Growing Media Options: Take the Test Before the Lesson©

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INTRODUCTION

Container crop producers are experiencing rising costs and concern for future availability of substrate components used to grow container plants. Rising fuel costs have dramatically affected the cost of Canadian peat moss. Additionally growers are experiencing increased prices and shortages of pine bark. Over the last 40 years nursery container crop producers have depended on pine bark as a by-product of forest operations. Pulp mills, fuel pellet mills, and other industries are increasingly turning to pine bark as a source of fuel, reducing supplies available to the horticultural market. Competition and increasing costs of substrate components threaten the future economic profitability of the floriculture and nursery industry. Therefore, investigation of alternative container substrates is necessary and paramount for sustainable container crop production practices.

Desirable physical and chemical characteristics of container substrate components have been described in many horticultural publications. Certainly, initial adequate air-filled porosity (AFP), stability resistance to decomposition during production, moderate pH, acceptable initial electrical conductivity, and balanced initial nutrient levels are cited as important parameters for evaluating alternative potting components. Testing these characteristics of experimental potting mixes before wide adoption for general use in greenhouses or nurseries as a potting substrate for new container crops is necessary to avoid problems during production cycles.

This article describes three testing procedures that growers can use to evaluate the efficacy of alternative potting components being considered for growing container crops. Air-filled porosity (AFP) is a very important physical characteristic of container substrates. Knowing the AFP of a potting mix provides knowledge useful for choosing container geometry suitable for a particular substrate, appropriate irrigation application and nutrient management practices. The first objective of this presentation is to describe a "home remedy" procedure for measuring AFP of container substrates that can achieve "reasonably" consistent results. The second objective is to measure nutrients soluble in the container substrate held within a container. Electrical conductivity (EC) increases proportionally with the dissolved salts (nutrients from substrate components or fertilizers) present in the solution. Therefore, measuring EC indicates the nutrient concentrations that will be initially experienced by roots of container-grown plants. Leaching fraction is proposed as one way for growers to determine if an irrigation system is dispensing irrigation for an appropriate length of time to adequately water the crop without over watering. Over watering may cause an excessive amount of water to flow out of the bottom of the container. High percentages of leachate leaving containers leaches nutrients from the container and results in larger volume of runoff that must be collected in detention or retention structures or filtered by landscape vegetative features. Therefore the third objective of this presentation is to provide growers with a procedure to measure leaching to determine if experimental substrates are compatible for normal irrigation cycles used at the nursery and if experimental substrates are compatible with current substrates used in production areas.

MATERIALS AND METHODS

Measuring Air-Filled Porosity. Measuring AFP requires an apparatus called a porometer. A brief summary for measuring AFP of experimental substrates will be described here, however more detail can be found in previously published articles (Bilderback, 2008, 2009). The first step is to construct at least three porometers. One-liter plastic milk or juice containers can be used for this purpose. The tops of each container are removed to create a closed container of any height, however if cut to the same height as 2.6-L nursery container, the AFP measured will simulate AFP values for 2.6-L containers. The volume of each container (porometer) must be determined by measuring how much water is required to exactly fill each milk container before it overflows. Number each porometer and record the number of milliliters required to fill each one. Record each volume on a data sheet and write the volume on the side of each porometer using a permanent marker. The individual total volume for each porometer is used to determine the percent AFP of the potting mix sample packed in each porometer. After determining the volume of each porometer, drill 3 or 4 small holes approximately 5.0 mm in diameter in the bottom of each container to allow drainage of water after saturation. Pre-moistening test substrates 12 to 24 h before testing is critical for achieving uniform and consistent results. Moisten the potting substrate to be tested 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. After removing the milk carton tops, individually weigh each porometer and record the weight. The weight of the porometer is subtracted from filled containers as a "tare" weight to provide an accurate mass of substrate in each porometer. Next, over fill each porometer with potting substrate, tap each porometer firmly 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 porometer (recorded as "Pack Weight" Table 1). Porometers with equal mass (weight) will have consistently similar AFP values. If considerable variability in mass is measured, re-pack porometers until mass values are similar. 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 media inside the porometer. Saturate test samples for approximately 1 h or until free water glistens between substrate particles at the top of the porometer. As the porometer is lifted from the saturation vessel, place a pan 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; Table 1). The drainage volume is divided by the total volume for each porometer to determine a percent AFP (recorded as percent AFP; Table 1). AFP 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 packing to match mass values of each replicate are followed, consistent results can be accomplished.

Pour-Through Extraction Procedure. The pour-through extraction procedure is a procedure that growers can use to achieve immediate information related to the electrical conductivity levels of experimental substrates (Wright, 1986) The pour-through extraction procedure does not disturb plant roots as do other procedures that require removing potting media from containers or sending samples to a laboratory. Three to five containers of the experimental substrate are thoroughly watered and allowed to drain. Following a 30-min. to 2-h draining period, additional water is gently "poured through" the container substrate. Water poured over the surface of the substrate displaces the solution in the container and is collected as it leaches from the drainage holes. A volume of approximately 50 ml from each container is desirable for measuring electrical conductivity. A variety of equipment can be used to monitor pH and EC separately (with two instruments) or together (with one instrument). Pens or meters are the standard instruments used to measure EC and pH, and both can be purchased from many horticulture or nursery supply retailers. Be sure to calibrate pH and EC on the instruments before each use. The pH of leachates collected from test substrates should range between 5.2 to 6.3 for optimal availability of nutrients for root adsorption. Pour-through leachate EC values for test substrates should range between 0.5 $mS{\cdot}cm^{-1}$ to 2.0 $mS{\cdot}cm^{-1}$. This would be 50 to 200 $mhos{\cdot}cm^{-1}$ or 500 to 2000 $\mu S{\cdot}cm^{-1}$. (For step by step pour-through procedures see LeBude, 2009). The leachate solution from test containers can be combined and sent to an analytical lab for a complete analysis of nutrients contained in the leachate. Suggested levels are shown in Table 2.

Leaching Fraction Measurements. To collect information related to leaching fraction (LF) nurseries need to set up a method to collect water leached from plant containers and from empty containers located next to plant containers at the same spacing used in the growing blocks (Ross et al., 2001). The method used at N.C. State University has been to place containers in buckets that tightly fit around the circumference of the container. Empty pots and pots with plants in buckets are placed in irrigation zones before an irrigation event (Bilderback, 2006). This method will work for automated irrigation systems or for manual irrigation valves. After the last irrigation (for multiple cycles), the volume of water collected in plant containers is divided by the volume of water collected from empty containers (Table 3). The percent LF is the volume collected in plant pots divided by the empty containers multiplied by 100 and should be 10% to 20% (0.1–0.2) or less to avoid over watering. If the percent LF is above the target LF, irrigation run time should be reduced. If the time required to obtain the target LF is considerably different from normal irrigation intervals at the nursery, the test substrate will require adjustment for successful crop production. Additionally, separate irrigation zones will be necessary if the LF is considerably different for test substrates compared to current potting substrates used for container production. This method also works to determine how long to irrigate zones during the growing season. In most cases, irrigation run time will need to be increased as plants grow and require more water. However, in some cases, irrigation run time may actually need to be reduced as plants develop larger canopies. Some plants have canopies that act as a funnel and actually capture water beyond the top diameter of the container greatly affecting LF measurements.

RESULTS

Table 1. Porometer (P) data recorded for a test container substrate.

Porometer	Pack weight[y]	Total volume	Drained volume	Percent AFP[Z]
MCP1	511.5	719	223	29.2
MCP2	505.0	720	232	32.2
MCP3	503.0	700	225	32.1

[Z]Air-filled porosity (AFP) calculated by dividing drained volume by total volume recorded and multiplied by 100.

Table 2. Nutrient capacity factors for experimental substrates suggested ranges and limits.

Nutrient capacity factors	Substrate leachate concentrations
pH	5.2–6.3
EC (Conductivity)	0.5–2.0 $mS \cdot cm^{-1}$
Nitrogen (N)	50.0–150.0 ppm
Phosphorus (P)	3.0–15.0 ppm
Potassium (K)	< 100.0 ppm
Calcium (Ca)	40.0–200.00 ppm
Magnesium (Mg)	10.0–50.0 ppm
Sulfur (S)	75.0–125.0 ppm
Sodium (Na)	< 50.0 ppm
Chloride (Cl)	< 70.0 ppm
Iron (Fe)	0.3–3.0 ppm
Manganese (Mn)	0.02–3.0 ppm
Zinc (Zn)	0.3–3.0 ppm
Copper (Cu)	0.01–0.5 ppm
Boron (B)	0.5–3.0 ppm
Molybdenum (Mo)	0.0–0.1 ppm

Table 3. Leaching fraction for five containers for a pine bark and builders sand (5 : 1, v/v) substrate.

Container	#1	#2	#3	#4	#5	Average
Plant container	250 ml	225	160	275	210	224
Empty container	775 ml	740	770	870	760	783
Leaching fraction	32%	30%	21%	31%	28%	29%

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