PART 2

Pine Bark
Handling and Aging

Here's part two of our three-part series highlighting the changes in the physical, hydrologic and chemical properties of pine bark over 12 months of managed aging. In this installment, researchers at North Carolina State University discuss how the aging process affects hydrologic properties, which are largely influenced by physical properties.

By Laura E. Kaderabek, Dr. Brian E. Jackson and Dr. Bill Fonteno

Containerized crop producers are becoming increasingly conscious of water use due to economic decisions, governmental restrictions and/or increased environmental sustainability concerns. Freshwater is a finite resource that is rapidly becoming more scrutinized in agricultural consumption, and ornamental crop producers must continually improve production sustainability with regard to irrigation to continue to stay economically viable.

Because of the coarse nature of pine bark substrates, frequent watering/irrigating is often required during outdoor container plant production. It has been demonstrated that irrigation water has a tendency to preferentially flow through certain portions of pine bark substrates in nursery containers, leading to uneven post-irrigation water distribution and unnecessary loss of water and leaching of fertilizers. Moisture content plays an important role in this preferential flow — at lower moisture contents an infiltrating channel of water will be relatively narrow and fast moving, whereas at high moisture contents it will be relatively wide and slow moving. This is due to the effect that moisture content has on the hydration efficiency, or wettability (degree of hydrophilicity/hydrophobicity) of a substrate.

In addition to issues involving preferential water and irrigation flow, hydrophobic properties of pine bark substrates may negatively affect the physical properties of the media and may result in a need for increased rewetting times between irrigations after excessive drying. The hydrophobic properties of bark increase with drying and once dry, pine bark substrates may be especially difficult to rehydrate.

The objective of this research was to investigate and quantify the changes in the hydrologic properties of pine bark during 12 months of managed aging, in order to better understand the aging process and utilize pine bark at various degrees of age and stability. The

FIGURE 1. Aerial view of the large-scale pine bark handling and aging project.

variation of bark materials in horticultural substrates is due in large part to the lack of understanding of processing and handling of these materials. Water, being the greatest limiting factor in plant growth, makes the understanding of the hydrologic properties of substrates essential in order to efficiently manage irrigation and fertilization in the nursery industry.

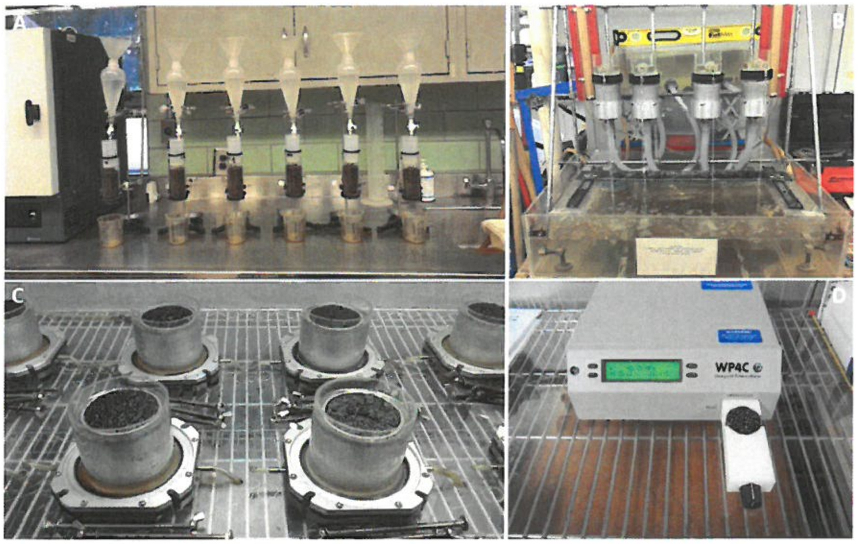

FIGURE 3. Various laboratory techniques for assessing physical and hydrological substrate properties. A) wettability/hydration technique; B) saturated hydraulic conductivity apparatus; C) substrate moisture tension plates; and D) Dewpoint Potentiameter for measuring unavailable water.

Sampling

Fresh longleaf pine bark (within days of being removed from freshly harvested trees) was hammer-milled to pass through a one-half-inch screen and placed in three piles of approximately 250 cubic yards each, with dimensions of approximately 55 by 33 by 10.5 feet (see Figure 1). These were treated as replications. Piles were sampled initially, then turned every four to six weeks using a front-end loader and subsequently sampled after turning for a period of 12 months. At each sample date, subsamples were taken from different locations on each pile to account for variation within the pile and to reduce possible errors due to stratification of constituents and conditions within the piles. These subsamples were combined into one representative sample per pile and tested for the following properties. Over time the changes in bark during the aging process can be seen by the change in color as well as physical texture (see Figure 2).

> "The decreased percolation of older bark compared to fresher bark would make significant changes to irrigation practices on a nursery, especially if bark of different ages was being used in the production system."

Laboratory analysis of substrates

Various techniques and procedures have been developed and utilized over the years to assess and characterize substrate physical and chemical properties. Many of these techniques have been adopted from the soil science world, while others have been specifically developed for the "soilless" substrate world. As technology and science advances, the use of new techniques is important in more accurately and thoroughly understanding substrates. For the purpose of studying the hydrologic properties of substrates, some of the techniques utilized include wettability measurements, percolation, water release determination and assessment of available and unavailable water (see Figure 3).

FIGURE 2. Pine bark changes color and texture (particle size) during the aging process.

Hydration efficiency

Often referred to as wettability, this is basically the ease (or difficulty) of a substrate to wet during an irrigation/rain event. It is well-known that organic materials can often be hydrophobic, especially when they are dry. The drier materials are (bark, for example), the more difficult it is for them to properly wet, and in many cases they can never fully be wetted to achieve their maximum water-holding capacities. It is for this reason that it is recommended that pine bark inventories at a nursery be wetted (sprinkler system installed) so that it is never allowed to be air-dried before potting. Once potted, a dry pine bark will often never be fully wetted with standard irrigation applications.

The hydration efficiency of the aged pine bark samples was assessed by measuring the water retention after 10 hydration events (simulated irrigations). Bark samples were analyzed at a 50 percent moisture content (moist) and at a 25 percent moisture content (dry). At 50 percent moisture content, we found that bark hydrated similarly for all ages (see Figure 4). This means that after the first irrigation event, bark was wetted to its maximum capacity (reached container capacity).

At 25 percent moisture content all samples showed less water uptake than at 50 percent moisture content, regardless of sample date. At 25 percent moisture content, fresh bark (month 0) never hydrated (reached container capacity). At month 6 the bark was able to reach its maximum hydration potential after five irrigation events. At month 12 it reverted back to a more hydrophobic state and never reached full hydration.

We hypothesize that when fresh (month 0), the bark never fully hydrated due to the particle size of the material being very large after the initial processing. The large particles created very large pores that the water flowed through quickly and easily in a vertical fashion, thereby not allowing the samples to be fully wet. At month 6 the particle size of the bark had decreased significantly (due to mechanical turning of the bark piles each month and because of microbial degradation of the bark in the piles), which decreased pore sizes, which thereby slowed the rate of water movement in the substrate. The slower water movement (percolation) allowed the samples to be fully wetted. At month 12 the inability of the bark to be hydrated after 10 irrigation events is thought to possibly be a result of the further reduction in the bark particles, which increased the density, decreased the percolation and increased hydrophobicity of the many small particles (fines) — which "repelled" more water.

Percolation

Percolation of water (sometimes referred to as saturated hydraulic conductivity) is one of the most important metrics for soil-water-plant interactions, as well as water solute movement and retention through the soil/substrate profile. Percolation refers to the steady infiltration rate at which water moves through the substrate after a head of water has accumulated on the surface and free drainage is occurring from the bottom.

An understanding of substrate percolation can potentially help growers make more informed irrigation decisions. The data obtained from this experiment indicated that percolation rates in pine bark decreased with age. Month 0 bark (fresh) had a water flow rate of 119 cm/min, month 6 bark had a flow rate of 80 cm/min and month 12 bark was recorded at 55 cm/min. This is likely due to the reductions in particle size over time, resulting from mechanical breakdown by turning and microbial degradation, as well as an increase in sand content. The smaller particles result in smaller pore sizes and an increased bulk density.

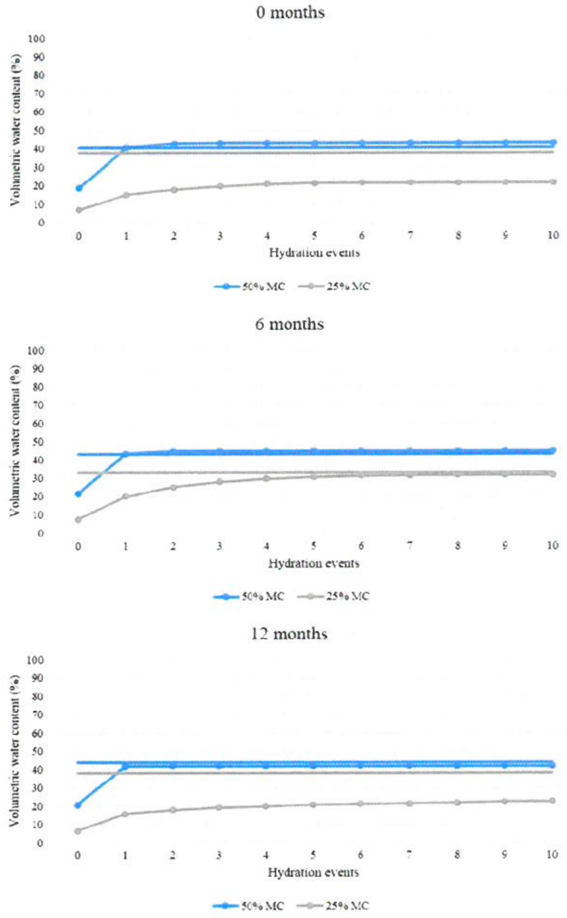

Figure 4. Hydration efficiency (wettability) of pine bark at 0, 6 and 12 months.

The decreased percolation of older bark compared to fresher bark would make significant changes to irrigation practices on a nursery, especially if bark of different ages was being used in the production system.

Unavailable water

Unavailable water is defined as the water that is adsorbed to the substrate particle surface that is held at a tension equal to or greater than what a plant can pull/access from the particles via its roots. This pressure is often described in terms of megapascals (MPa). In other words, it is the percent of water remaining in the substrate that a plant is unable to utilize. Permanent wilting point varies with the substrate and the crop being grown; therefore, the potential at which water in the substrate ceases to be available is not always the same. In organic substrates, the volumetric fraction of

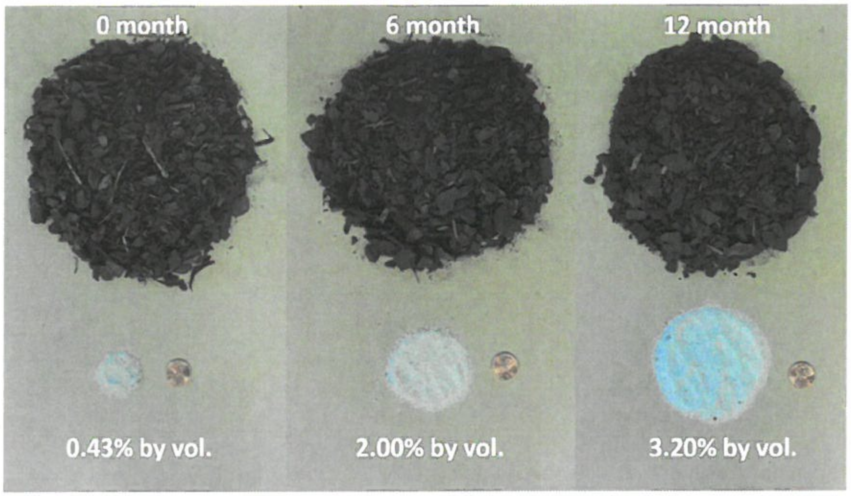

Figure 5. Amount of sand that accumulates in pine bark supplies over the course of one year. The sand can have significant influences on hydrologic properties as well as increased density, which affects the volume that can be shipped from the supplier to a grower.

unavailable water is larger than that of mineral soils, due to the increased surface area of organic particles.

In our year-long aging study we found no differences in unavailable water for pine bark with average values (at -1.5 MPa) of 6.90 percent, 6.90 percent, 6.86 percent, 7.29 percent and 8.50 percent for months 0, 3, 6, 9 and 12, respectively. Our results are similar to some recent published work that used the same dewpoint potentiametry technique that we used in our work. The Dewpoint Potentiameter has only recently been proved to be a better technique to more accurately access substrate unavailable water. Previous work over the last several decades used a pressure plate apparatus that is commonly used in mineral soils for determining unavailable water. Results from the pressure plate technique are much higher (inaccurately so), therefore much of the previous work with pine bark substrates has shown that the percent unavailable water was much higher. In most cases, previous literature and substrate recommended guidelines were in the range of 25 to 35 percent unavailable water for pine bark. The discovery, adoption and transition to new tools and procedures like dewpoint potentiametry allow researchers to more accurately describe, quantify and characterize pine bark (and other) substrate materials.

Influence of sand

The "contamination" of pine bark with sand over the course of a year is something that is typical at most bark suppliers. Sand can be introduced to aging piles of bark via the wind and during the turning process that occurs regularly (ideally every month). Bark suppliers who are located on sandy soils will likely have more sand incorporation over time than a supplier on clay soil.

The amount of sand that accumulated in the bark for this trial increased from 0.43 percent (by volume) at the beginning to 2.00 percent at month 6, and finally to 3.20 percent by month 12 (see Figure 5). Even though the amount of sand is low (by volume), the weight that it adds to the bark can be substantial, especially as it influences shipping. The sand in the bark can also influence the hydrologic properties of the bark by decreasing pore sizes, slowing or increasing percolation, improving wettability, increasing weight/densities, and so on. Many growers add sand (usually around 10 percent) to their pine bark substrates, which can further increase these properties.

Part III of this series will address the effects of pine bark age and handling on nursery substrate chemical properties; watch for it in the August issue.

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