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Available Water and Root Development Within the Micropores of Pine Bark Particles[1]

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Abstract

Internal pore space, root development, and available water within pine bark particles were studied. Internal porosity constituted about 43% of a pine bark particle. Scanning electron microscopy (SEM) revealed that roots of *Coleus blumei* and *Vaccinium ashei* were attached to the exterior surface of pine bark particles and had invaded the micropores. Growth of *Raphanus sativus* seedlings in water-saturated bark pieces demonstrated that internally adsorbed water was utilized provided that root development occurred within the bark particle.

Index words: *Coleus blumei* Benth., *Vaccinium ashei* Reade, *Raphanus sativus* L., internal porosity, bark structure

Introduction

Bark of *Pinus taeda* L., *P. echinata* Miller, *P. elliottii* Engelm., and *P. palustris* Miller is used extensively by Southern nurserymen in the formulation of potting media for container plant production. Use of pine bark is advantageous because: a) it is a renewable resource (5); b) it is available at lower cost than imported peat moss (8); c) it can be processed by hammer-milling and screened to provide a standard product (5); and, d) it suppresses certain soil-borne plant pathogens (4, 6). An important characteristic of pine bark is its slow rate of decomposition (6), important to the nurseryman because of the degree of stability bark imparts to the physical structure of a container medium. Rapid decomposition of organic matter in a container substrate results in undesirable changes in the physical structure of the medium. Thus, air space and drainage are usually diminished ultimately causing root rot problems.

Plants growing in pine bark develop extensive, active root systems throughout the container medium profile and often penetrate bark particles. In addition, observation indicates that established plants growing in certain bark or bark-based media require less frequent irrigation when compared to plants growing in a similar medium containing peat moss (Fig. 1) (5, 7). Apparently, utilization of pine bark in the growing medium results in greater H_2O availability, not to be confused with retention, to the plant (5).

In a study by Airhart et al. (1), scanning electron microscopy (SEM) was used to identify the surface characteristics of milled pine bark particles. Numerous external openings, cracked cell walls, and internal cellular connections were observed (Fig. 2) confirming the hypothesis of Brown and Pokorny (2) that capillary pores exist within the internal structure of bark; these internal pores may serve as a reservoir for water and nutrients. However, water adsorbed internally by porous amendments such as vermiculite, hardwood bark, and others is generally not considered available for plant use (10).

This study was conducted to study the quantity of micropores of a pine bark particle which might retain water, and to determine if internally adsorbed water by bark particles is available for plant use.

Materials and Methods

Mulch grade pieces (7-10 mm in thickness and > 2.5 cm in length) (0.28 in-4 in thickness and >1 in length) of pine bark, *Pinus taeda,* were oven-dried at 80°C (176°F). Ten pieces were reduced to 2.5 cm^2 (1 in^2) while 10 pieces remained intact. Moisture adhering to the external surface of each particle was determined by surface wetting with 0.13% surfactant solution and removing the excess solution with absorbent paper. Treated bark particles were weighed, and the volume determined using a water pycnometer.

Oven-dried particles were submerged in water in a vacuum desiccator and subjected to -150 mm of Hg pressure for 96 hours to ensure thorough wetting of particles. Water-saturated particles were then weighed. Internal pore space (percentage by volume) was calculated as:

$$P_1 = (W_1 - W_2)/V_1 \times 100 \qquad [1]$$

where,

P_1 = internal pore space (%/volume)
W_1 = saturated weight
W_2 = surface wet weight
V_1 = volume of pine bark particle.

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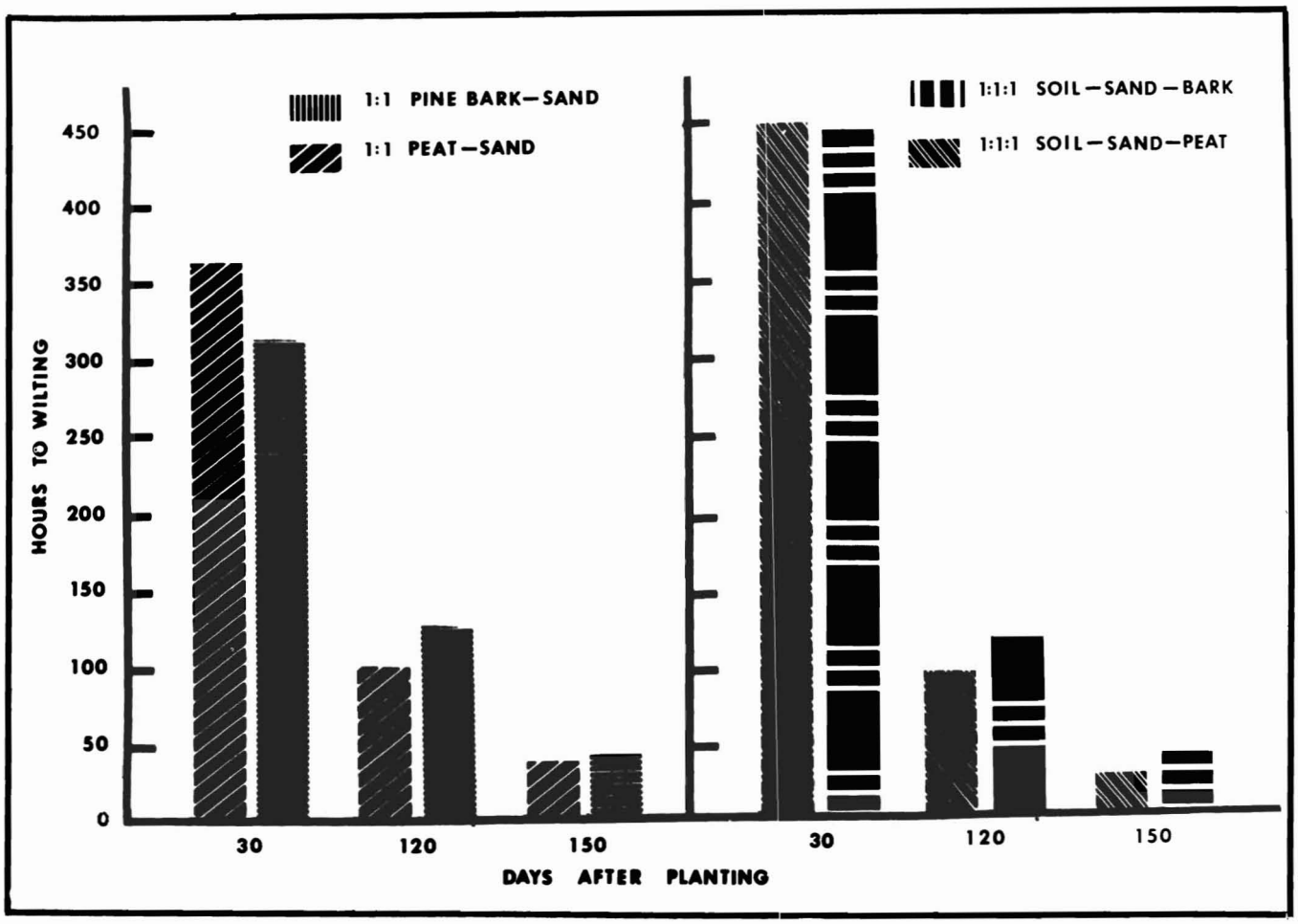

Fig. 1. Influence of peat moss and pine bark as a container medium amendment on available soil moisture as indicated by wilting of the indicator plant, *Hypericum* 'Hidcote.'

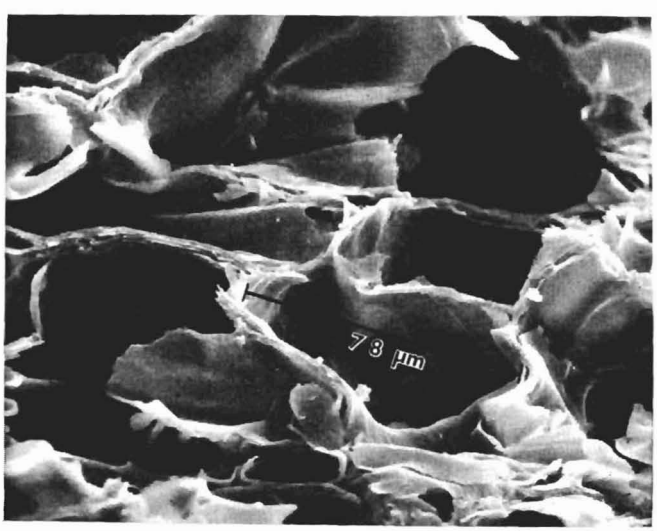

Fig. 2. Internal structure of a pine bark particle showing numerous pores (X610).

Seeds of radish (*Raphanus sativus* L. 'Cherry Belle') were pregerminated on Whatman No. 1 filter paper in covered Petri dishes (100 mm dia X 15 mm deep) (4 in dia X 0.6 in deep) at 20-25 °C (68-77 °F) under fluorescent light (49.3 μmol $s^{-1}m^{-2}$). Pregerminated seed was used experimentally when radicles were approximately 2 mm (0.08 in) in length.

Fifty pieces of pine bark (25 X 19 X 9 mm) (1 X 0.76 X 0.36 in) were oven-dried at 80 °C (176 °F) and saturated with deionized water in a vacuum desiccator as previously described; excess surface water was removed with absorbent paper. A radish seed with emerging radicle was inserted into a pre-drilled hole in each bark piece; oven-dried pieces were similarly seeded. Each seeded bark piece was placed in a culture tube which was then sealed with a plastic cap; culture tubes were then placed under cool white fluorescent lights (0800 hours to 2400 hours daily). The experiment was conducted as a completely randomized design with 25 replications on April 24, and repeated on May 5. Plant fresh weight was determined at the conclusion of the experiments.

Humidity differences between culture tubes containing water-saturated and oven-dried bark pieces may possibly have accounted for observed growth differences. Thus, the above experiment was repeated on

May 14 with the inclusion of an additional treatment in which an unseeded water-saturated bark piece was suspended in the top of those culture tubes containing seeded oven-dried bark particles.

For SEM examination of root development in pine bark particles, plants with fibrous roots with numerous root hairs (*Coleus blumei)* and those with small, fine lateral roots (*Vaccinium ashei*) were grown in 100% pine bark in 10 cm (4 in) plastic pots. Roots were washed free of loose bark. Roots with adhering bark were dissected and fixed with 2% glutaraldehyde in 0.1M cacodylate buffer (pH 7.2) for 2 hours. The fixed root/bark pieces were then dehydrated in an ethanol series (20%, 35%, 50%, 60%, 75%, 85%, 95%, and 100%), mounted on aluminum stubs and sputter-coated with approximately 300 A gold-palladium. Specimens were observed under a Cambridge Mark IIA SEM.

Results and Discussion

Internal pore space of pine bark particles was 42.7% to 44% of their volume (Table 1). Particle configuration did not affect internal porosity. Spomer (9) reports similar values for soil amendment grade hardwood bark.

Pregerminated radish seed planted in oven-dried bark particles ceased development while growth continued in water-saturated bark. Plants in water-saturated bark were well-anchored demonstrating that roots had penetrated the particles. Since the sole water source for plant use existed within internal pores of the bark particles, roots were absorbing this water to support top growth as postulated by Airhart et al. (1). Increasing humidity in the culture tubes containing dry bark did not enhance germination (Table 2).

Root-bark interactions were observed with coleus and blueberry plants grown in 100% pine bark. Coleus roots attached to bark particles primarily through root hair connections. An abundance of lateral roots occurred along the exterior surface of the bark particle (Fig. 3A); penetration and anchorage of root hairs at the bark surface occurred. Less frequently, coleus roots were found within cracks and crevices (Fig. 3B). However, roots were found growing through and terminating in the particles. Finely fibrous blueberry roots penetrated bark particles (Fig. 3C), and lateral roots often occurred at irregular surface areas (Fig. 3D).

Table 1. Internal porosity of 2 types of pine bark particles obtained from mulch grade bark (*Pinus taeda* L.).

Particle Size	Internal Pore Space[z] Vol (%)	SE
Intact particle >2.5 cm	44.0	±2.4
2.5 cm² particle	42.7	±2.8

[z]Values are the means of 10 replications.

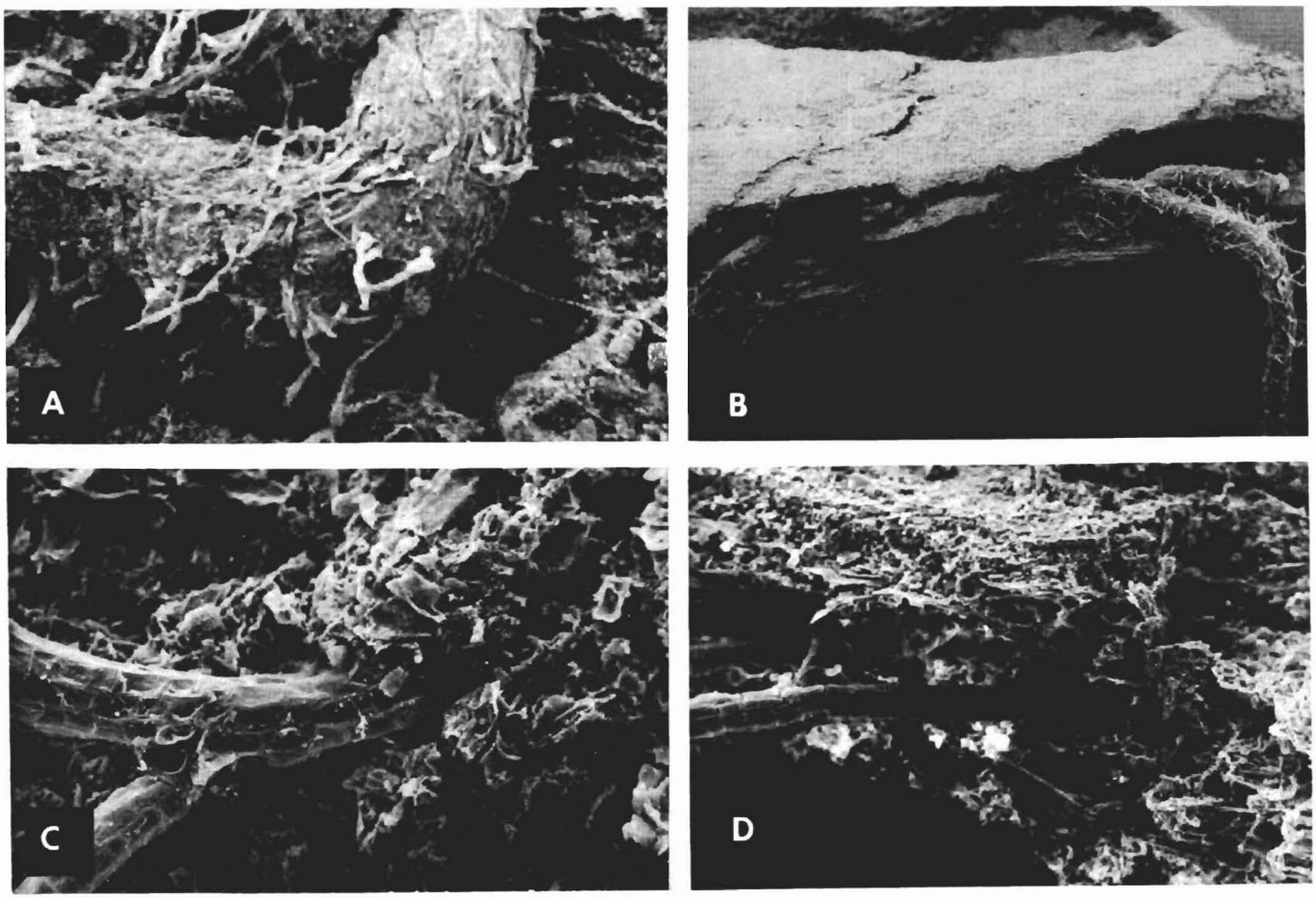

Fig. 3. A) Coleus root hairs on surface of bark particle (X125); B) Lateral coleus root penetrating bark particle (X50); C) Blueberry root occurring in bark particle (X100); and D) Branched lateral root of blueberry penetrating bark particle in several places (X50).

Table 2. **Availability of water within a pine bark particle to support growth of *Raphanus sativus* L. 'Cherry Belle.'**

	Top fresh wt (mg)[z]		
	Oven-dried pine bark	**Oven-dried pine bark** + humidity	**Water-saturated** pine bark
24 Apr-1 May	0.0	——	39.7[y]
5 May-12 May	0.0	——	36.0
14 May-21 May	0.0	0.0	38.0

[z]Values are means of 25 replications.

[y]Significantly different at 1% level. Oven-dried bark vs water-saturated bark (F-test).

Roots grow through spaces existing between soil particles, aggregates, cracks, and crevices (12). Water is absorbed by roots from that retained in soil capillary pores and that adsorbed on particle surfaces (3, 11). Root development and water absorption is thought to occur in essentially the same way in a container medium since internally held water is considered unavailable for plant use (9, 10). The invasive nature of plant roots in a pine bark medium, however, illustrates that water and nutrient uptake is not entirely a passive mechanism. Water uptake is increased by root penetration of bark particles above that supplied by capillary water and simple diffusion gradients dictated by moisture gradients within a particle. Further study is required to determine the quantity of internally held water available for plant use.

Significance to the Nursery Industry

Pine bark is a porous medium or medium component in which the internal pores serve as a reservoir for water and perhaps nutrients. Results of this study show that internally adsorbed water is available for plant use provided roots penetrate the pine bark particles. Thus, after plant establishment, less frequent irrigation may be needed in contrast with media composed of components other than pine bark. Water, and possibly nutrients, might be conserved and costs reduced.

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