A Nursery Friendly Method for Measuring Air Filled Porosity of Container Substrates

Ted Bilderback

NC State University, Dept. of Horticultural Science, Raleigh, NC 27695-7609

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Significance to Industry: "Home Remedies" for measurement of air and water holding capacities of nursery potting substrates rarely provide consistent results, therefore, such measurements are infrequently attempted. The description for construction of a "home built" porometer apparatus to measure air-filled porosity (AFP) is described. If important steps for pre-moistening samples and for packing to match the weight of each replicate sample in porometers are followed, consistent results for air filled porosity can be accomplished.

Nature of Work: Growing plants in containers requires a growing substrate that provides acceptable aeration and moisture retention characteristics. Unfortunately, actual measurement of air and water holding capacities of nursery potting substrates are rarely attempted. Failure to measure physical properties of substrates is due to lack of appropriate equipment, adequate guidelines for procedures, and inconsistent results. Furthermore, few professional soil and plant analytical laboratories offer physical properties analyses of container substrates for the same reasons. Air-filled porosity is a very important physical characteristic of container substrates. Knowing the air-filled porosity of a potting mix provides knowledge useful for choosing containers suitable for a particular substrate, appropriate irrigation application, and nutrient management practices. The objective of this work was to present a “home remedy” procedure for measuring air-filled porosity of container substrates that can achieve “reasonably” consistent results.

Porometer construction: Measuring air-filled porosity requires an apparatus called a porometer. Therefore, the first step is to construct porometers. One-liter plastic drink containers or milk jugs can be used for this purpose. Tops of these containers can be removed to create a closed container of any height, however if cut to the same height as a # 1 nursery (2.6 L) container, the air-filled porosity measured will simulate air-filled porosity values for 2.6 L containers. At least three plastic carton porometers for each substrate to be simultaneously tested should be cut as closely as possible to the same height so they will hold the same volume of water. The volume of each container must be determined by measuring how much water is required to exactly fill each milk container before it overflows. Number each plastic carton porometer and record the number of milliliters required to fill each container. These numbers can be recorded on a data sheet and can also be written on each porometer using a permanent marker (recorded in Table 1 as total volume). For example, plastic carton porometers numbered 1, 2, and 3 have volumes of 719 ml, 720 ml, and 700 ml carton volume, respectively. The individual total volume for each porometer is used to determine the percent air-filled

porosity of the potting mix sample packed in each porometer. After determining the volume of each porometer, drill 3 or 4 small holes approximately 5 mm in diameter in the bottom of each container to allow drainage of water after saturation.

*Pre-moistening Substrate to Be Tested***.** Pre-moistening 12–24 h before testing is critical for achieving uniform and consistent results. Pre-moistening allows organic components to wet uniformly throughout their matrix. The potting substrate to be tested should be moistened to a consistency where if squeezed by hand, a drop or a few drops of water might be squeezed out between fingers. After premoistening, the potting medium should be left in a plastic bag overnight before testing. If organic potting components are used immediately after moistening, samples frequently do not become thoroughly moistened causing erroneous readings and inconsistency between replicated samples. It is critical for the substrate to have a structure that does not change during saturation. Pre-moistening reduces shrinking or swelling characteristics and therefore may eliminate repeating packing and saturation steps (1).

Packing Porometers with Substrate: After removing the plastic carton tops, individually weigh each porometer and record the weight. The weight of the plastic carton is subtracted from filled cartons as a “tare” weight to provide an accurate mass of substrate in each porometer. Next, overfill each porometer with potting substrate; tap each porometer firmly 3–5 times on a table or bench to eliminate air pockets and establish a bulk density. Carefully scrape excess potting substrate from the surface of the porometer, maintaining an even surface at the exact level of the top of the porometer. Weigh each filled porometer and subtract the weight of the plastic carton. The weight of the substrate in each porometer should be equal to achieve consistently similar air-filled porosity values. If considerable variability in weight is measured, re-pack porometers until the values are similar. [This step assumes that the total volumes of porometers are equal.]

Saturate Substrate in Porometers: After packing, porometers are set upright in a vessel large enough for all of the test porometers to stand erect and tall enough to add water to the top of the porometers. A household plastic paint bucket may be useful for this purpose. After placing porometers in the vessel, slowly add water until the level of the water outside of the porometers reaches just to the top of each porometer without overflowing onto the surface of the substrate. Precaution must be made to keep the porometers upright and to prevent substrate from floating out of the top of the porometers. Some innovations maybe required, however a weight placed on the top of the porometer that does not compress the substrate will stabilize the porometers and keep the potting medium inside the porometer. Saturate test samples for approximately 1 h or until free water glistens between substrate particles at the top of the porometer. Additional water may be needed as it is adsorbed by the substrates components being saturated. If the substrate in the porometers shrinks or swells more than 3 mm from the top of the porometer during saturation, the air filled porosity values are not valid. Multiple saturation and drainage cycles may be required to stabilize the substrate bulk density; however re-filling and packing porometers to identical weights will then be required.

Collecting and Measuring Drainage: Saturation of each porometer can be observed when water is seen at the surface of the substrate. Drainage from each porometer must be measured individually. This step may require practice. Fingers are used to prevent leaking from the drainage holes while the porometer is lifted from the saturation vessel and a pan is quickly placed under the drain holes. Porometers can be balanced on supports placed in the bottom of the drainage pan and allowed to fully drain. After draining has stopped, the drained volume is measured and recorded for each porometer (Table 1).

Calculating air filled porosity: The drainage volume is divided by the total volume for each porometer to determine a percent air-filled porosity (Table 1). Air-filled porosity measurements are added and divided by the number of porometers to obtain an average AFP for each test substrate. Changes in air filled porosity during a growing season or over a production cycle can be measured by placing porometers packed with substrate in containers which are set in nursery growing beds. Decomposition shrinkage should be measured and marked from the top of the porometer. The volume of the porometer marked at the surface of the substrate would be used as the new total volume and calculations followed as described above. If the important steps for pre-moistening samples and for packing to match the weight of each replicate sample in porometers are followed, consistent results can be accomplished.

Acknowledgements: The description for construction of a home constructed porometer apparatus described here was adapted from porometers observed during a visit with Chris Hughes, at BlueMountain Nursery, Tapanui, South Island, New Zealand.

Literature Cited:

1. Fonteno W.C., C.T. Harden and J.P Brewster. 2003. Procedures for determining physical & hydraulic properties of horticultural substrates. Hort. Substrates Lab. NCSU, Raleigh, NC. (http://www.ncsu.edu/project/hortsublab/pdf/porometer_manual.pdf).

Table 1. Plastic carton porometer (PCP) data recorded for a container substrate[z]

Porometer	Pack weight[y] (g)	Carton volume (ml)	Drained volume (ml)	AFP %
PCP1	511.5	719	223	29.2
PCP2	505.0	720	232	32.2
PCP3	503.0	700	225	32.1

[z] N.Z. Peat Southland Tree and Shrub Mix is 35% peat moss (0–20 mm); 35% composted pine bark (0–13mm); and 30% medium pumice.
[y] Variation in AFP could be decreased by adjusting carton volume, and insuring consistency in pre-moistening substrates to create equal pack weight of PCP1 to PCP2 and PCP3.
[x] Air-Filled Porosity (AFP) calculated by dividing Drained volume by Total volume recorded. NCSU Porometer data mean of 3 replications was 29.5% AFP.