Water Retention of Processed Pine Wood and Pine Bark and Their Particle Size Fractions©

Ted C. Yap, Brian E. Jackson, and **William C. Fonteno**

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

Email: tcyap@ncsu.edu

INTRODUCTION

The wettability of a material intended for horticultural use is integral for high quality plant growth and performance. The ability of a substrate material (organic or inorganic) to capture and retain water (wettability) contributes to water-holding capacity and improved plant growth (Plaut et al., 1973). Many horticultural substrate materials, such as pine bark, experience hydrophobicity at low moisture levels (Beardsell and Nichols., 1982; Fonteno et al., 2013; Michel et al., 2001) which in turn has deleterious effects on irrigation efficiency and crop production. Further advantages of a substrate material being able to capture water include maintaining plant quality in post-production retail environments. Some research suggests that the variation in size and structure of milled pine bark particles may contribute to water holding (Airhart et al., 1978). The purpose of this study was to explore how processed pine wood, pine bark, and their resulting particle fractions capture and retain water using the wettability method described by Fields et al (2014).

MATERIALS AND METHODS

Unprocessed pine bark nuggets and coarse loblolly pine wood chips (*Pinus taeda)* were acquired from local sources in Southeast NC. Both materials were processed in a hammer mill (Model 35; Meadows Mills, North Wilkesboro, NC) at the Substrate Processing and Research Center located at the Horticultural Field Laboratory on the campus of North Carolina State University located in Raleigh, NC. The materials were then processed through a hammer mill with no screen inserted in order to assure a wide variation of particle sizes (known to occur as experienced in personal observations). Moisture content of the materials were not adjusted prior to processing but were processed as received. To prevent moisture loss after milling, processed materials were sealed in plastic 55-gallon drums for further testing. Both the processed pine wood and pine bark were then sieved and grouped into four individual size fractions: Extra-large, > 6.3mm, Large, < 6.3mm > 2mm, Medium, < 2 > 0.5mm and Fine, ≤ 0.5mm. Materials were not oven dried as is typical for particle size distribution analysis, in order to avoid hydrophobicity observed in organic materials and the need to keep the substrates moist for wettability testing. Substrates were sieved at the moisture content (MC) observed after milling, 29% and 44.5% for the pine wood and pine bark respectively. The sieved fractions and the non-sieved pine wood and pine bark, were then hydrated to a MC of 50% by weight for testing. Additionally, materials were tested at 25% MC. To achieve the lower MC approximately 300 ml of each substrate were spread 2 cm deep on a tray and allowed to air-dry until reaching 25% MC. A total of 20 treatments were used in this study [2 materials x 5 substrates (four fractions plus the non-sieved material) x 2 MC = 20 treatments].

Water capture and retention of materials were determined by the wettability protocol described by Fields et al. (2014). The equipment used for water capture testing consisted of a transparent cylinder 5 diameter × 15 cm height, with a mesh screen attached to the bottom using a rubber ring; a 100 ml plastic vial, 4 cm diameter; a 250 ml separatory funnel; and a 250 ml beaker placed at the bottom. The vial had 5 holes in the bottom in order to act as a diffuser, effectively spreading the force of water over the surface of the materials. The vial was fixed into position in the top of the transparent cylinder with a rubber O-ring to allow for precise adjustments in positioning. The transparent cylinders were packed to a bulk density within 5% of samples of the same material. Each hydration event used 200 ml of water. Flow was controlled with the funnel stopcock and water diffused evenly onto the materials. Water effluent that drained through the materials was recorded and the moisture retained was calculated by subtraction. Ten hydration events were conducted on each of the 20 treatments with 4 replications per treatment. Values at 10 were used as an estimation of maximum hydration. This experiment was a completely randomized design. Data were analyzed using general linear model procedures and regression analysis (SAS Institute version 9.3, Cary, NC). Means were separated by least significant differences at $P \leq 0.05$.

RESULTS AND DISCUSSION

Volumetric water content (the amount of water retained after each hydration event) in fractioned wood treatments with an initial MC of 50% (Fig. 1) were significantly greater after 10 hydration events than wood fractions with an initial MC of 25% (Fig. 2). This was not seen in the initially processed non-sieved pine wood material. The improved wettability of wood with higher MCs has been seen in previous work (Fields et al., 2014). Bark however did not react as expected or as previous report by Fields et al., 2014. Hydration curves (Figs. 3 & 4) exhibited different patterns for 50% and 25% MC. However the only significant difference at the end of the 10 hydration events was seen in the medium size (2.0 to 0.5mm) particles with 78% and 68% water content for the 50% and 25% MCs respectively. Fines for both materials retained the most amount of water compared to any other treatment (Table 1.). The behavior observed in bark at 25% MC is contrary to the hydrophobic nature that one would expect, and that has been observed (Airhart et al., 1978; Fields et al. 2014) in pine bark at low MCs. One possible explanation for this may be that the milled bark was processed differently than would commonly be found within industry practices. The random fracturing of particles during processing may have contributed to changes in particle surface area and structure of the bark, allowing it to capture water more efficiently. Further research is needed comparing the water capture of unprocessed versus hammer milled pine bark, fresh versus aged pine bark when unprocessed and when hammer milled.

Additionally the initial moisture content of these materials at the time of hammer milling may also have an influence on the subsequent substrate surface area, size and structure. Only after exploring how these variables relate to internal porosity, water availability and the hydrophobic nature of pine wood and pine bark materials could these substrate materials be better understood. Potential implications of engineering pine bark and pine wood substrates to capture and release water easily and efficiently could vastly improve crop irrigation management and substrate wettability issues.

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Table 1. Water content (% volume) of processed pine bark and pine wood after ten hydration events (maximum hydration).

Initial Moisture Content	Extra–large (>6.3mm)	Large (6.3 to 2.0mm)	Medium (2.0 to 0.5mm)	Fines (≤0.5mm)	Whole Material
Wood 25%	31.9 b[z]	24.1 b	49.9 c	54.5 b	56.0 b
Wood 50%	39.0 a	45.7 a	66.4 b	80.3 a	58.5 b
Bark 25%	25.4 c	44.2 a	67.6 b	82.4 a	74.0 a
Bark 50%	29.5 bc	51.0 a	76.7 a	79.8 a	74.5 a

[z]Means separation between all materials by LSD, $P<0.05$. Means followed by the same letter in the same column are not significantly different.

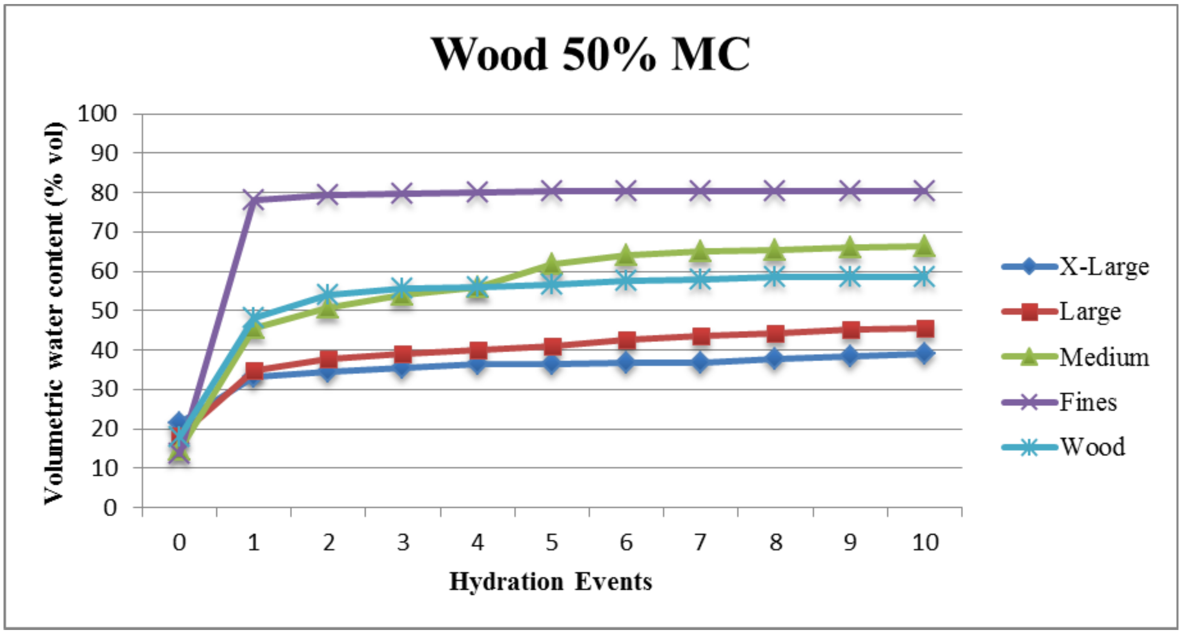

Figure 1. Hydration curves for processed pine wood and corresponding fractions with an initial moisture content (MC) of 50%. Volumetric water content is the amount of water retained after each hydration event. X-large particles > 6.3mm in diameter. Large particles < 6.3mm > 2mm in diameter. Medium particles < 2 > 0.5mm in diameter. Fine particles ≤ 0.5mm in diameter. Processed wood non-sieved material.

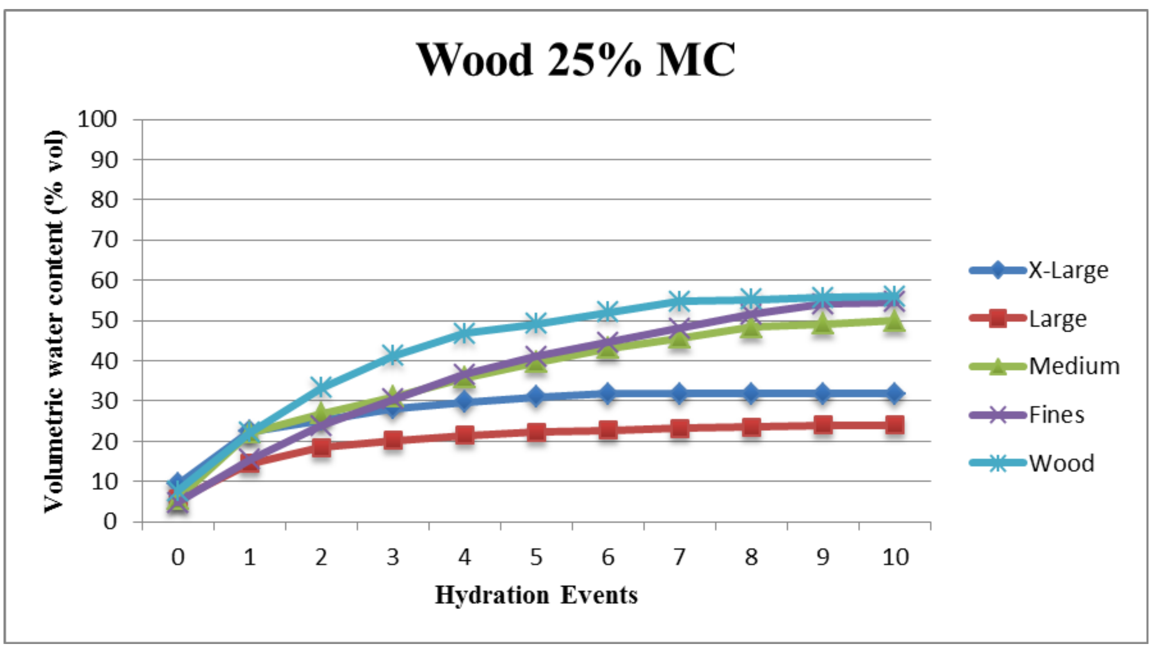

Figure 2. Hydration curves for processed pine wood and corresponding fractions with an initial moisture content (MC) of 25% (by weight). Volumetric water content is the amount of water retained after each hydration event. X-large particles > 6.3mm in diameter. Large particles < 6.3mm > 2mm in diameter. Medium particles < 2 > 0.5mm in diameter. Fine particles ≤ 0.5mm in diameter. Processed wood non-sieved material.

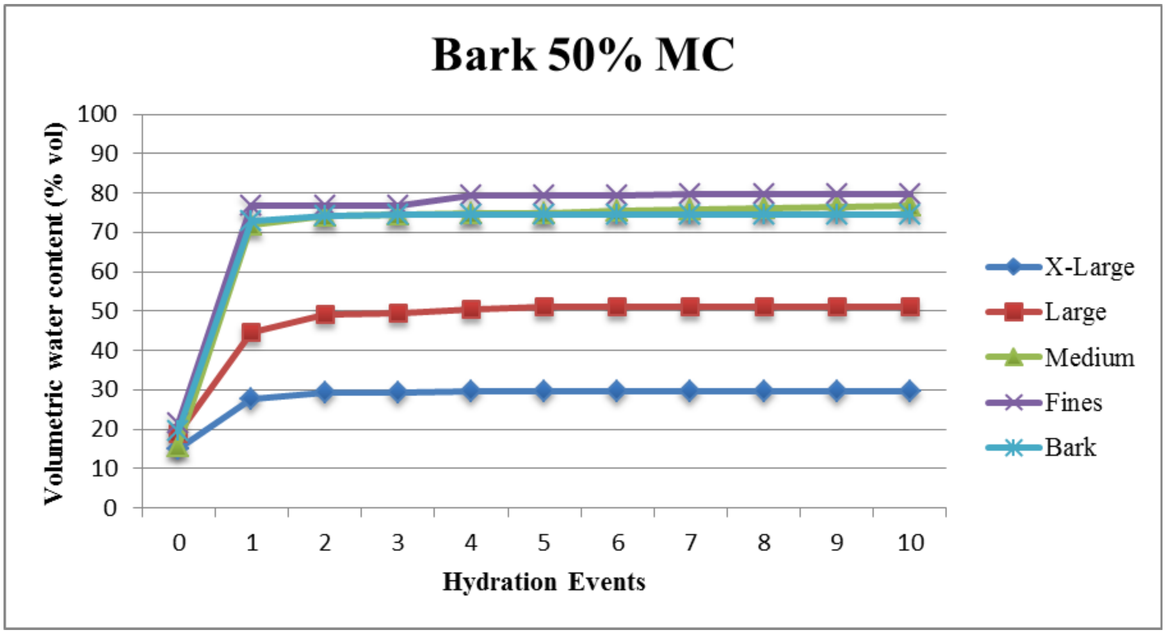

Figure 3. Hydration Curves for processed bark material and corresponding fractions with an initial moisture content (MC) of 50%. Volumetric water content is the amount of water retained after each hydration event. X-large particles > 6.3mm in diameter. Large particles < 6.3mm > 2mm in diameter. Medium particles < 2 > 0.5mm in diameter. Fine particles ≤ 0.5mm in diameter. Processed bark non-sieved material.

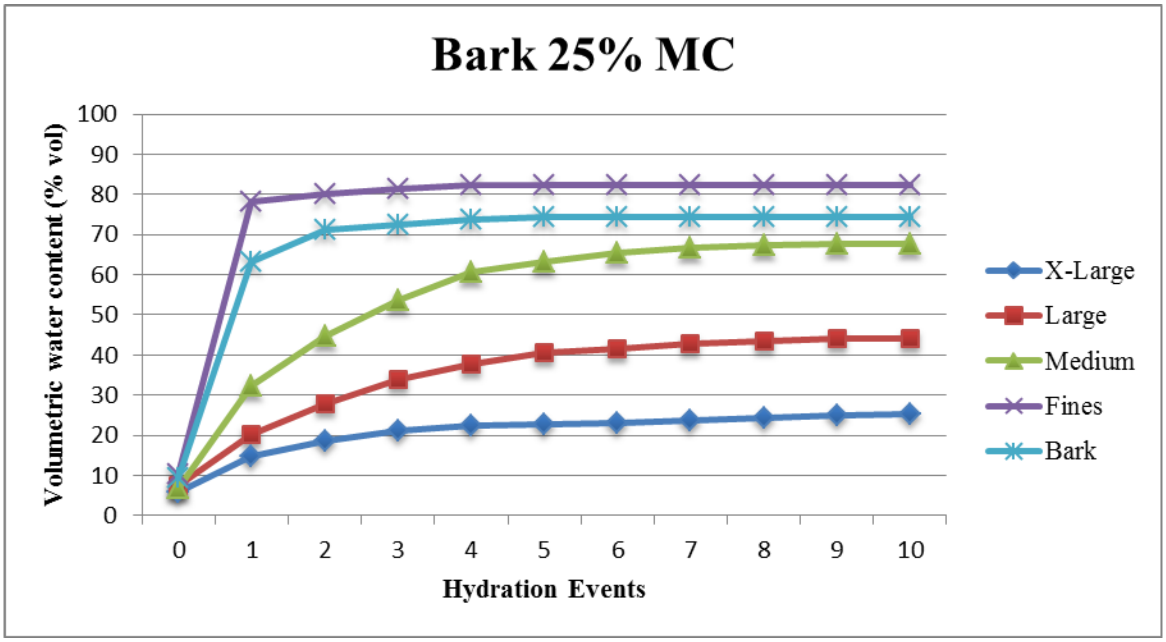

Figure 4. Hydration Curves for processed bark material and corresponding fractions with an initial moisture content (MC) of 25%. Volumetric water content is the amount of water retained after each hydration event. X-large particles > 6.3mm in diameter. Large particles < 6.3mm > 2mm in diameter. Medium particles < 2 > 0.5mm in diameter. Fine particles ≤ 0.5mm in diameter. Processed bark non-sieved material.