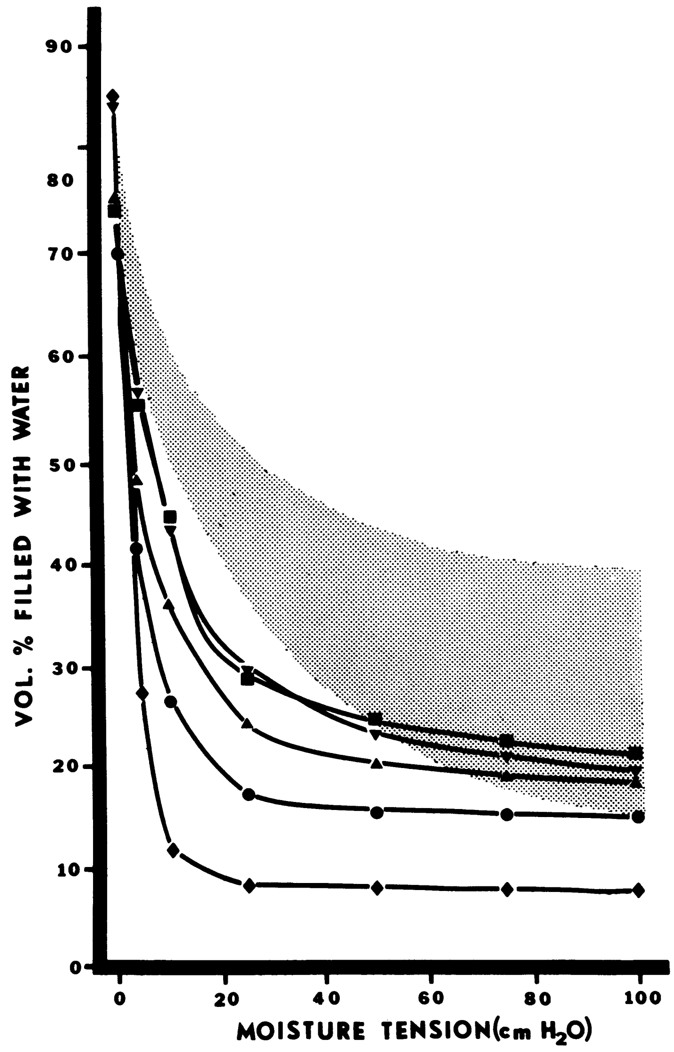

Fig. 2. Moisture retention curve for 5 media 14 weeks after potting. Shaded area of figure defines ideal moisture retention of a medium as determined from de Boodt and Verdonck (7).

◆ = Peanut hulls
● = Peanut hulls + pine bark
▼ = Peanut hulls + peat
▲ = Peanut hulls + pine bark + peat
■ = Pine bark + peat

particle size distributions, the volume of water held at a specific tension varies greatly from one medium to another. Therefore, one must be cautious when describing water characteristics solely in terms of moisture tensions. However, under these qualified conditions, these terms are very descriptive and tend to standardize water-holding characteristics of porous media and were used as points of reference for this study.

Total porosity. PH and PH + P had the highest total porosities and PH + PB had the lowest (Table 2). The use of total porosity to characterize a medium should be used with extreme caution. Total porosity does not delineate the number of macro- and micropores. Consequently, the rate of water release cannot be discerned from TP alone.

Air space. There was over a twofold difference in the air space volumes of the 5 media (Table 2). Ph showed the highest, 72.9%, with PB + P the lowest at 30%. This high air space value would make water retention difficult since 85% of the total porosity of PH would be unavailable to hold water. The 3 amended peanut hull media had lower AS than the PH medium, but would still be considered high.

Easily available water. The peat-containing media had similar EAW which is within the proposed acceptable range. PH + PB had a lower EAW while the PH medium retained very little water. The level of EAW seemed to coincide with the proportion of peatmoss in the media.

Water buffering capacity. The PH + P medium had a WBC which fell near the proposed acceptable range with PB + P showing a similar but slightly lower WBC. When the percent volume of peatmoss was less than 50, as in the PH + PB + P, or completely omitted from the medium, WBC was extremely low. This indicated that peanut hull-containing media amended with less than 50% peatmoss had little water reserve available for plant growth.

Bulk density. All 5 media were relatively lightweight with PH + PB showing a twofold increase in bulk density over PH + P. The relationships of all media were as follows: PH + PB > PB + P, PH + PB + P > PH > PH + P.

Water-holding characteristics. The moisture retention curves for the 5 media are shown in Fig. 2. Peanut hulls showed high total porosity (at 0 cm pressure) but very low water-holding capacity (at pressures > 10 cm) due to a large number of macropores. A 50% volume addition of peatmoss retained the same total porosity (Table 2), but resulted in the highest moisture retention, similar to the PB + P medium (Fig. 2). The PH + PB medium had the lowest total porosity (Table 2) and low water-retention capability (Fig. 2). An acceptable moisture retention zone was generated from the proposed acceptable ranges of media characteristics by de Boodt and Verdonck (Table 2). Curves falling below the zone would have rapid water release and low water-holding capacity. Conversely, curves above this zone would characteristically have less air space and greater water-holding capacity. Media containing peanut hulls generally fell below the zone because of rapid water release due to a large number of macropores. Media containing peatmoss produced curves closer to the proposed zone. The addition of peatmoss to the peanut hull media generally caused the greatest increase in water-holding capacity.

Plant growth. High quality azaleas were produced in all 5 media. Azalea top dry weight was similar among the 4 media containing PH and was similar among the 3 media containing peatmoss (Table 3). Top dry weight of azalea in PB + P medium was less than top dry weight in PH and PH + PB. Root dry weight was greater in the PH medium than PH + P or

Table 3. Root and shoot dry weight and growth of 'George L. Taber' azaleas grown in 5 media[z].

Media[y]	Top dry wt (g)	Root dry wt (g)	Growth increase (%)
PH	1.30a[x]	0.95a	80.3ab
PH + PB	1.42a	0.88ab	83.5a
PH + P	1.24ab	0.46b	74.7b
PH + PB + P	1.21ab	0.55ab	76.2b
PB + P	0.86b	0.45b	67.9c

[z] Each value is the mean of 4 plants per replication representing 16 plants.
[y] See Table 1 for medium composition.
[x] Mean separation within columns by Duncan's multiple range test, 5% level.

PB + P media. The percent growth increase was the greatest in the PH + PB and lowest in the PB + P medium.

Peanut hulls in a potting medium increase particle size, total porosity, and air space, and decrease easily available water, water-buffering capacity, and bulk density.

Uniform irrigation was designed to never allow any of the media to dry out. Therefore, the effect of water stress on azalea growth was minimized. However, the high water-holding capacity and resulting frequent irrigation of the PB + P medium may have reduced aeration and limited growth. These data suggest that peatmoss was not necessary for azalea production. Also, peanut hulls improved the percent increase in growth, but added more frequent irrigation. Of the media tested, best growth of 'George L. Taber' azalea was obtained with the PH + PB medium.

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Effect of Root Zone Heating on Growth of Poinsettia[1]

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Abstract. **Poinsettias (*Euphorbia pulcherrima* Willd. cvs. Annette Hegg Supreme, V-10, and Brilliant Annette Hegg) were grown on heated benches and exposed to root zone temperatures between 18° and 29° C. Increasing media temperatures affected bract size and development, internode length, fresh and dry weight of stems, leaves, and bracts, as well as the number of axillary shoots of cultivars differentially. In general, plants grown at higher temperatures were shorter, had more prominent axillary shoots, and developed anthocyanin sooner than unheated controls.**

With the rising cost of fossil fuel, greenhouse growers are looking for alternative heat sources. The use of solar energy or waste water from power plants may provide this alternative energy source for the production of greenhouse crops (1, 20). Warm water is often stored under the floor (20, 26), and provides radiant heat to warm the root systems of plants. A warmer than normal root temperature appears to affect many aspects of plant growth, namely, flower formation (23), nutrient uptake (8, 17), fresh and dry weight accumulation (27), as well as photosynthesis and photosynthate translocation (4). A heating system that will warm the roots may prove beneficial to overall crop performance and may compensate for a lower than conventional air temperature and, thus, may conserve fuel (22).

Observations of media temperature effects on the growth of greenhouse plants are needed to provide a reference source for judgments on alternative heating methods. In this study, poinsettias were selected as the experimental plant material since

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