Monitoring soilless substrate solution pH and soluble salts in containerized ornamental nursery crops

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What you need

- Saucers or pans
- Rings or items to raise the container
- 2 oz (60 ml) cups or vials
- 32 oz (1 L) Graduated container
- pH and electrical conductivity (EC) meter
- pH standards (pH 7 and/or pH 4)
- EC standard (probe specific)
- Notebook and pencil

Potential supplies utilized to conduct a pour-through

The pour-through or Virginia Tech Extraction Method (VTEM) was developed as an on-farm, in-situ method to extract the substrate solution from ornamental containerized crops grown in soilless substrates. The substrate solution herein is defined as the water that bathes roots and provides mineral nutrients as water-soluble salts at a given pH. The objective of the pour-through procedure is to add the minimal amount of water to displace a non-contaminated extract of the equilibrated substrate solution that reflects the pH and electrical conductivity (EC) of the bulk substrate solution. Substrate solution extracts provide an average value of the bulk of the substrate and cannot be used to make inferences about the solution immediately surrounding the root, substrate amendments or chemical amendments. The solution surrounding each of these may have differing pH and concentration of soluble salts

Why:

The pour-through procedure is a low cost, simple method for growers to collect a fraction of the substrate solution to infer the acidity or basicity of the whole as measured by hydrogen concentration (pH) and ability of the solution to conduct electricity (EC). EC can then be correlated with the concentration of salts or ions in the water. Collected solution can also be sent to a laboratory and analyzed to determine specific mineral nutrient concentrations. This detailed analysis can assist in identifying specific nutrient deficiencies or toxicities.

Substrate pH for the majority of container plants should be approximately pH 5.5 and potentially lower for ericaceous or other acid-loving plants. If pH rises above the target level for a given crop being monitored, corrective action should be taken, an on-farm critical analysis should be conducted and cultural practices adjusted to take corrective action for future plantings.

Electrical conductivity (EC) as a measure of the salt concentration in containers is optimal for growth between 0.5 and 1.5 dS/m and reflects the soluble salts being contributed by fertilizer. The salts contributed by fertilizer or other chemical amendments leach from the container or are absorbed by the plant throughout the production process. By measuring the salt concentration of substrate solutions, we can gauge the amount of fertilizer that remains in containers. Low salt levels indicate little available mineral nutrients, while high soluble salt concentrations indicate sufficient or excessively high nutrient levels. Due to uneven release of most controlled release fertilizer products, EC readings above or below recommendations are common for several weeks after a fertilizer is applied. During this time and also when the peak release of nutrients occurs, it is important to monitor irrigation to prevent desiccation. Low initial soluble salts can result in delayed crop growth, whereas high salts can "burn" plants or cause foliar necrosis. More intense plant damage from high salts can occur when containers dry excessively. EC readings are most helpful as a management tool for measuring fertilizer release rate and duration under the specific environmental and management practices at your facility. This information allows you to assess whether the chosen fertilizer provides nutrients at desired times when the plant is growing and determine when a supplemental fertilizer application is necessary.

Pour-through data cannot be used as the sole indicator of current and future containerized crop health. Growers must consider pH and EC in conjunction with cultural practices, pest management, chemical and fertilizer application records and visual signs of plant vigor.

When:

The pour-through method provides the greatest insight to the grower when repeated throughout the year and over multiple production cycles, generating a historical record. A pour-through conducted in the initial weeks after potting provides information on how quickly and to what extent the added lime or dolomite buffer changes substrate pH. Furthermore, an initial pour-through provides insight into the salt contribution of the "starter package" or "premix". Continued pour-throughs throughout the production cycle provide insight into the duration of the liming package, as well as release and longevity of the fertilizer. Repeating a pour-through each year allows you to infer the change in substrate chemical properties resulting from substrate, chemical amendments and cultural practices specific to your nursery.

How:

Step-by-Step Instructions

- Irrigate plants normally, allowing the containers to become saturated (at container capacity). Wait 45 to 75 minutes (no less than 30 minutes and no longer than 90 minutes) before proceeding with the pour through. This allows excess water to drain and the substrate solution to equilibrate with soluble salts contributed by the substrate and chemical amendments (fertilizer, gypsum, etc).
- Approximately 60 minutes after irrigation, sample within a given area or crop of interest by collecting leachate from containers in a diagonal or "X" pattern, depending on the size of the block. Larger blocks require more plants to be sampled.
- Set up: Place selected containers straight and upright on a ring in a clean dry saucer. Using the ring ensures salts from the container do not contaminate the sample skewing the results.

A straight and upright container placed on a ring in a clean dry saucer ready for a pour-through.

- Pour the appropriate amount of on-site water (Table 1) slowly over the container surface in concentric circles between the wall and center of the container. Water needs to be poured slowly in the case of coarser or more porous substrates to allow time for the added water to move through the substrate profile and equilibrate.

Area of the substrate surface in which water is to be applied slowly in concentric circles.

Container	Pour-Through
gal (liters)z	oz (ml)z
1 (4)	4 (120)
3 (12)	12 (350)
5 (10)	20 (600)
7 (27)	30 (825)
10 (38)	40 (1,200)
15 (57)	60 (1,775)
25 (95)	100 (3,000)

Table 1. Approximate amount of water to be added via the pour-through for various container sizes to produce approximately 2 oz (60 ml) of leachate.

[z]Gallons, ounces, and their conversions to liters and milliliters are rounded for ease of use.

- Wait approximately 15 minutes or until an adequate amount of leachate or substrate solution extract is collected (up to 2 oz or 60 mL). Move the container to the side and pour the substrate solution extract from the saucer into a clean cup or vial.
- Use a calibrated pH and EC meter to measure the substrate solution extract. Record the date, time of day, crop, location, amount of water used for pour-through, and container size in addition to pH and EC. It is also best to record the units used to report EC as well (Table 2). If samples are being sent for lab analysis, collect separate samples that were not used to determine pH and EC to ensure the samples are not contaminated by the probe.

Use of EC meter to obtain reading on leachate sample.

mS/cm dS/m mmhos/cm[z]	Mhos/cm S/cm[y]	µS/cm[x]
0	0	0
0.5	50	500
1.0	100	1000
1.5	150	1500
2.0	200	2000
2.5	250	2500
3.0	300	3000

Table 2. Common conversions among units of electrical conductivity.

[z] mS/cm=MilliSiemens x 10^{-3}/cm, dS/cm=DeciSiemens x 10^{-3}/m, mmhos/cm=Millimhos x 10-3/cm.
[y]Mhos/cm=Mhos x 10^{-5} /cm, S/cm=Siemens x 10^{-5}/cm
[x]_S/cm=MicroSiemens x 10^{-6}/cm.

Large Container Alternative:

An alternative method to collect a substrate solution extract is to lift and tip the container approximately 45 degrees. This changes the height of the water table resulting in drainage of equilibrated substrate solution. This can be done 30 to 45 minutes after the container was irrigated. This method is particularly useful for measuring pH and EC of large containers.

An alternative way to obtain leachate is to lift and tip containers.

Further Considerations:

The most common problem with the pour-through procedure occurs when the applied-water contaminates the extract-water. Most container substrates have between 70 and 80% pore space, with only 20 to 30% of the container filled with solid particles. Water can move rapidly through these substrates or between the container side and substrate in a process called channeling. Contamination occurs more often in medium-or coarse- grade bark and root bound plants – in these conditions, special care in sampling technique is required to prevent channeling. Substrate particle size and the stage of crop production appear to be the most important factor that affects channeling and subsequent sample contamination.

Take care to slowly apply water in concentric circles on the container surface when conducting the procedure and avoid the region near the container wall. The speed and location at which water is applied to the substrate surface greatly affects the consistency and accuracy of results. Slow, steady application evenly distributed over the substrate surface yields more consistent results. Contamination often occurs due to unevenly applied water from plant canopy interference or dumping water on the substrate surface too quickly or in one location.

Consistency is the most critical component of this procedure. Sampling should occur at roughly the same time each day. A greater amount of solution is displaced with greater ease and less error if the pour-through is conducted when the substrate is still close to saturation (at container capacity) from irrigation and plant water use is minimal. The later the crop is in the production process the more difficult it can be to get the needed volume of extract. Therefore you need to apply the water nearer to when irrigation has completed (approximately 30 to 45 minutes after irrigation) and/or increase the amount of added solution. Regardless, the time that lapses between irrigation and conducting the pour-through should be the same every time.

If using cyclic irrigation (or if irrigation scheduling does not allow for irrigating consistently during the same part of the day), the individual containers can be pulled aside and hand watered at the appropriate time. Carefully irrigate to allow the container to saturate without causing the water to drain through the bottom of the container. After 30 minutes, apply the appropriate amount of irrigation water and follow the remaining procedures described above. This approach can also be used for crops where irrigation is not adequately saturating the substrate because of the irrigation system being used, substrate, or crop development stage.

When conducting the pour-through using the conventional method, tilting the container by picking it up with one hand increases drainage before measuring. However, this will skew the results. Every effort should be made to keep the containers level as they are moved around for measuring.

Water used to irrigate nursery crops also contributes to the pH, EC, and nutrient levels in the soilless substrate. To determine its contribution, sample nursery irrigation water from an irrigation nozzle just before it is applied to crops rather than collecting water from the surface of an irrigation basin or at the pump. You can approximate the soluble salt concentrations in the container derived from the fertilizer in the substrate by subtracting the EC value of the irrigation water from the EC value of the container leachate.

Capacity Factor	Irrigation Water	Leachates (BMP's & VTEM[Y])
pH	5.4-7.0	5.2-6.3
Conductivity (mS/cm)	0.2-2.0	0.5-2.0
Total Dissolved Salts	<1000 ppm	<1400 ppm
Bicarbonate	<122 ppm or <2 meq/L	
Alakalinity (carbonate + bicarbonate) [1 meq/L = 50 ppm CaCO3]	<100 ppm CaCO3 or <2 meq/L	

Table 3. Suggested limits and ranges for chemical capacity factors for irrigation water, midseason substrate leachate of woody ornamental nursery container crops

[b]BMP stands for "best management practice" and VTEM stands for "Virginia Tech Extraction Method"

Conclusion:

Measuring EC and pH of container substrate solutions provides growers with a unique tool to gauge nutrient release patterns and availability. When plant growth or plant health is poor, the first diagnostic should be measurement of EC and pH of the substrate solution. Many times, low nutrient availability in containers releases a cascade of indirect foliar and growth problems that can misdirect growers in problem diagnosis. Keeping track of your efforts to monitor salts and pH in container substrates can result in early detection or assist in diagnosis of plant health issues. Using pour-through's to consistently monitor crops can improve awareness of how the substrate components and amendments are performing in the container, potentially preventing plant health issues and therefore saving money.

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