Changes in the Physical, Chemical, and Hydrologic Properties of Pine Bark over Twelve Months of Aging©[1]

Laura E. Kaderabek, Brian E. Jackson, and William C. Fonteno

Department of Horticultural Science, North Carolina State University, Raleigh, North Carolina 27695-7609, USA

Email: lekadera@ncsu.edu

INTRODUCTION

Pine bark is one of the most commonly used organic horticultural substrate components in the southeastern U.S., but it can also be one of the most variable. It may be used fresh, aged, or composted, and aging and composting times may vary between suppliers, or even for the same supplier at different times of the year (Jackson, 2014). Aging refers to the stockpiling and weathering of bark in windrows prior to its use, with no fertilizer additions or pH adjustments, and no attempt to control the moisture content (Pokorny, 1979). While aging is most commonly used in the southeastern U.S., interest in fresh pine bark has increased because of its lighter weight, which reduces transportation costs (Fields et al., 2012).

In addition to variability within pine bark substrates, variability exists within the literature on these substrates as well, with discrepancies in the findings from the few studies that have investigated differences in pine bark age. Self and Pounders (1974) have shown that many plants can be grown in fresh pine bark, however Laiche (1974) reported reduced plant quality due to difficulty maintaining adequate moisture levels during the first three months after transplanting. Fresh pine bark has been shown to have higher air space (AS), lower container capacity (CC), and lower available water content when compared to aged bark, which could require changes in irrigation management (Bilderback et al., 2005).

---

[1]First Place – Graduate Student Research Paper Competition

The duration of aging, pre-processing conditions, and manufacturing methods can alter the physical properties of pine bark substrates (Bilderback et al., 2005), and aged bark should theoretically hold more water due to an increase in the percentage of fines (Jackson, 2014), increased uniformity of particle sizes, and decreased hydrophobicity due to the decomposition of wood and cambium (Bilderback, 2002).

Although there are no universally accepted standards for the physical properties of horticultural substrates, the Southern Nursery Association (SNA) provides suggested ranges for the best management practices (BMP) of horticultural substrates for nursery production. These ranges are 50% - 85% for total porosity (TP), 10% - 30% for AS, 45% - 65% for CC, and 0.19 - 0.70 g/cm^3 for bulk density (BD; Bilderback et al., 2013). If substrates are within these ranges, irrigation and nutrient programs may be managed more efficiently (Bilderback et al., 2005). Hydration efficiency (HE), defined as the ability of a material to capture and retain water in the fewest number of water applications (Fields et al., 2014), is also an important property of a horticultural substrate in terms of water management. It has been reported that fresh pine bark may be difficult to hydrate (Pokorny, 1979).

MATERIALS AND METHODS

Pine Bark Acquisition and Sample Preparation. To investigate the changes in physical, chemical, and hydrologic properties of pine bark at different ages, a long term, commercial-scale study was implemented at TH Blue, Inc., a pine bark supplier in Eagle Springs, North Carolina on 20 August 2015. Fresh longleaf pine bark (*Pinus palustris* L.; Jordan Lumber Company, Mt. Gilead, NC and Troy Lumber Company, Troy, NC) was hammermilled and screened through a 5/8” screen on site, and the fines were then placed in three piles (replications) of 191 m^3 (250 yd3) each (Fig. 1), approximately 17m x 10.1m x 3.2 m (55ft x 33ft x 10.5ft). Beginning at time zero and every four weeks for a period of 12 months, the piles were turned, and one week after turning stratified subsamples were taken from three different heights (top, middle, and bottom) at depths of 1’- 4’ to account for variations in pile depth and height. The stratified subsamples were mixed into one composite sample for each pile replication and tested for physical, chemical, and hydrologic properties. Results from samples taken at 0, 3, 6, 9, and 12 months of aging are presented here.

Physical properties. Physical properties (CC, AS, TP, and BD) were determined using the NCSU Porometer procedure (Fonteno et al., 2010). Three replications from each pile were measured, equaling nine replications per age. Data were subjected to Tukey’s Range Test and means were separated by least significant differences at $P \leq 0.05$ (version 9.2: SAS Institute, Cary, N.C.).

Chemical properties. Electrical conductivity (EC) and pH were measured with a pH/EC meter (HI 9811, Hanna Instruments, Ann Arbor, MI) using the 1:1 dilution method. Three replications from each pile were measured within two days after sampling, equaling nine replications per age. One hundred mL of sample material was mixed with 100 mL deionized water, stirred, and allowed to equilibrate for 15 minutes before measuring. Data were subjected to Tukey’s Range Test and means were separated by least significant differences at $P \leq 0.05$ (version 9.2: SAS Institute, Cary, N.C.).

Hydrologic properties. Hydration efficiency (HE) of the pine bark samples was determined by measuring the water retention of 10 consecutive hydration events as described by Fields et al. (2014). Four replications from each pile were measured, equaling 12 replications per age. Samples were dried down from 60% moisture by weight (moisture content at sampling) to 50%. The moisture contents of the hydration events were measured by volume in order to make comparisons to CC, which is a volumetric measurement. For comparison purposes across each age, HE values were assigned. The HE value is the number of hydration events required to bring the sample to CC. For example, if CC was reached at the first hydration event, a HE value of 1 would be achieved. Container capacity data were subjected to Tukey’s Range Test and means were separated by least significant differences at $P \leq 0.05$ (version 9.2: SAS Institute, Cary, N.C.).

RESULTS AND DISCUSSION

Over the course of twelve months of aging, CC and BD increased while AS decreased, and values for TP, although different for different ages, showed minimal changes over time (Fig3. 2 and3). The changes in CC, AS, and BD while TP remained consistent is likely due to an increase in the percentage of fines as the bark decomposed (data not shown), resulting in a shift to smaller pore sizes in the same total pore volume. Container capacity increased from 36% at month zero to 51% at month 12 (Fig. 2), with months zero and three falling below the BMP guidelines and having lower values than months 6, 9, and 12. Air space decreased over time, from 43% at month zero to 32% at month 12. Air space values for all ages were higher than the BMP guidelines. Bark aged nine and 12 months had BD values that fell within the lower limit of the suggested BMP range of 0.19 g/cm^3 to 0.70 g/cm^3.

The pH increased over the course of twelve months from 4.2 to 4.5, which is within the range of 4.1 – 5.0 described by Pokorny (1979). Electrical conductivity decreased from 0.06 to 0.03 (Fig. 3). An increase in pH with a decrease in EC over time is indicative of aerobic activity, which is to be expected in a normal pine bark processing operation. Although the changes in pH were different over the five different ages, the rise was not substantial, which agrees with Pokorny's findings. Lemaire (1998) also reported an increase in pH over the course of six months for pine bark compost, although it was unclear if the pine bark was truly composted instead of aged.

Despite the differences in the physical properties between the different ages of bark, HE values were within .97 to 1.00, which means that the CC of the material at 50% gravimetric moisture content was reached within one hydration event for all ages (Figs. 2 and 4). Months 0, 3, and 6 had lower values for container capacity than months 9 and 12; however, all CC values were within 40% - 46% (Fig. 5).

The results from this study show that pine bark fines aged from six to 12 months have physical properties closest to the SNA BMP guidelines, but fresh pine bark had equivalent HE values as aged bark at 50% moisture content. This suggests that wetting fresh pine bark may not be an issue under normal production conditions; however, other factors such as AS and CC need to be taken into consideration in terms of irrigation management when using fresh bark. This study also illustrates the importance of frequently checking bark supplies and establishing a good relationship with the bark supplier in order to ensure product consistency.

Literature Cited

Bilderback, T.. 2002. Substrates for plants grown in big containers? Proc. N.C. Nursery Short Course 4:11-14.

Bilderback, T.E., Warren, S.L., Owen, J.S. and Albano, J.P.. 2005. Healthy substrates need physicals too! HortTech. 15:747-751

Bilderback, T.E., Boyer, C., Chappell, M., Fain, G., Fare, D., Gilliam, C.H, and Jackson, B.E. 2013. Best management practices: Guide for producing container-grown plants. 3rd Ed. Southern Nurserymen's Assoc., Marietta, GA.

Fonteno, W.C. and Harden, C.T. 2010. Procedures for determining physical properties of horticultural substrates using the NCSU Porometer. Horticultural Substrates Lab, North Carolina State University.

Fields, J.S., Jackson, B.E. and Fonteno, W.C. 2012. Pine bark physical properties influenced by bark source and age. Comb. Proc. Intl. Plant Prop. Soc. 62:433-437.

Fields, J.S., Fonteno, W.C., and Jackson, B.E. 2014. Hydration efficiency of traditional and alternative greenhouse substrate components. HortScience 49:336-342.

Jackson, B.E. 2014. Substrate Discrepancies. Nursery Management. October, 30(10):14-26.

Laiche, A.J., Jr. 1974. Pine bark growing media-fertility studies for the production of container-grown ornamentals. MAFES Res. Highlights. 37:1-3.

Lemaire, F. 1998. Consequences of Organic Matter Biodegradability on the Physical, Chemical Parameters of Substrates. Acta Horticulturae, 469:129-138.

Pokorny, F.A. 1979. Pine Bark Container Media – An Overview. Proc. Inter. Plant Prop.

Soc. 29:484-495 Self, R.L. and Pounders, C.T.. 1974. Comparison of sulfur-coated urea and nitroform in potting soils. Proc. SNA Res. Conf. 19:22-23

Fig. 1. The long term, commercial scale pine bark aging study located at T.H. Blue, Inc., Eagle Springs, NC. Pine bark fines (5/8”) were placed in three pile replications and aged for 12 months.

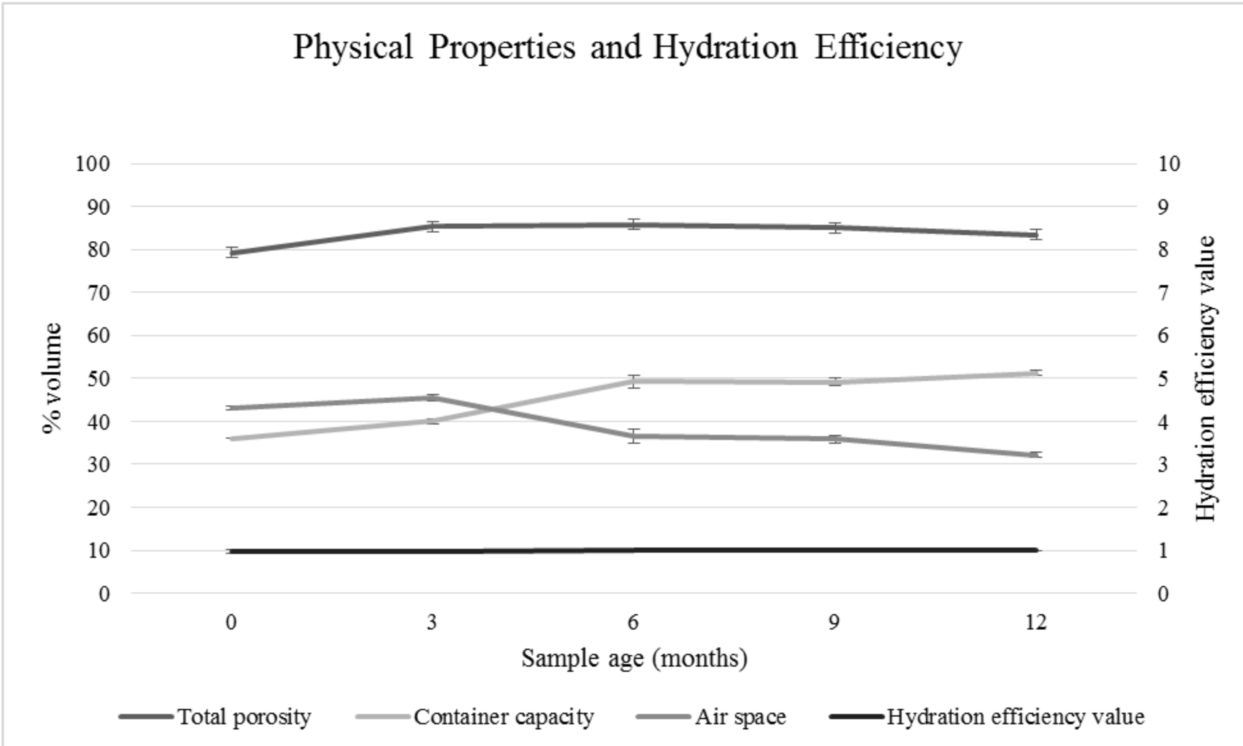

Fig. 2. Changes in physical properties (total porosity, container capacity, and air space) and hydration efficiency values for pine bark sampled at five different ages (0, 3, 6, 9, and 12 months).

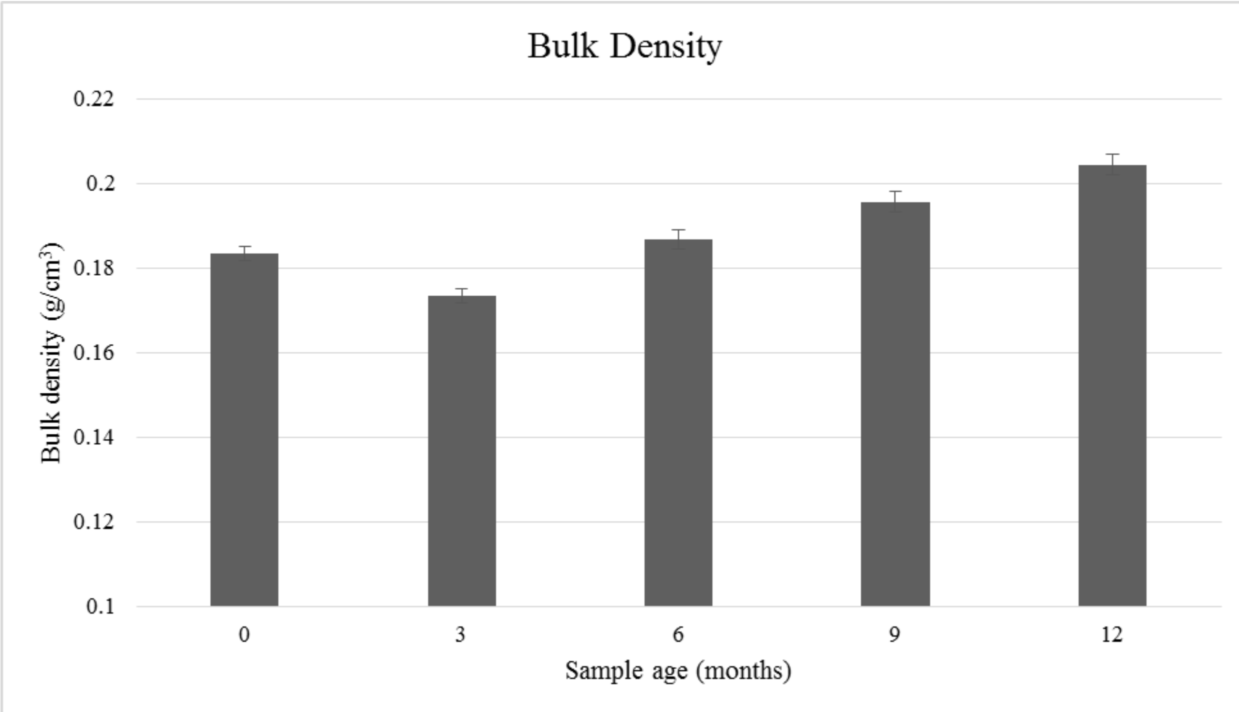

Fig. 3. Bulk density of pine bark sampled at five different ages (0, 3, 6, 9, and 12 months) determined using the NCSU Porometer Method.

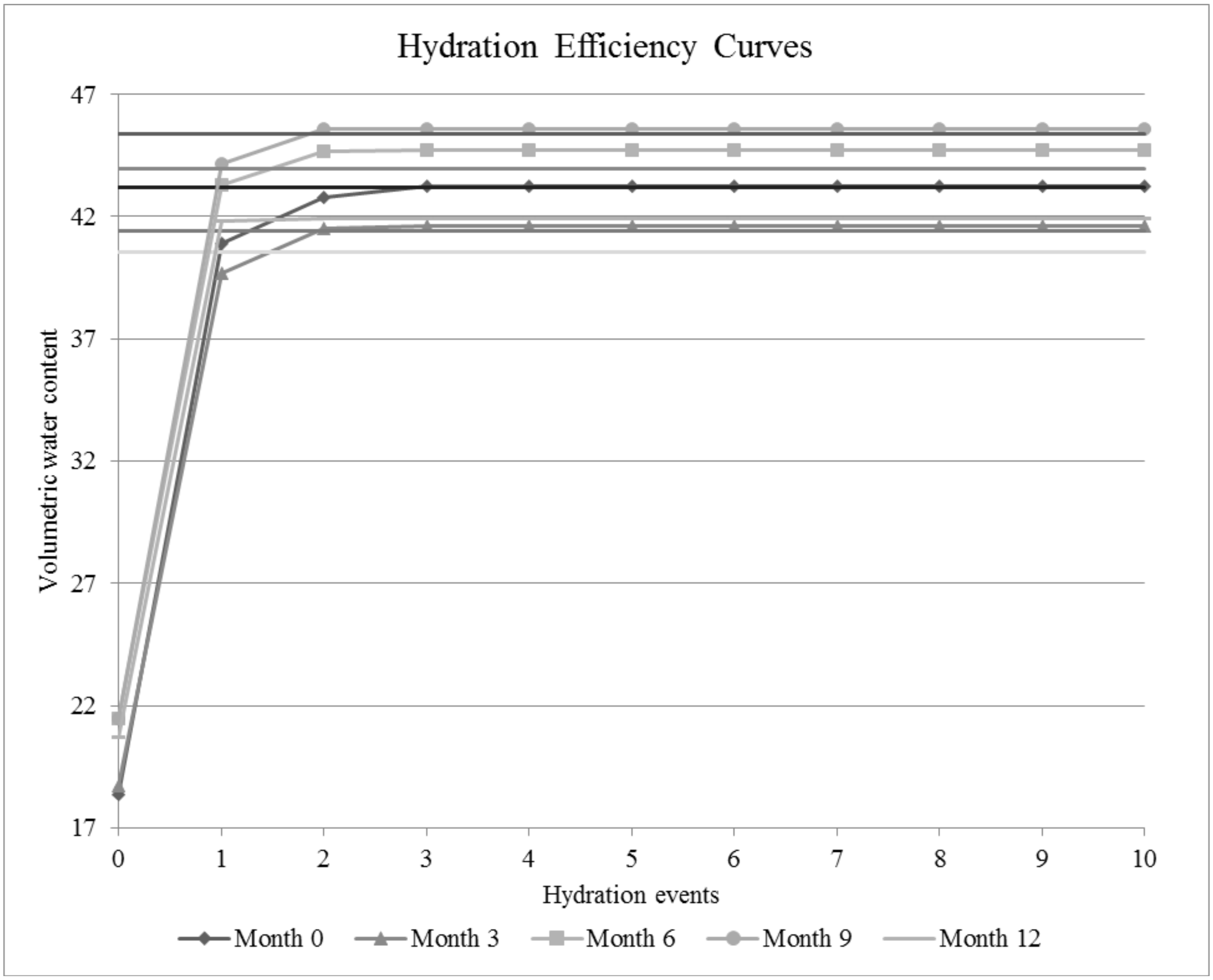

Fig. 4. Hydration efficiency curves for pine bark sampled at five different ages (0, 3, 6, 9, and 12 months) at 50% gravimetric moisture content, with container capacity for each age represented as solid lines of the same color. Means separations are shown for container capacity at each age.

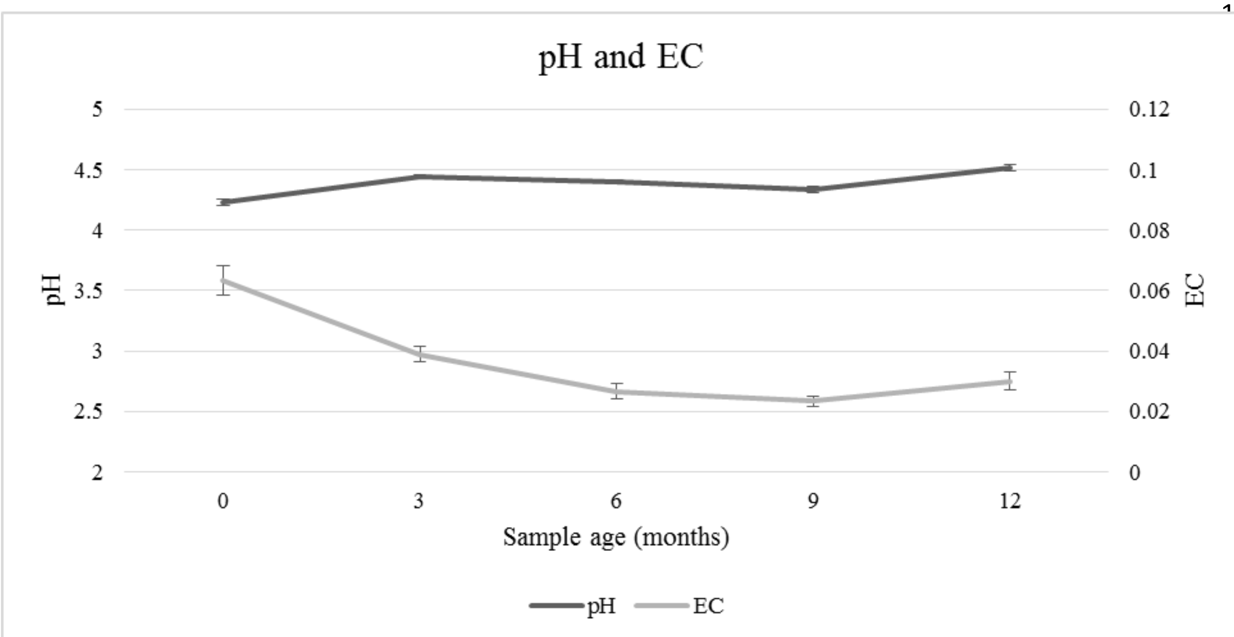

Fig. 5. pH and EC of pine bark sampled at five different ages (0, 3, 6, 9, and 12 months).