

Chapter 13

Recommended Test Procedures for Greenhouse Growth Media

Daryl Warnke – NCR-13

Root media used for production of plants in greenhouses and nurseries are composed of light-weight, natural and processed material such as peat, perlite, vermiculite, sand, bark, coconut fiber (coir), compost and similar materials. These are mixed together in various combinations to provide the actual root media. These lightweight mixes are easy to handle and provide good aeration and moisture-holding properties, but provide limited nutrient-holding capability. Natural soil systems provide plant available nutrients in the soil solution (intensity factor) and have a reserve nutrient supplying capacity with exchangeable cations, “fixed” nutrients and insoluble complexes (capacity factor). Most prepared root media contain only small amounts of soil, if any, and therefore have a limited nutrient reserve (capacity factor). Hence, the availability of nutrients in most prepared root media is dependent on the intensity factor.

Geraldson (2) developed an “intensity and balance” testing system for poorly buffered sandy soil systems using the saturation extraction approach adopted by the U.S. Salinity Laboratory (9). Lucas et al. (4, 5) found that saturation extracts of greenhouse root media gave a reliable measure of plant available nutrients. Researchers in the Netherlands (6, 7) have also reported saturation extract results to be a dependable measure of the available nutrient status of peat-based mixes. In summarizing test results over a 2-year period, Whipker et al. (16) demonstrated that root media analysis by saturation extraction is a valuable tool for evaluating greenhouse nutrition problems.

Saturation extraction methodology provides several advantages over previous procedures (11, 12, 14). For many years, soil testing laboratories have handled prepared soilless root media samples in a manner similar to that for field soil samples. Analytical procedures used have been modifications of the Spurway (8) test procedures. These worked well for testing greenhouse soil mixes when soil was the base material. However, as the composition of greenhouse root media has changed to include peat and processed materials, the field soil testing procedures have become inadequate. The major shortcomings in treating greenhouse root media in the same way as field soils are related to handling and diagnostic sample size. Drying, grinding and sieving of greenhouse samples result in significant alteration of the sample properties. Trying to measure out a uniform, small sample (2.0 or 1.7 cm³) from a heterogeneous mix of materials is difficult. Interpretation of the results must take into account the bulk density which may range from 0.2 to 1.2 g/cm³. The Saturated Media Extract (SME) approach has been shown to successfully eliminate these handling, sampling and interpretation problems (11, 12, 14). This procedure can also be used to evaluate the suitability of composts for use in growing plants.

With the saturation procedure a large sample of the root media (400 cm³), just as the grower uses it, is extracted and analyzed, reducing sampling error. With no preliminary handling

Chapter 13.

necessary, samples can be processed and analyzed quickly. The water holding characteristics of the various root media tend to be related to the bulk density. This acts as an automatic compensator for differences in bulk densities which affect interpretation of results from saturation extracts. As demonstrated by Geraldson (3), nutrient balance is very important in weakly buffered systems such as exist with many greenhouse root media. With the SME approach, nutrient balance information is readily calculated. Root media which contain slow-release fertilizer can be extracted by the saturation extract method with very little inflation of the tests results (13). With other handling and extraction procedures, test values are greatly inflated due to excessive solubilization of the slow-release fertilizer.

Available micronutrient levels in plant growth media are important for the growth of container grown plants. In peat and bark based root media, the basic micronutrients are complexed by organic compounds (10). Hence, the concentrations of these micronutrients in a water saturation extract are quite low. Zinc and manganese concentrations rarely exceed 0.8 mg/L and iron rarely exceeds 4.0 mg/L. Therefore, it is difficult to distinguish between deficient and adequate levels.

In evaluating 15 extractants, Berghage et al. (1) found that extractable levels of iron, manganese and zinc could be increased greatly by using weak solutions of various salts, acids or chelates in the saturating solution with the saturation extract procedure. Saturation with a 0.005 M DTPA solution was found to most consistently increase extractable micronutrient levels while having only a minor effect on the other key test parameters: total soluble salts and extractable levels of nitrate, phosphorus, potassium, calcium, magnesium, sodium and chloride.

Saturated Media Extract Method

The Saturated Media Extract Method (SME) was developed at Michigan State University and has been routinely used in their soil testing lab. It allows extraction of moist samples just as they come from greenhouses. Drying of samples is unnecessary and undesirable. Storage of prepared root media in either the dry or moist state will influence the soluble nitrate-nitrogen (N) and soluble salt levels. If samples will not be extracted within two hours of receipt, store them under refrigeration (~4°C).

Equipment:

1. 600 mL plastic beaker
2. Spatula
3. Buchner funnel, 11 cm
4. Filter paper (Whatman No. 1) 11 cm
5. Vacuum flask, 500 mL
6. Vacuum pump
7. Vial, snap-cap 100 mL
8. Conductivity meter, (Solu-bridge 31 or equivalent)
9. Conductivity cell with cell constant equaling 1.0

Recommended Test Procedures for Greenhouse Growth Media

10. Thermometer
11. pH meter with expanded scale or specific ion meter
12. pH glass electrode with a paired calomel reference electrode
13. Nitrate electrode with paired reference electrode
14. Colorimeter
15. Flame emission, atomic absorption and/or plasma emission spectrophotometer
16. Volumetric flasks and pipettes as required for preparation of reagents and standard solutions

Reagents:

1. Distilled or deionized water
2. 0.01M potassium chloride (for standardizing solu-bridge)
3. Reagents for determining pH, nitrate-N, phosphorus, potassium, calcium, magnesium and micronutrients of interest

Procedure:

1. Fill a 600 mL beaker about two-thirds full with the root medium. Gradually add distilled/deionized water while mixing until the sample is just saturated. At saturation the sample will flow slightly when the container is tipped and is easy to work with a spatula. After mixing, allow the sample to equilibrate for 1 hour and then recheck the criteria for saturation. The saturated sample should have no appreciable free water on the surface, nor should it have stiffened. Adjust as necessary by addition of root medium or distilled water. Then allow to equilibrate for an additional 30 minutes.
2. Determine the pH of the saturated sample by carefully inserting the electrodes. Wiggle the electrodes gently to attain good solution contact. Take pH readings at 3 or 4 discreet locations in the container (left, right, and center for example) and average the readings. If pH readings vary more than 0.5 units from lowest to highest, homogenize the paste by stirring with a clean spatula and retake readings.
3. Attach a Buchner funnel lined with filter paper to a vacuum flask. Apply a vacuum and transfer the saturated sample into the Buchner funnel. Spread the sample out with a spatula and tap the funnel to eliminate entrapped air and to insure good contact between the saturated sample and the filter. Continue vacuum, collecting the extract in the flask. No more than 15 minutes of vacuum should be required. Transfer the extract to a snap-cap vial. All subsequent analyses are done on the extracted solution.

Chapter 13.

4. **Soluble Salts:** Use 0.01M KCl to calibrate the solu-bridge. Prepare a 0.01M KCl solution by dissolving 0.7456g KCl in about 800 mL of distilled or deionized water. Then bring it to 1 L volume with distilled or deionized water. With the temperature adjustment properly made, a 0.01M KCl solution should have an electrical conductivity of 1.418 dS per m (mS per cm). *Note:* For those with older solu-bridges:

$$1.0 \text{ dS m}^{-1} = 1.0 \text{ mmho cm}^{-1}.$$

- To determine the electrical conductivity of the extract solution, check its temperature and adjust the temperature dial on the solu-bridge (not necessary if conductivity meter has automatic temperature compensation). Rinse the electrode and dip the conductivity cell into or fill it with the extract solution and record the reading in dS m⁻¹ (mS cm⁻¹).
5. **Nitrate-N and Ammonium-N, Chloride:** Nitrate and ammonium can be determined with the appropriate specific ion electrode or colorimetrically by cadmium reduction (nitrate) and Nesslerization (ammonium) through an autoanalyzer unit. With the high concentrations of nitrate usually present, use of a nitrate electrode is preferred. After establishing the standard curve, determine the nitrate-N content with a nitrate electrode. Determine the millivolt reading with a specific ion meter or an expanded scale pH meter, and obtain the concentration of nitrate from a standard curve of Emf vs. nitrate concentration. Determine the chloride concentration with a chloride electrode and specific ion meter or by Ion Chromatography (IC).
 6. **Phosphorus, potassium, calcium, magnesium, sodium:** Determine phosphorus on a aliquot of the extract by one of the accepted colorimetric procedures or with an ICP (inductively coupled plasma emission spectrograph). Determine potassium, calcium and magnesium on an aliquot of the extract by flame emission or atomic adsorption spectroscopy or with an ICP.
 7. **Micronutrients:** Most micronutrients of interest can be determined with an ICP or atomic adsorption unit.

Modified (DTPA) Saturated Media Extract Method

Reagent:

By using 0.005M DTPA as the primary saturating solution, extraction of the basic micronutrients (zinc, manganese, iron and copper) can be greatly enhanced. Some indication of boron availability may also be determined. For each liter of DTPA solution to be prepared, transfer exactly 1.97 g dry DTPA (diethylenetriaminepenta-acetic acid) into a 1 L volumetric flask and add about 800 mL of distilled or deionized water. Heating the water to 50°C and stirring facilitates dissolution of the DTPA. After the solution has cooled, make to volume with distilled or deionized water. The modified SME method involves a change in the procedure used to saturate the growth media and in the measurement of pH.

DTPA Saturation Extract Preparation:

1. Place 400 cm³ of growth media into a 600 mL beaker.
2. Add 100 mL of 0.005 M DTPA.
3. While mixing, gradually add deionized water to bring the media just to the point of saturation.

From this point on, proceed as indicated under the original SME Method, except for pH determination. Since the DTPA solution affects the media pH, use one part of the media by volume and two parts of deionized water by volume for a separate determination of the media pH.

Calculating Nutrient Balance

Soluble salt levels are reported as dS m⁻¹ or mS cm⁻¹. The electrical conductivity (dS m⁻¹ or mS cm⁻¹) can theoretically be converted to ppm (mg/L) by multiplying by 640. However, empirically, 700 seems to provide more practical information. Results for nitrate-N, phosphorus, potassium, calcium, magnesium, sodium and chloride are reported as mg/L of extract. Nutrient balance is determined by calculating the percent of total soluble salts for each nutrient as follows:

$$\% \text{ Nutrient} = \frac{[\text{nutrient conc. (mg/l)} \times 100]}{\text{Total soluble salt conc. (mg/l)}}$$

$$\text{Total soluble salt conc.} = \text{electrical conductivity} \times 700$$

Interpretation

The suitable pH, soluble salt and nutrient levels vary with the greenhouse or nursery crop being grown and management practices. The general guidelines given in Table 13-1 can be used in making a preliminary judgment of the results obtained with either the water or DTPA saturation extracts. When using the DTPA Extraction Method, the generally adequate ranges for key micronutrients are: boron, 0.7 to 2.5 mg/L; copper, 0.5 to 1.5 mg/L; iron, 15 to 40 mg/L; manganese, 5 to 30 mg/L; and zinc, 5 to 30 mg/L. The specific satisfactory levels vary with the crop being grown.

Table 13-1. General interpretation guidelines* for greenhouse growth media analyzed by the Saturated Media Extract Method.

Analysis	Low	Acceptable	Optimum	High	Very High
Soluble salt, dS/m	0-.75	0.75-2.0	2.0-3.5	3.5-5	5.0+
Nitrate-N mg/L	0-39	40-99	100-199	200-299	300+
Phosphorus mg/L	0-2	3-5	6-10	11-18	19+
Potassium mg/L	0-59	60-149	150-249	250-349	350+
Calcium mg/L	0-79	80-199	200+	-	-
Magnesium mg/L	0-29	30-69	70+	-	-

** These guidelines are suitable for use with results obtained by either water or DTPA extraction.*

Desired nutrient balance is to have 8 to 10 percent of the total soluble salt be nitrate-N, less than 3 percent ammonium-N, 11 to 13 percent potassium, 14 to 16 percent calcium and 4 to 6 percent magnesium. If chloride and sodium are determined, their percentage should each be less than 10 percent. Adjustments in available nutrient levels can be made by the following additions (12, 13, 15); 75 g calcium nitrate (15-0-0) per cubic meter (2 oz./yard³) to increase the test level 10 ppm N; 600 g (0-46-0) per cubic meter (1 lb./yard³) to increase the test level 5 ppm phosphorus; and 55 grams potassium nitrate per cubic meter (1.5/yard³) to increase the test level 10 ppm K.

Recommended Test Procedures for Greenhouse Growth Media

References

1. Berhage, R.D., D.M. Krauskopf, D.D. Warncke, and I. Widders. 1987. Micronutrient testing of plant growth media: Extractant identification and evaluation. *Comm. Soil Sci. Plant Anal.* 18:1089-1110.
2. Geraldson, C.M. 1957. Soil soluble salts – determination of and association with plant growth. *Proc. Florida State Hort. Soc.* 71:121-127.
3. Geraldson, C.M. 1970. Intensity and balance concept as an approach to optimal vegetable production. *Comm. Soil Sci. Plant Anal.* 1:187-196.
4. Lucas, R.E., and P.E. Rieke. 1968. Peats for soil mixes. 3rd Int'l. Peat Congress 3:261-263.
5. Lucas, R.E., P.E. Rieke, and E.C. Doll. 1972. Soil saturated extract method for determining plant nutrient levels in peats and other soil mixes. 4th Int'l. Peat Congress 3:221-230.
6. Sonneveld, C., and J. van den Ende. 1971. Soil analysis by means of a 1:2 volume extract. *Plant and Soil* 35:505-516.
7. Sonneveld, C., J. van den Ende, and P.A. van Dijk. 1974. Analysis of growing media by means of a 1:1½ volume extract. *Comm. Soil Sci. Plant Anal.* 5:183-202.
8. Spurway, D.H., and K. Lawton. 1949. Soil Testing. *Mich. Agri. Exp. Sta. Bul.* 132.
9. U.S. Salinity Laboratory Staff, 1954. *Diagnosis and Improvement of Saline and Alkali Soils.* USDA Agric. Hand. No. 60, U.S. Government Printing Office, Washington, D.C.
10. Verloo, M.G. 1980. Peat as a natural complexing agent for trace elements. *Acta Hort.* 99:51-56.
11. Warncke, D.D. 1975. Greenhouse soil testing. *Proc. 5th Soil-Plant Analyst Workshop, NCR-13 Comm., Bridgeton, Mo.*
12. Warncke, D.D. 1976. Saturation extractable nutrient levels of six greenhouse soil mixes equilibrated with four rates of fertilizer. *Agron. Abst. Amer. Soc. Agron., Madison, Wis.,* p. 155.
13. Warncke, D.D. 1979. Testing greenhouse growing media: Update and research. *Proc. 7th Soil-Plant Analyst Workshop, NCR-13 Comm., Bridgeton, Mo.*

Chapter 13.

14. Warncke, D.D. 1986. Analyzing greenhouse growth media by the saturation extraction method. Hort. Sci. 21:223-225.
15. Warncke, D.D., and D.M. Krauskopf. 1983. Greenhouse growth media: Testing and nutritional guidelines. Mich. State Univ. Coop. Ext. Bul. E-1736.
16. Whipker, Brian E., Terri Kirk and P. Allen Hammer. 1994. Industry root media analysis results: Useful in determining greenhouse nutrition problems and educational opportunities. Comm. Soil Sci. Plant Anal. 25:1455-1469.