USING THE POURTHRU PROCEDURE FOR CHECKING EC AND pH FOR NURSERY CROPS

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Introduction:
Every nursery needs to have someone who routinely checks Electrical Conductivity (EC) also called soluble salts, and pH of container crops, potting inventories and irrigation water. Checking EC and pH should be considered part of the quality control and scouting program in the nursery. Results from testing 3 to 5 containers in a irrigation zone each week can be used to schedule irrigation the following week. Comparing leachate solution collected from containers to water collected from irrigation nozzles provides a good insight into nutrient levels in the containers. Checking EC and pH of nursery crops grown in containers doesn't have to be time consuming, complicated or difficult. The intention of this article is to review the procedure and update growers on the Virginia Tech Extraction Method (VTEM), also called the PourThru extraction procedure.

Equipment
A variety of equipment can be used to monitor pH and EC. Equipment usually can be purchased as a pen or a meter . Many horticulture or nursery supply companies carry pH and EC testing equipment and standards. Most pens and meters are temperature compensating, however read the information that comes with the equipment to determine if any adjustments are necessary related to environmental conditions. If you purchase a pH meter or pen, you should also order a pint of pH 4 or 7 buffer (standardizing) solution. A standard solution should also be purchased when you purchase EC pens and meters to assure your equipment is calibrated and working properly.

Some units such at the Myron-L AG-6 can be bought as an all in one unit, including both pH and conductivity. All in one units have a built in cup to hold the leachate solution which makes them very suitable for use in the nursery when using a truck tail gate or wagon bed in the same manner as a lab bench. An EC / pH combination unit such as the Myron AG-6 costs around $400. A Hanna combo portable meter which uses a cable to connect the EC and pH electrodes to the meter sells for less than $175.

Individual EC and pH pens are generally inexpensive (approximately $45 to $95) and accurate. EC and pH pens do not have a cup to hold the solution being tested so a beaker or drinking cup is used to hold the leachate solution during testing. The disadvantage of using pens is that narrow bottomed cups are spilled easily on uneven terrain when the test pen is placed in the cup or beaker. Wider vessels could be used but require more leachate solution in order to cover the sensors on the testing pens. Glass pH electrodes are usually necessary for dependable pH readings. You can also depend upon glass electrodes not lasting forever. When a pH pen or meter will no longer standardize using the pH 4 or 7 buffer, it's time to replace the pen or the electrode. They last longer if they are left in pH buffer (4 or 7) and not left dry when stored. A normal life for a pH electrode may be 2 years, but it's a good investment if it used during its' life and not set on a shelf and left to dry out.

Interpretation of Results

One of the most difficult parts of the testing (EC) is understanding what the numbers mean when you read them from a meter or pen. Older conductivity meters (often called solubridges) provided readings as mhos x 10^{-5}. Most new conductivity meters such as a Myron AG-5/AG-6 or Hanna Meters give results in mmhos / cm x 10^{-3}, called mmhos (milli-mhos) or using the international units deci-Siemens / meter (dS/M); A reading of 0.5 dS/M (mmhos/cm) on a Myron Meter or Hanna Meter would equate to a reading of 50 mhos / cm on a Beckman solubridge. The unit of measure most conductivity pens use is micro-mhos (micro-siemens is the international unit) which is the same as mhos/cm x 10^{-6}. This means that the decimal place for micro-siemens is 3 places to right when comparing to milli-mhos (0.5 dS/M (milli-mhos) = 500 micro-siemens = 50 mhos x 10^{-5}).

A conductivity pen which reads a range of 10 to 1990 micro-siemens, is equivalent to the 0.01 to 1.9 dS/M range**. Nurseries should purchase pens that read in this range (10 to 1990 micro-siemens).** Other pens read higher or lower ranges. For example, a pen which reads 100 to 19,900 micro-siemens is reading 0.1 to 19.9 milli-mhos, generally too high for horticultural use. PourThru guidelines for most crops suggest leachate conductivity levels should range between 0.5 dS/M to 2.5 dS/M during periods of active growth. Therefore, the 10 to 1990 micro-siemen pens are the best choice of pens for measuring conductivity in nursery containers, but will not be able to read high conductivity levels above 2.0 dS/M. TDS (Total Dissolved Salts) pens are also sold and they read parts per million. They may be more difficult to relate to information you read about conductivity, but dividing the total dissolved salts reading in parts per million by 700 should place the reading in an approximate dS/M conductivity range. A reading of 1400 ppm total dissolved salts is equivalent to 2.0 dS/M, which is generally considered high for pine bark:sand nursery potting mixes. For a detailed explanation of units used for EC and conversion factors please see the information leaflet entitled*: pH and EC Meters-Tools for Substrate Analysis*, Cavins et al., December 2000 (http://www.ces.ncsu.edu/depts/hort/floriculture/Florex/PH%20EC%20Meter%20Comparison.pdf)

Extraction Procedure

The PourThru extraction procedure does not disturb plant roots as is necessary with other extraction procedures such as the Saturated Medium Extract procedure used at many commercial testing labs or the 1 to 2 procedure previously used by growers. In brief, 30 minutes to two hours after irrigation, pour approximately $^{1}/_{2}$ cup (120 milliliters; 4.0 fl.oz.) of water over the surface of a 1 gallon container or 1.5 cups (360 milliliters; 12 fl.oz.) over a 3 gallon container for pine bark : sand potting mixes. More water may be required if the container mix contains sphagnum peat moss or other organic substrate amendments. Distilled water is recommended for determining existing leachate concentrations, however using water from irrigation risers for most production conditions is acceptable since the irrigation water contributes to the pH, EC and nutrient levels in the container. Reading the EC of the irrigation water and subtracting it's EC value from the container leachate EC indicates soluble salt concentrations in the container derived from fertilizer.

Leachate solution can also be obtained by picking up containers and tipping the container to drain leachate from drainage holes. Tipping the container 30 to 60 minutes after irrigation of containers provides a true reading of EC and pH levels in the container solution available to plant. It is important to remember that the PourThru extraction procedure provides an average of EC and pH concentrations in the container. If fertilizer is placed in one spot on one side of the plant in the container, the Pour Thru will not provide an accurate reading for the concentrated zone around the fertilizer; it will provide an average reading for the container.

Conductivity and pH equipment should be readily available to employees and keeping it with them in their vehicle or work area provides an opportunity to check EC and pH as part of the routine nursery scouting program. If equipment is kept in a truck cab, place it in an insulated cold drink cooler. This will modify temperatures and reduce exposure of the equipment to extreme heat, cold and evaporative conditions, thus extending the useful life. Employees should be trained to use and calibrate the equipment using clean, fresh standards. Calibrating both pH and EC equipment should be done daily before use or each time before testing a group of solutions, and between samples, if critical decisions are going to be made on results or the readings seem questionable.

Using EC and pH to Monitor and Manage Fertility, Irrigation and Potting Substrates

Growers should trouble shoot fertilizer and nutritional status by monitoring EC and pH of container leachates during the growing season. The Southern Nursery Association Best Management Practices (SNA BMP) manual recommends that growers monitor EC at least once a month. Minimal levels for EC should range from 0.2 to 0.5 dS/m for Controlled Release Fertilizer's (CRF) and 0.5 to 1.0 dS/m for liquid feed or combinations of CRF's and liquid feed applications. Maximum levels for most pine bark based substrates should not exceed 2.0 dS/m. Desirable nutrient levels are published in the SNA BMP manual (See Table 1). Sending the leachate solution for laboratory analysis at least once during the growing season is a good idea, so that actual nutrient levels in the container are known and corrected if needed. Having leachates analyzed during hot and dry periods during the growing season is a good idea. EC can build up in the irrigation water. The EC may be chlorides and sulfates, not essential nutrients.

Growers can plot or record average leachate EC and pH values from 3 to 5 containers that are scattered over a block of plants in an irrigation zone. A flag can be placed in these containers for all sampling in the block. Routinely sampling leachates for EC and pH will provide data on when the fertilizer runs out, if irrigation volume is enough or too much or if the irrigation distribution is uniform or not over the block. Sampling containers diagonally across a growing block can help diagnosis poor uniformity in irrigation patterns. This may simply be caused by a plugged nozzle but will be evident from differences in EC in containers, since some plants receive more irrigation than others. Some nurseries monitor irrigation blocks weekly and use the EC readings as part of their strategic planning for irrigation the following week. If EC concentrations from representative containers in an irrigation zone are high, for example 1.8 dS/M to 2.0 dS/M at the end of a week, irrigation time (volume) would be increased the next week. If the EC readings were low for example, 0.2 dS/M to 0.3 dS/M, irrigation volume would be reduced in that zone the next week to decrease leaching of nutrients. For nurseries that use cyclic irrigation, the length of time for the last irrigation cycle may be increased to decrease EC concentrations.

When plant foliage becomes chlorotic or off color, analyzing container leachate and leaf tissue are the best diagnostic steps to determine nutritional disorders. A leaf tissue lab sample should include 20 to 100 leaves (depending on the size of the leaves) of the most recently fully expanded leaves. Sending a leachate sample with the leaf tissue sample provides information of recent and current nutrient conditions in the container. Results generally provide insight into problems related to nutritional imbalances in the plant or substrate.

As growers test different potting materials such as composts, monitoring pH and EC is very important. Composts should have a pH near 7.0. If the pH is lower, it probably is not completely stable or it may be used if mixed with other organic materials. Animal waste composts blended with bark need to be tested before use. Some may go off the scale of the conductivity meter. Composts with very high EC can only be blended safely at volumes of 5 to 10 % to avoid plant damage. Leaching animal composts is often necessary before blending. The leachates may be collected and re-cycled over other compost inventories at the composting facility.

Sampling pH and EC of potting components before potting can save a great deal of trouble and plant loss. Organic potting components such as pine bark, or composts are very biologically active. If moisture, temperature and oxygen in inventories are not managed, inventories can become anaerobic which usually is accompanied by low pH and high EC which can damage nursery crops. For example, pine bark has a pH of 4.0 to 4.2. If it has some sand or grit in it, the pH may be higher, 4.8 to 5.0. If the pH is below 3.8, growers should defer use of the inventory. EC readings may be very high also, for example, 1.5 dS/M to 2.5 dS/M has been recorded. Pine bark with these pH and EC characteristics should be irrigated to leach the inventory with a hose or sprinkler irrigation, followed by turning the inventory. Deferring use of the inventory may be required for several days until acceptable pH readings in the 4.0 to 4.2 range and EC readings below 0.5 dS/M are measured. In some cases where pH and EC reading seem marginal for use growers may want to blend affected inventory with other inventories in a 50:50 mix to reduce risk of damaging nursery crops.

A pH meter is also useful to monitor pH in containers during the growing season. Leachate pH levels will change as nutrients, particularly Ca and Mg (dolomitic limestone) are used and leached from containers. Container plants often run out of Ca and Mg as well as minor nutrients a year after potting. This lack of Ca, Mg and minor nutrients may cause a noticeable drop in pH. However, a rise in pH can also occur. As nutrients are washed out or used, the medium has less buffering capacity and may reflect the pH of the irrigation water, which is often around pH 7.0.

A thorough nutrient application program at a nursery must include analysis and recognition of what nutrients are contributed by the irrigation water. Surface and groundwater can have mineral and nutrient levels that affect plant growth and irrigation systems. Recycled irrigation supplies frequently contain significant amount of soluble nutrients. Many irrigation supplies contain enough calcium for plant growth without addition of supplements such as dolomitic limestone. Iron, boron, sodium, and chloride are occasionally high enough in water supplies to make them unsuitable for growing nursery container crops. Nurseries can avoid major nutritional disorders in crops by sending water samples to analytical laboratories for determination of nutrient levels.

How To Do A Pour Thru on Container Nursery Crops

* Irrigate nursery containers to container capacity (10% to 20 % leaching expected).

* Wait 30 minutes to 2 hours for equilibration of nutrients in container solution.

* Place containers to be tested in a shallow saucer to collect leachate.

Pour $^{1}/_{2}$ cup (120 milliliters; 4.0 fl.oz.) of water over the surface of a 1 gallon container

Pour 1 $^{1}/_{2}$ cups (360 milliliters; 12 fl.oz.) over the surface of a 3 gallon container (Figure 1 below).

* An alternative for nursery containers is to lift and tip containers to drain leachate into a collection vessel (Figure 2 below).

* Calibrate the pH and EC test equipment using manufacturers descriptions and appropriate standard solutions.

* Read and record results.

* Develop a log book for crops and irrigation zones for the season.

Desirable nutritional levels for Virginia Tech Extraction Method (VTEM) interpretation of the solution, liquid or CRF fertilizers.[z]

Nutrient parameter	Desirable levels [y] Solution only or CRF and Solution	CRF only
pH	5.0 to 6.0	5.0 to 6.0
EC, dS/m (mmhos/cm)	0.5 to 1.0	0.2 to 0.5
Nitrate-N, mgL (ppm)	50 to 100	15 to 25
Phosphorus, mg/L	10 to 15	5 to 10
Potassium, mg/L	30 to 50	10 to 20
Calcium, mg/L	20 to 40	20 to 40
Magnesium, mg/L	15 to 20	15 to 20
Manganese, mg/L	0.3	0.3
Iron, mg/L	0.5	0.5
Zinc, mg/L	0.2	0.2
Copper. mg/L	0.02	0.02
Boron, mg/L	0.05	0.05

[z] Table and data adapted from Best Management Practices: Guide for Producing Container-Grown Plants; Southern Nursery Association. Marietta, GA. (Yeager, et al., 1997).
[y] Levels should not drop below these concentrations during periods of active growth.

Related Publications

The following publications are available through local N.C. Cooperative Extension Service Centers or Extension Horticulture, NC State University, Box 7609, Raleigh, NC 27695-7609 website:

Cavins, Todd J., J.L. Gibson, Brian E. Whipker, and William C. Fonteno. 2000. pH and EC Meters-Tools for Substrate Analysis. http://www.ces.ncsu.edu/depts/hort/floriculture/Florex/PH%20EC%20Meter%20Comparison.pdf

Bailey, Doug, Ted Bilderback, and Dick Bir. 1996. Water considerations for container production of plants. *Hort. Information Leaflet* No. 557. pages 1-11. http://www.ces.ncsu.edu/depts/hort/hil/pdf/hil-557.pdf

Bilderback, T.E., R.E. Bir, and J. Midcap. 1995. *Managing drought on nursery crops*. http://www.ces.ncsu.edu/drought/dro-18.html

Yeager, Thomas, Charles Gilliam, Ted Bilderback, Donna Fare, Kenneth Tilt, and Alex Niemiera. 1997. *Best Management Practices Guide for Producing Container-Grown Plants*. (May be purchased from the Southern Nursery Association, 1000 Johnson Ferry Road, Suite E-130, Marietta, GA 30068-2100; Tel: 770-973-9026; Fax: 770-973-9097)