Aging in place

This is the final article in a six-part series highlighting various horticultural uses of pine trees, pine bark, and associated products as well as data from substrate science research trials.

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Time and handling will change physical and hydrological properties of pine bark substrates.

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Aged pine bark is the one of the most common organic substrate components in the United States, with bark from loblolly (*Pinus taeda*) or longleaf (*Pinus palustris*) pines being the most prominent in the Southeastern U.S. Aging is a process in which the bark is piled on the ground in windrows and allowed to age for a period of time, usually six months to one year (although it may be as short as six weeks or as long as 18 months), with no nitrogen amendments.

Bark particle sizes which are critical in substrate formation and function, change during the aging and handling process of creating substrates.

Aging time can vary between suppliers, or even for the same supplier, based on factors such as space allocation/shortages, product demand or preference. The resulting end-products are all sold to the consumer (growers or growing media manufacturers) as "bark substrates," but these materials can be very different in

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Fig. 1: Raw pine bark after being removed from harvested trees (A), hammer-milled fresh bark (B), bark after one month aging in windrow (C), and bark after eight months of managed aging in windows (D).

terms of their physical, chemical and hydrologic properties. Bark suppliers in the Southeast have indicated the demand for fresh pine bark has increased because of its lighter weight and cheaper transportation costs. Although both fresh and aged bark can be used successfully, there have been discrepancies in the literature about negative effects of fresh pine bark on plant growth. Bark substrates, like any organic material, are living/biological and dynamic entities that are continually changing over time, and bark of different ages, which are all sold as "aged bark," may not have the same properties.

The Horticultural Substrates Lab at North Carolina State University has spent the past several years working to gain a greater understanding of how pine bark substrates are influenced by aging and how/if those changes influence usability and plant production management strategies. A long-term study was implemented to quantify the changes in the physical, chemical, and hydrological properties of pine bark over the course of one year of aging.

Fresh pine bark (within days of being removed from freshly harvested trees) was hammer-milled to pass through a one-half-inch screen (Fig. 1) and placed in three piles of approximately 250 cubic yards each, with dimensions of approximately 55 x 33 x 10.5 feet. These were treated as replications. Piles were sampled initially, then turned every 4 to 6 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 various physical, chemical and hydrological properties.

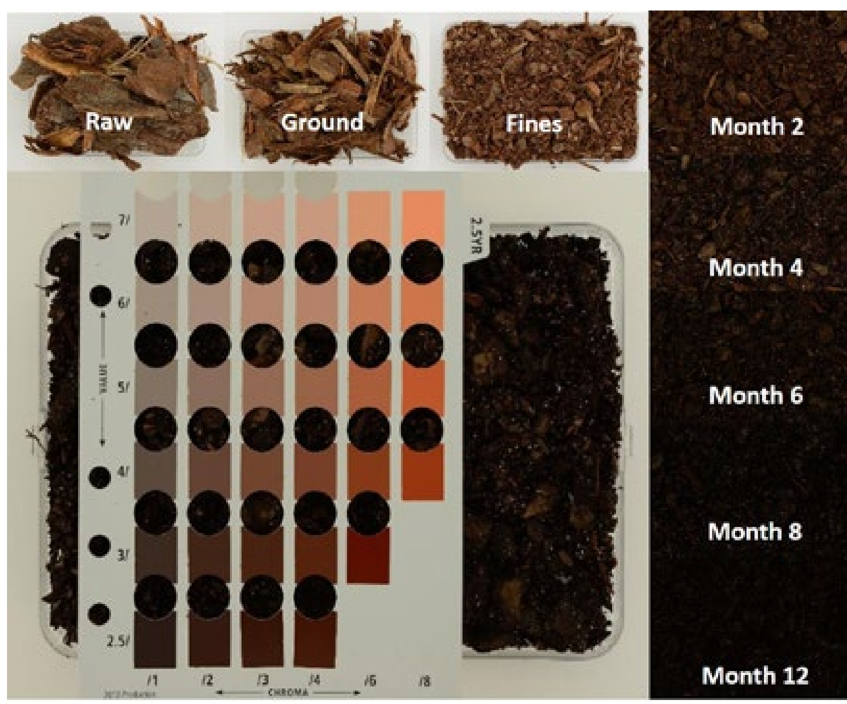

Fig. 2: Indicators of bark maturity can possibly be assessed by quantifying the change in color of the bark material over time using a color scale.

Color changes

Over time the changes in bark during the aging process can be seen by the change in color as well as physical texture (Fig. 1). The heat created during the thermophilic phase of the decomposition process causes the color of the bark to darken as it ages. At the beginning of aging (or composting) of organic material the material may be a lighter brown, and as the biological activity increases over time the organic material will become a dark brown or black as the rate of biological activity changes. Color is a sensory parameter that is frequently used anecdotally in the industry when discussing age and usability of pine bark in horticultural substrates but has not been measured in the literature. The measurement of color has recently been suggested as a parameter to determine

Figure 3: Laboratory analysis of aged pine bark substrates are used to quantify changes in hydration/wettability (A-B), saturated hydraulic conductivity (C), physical properties and water retention/release properties (D).

stability in composting systems. In this long-term aging study, the color of the

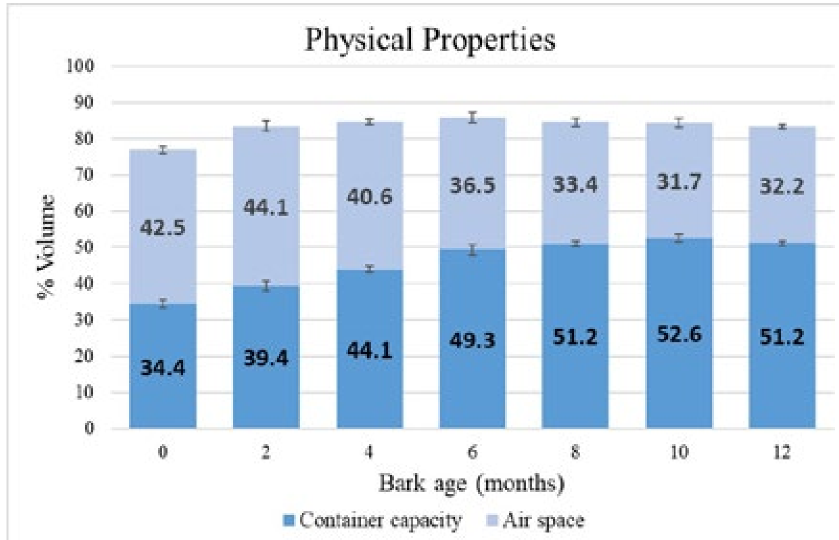

Figure 4: Physical properties (container capacity and air space) of pine bark substrates that have been aged for 0, 2, 4, 6, 8, 10, and 12 months in a managed commercial-scale aging experiment.

bark darkened over time as expected, beginning as a reddish brown and getting progressively darker through month 5, eventually stabilizing to a dark brown (Fig. 2). During months 6 through 12 the bark continued to slightly darken each month, which could be noted by careful observation, but were not able to be differentiated using our color chart test methods.

Hydrologic properties

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 industry. 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 changes in physical and hydrologic properties of substrates, some of the analysis techniques preformed included wettability/hydration measurements, percolation, water release patterns and assessment of available and unavailable water (Fig. 3).

Percolation of water (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 decrease was due to the reductions in bark 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. 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 were being used in the same production area.

The "contamination" of pine bark with sand over the course of time is something that is typical at most bark

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suppliers. Sand can be introduced to aging piles of bark via the wind and during the turning process which 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% (by volume) at the beginning (month 0) to 2.00% at month 6 and finally to 3.20% by month 12. Even though the amount of sand is low (by volume) the weight that it adds to the bark can be substantial especially as it relates to shipping. The sand in the bark can also influence the hydrologic properties of the bark by filling larger substrate pores (making them smaller which increases water retention), slowing or increasing percolation, improving wettability, increasing weight/densities, etc. Some growers also choose to add sand (usually around 10%) to their pine bark substrates which can further affect these properties. Growers should consider if the addition of sand to their bark substrates is of benefit to their production management practices or not. A load of bark substrate without sand could allow for significantly more yardage on a truck due to the lighter weight of the product.

Physical properties

The desirable physical characteristics of container substrates can be described in terms of their bulk density, total porosity, container capacity, and air space. The storage and management of pine bark, such as duration of aging, preprocessing conditions, and manufacturing methods can have a great effect on altering these properties. Fresh pine bark has been reported to have higher air space and lower container capacity, and thus lower available water content, when compared to aged bark, which could require changes in irrigation management during crop production. Aged bark will hold more water (unless it is screened) due to an increase in the percentage of fine particles, increased variability of particle sizes, and decreased hydrophobicity due to the decomposition process. In our long-term study we found that over the course of the aging process, container capacity and bulk density increased while air space decreased (Fig. 4). These trends were expected and follow previous studies of aging bark and other organic materials. Total porosity increased between month 0 and 2 from 77% to 83.5%, but there were no differences throughout the remainder of the study, with 12-month old bark having a total porosity value of 83.4%. From 0 to 6 months, air space decreased while container capacity increased. Container capacity, air space, and total porosity did not change from 6 to 12 months. Container capacity increased from 34% at month 0 to 51% at month 12, but did not change significantly from month 6 to 12, while air space decreased from 43% at month 0 to 32% at month 12. Bulk density increased from 0.18 g/cm3 to 0.20 g/cm3, increasing over months 0 through 10 and stabilizing for the remainder of the study. The changes in container capacity, air space, and bulk density correspond to the increase in the percentage of smaller particles as the bark aged.

The demand and use of bark substrates are expected to increase in the coming years due to the forecasted increase in soilless substrate usage. Whether used fresh or aged, these products can be engineered and formulated to offer high quality substrates for container nursery production and for use as a major component in greenhouse mixes as well as hobby (retail) products. NM

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