Greenhouse Toolkit Series:

Keeping in Front of the Curve: pH and EC Monitoring

In part two of this five-part series about the tools you need to keep track of your greenhouse environment, learn about the various methods for tracking pH and EC.

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Fertilizer, substrates, and water are the basic fundamentals for growing plants. A plant nutrition management and monitoring program starts with knowing what is in the pot. In-house nutrient monitoring will provide you with key pH and EC (electrical conductivity) information needed for a successful crop. If the substrate pH is too high, then interveinal chlorosis occurs (Figure 1). Lower leaf yellowing is the typical symptom that occurs if the substrate EC is too low (Figure 2).

Careful monitoring of the substrate pH and EC will help to avoid nutrient disorders. Setting up a monitoring system is easy to do and the steps are highlighted here.

Figure 1. **Iron chlorosis induced by elevated substrate pH levels readily occurs above pH 6.3 to 6.5 with hydrangeas. A pH and EC monitoring program will help prevent this situation.** Photo by Brian Whipker

In greenhouse production, there are three primary methods that are used to monitor your crop's nutritional status: Saturated Media Extract, 1:2, and PourThru.

Figure 2. **Lower leaf yellowing is an indication that the substrate EC levels are too low. While in-house EC monitoring will confirm a low fertilizer level, it will not identify which elements are limited. To determine those values, submit a substrate sample to a commercial lab for complete analysis.** Photo by Brian Whipker

Saturated Media Extract Method

This is the primary procedure used by the commercial substrate testing labs. It would involve the submission of a substrate sample of around 2 cups in volume.

Steps:

1. Typically, a handful of the substrate is removed from the side of approximately 15 to 20 pots for a

››› Cutting Room Floor

This article is the second in a five-part series. You can find the first article, "Infrared Thermometers for Monitoring Plant and Substrate Temperatures," on **GreenhouseGrower.com**.

composite sample. The handful is taken from the middle third of the pot. This provides the best representative sample of the nutritional status of the pot.

2. Mix the sample so it is homogenous.

3. Remove large roots removed from the sample. The sample can then be sent to a commercial lab for analysis.

4. Note: If submitting a sample directly from a new bag, slightly moisten the substrate before mailing the sample. The water will allow time for the lime to react during the shipping process and this will provide a representative reading on the substrate pH.

Advantages: Aside from obtaining pH and EC values, labs also will report on the other nutrients in the substrate. Periodically obtaining a complete snapshot of nutrient levels is extremely beneficial during the growing season.

Disadvantages:

- Must be sent out to a commercial lab in most cases to obtain more detailed nutrient levels besides pH and EC.
- Cost associated with the test
- Destructive removal of the substrate and root damage
- Takes a few days before results are known.

1:2 Method

The 1:2 Method historically has been the primary method used to conduct in-house testing because it is so easy to do. It is used less

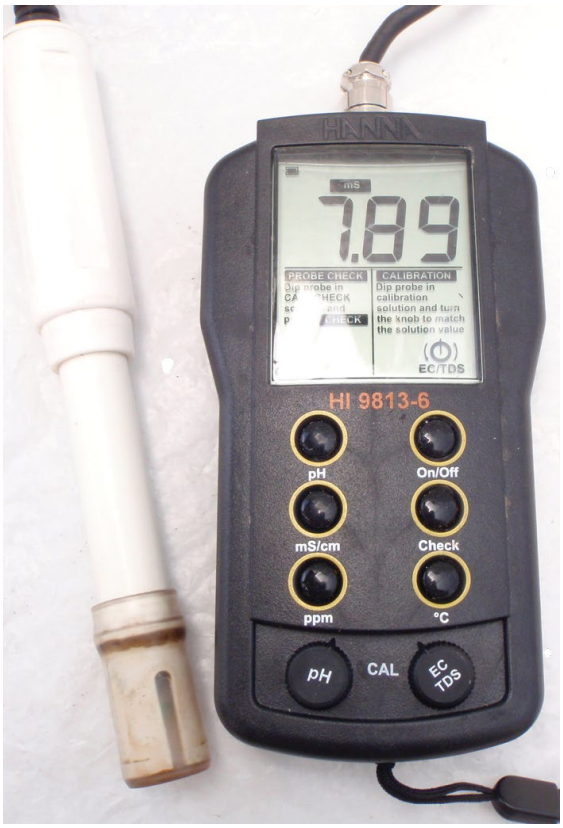

Figure 3. **Select a combination pH and EC meter that is value priced, easy to calibrate, and reports EC in mS/cm.**
Photo by Brian Whipker

often now after North Carolina State University introduced the PourThru method for greenhouse crops.

Steps:

1. Typically, a handful of substrate is taken from the side of approximately 10 pots for a composite sample. The handful is taken from the middle third of the pot. This provides the best representative sample of the nutritional status of the pot.

2. Remove large roots from the sample.

3. Mix the sample thoroughly to ensure that a representative sample is obtained from it.

4. Note: If submitting a sample directly from a new bag, place two cups in a plastic bag, slightly wet the substrate, and allow it to sit for four days. The water will help the lime to react during this time, allowing for a representative reading of the substrate pH.

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Considerations for Setting Up In-House Substrate Testing

When selecting a meter, what should you look for? The authors prefer combination pH and EC meters (Figure 3). They are easy to calibrate by hand. It is preferred that the EC values are expressed in mS/cm for quick comparisons with published values. There are a few low-cost options that growers may want to consider. The Hanna 9813-6 meter costs approximately $200. It is what is used at North Carolina State University for Extension sample diagnosis in the field, research, and in the floriculture classes. The Milwaukee Instruments MW802 meter is another low-cost option priced at approximately $150.

To conduct PourThru monitoring, assemble an equipment kit. Here are the supplies you will need:

- pH/EC meter (discussed above)
- Plastic saucers (5 to 10) (clear plastic saucers cost less than $1 each)
- Sample cups (3-ounce plastic Dixie cups, which cost approximately $3 per 80)
- pH standard(s) (pH 4, 7, and 10) (Use colored standards. pH 7 standards are typically pink.) For single point calibration electrodes, a pH 7 standard is typically used.
- EC standard: 1.41 mS/cm is used for many models, but check the recommendations. This solution is typically clear.
- Wash bottle (useful for rinsing the electrode between samples)
- Paper towels (for wiping off the electrode)
- Distilled water

Table 1. **Electrical conductivity (EC) interpretation ranges (in mS/cm) for various substrate extraction methods. Values are based on actively growing plants that have medium nutrient requirements and are irrigated overhead[1].**

Interpretation Ranges	1:5 (Used in Europe)	1:2	SME	PourThru (bottom irrigated)	PourThru (top irrigated)
Very Low	0 to 0.11	0 to 0.25	0 to 0.75	0 to 0.75	0 to 1.0
Low	0.12 to 0.35	0.26 to 0.75	0.76 to 2.0	0.76 to 2.0	1.0 to 2.6
Normal	0.36 to 0.65	0.76 to 1.25	2.0 to 3.5	2.0 to 3.5	2.6 to 4.6
High	0.66 to 0.89	1.26 to 1.75	3.5 to 5.0	3.5 to 5.0	4.6 to 6.5
Very High	0.9 to 1.10	1.76 to 2.25	5.0 to 6.0	5.0 to 6.0	6.6 to 7.8
Extreme	>1.1	>2.25	>6.0	>6.0	>7.8

[1] Adjust ranges 25% to 30% lower for sub-irrigated plants or plants that require a lower overall nutrient level. Adjust ranges 25% to 30% higher for heavy feeders.

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5. Place one cup of substrate in a plastic container large enough to hold at least three cups.

6. Add two cups of distilled water, stir the sample to make sure it is all wet. The solution will be soupy because of the excess water.

7. It is advisable to wait at least 30 minutes and up to 60 minutes before testing for EC and pH values.

8. Because of the extra water used, the recommended EC values will be lower than the recommendations for the other two methods. Compare results to the recommended ranges.

Advantages: This method is quick and easy to use. Because you can conduct this test in-house, it is a very cost-effective way to monitor the substrate pH and EC.

Disadvantages: This method can result in destructive removal of the substrate and root damage.

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PourThru Method

The research adaptation of the PourThru method to greenhouse crops and determination of optimal pH and EC ranges was conducted at North Carolina State University more than 15 years ago. Since that time, this method has become the preferred method for in-house testing for pH and EC values.

Steps:

1. Irrigate the crop 30 to 60 minutes before starting, using fertilized water, if you typically fertigate.
2. Place saucer under pot.
3. Add 30 to 100 ml of water.
4. Collect 35 to 50 ml for sampling.
5. Calibrate the meter.
6. Test three to five pots per group for a representative sample.

Advantages: This method is quick and easy to conduct. In addition, the plant's roots are not disturbed because no substrate is removed.

Disadvantages: Customized recommendations must be followed for top- versus bottom-irrigated plants. This is because fertilizer salts accumulate in horizons differently depending on if the plant is top irrigated (in which case salts accumulate at the bottom of the pot) or for bottom irrigated plants (in which case salts accumulate at the top of the pot).

Interpretation

pH values are similar no matter which of the three methods you use. Because of the dilution variation among the methods, one will see differences in EC values. Table 1 contains EC interpretation values for comparison.

Corrective Steps

Corrective steps for pH can be found in e-GRO Alert 4.02 (**https://goo.gl/1agM6E**).

Tracking Values Over Time

A group of university researchers from Virginia Tech, Clemson University, University of New Hampshire, and North Carolina State University developed a free web-based tracking tool for plotting PourThru pH and EC values over time. The project was funded by the American Floral Endowment and Horticultural Research Institute. It can be accessed at **GroZoneTracker.com**. **GG**

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