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Measuring Air-Filled Porosity for Container Substrates©

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INTRODUCTION

Growing plants in containers requires a growing medium 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 when attempted. 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 presentation and proceedings article is to describe "home remedy" procedures for measuring air-filled porosity of container substrates that can achieve "reasonably" consistent results.

Significant contributions of this presentation are the guiding principals for premoistening substrate samples and steps to improve procedures used for filling ("packing") porometers test samples. The description for construction of a home constructed porometer apparatus to measure air-filled porosity described below was adapted from porometers observed during a visit with Chris Hughes, at Blue Mountain Nursery, Tapanui, South Island, New Zealand. Procedures for improving preparation of samples tested in home-made porometers are modified guidelines described in the North Carolina State University, Horticultural Substrates Laboratory Manual authored by W.C Fonteno and C.T. Harden, 2003 (http://www.ncsu.edu/project/hortsublab/pdf/porometer_manual.pdf).

POROMETER CONSTRUCTION

Measuring air-filled porosity requires an apparatus called a porometer. Therefore, the first step is to construct several porometers. One-liter plastic milk jugs can be used for this purpose. Tops of milk containers can be removed to create a closed container of any height, however if cut to the same height as a 2.6-L nursery container, the air-filled porosity measured will simulate air-filled porosity values for 2.6-L containers. At least 3 milk containers 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 milk container 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, milk cartons numbered 1, 2, and 3 have volumes of 719 ml, 720 ml, and 700 ml total volume, respectively. The individual total volume for each milk container [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 pre-moistening, 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 the packing and saturation steps described below.

Packing Porometers with Substrate. After removing the milk carton tops, individually weigh each porometer and record the weight. The weight of the milk container is subtracted from filled containers 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. 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 milk container. 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. Following packing procedures, 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, but in general, 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 volume of the water drained is measured and recorded for each porometer (recorded as drained volume in Table 1).

Table 1. Milk carton porometer (MCP) data recorded New Zealand Peat Southland Tree and Shrub Mix[z]

Porometer	Pack weight[y]	Total volume	Drained volume	AFP[x] (%)
MCP1	511.5	719	223	29.2
MCP2	505.0	720	232	32.2
MCP3	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 Pack weight of MCP1 to MCP2 and MCP3 pack weights.

[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.

CALCULATING AIR-FILLED POROSITY

The drainage volume is divided by the total volume for each porometer to determine a percent air-filled porosity (recorded as percent AFP in Table 1). Air-filled porosity measurements are added and divided by the number of porometers to obtain an average AFP for each test substrate. 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.