

Wettability and hydrology of various wood fiber substrates and substrate components

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Abstract

With the increased development, commercialization, and use of wood substrates as substrate components, there is a continual need for research and data on these popular materials. To better understand the physical properties, wettability, hydration efficiency of wood substrates, we obtained three commercial wood fiber products and tested them in combination with sphagnum peat. The three wood fiber materials were blended with peat at 20, 30, and 40% (by volume) and their physical properties (total porosity, container capacity, air space, and bulk density) were analyzed using the North Carolina State University (NCSU) Porometer procedure. The materials were also tested un-amended (at 100%). As the percent wood fiber increased, substrate air space increased and container capacity decreased. Substrates comprised of 100% wood fiber had total porosities above 95%. Wood fiber additions to peat at the lowest rate (10%) increased peat's wettability and hydration efficiency compared to peat alone at 25% initial moisture content. The variation in wood substrate components (method of processing, species of origin, particle size, particle shape, texture, etc.) may have some influence on the physical and hydrological properties of substrate formulations.

Keywords: wood substrate, wood chips, growing media, physical properties

INTRODUCTION

The use of wood as a substrate component first began in Europe during the 1980s and 1990s in response to uncertainties surrounding the availability and affordability of peat. This technology was later adopted in the United States following the work done by Laiche and Nash (1986) and later by Wright and Browder (2005). Since then, much research has been conducted on different wood substrate materials making them a viable component in substrate formulations. With availability increasing and viability better understood, many large growers are incorporating wood substrate components into their substrate blends. Wood substrates have been reported to have little visual shrinkage during production (Jackson and Wright, 2009) leading to more stable physical properties of substrates containing a wood component. For this reason, wood substrate components may provide a cheaper alternative to tradition materials such as perlite and vermiculite.

An understanding of wettability and hydration efficiency is necessary to pursue more effective substrates. Substrates possessing an ideal wettability provide an even distribution of water and nutrients to the root environment. Irrigation events and nutrient inputs can be minimized, avoiding excessive runoff, and allowing for more profitable container production (Fields et al., 2014a, b; Fonteno, 1993; Fonteno et al., 2013). The purpose of this research was to better understand the physical and hydrological characteristics of three commercially available wood fiber substrates, and the characteristics they impart on blends containing them.

MATERIALS AND METHODS

Three wood fiber substrate components were chosen based on their differences in visual appearance (Figure 1). These wood materials were labeled wood fiber 1 (WF1), wood fiber 2 (WF2) and wood fiber 3 (WF3). A compressed bale of Canadian sphagnum peat (BPP;

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Berger, Saint-Modeste, QC, Canada) was fluffed/reconstituted and wetted by hand before use. Volumes of peat and wood fiber, in ratios of 90:10, 80:20, 70:30, 60:40, were then blended. The blends were stored in sealed bags to allow moisture to equilibrate.



Figure 1. Three wood fiber substrates tested for physical and wettability properties, wood fiber 1 (A), wood fiber 2 (B), wood fiber 3 (C).

The physical properties (total porosity, container capacity, air space, and bulk density) were determined using the NCSU Porometer method established by Fonteno et al. (1995). The three unamended wood fiber materials, along with peat, were also tested. Differences in physical properties were analyzed using SAS (version 9.4; SAS Institute, Cary, NC). PROC ANOVA was used to determine minimum significant differences among means using the Tukey adjustment. The wettability and hydration efficiency were determined using the method described by Fonteno et al. (2013). Each hydration event consisted of 200 mL water being applied to the substrate. As the water percolated through the substrate, it was either sorbed into or onto the substrate or passed through the substrate and was collected into a beaker below. Water volume collected in the beakers was recorded and water retained by the substrate was calculated by subtracting leached water (effluent) from total water applied (200 mL). This procedure was repeated for a total of 10 hydrations for each sample. Each wood fiber was blended with peat volumetrically at a ratio of 90:10 (10% wood fiber). Each of these substrate blends were dried down to a moisture content of 25% before the wettability test was performed. Two treatments of unamended peat were also tested. The first was dried down to a moisture content of 25% and, for the sake of comparison, the second was dried down to a moisture content of 50%. Four replications of each substrate treatment were analyzed for hydration efficiency.

RESULTS AND DISCUSSION

When comparing wood fiber blends to 100% peat, the addition of WF2 caused an increase in total porosity at ratios of 20, 30, and 40%. WF1 had no effect on total porosity at ratios 20 and 40%, but at 30% a slight decrease (3%) was observed. It is unclear why this slight change occurred in the WF in this middle percent and not the higher (40%) range. WF3 also had no effect of total porosity at ratios of 20 and 40%, however, at 30% an increase occurred. WF1 and WF3 had no effect on the container capacity of peat at ratios of 20 and 30%, but caused a decrease at 40%. WF2 had no effect on container capacity at ratios of 20,

30, and 40%. An increase in air space was caused by WF1 and WF2 at ratio 40%, but neither had an effect at 20, and 30%. WF3 caused an increase in air space at ratios 30 and 40%, and had no effect at 20% (Table 1). Although the characteristics of these three materials were not the same as peat, they had little effect on its physical properties when blended at ratios of 20, 30 and 40%.

Table 1. Physical properties of sphagnum peat amended with wood fibers and unamended wood fibers^a.

Substrates	Total porosity ^b (% vol)	Container capacity ^c (% vol)	Air space ^d (%vol)	Bulk density ^e (g cm ⁻¹)
Peat 100 ^f	91.1 b ^g	76.1 a	15.1 c	0.10 d
WF1 20 ^h	90.9 b	71.7 ab	19.3 cb	0.11 c
WF1 30	87.0 c	72.5 ab	14.5 c	0.12 b
WF1 40	90.9 b	68.5 b	22.4 b	0.12 bc
WF1 100	93.8 a	58.7 c	35.1 a	0.14 a
Peat 100	91.1 c	76.1 ab	15.1 c	0.10 a
WF2 20	93.9 b	74.2 ab	19.8 c	0.09 b
WF2 30	95.4 ba	76.7 a	18.7 c	0.09 bc
WF2 40	96.5 a	70.6 b	25.9 b	0.08 c
WF2 100	97.4 a	62.2 c	35.1 a	0.07 d
Peat 100	91.1 c	76.1 a	15.1 d	0.10 a
WF3 20	92.2 bc	74.1 a	18.1 dc	0.10 ab
WF3 30	94.1 ba	71.9 ba	22.2 bc	0.10 a
WF3 40	93.2 abc	67.7 b	25.5 b	0.09 cb
WF3 100	94.9 a	55.1 c	39.8 a	0.09 c
Peat 100	91.1 a	76.1 a	15.1 b	0.10 c
Perlite 20	86.6 b	67.6 b	19.0 ab	0.11 b
Perlite 30	83.7 c	60.0 c	23.7 a	0.12 a
Perlite 40	82.8 c	61.3 c	21.5 a	0.12 a

^aPhysical property data represent the mean ($n=3$). Analysis performed using the North Carolina State University Porometer method (Fonteno et al., 1995).

^bTotal porosity is equal to container capacity + air space.

^cAir space is the volume of water drained from the sample ÷ volume of the sample.

^dContainer capacity is (wet weight – oven dry weight) ÷ volume of the sample.

^eBulk density after forced-air drying at 105°C for 48 h; 1 g cm⁻¹ = 0.5780 oz inch⁻³.

^f100% sphagnum peat moss.

^gMeans were separated within a column and peat amendment by Tukey's mean separation ($p \leq 0.05$).

^hSubstrates were formulated with 80, 70, 60% sphagnum peat/20, 30, 40% wood fiber or perlite, or 100% wood fiber.

When tested for wettability, WF1, WF2, and WF3 increased the container capacity of 100% peat from 25.5% to 64.2, 57.7, and 71.9%, respectively. All wood fiber blends increased the container capacity of unamended peat at 25% moisture content to similar levels of unamended peat at 50% moisture content (Figure 2). This indicates the potential of wood fiber to improve the hydrophobic nature of 100% peat when at low moisture contents.

All wood fiber blends increased the moisture retention of peat, with WF1 causing the most pronounced initial increase (Figure 3). These results indicate that the addition of wood fiber to peat can increase the ability to retain moisture when compared to dry peat (25%) alone.

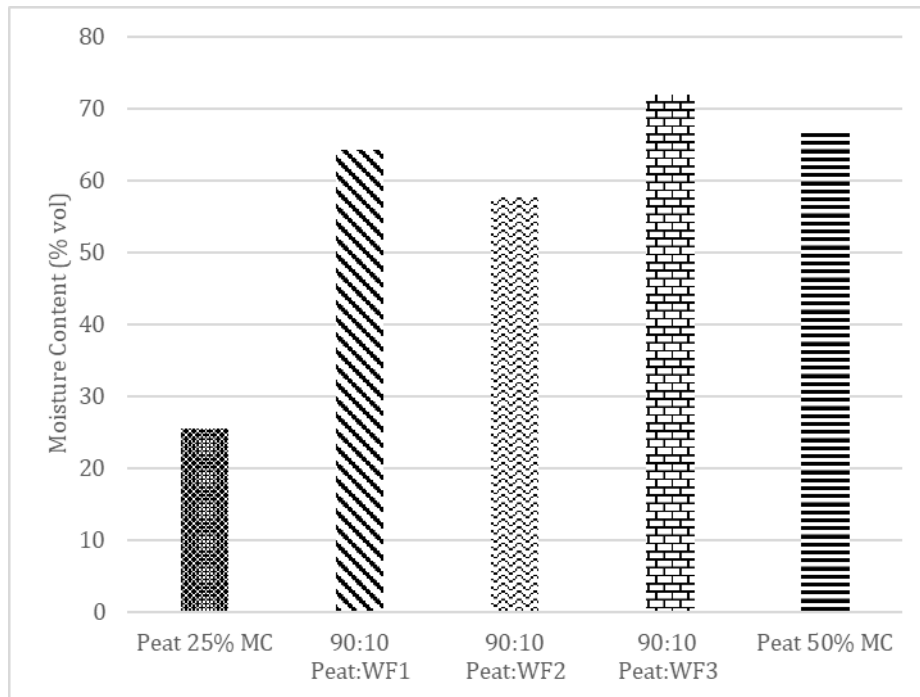


Figure 2. Container capacity for sphagnum peat, wood fiber blends at ratio 90:10 (by volume) at moisture content 25%, unamended peat at 25% moisture content and 50% moisture content also included.

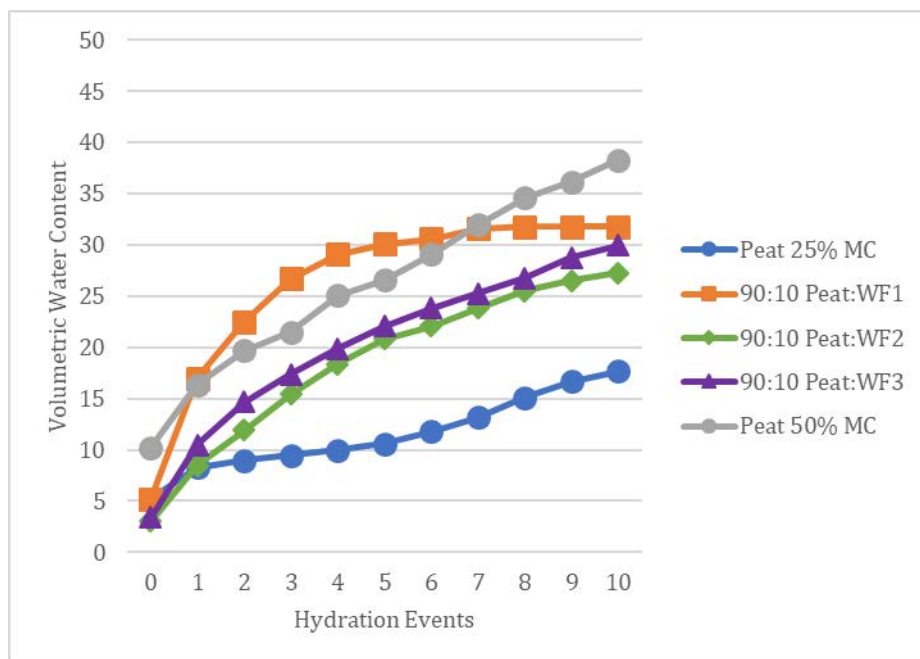


Figure 3. Wettability curves for sphagnum peat, wood fiber blends at ratio 90:10 (by volume) at moisture content 25%, unamended peat at 25% moisture content and 50% moisture content also included.

The addition of 20, 30, 40% wood fiber to peat caused little significant differences in physical properties when compared to 100% peat. Although changes in physical properties were slight, blends containing wood greatly increased the moisture retention and container

capacity compared to dry peat alone. These data provide some evidence of the similarity and differences of the three different wood materials evaluated in these trials. Despite there being differences in size, shape, and structure of the differently processed wood materials, at lower incorporation amounts (40% and less) there may not be much difference in the way they behave/perform when blended with peat. Must work is still needed in fully characterizing and understanding the function and properties of wood substrate components as the interest and use of them increases in horticultural crop production.

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