Continuous Columns for Determining Moisture Characteristic Curves of Soilless Substrates

Marta Mielcarek[1], James Owen, Jr. [1], James Altland[2], and Magdalena Zazirska[1]
[1]North Willamette Res. Ext. Ctr., Oregon State Univ., Aurora, OR 97002-9543
[2]USDA-ARS, Application Technology Research Unit, Wooster, OH 44691
marta.mielcarek@oregonstate.edu

Index Words: Douglas fir bark, pumice, peat, available water, water buffering capacity

Significance to the Industry: A new system employing continuous columns was developed to measure moisture characteristic curves for soilless substrates. Data from columns can be used to calculate the amount of available water for a given substrate in any container size. Continuous columns were successfully used to determine moisture characteristic curves within one week using easily attainable, inexpensive materials. This method provided consistent results over time and was sensitive enough to differentiate water distribution between substrates.

Nature of Work: Sound water management is essential for effectively producing nursery crops. Understanding substrate water availability is a critical component to managing irrigation properly. Conventional methods employed to measure water relations of soilless substrates are based on container capacity of a static system, and less often to measure moisture characteristic curves over a wide range of tensions. Substrate water holding capacity determined by the NCSU porometer method provides useful information to growers, but an understanding of the complete moisture characteristic curve can provide more detailed information about the hydrology of a given substrate, such as easily available water and water buffering capacity (1,2). However, conventional methods to determine moisture characteristic curves are expensive and time-consuming. The objective of this paper is to report a method for generating moisture characteristic curves of soilless substrate that is quick, inexpensive, and offers greater precision at low tensions.

Douglas fir (*Pseudotsuga menziesii*) bark (DFB) [screened to 0.9 cm (0.4 in)] was collected from stockpiles intended for nursery container production (Marr Bros. Monmouth, OR). Unscreened pumice (<0.95 cm (0.38 in), Pro-Gro, Sherwood, OR) and Canadian sphagnum peat (Sun Gro Horticulture Canada Ltd., LAVAL, Quebec) were used to make three substrates including: 1) 70:30-DFB:pumice (by vol.); 2) 70:30 DFB:peat (by vol.); and 3) DFB (not amended). Substrates were adjusted to 1.5 $g \cdot g^{-1}$ mass wetness. The DFB substrate was used to generate moisture characteristic curves over multiple dates to ensure the procedure was reliably repeatable. The 70:30-DFB:pumice and 70:30-DFB:peat substrates were used to determine if our method was able to differentiate between substrates of presumably different water holding capacities.

Columns [112 cm (44.1 in) tall by 7.6 (3.0 in) cm i.d.] were cut from schedule 40 polyvinyl chloride (PVC) rigid pipe. Columns were extended for packing by adding 30 cm (11.8 in) long sections of schedule 40 PVC rigid pipe using clear packing tape. Columns were hand packed. Substrate was constantly settled while packing by tapping on the column wall at 100 taps per minute with a schedule 40 PVC rigid pipe [61 cm (24 in) long by 1.3 cm (0.5 in)]. One 30 cm (12 in) PVC pipe extension was removed. A base was placed on column using a rubber coupling [8.6 cm (3.4 in) i.d.] and fastened with hose clamps (Fernco, Inc. Davison, MI). The based contained rigid mesh screen to ensure the substrate remained stable in the column. To ensure uniform bulk density columns were inverted and the length of the column was again tapped. The second 30 cm (12 in) long extension was removed after tapping the inverted column. A 9.5 cm (3.7 in) wide petri dish was used to cover the top of the column to minimize evaporation. Columns were bottom saturated with water for ≥ 4 hr, remained saturated for ≥ 8 hr, and then allowed to drain to ≈ 6 cm (2.4 in) above the base of the column (Z_o) for ≥ 4 hr. Columns were placed in a freezer at -21°C (-6°F) for ≥ 2 d. Frozen cores were cut into ten section [≈10 cm (3.9 in) tall] starting ≈ 6 cm (2.4 in) above the base of the column at Z_o. Columns were cut using a Ridgid compound miter saw (Ridgid Tool, Elyria, Ohio) equipped with a 0.2 cm (0.1 in) thick, 25 cm (10 in) diameter saw blade with 200 teeth (Oldham Co., Brooklyn, N.Y.) or a ¾ HP Jet Horizontal Bandsaw (Jet, Rockford, IL) with a 0.9 mm (0.03 in) thick 2 cm (0.8 in) wide saw blade . Actual height of cut strata was determined by measuring the height at four points along the circumference of each cut section; volume was calculated for each strata separately using its averaged height. Each cut section was weighed, oven dried at 60°C (140°F) for 3 d and weighed again to determine container capacity.

Responses between water content (θ = volume of water / total volume) and column height (tension = cm of water) were fit with sigmoid curves using the NLIN procedure in SAS version 9.01 (SAS Inst. Inc., Cary, NC). Models were fit as a four parameter curve with the following equation: $f(x) = c + (d - c)/(1+(x/i)^b)$, where the solved parameter for c represents residual water content or the point where the curve plateaus at minima, d represents the water content at complete saturation (or total porosity), *i* represents the inflection point in the sigmoid curve, and b represents the slope of the line at the inflection point. Lines for each substrate were compared using the Lack of Fit test (3).

Results and Discussion: Moisture characteristic curves for DFB (not amended) were estimated on three dates. The lack of fit test indicated that lines were similar, demonstrating this procedure provides consistent results over time when analyzing a similar substrate (Fig. 1). The procedure took one week each time it was performed (including: saturating, draining, freezing, and drying). This is a much shorter period of time than is required for other procedures that use some sort of applied pressure apparatus (4 to 6 weeks).

Pumice amended substrate (70:30-DFB:pumice) resulted in moisture characteristic curves similar to DFB. The moisture characteristic curve for 70:30-DFB:peat differed from the other two, in that it had higher *i* and b resulting in a gentler curve (Fig. 2). This indicates greater available water across the tension range of 0 to 30 cm (0 to 2.9 KPa). Using criteria set forth by Handreck.and Black (2002) we find that 70:30-DFB:peat has twice the amount of readily available water when compared to DFB (not amended) which equated into ≈ 300 mL (10 ounces) of more available water per 1 gallon container (Table 1). This is a result of the redistribution of available water due to individual characteristics of peat. The addition of peat increased the amount in easily available water from just 2% up to 16% and decreased water buffering capacity from 6% to 2% when compared to DFB substrate. With pumice (70:30-DFB:pumice), easily available water increased from 2% to 5% while water buffering capacity dropped from 6% to 1% when compared to non-amended DFB substrate (Table 1).

The procedure described herein is sensitive enough to differentiate between substrates of different water holding capacity. The data show the most critical range of tension for distinguishing moisture characteristic curve of different substrates is between 0 and 30 cm (12 in) of tension. We measured water availability in 10 cm (4 in) sections starting at 5 cm (2 in); however, it would be possible to measure water availability in as little as 2.5 cm (1 in) sections to improve precision at lower tensions [0 to 30 cm (1 to 12 in)]. Data from these curves can be used to determine easily available water and water buffering capacity, thus providing a broad understanding of the soilless substrate hydrology.

Literature Cited:

1. DeBoodt, M. and O. Verdonck. 1972. The physical properties of the substrates in horticulture. Acta Hort. 26:37-44.
2. Handreck, K. and N. Black. 2002. Growing media for ornamental plants and turf. 3rd ed. UNSW Press, Sydney, Australia.
3. Schabenberger, O. and F.J. Pierce. 2002. Contemporary Statistical Models for the Plant and Soil Sciences. CRC Press LLC, Boca Raton, FL.

Table 1. Readily available water (RAW; 10 to 100 cm tension), easily available water (EAW; 10 to 50 cm tension), and water buffering capacity (WBC; 50 to 100 cm tension) for three Douglas fir bark (DFB) based substrates expressed as percent volume and water capacity of 1 gallon container.

Soilless Substrate	RAW_{total}	EAW_{10-50}	WBC_{50-100}
		Percent volume	
DFB (not amended)	8[z]	2	6
70:30-DFB:peat	18	16	2
70:30-DFB:pumice	6	5	1
		Capacity (mL) of 1 gal. (4 L) container	
DFB (not amended)	309	79	230
70:30-DFB:peat	733	643	89
70:30-DFB:pumice	227	210	17

[z] 30 mL = 1 oz

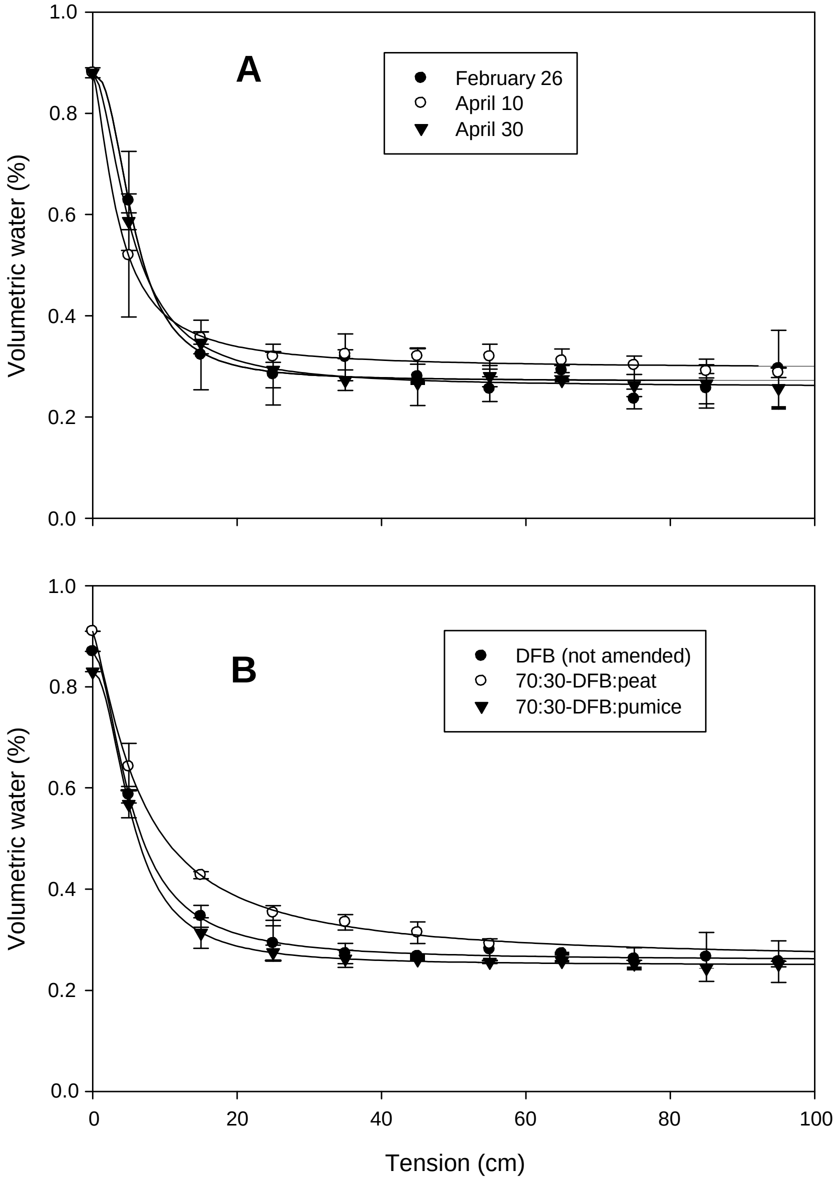

Figure 1. (A) Uniformity of Douglas fir bark moisture characteristic curve over thee dates. (B) Substrate moisture characteristics of three soilless substrates commonly used in

the US Pacific Northwest.