PART I

Pine Bark
Handling and Aging

In this first article of a three-part series highlighting the changes in the physical, chemical and hydrologic properties of pine bark over 12 months of managed aging, researchers at North Carolina State University discuss their findings on the effects on substrate physical properties.

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

Aged pine bark is the one of the most common organic substrate components in the U.S., with bark from loblolly or longleaf 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. Aging time can vary between suppliers, or even for the same supplier, based on factors such as space shortages, product demand or preference. The resulting end-products are all sold to the consumer as the same product, but can be very different in 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 is working to gain a greater understanding of how pine bark substrates are influenced by aging. A long-term study was implemented to quantify the changes in the physical, chemical and hydrological properties of longleaf pine bark over the course of one year of aging.

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. 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.

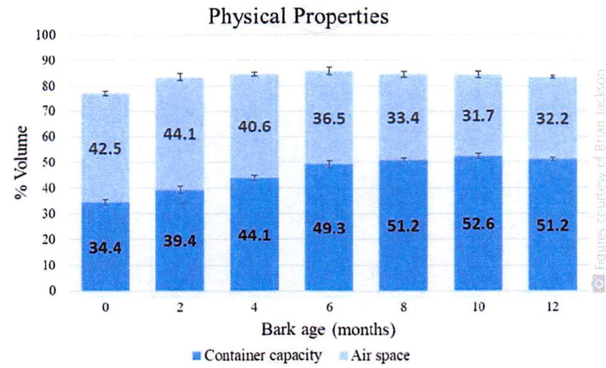

FIGURE 1. Physical properties of pine bark over 12 months of aging.

Physical properties

The desirable physical characteristics of container media 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 should theoretically hold more water due to an increase in the percentage of fines, increased uniformity of particle sizes and decreased hydrophobicity due to the decomposition of wood and cambium.

We found that over the course of the aging process, container capacity and bulk density increased while air space decreased (see Figure 1). Total porosity increased between month 0 and month 2 from 77 percent to 83.5 percent, but there were no differences throughout the remainder of the study, with 12-month-old bark having a total porosity value of 83.4 percent. 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 percent at month 0 to 51 percent at month 12, but did not change significantly from month 6 to 12, while air space decreased from 43 percent at month 0 to 32 percent 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.

Temperature

Temperature profiles during the aging process are characterized by:

- a rapid initial increase in temperature,
- a sustained high-temperature period, and
- a decline to near-ambient temperatures.

The initial rise and high temperature period is caused by exothermic reactions associated with the microbial degradation of the readily biodegradable organic matter in the bark. The subsequent decrease in temperature generally occurs due to a decrease in microbial activity as the easily biodegradable materials are consumed and more resistant compounds remain such as cellulose and lignin.

Pile temperatures were measured on site at each sample date (see Figure 2). Measurements were taken at three different heights at depths of 1, 2, 3 and 4 feet using three 4-foot compost monitoring temperature probes. Temperature data were analyzed as separate readings at each height and depth, as well as averaged across all pile heights and depths to give an average pile temperature per sample date.

There was an initial increase in pile temperature from ambient temperatures at installation, followed by a four-month-long thermophilic phase of the decomposition process. During months 2 through 4, piles maintained average temperatures between 127 to 135 °F, then decreased during months 5 and 6 as microbial activity and ambient temperatures decreased, followed by a gradual increase throughout the remainder of the study, presumably in response to warmer ambient temperatures throughout the spring and summer months. Thermal imaging with a FLIR C2 handheld camera was also investigated as a potential technique to measure pile temperature.

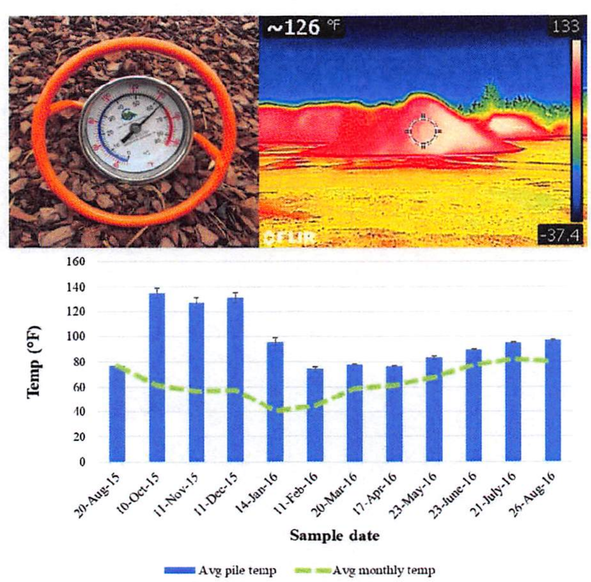

FIGURE 2. Measuring bark pile temperatures using probes and thermal image analysis

Color

The heat created during the thermophilic phase of the decomposition process causes the color of the bark to become darker 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 declines 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 stability in composting systems. The color of the bark darkened over time, beginning as a reddish brown and getting progressively darker through month 5, eventually stabilizing to a dark brown (see Figure 3). During months 6 through 12 the bark continued to slightly darken each month, which could be noted by careful observation, but this could not be differentiated using our test methods.

Volume and density

As bark ages, there will be an increase in smaller particles over time due to mechanical breakdown from turning and microbial activity. The volume reduction of bark piles during aging can be due as much, if not more, to reductions in particle size and pore volume as to mass loss from microbial activity. This increase in bulk density over the course of aging results in higher freight costs and less volume (yards) per truck load when compared to fresh bark.

Average pile bulk density calculated for material "as-is" on site increased over 12 months from 15.6 lbs/ft^3 at month 0 to 26 lbs/ft^3 at month 12, while the average pile volume decreased from approximately 250 yd^3 at month 0 to 184 yd^3 at month 12 (see Figure 4). This translates to a 27 percent decrease in volume over time with a 60 percent increase in bulk density. These data may give better insights into transportation costs associated with pine bark shipping of different ages.

White wood and sand

During the debarking process, wood (xylem) may accompany the bark and this material is referred to as white wood. White wood content in pine bark substrates is variable and influenced by many factors including tree species, time of harvest, bark thickness at time of removal, debarking method and variations in processing.

Fresh pine bark tends to have more white wood than aged bark, because it has had less time to break down. However, even after aging much of the white wood may remain, but it is stained black and is more difficult to see. The amount of white wood decreased from 6.3 percent at month 0 to 3.8 percent (by volume) at month 12. Other bark supplies/suppliers may have higher percent white wood present, but that does not suggest the bark quality is bad. White wood is not detrimental to crop growth like once believed, so this should have no negative effect on the quality of the bark substrate.

The amount of sand that accumulated in the bark as a result of being piled on the ground and turned every month with a front-end loader was also calculated. At the beginning of the study (month 0), the sand content was 0.43 percent by volume and 2.8 percent by weight of the pine bark. At month 6 the sand content was 2.02 percent by volume and 13.01 percent by weight. At month 12 the sand content was 3.19 percent by volume and 20.15 percent by weight. The high sand content found in this study was a result of the sandy soil of the testing location. All bark supplies/suppliers may not have the same sand accumulations. This sand percent (and weight) can be significant in shipping weights and should be monitored/considered.

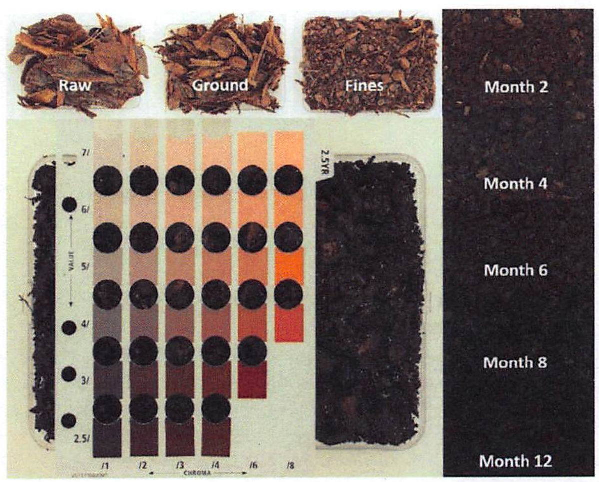

FIGURE 3. A Munsell Soil Color book was used to assess changes in bark color.

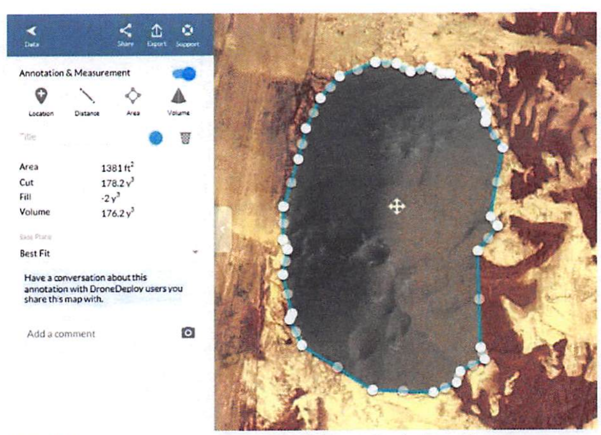

FIGURE 5. Image from a drone using volume calculating software to estimate bark pile inventories.

Conclusions

Data from this long-term study were consistent with previously reported data on fresh and aged pine bark and provides additional new information on pine bark at specific ages of a year-long aging process. Bark managed under these conditions appeared to stabilize around six months of aging, as shown by decreases in average and stratified pile temperatures, a decrease in pile volume, color darkening and decreased white wood content. An increase in container capacity and subsequent decrease in air space and an increase in bulk density were also seen.

It is important to note that the results from our study cannot be applied or assumed for other bark suppliers. Different bark suppliers have different methods of processing their bark, different methods to turn/handle their materials, have space limitations, supply and demand issues, and so on, that can influence the end-product. Bark that is handled and treated differently may yield different end products that can be used successfully, but may not be identical to what is presented here. However, understanding potential differences is not only important in producing consistent materials, but it is key in understanding how to utilize bark of specific ages and predicting how they may perform once used as a container substrate.

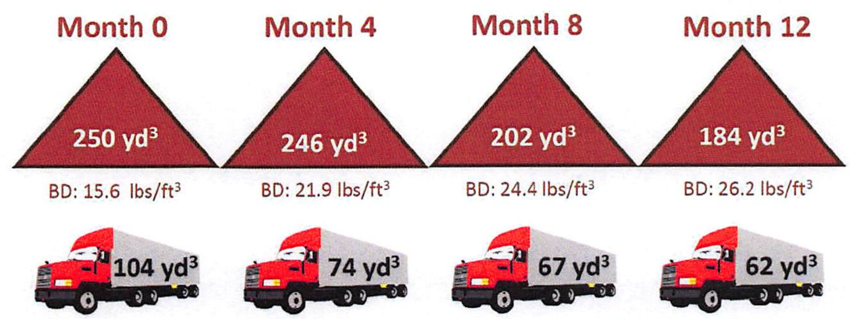

FIGURE 4. Bark pile volume decreases over time while the bark increases in weight (bulk density), which can directly affect the quantity (yards) of bark that can be shipped.

This study also illustrates the importance of frequently checking bark supplies and establishing a good relationship with the bark supplier to ensure product consistency. We advise all bark consumers to visit their bark supplier, ask questions and make it a habit to check their bark for consistency and quality.

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

Laura Kaderabek is a graduate student at North Carolina State University and can be reached at *lekadera@ncsu.edu*. Dr. Brian E. Jackson is an Associate Professor and co-director of the Horticultural Substrates Laboratory in the Department of Horticultural Science at NC State University; he can be reached at *Brian_Jackson@ncsu.edu_*. Bill Fonteno is a professor and co-founder/director of the Horticultural Substrates Laboratory at NC State University; he can be reached at *bill_fonteno@ncsu.edu*.