PURDUE UNIVERSITY

PURDUE EXTENSION

HO-237-W

# Commercial Greenhouse and Nursery Production

Purdue Department of Horticulture and Landscape Architecture

***www.hort.purdue.edu***

Purdue Floriculture

***flowers.hort.purdue.edu***

## pH and Electrical Conductivity Measurements in Soilless Substrates

*Diane M. Camberato, Roberto G. Lopez, and Michael V. Mickelbart*

EXPERT REVIEWED

Nutritional problems are one of the primary causes of poor crop quality and plant losses in greenhouses and nurseries. Monitoring the pH and electrical conductivity (EC) of growing substrates gives you the ability to correct issues before they become problems that damage crops. This publication recommends best practices for establishing a pH and EC testing program in soilless substrates and outlines the procedures, advantages, and disadvantages of three accepted methods for testing media solutions.

The pH of the growing substrate or media affects the availability of nutrients, especially micronutrients. EC is a measure of the dissolved salt concentration in a growing substrate. EC values provide a measure of the amount of fertilizer available for plant growth or indicate an accumulation of salts in the media.

It is important to routinely monitor substrate pH and EC levels before nutrition problems arise. Affordable, easy-to-use equipment and simplified monitoring methods make such monitoring easier for greenhouses and nurseries of all sizes.

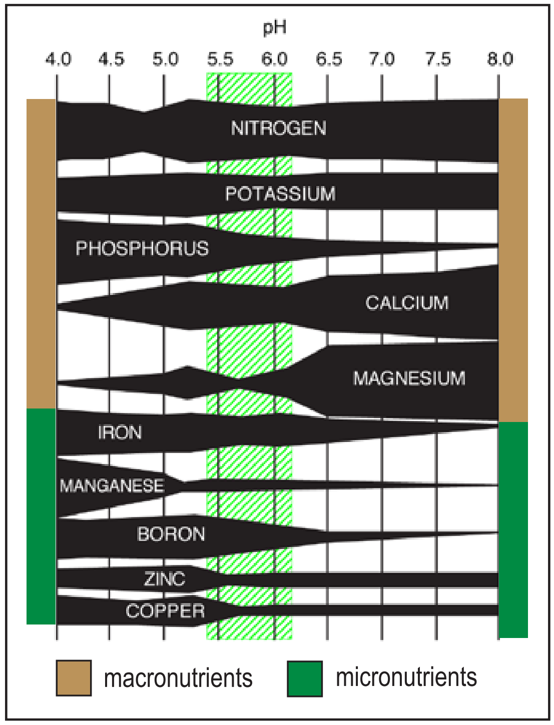


***Figure 1.*** *The pH of soilless substrates affects the amount of nutrients available to plants. The shaded area represents the levels recommended for most greenhouse crops.* **Source:** 1, 2, 3's of PourThru (Brian E. Whipker, Todd J. Cavins, and William C. Fonteno; North Carolina State University, 2001).

Producers in the upper Midwest should also measure alkalinity, a measure of basic ions (bicarbonate and carbonate) dissolved in the water. High alkalinity can increase substrate pH over time. Having a professional laboratory test irrigation water before beginning any pH and EC monitoring program is beneficial. Additional substrate and/or plant tissue analyses are necessary for determining which nutrients are present and in what quantity.

All nutrients are readily available at a pH of 5.4 to 6.2, but each plant species has an optimal pH range (Figure 1). Obtain this information for each crop you are growing when you begin your monitoring program. There is also an acceptable range for soluble salt content specific to plant species (Table 1).

*Table 1. Nutrient requirements of greenhouse crops with electrical conductivity ranges using the saturated media extract (SME) and PourThru methods.*

**Light**

*(SME EC of 0.76 to 2.0 mS/cm) (PourThru EC of 1.0 to 2.6 mS/cm)*

| | | | |
|---|---|---|---|
| African violets | Begonia (Tuberous) | Gerbera | Snapdragon |
| Ageratum | Caladium | Gloxinia | Vegetative cuttings (during rooting) |
| Anemone | Calceolaria | Impatiens | Zinnia |
| Asclepias | Calla Lily | Marigold | |
| Aster | Catharathus | New Guinea impatiens | |
| Astilbe | Celosia | Orchids | |
| Azalea | Coleus | Pansy | |
| Begonia (fibrous) | Cosmos | Plugs | |
| Begonia (Hiemalis) | Cyclamen | Salvia | |
| Begonia (Rex) | Freesia | Streptocarpus | |

**Medium**

*(SME EC of 1.5 to 3.0 mS/cm) (PourThru EC of 2.0 to 3.5 mS/cm)*

| | | | |
|---|---|---|---|
| Alstroemeria | Crossandra | Lily, Asiatic & Oriental | Portulaca |
| Alyssum | Dahlia | Lily, Easter | Ranunculus |
| Bougainvillea | Dianthus | Lobelia | Rose |
| Calendula | Dusty Miller | Morning Glory | Sunflower (potted) |
| Campanula | Exacum | Ornamental Kale | Verbena |
| Cactus (Christmas) | Geranium (cutting) | Ornamental Pepper | |
| Carnation | Hibiscus | Oxalis | |
| Centaurea | Hydrangea | Petunia | |
| Cleome | Kalanchoe | Phlox | |
| Clerodendrum | Larkspur | Platycodon | |

**Heavy**

*(SME EC of 2.0 to 3.5 mS/cm) (PourThru EC of 2.6 to 4.6 mS/cm)*

Chrysanthemum
Poinsettia

*Adapted from:* Monitoring and Managing pH and EC Using the PourThru Extraction Method *(Todd J. Cavins, Brian E. Whipker, William C. Fonteno, Beth Harden, Ingram McCall, and James L. Gibson; North Carolina State University Horticulture Information Leaflet 590, 2000).*

## Starting a Monitoring Program

*Monitoring and Managing pH and EC Using the PourThru Extraction Method* (North Carolina State Cooperative Extension Horticulture Information Leaflet 590, www.ces.ncsu.edu/depts/hort/floriculture/hils/HIL590.pdf) includes a chart showing the optimal pH ranges for specific plant species. Table 1 shows the acceptable soluble salt content ranges for specific plant species.

Monitoring substrate solution pH and EC requires a metering device that will measure both. Portable, affordable units are available and very accurate. Units that feature automatic calibration and temperature compensation are desirable. However, standard solutions for both pH and conductivity are necessary to calibrate instruments. Always store the instruments and solutions properly in a room with low humidity and at room temperature. Never store solutions or meters in the greenhouse or outside.

Substrate testing involves extracting a sample of substrate solution with distilled water (no mineral content) and measuring the pH and EC of the extract. Testing that requires sticking a sensor directly into the substrate to take readings is not recommended unless the substrate moisture content is highly consistent and the person testing the substrate consistently measures on the same day of the week as part of an established and routine monitoring program.

Onsite pH and EC monitoring programs allow growers to see trends during the crop production cycle and to make adjustments before crop vigor or quality problems, such as chlorosis in *Calibrachoa* and maple induced by high pH, manifest themselves

*Figure 2. Both this Calibrachoa (top) and this maple show signs of iron deficiency that was induced by high substrate pH.*

(Figure 2). Measure and record substrate pH and EC over time since they can change (Figure 3). These changes depend on several factors, including the medium, fertilizer, irrigation water quality, and plant species. Data from pH and EC monitoring, together with crop production logs, provide valuable clues if problems arise.

There are three accepted methods for extracting media solution for testing: the PourThru test, saturated media extract test, and 1:2 dilution test. The sections below describe the steps for each method (simplified for commercial greenhouse or nursery settings), with the advantages and disadvantages of each.

Regardless of method, a good testing program involves taking five to ten samples of each crop type (container volume, etc.) and taking additional samples for each substrate and fertilizer type. Then, measure the samples separately and base management decisions on the average.

The target EC range varies by sampling method. See Table 2 on page 4 to interpret EC readings for each extraction method.

## PourThru Test

The PourThru extraction method has several advantages: it samples the solution from the entire root zone, is nondestructive, and can be used with media that contain slow- or controlled-release fertilizers. It also can be used to test the bark, coconut coir, or sphagnum moss media used to grow orchids.

The major disadvantage of this method is that results are variable. Sampling from dry pots may result in greater EC because of higher salt concentration. Adding too much water could dilute the sample and result in a lower EC. Irrigating the crop as usual (see step 1 below) and monitoring the volume of water added (see step 4) will help minimize these sources of variation.

To sample using the PourThru test method:

1. Fertigate or irrigate the crop as usual for your production program and establish a specific testing day if fertigation is conducted once a week.
2. Allow the substrate to drain for 30 to 60 minutes.
3. Place a saucer under the pot.

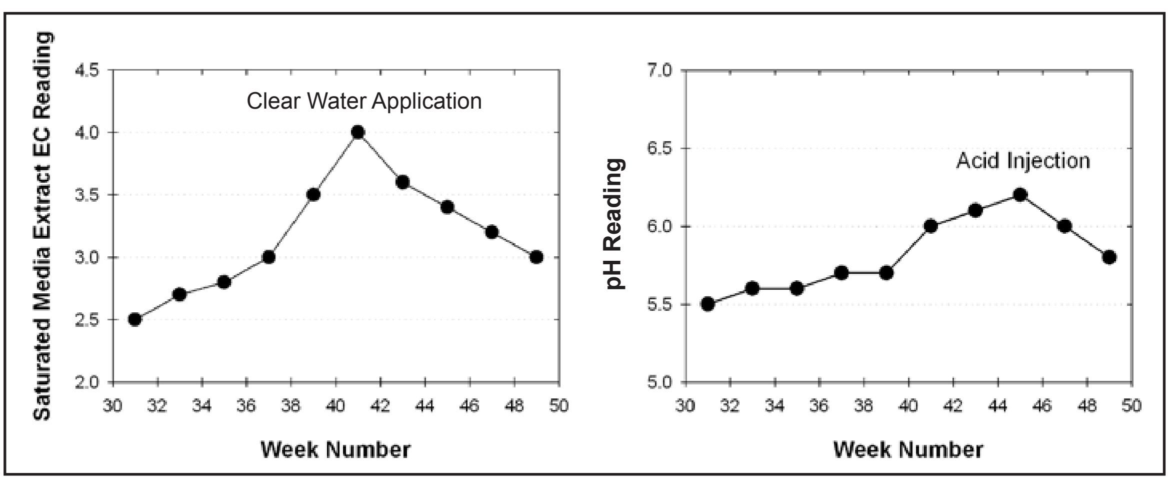


*Figure 3. These graphs are examples of weekly EC and pH monitoring of a poinsettia crop using the saturated media extract method.*

***Table 2.*** *Target EC ranges by sampling method and indication of nutritional status.*

| PourThru | 1:2 | SME | EC | Indication |
|---|---|---|---|---|
| 0 to 0.9 | 0 to 0.25 | 0 to 0.75 | Very Low | Nutrient levels may not be sufficient to sustain rapid growth. |
| 1.0 to 2.6 | 0.26 to 0.75 | 0.76 to 2.0 | Low | Suitable for seedlings, bedding plants, and salt sensitive plants. |
| 2.7 to 4.6 | 0.76 to 1.25 | 2.1 to 3.5 | Normal | Standard root zone range for most established plants. Upper range for salt sensitive plants. |
| 4.7 to 6.5 | 1.26 to 1.75 | 3.6 to 5.0 | High | Reduced vigor and growth may result, particularly during hot weather. |
| 6.6 to 7.8 | 1.76 to 2.25 | 5.1 to 6.0 | Very High | May result in salt injury due to reduced water uptake. Reduced growth rates likely. Symptoms include marginal leaf burn and wilting. |
| >7.8 | >2.25 | >6.0 | Extreme | Most crops will suffer salt injury at these levels. Immediate leach-ing required. |

*Adapted from:* Monitoring and Managing pH and EC Using the PourThru Extraction Method *(Todd J. Cavins, Brian E. Whipker, William C. Fonteno, Beth Harden, Ingram McCall, and James L. Gibson; North Carolina State University Horticulture Information Leaflet 590, 2000).*

4. Apply enough distilled water (approximately 100 milliliters (3.4 ounces) per 6.5-inch pot) to collect as close to 50 milliliters (1.7 ounces) of leachate as possible. More than 70 milliliters (2.4 ounces) of leachate can dilute the salt content, while less than 50 millileters of leachate may not provide enough solution to cover the probe (Table 3, Figure 4).
5. Measure the pH and the EC of the leachate.

## Saturated Media Extract Test

The saturated media extract test has the advantage of being an accurate test. However, it requires removing substrate from the pot, which can be a disadvantage because this disturbs the roots, and care must be taken to avoid breaking any fertilizer prills if the substrate contains slow-release fertilizer.

To sample using the saturated media extract method:

1. Obtain a 200- to 300-milliliter (7- to 10-ounce) sample of substrate from the root zone (avoid sampling from the top inch and bottom inch of the pot because of the potential for a higher salt content).
2. Place the sample in a 500-milliliter (17-ounce) beaker or container.
3. Add only enough distilled water to wet the sample to saturation — there should be no free water on the sample surface (Figure 5).
4. Let the sample stand for 30 minutes to equilibrate.

***Table 3.*** *Estimated amount of distilled water to apply to various pot sizes to obtain 50 milliliters (1.7 ounces) extract for the PourThru Extraction Method.*

| Pot Size | Estimated Quantity of Distilled Water | |
|---|---|---|
| | Milliliter | Ounces |
| 4, 5 or 6 inch | 75 | 2.5 |
| 6.5 inch azalea | 100 | 3.5 |
| 1 quart | 75 | 2.5 |
| 1 gallon | 150 | 5.0 |
| 3 gallon | 350 | 12.0 |
| 606, 1203 or 1204 flats | 50 | 2.0 |

*Adapted from:* Monitoring and Managing pH and EC Using the PourThru Extraction Method *(Todd J. Cavins, Brian E. Whipker, William C. Fonteno, Beth Harden, Ingram McCall, and James L. Gibson; North Carolina State University Horticulture Information Leaflet 590, 2000).*

***Figure 4.*** *The goal for the PourThru test is to collect a leachate sample of approximately 50 milliliters (1.5 ounces).*

***Figure 5.*** *When using the saturated media extract method, the substrate should be saturated, but no free water should be visible on the sample surface.*

5. Pour the mixture into a clean funnel lined with a filter (such as a coffee filter, or a tea or wire mesh strainer) to avoid getting substrate in the solution (Figure 6). Attaching a vacuum line or squeezing the solution through the filter with a spatula or gloved hand, can help obtain the sample more quickly.
6. Measure the pH and the EC of the leachate.

## 1:2 Dilution Test

The 1:2 dilution test has similar advantages and disadvantages as the saturated media extract test. A significant advantage of the 1:2 dilution test is that the amount of water added to the substrate is defined, rather than left to personal judgment (wet to saturation).

To sample using the 1:2 dilution method:

***Figure 6****. For the saturated media extract and 1:2 dilution methods, pour the samples into a clean funnel lined with filter paper or coffee filters to collect the extract.*

1. Combine one part (by volume) of substrate with two parts (by volume) of distilled water. For example, combine 4 ounces of substrate with 8 fluid ounces of distilled water in a 16-ounce container, or combine 1 cup of substrate with 2 cups of water (Figure 7).
2. Let the sample stand for 30 minutes to equilibrate.
3. Pour the mixture into a clean funnel lined with a filter (such as a coffee filter, or a tea or wire mesh strainer) to avoid getting substrate in the solution (Figure 6). Attaching a vacuum line or squeezing the solution through the filter with a spatula or gloved hand, can help obtain the sample more quickly.
4. Collect the extract in a clean container and measure the pH and EC.


***Figure 7.*** *In the 1:2 dilution method, combine one part (by volume) of substrate with two parts (by volume) of distilled water.*

## Important Considerations

Regardless of the sampling method, there are a number of things to keep in mind:

- Calibrate the pH/EC meter with standards to the pH range you are testing. For example, testing peat or bark may require the calibration to be set at 4.0.
- Be consistent. It is better if the same person can do the test each time.
- Know the acceptable pH and EC ranges for your crop and monitoring method. The values will be different depending on the sampling method you choose.
- Track your values over time on a graph. This is the real value of testing. The data and graphs will reveal trends and be a critical piece of information to share when seeking advice from diagnostic labs (such as the Purdue Plant and Pest Diagnostic Laboratory) or experts about problems only indirectly related to pH or EC.
- Make adjustments to fertilization and water quality in a timely manner based on trends.
- Closely monitor these measurements for crops with long production cycles, such as poinsettias or 2-gallon shrubs.
- Use data when reviewing the growing season to make adjustments for the following year.

*To see other publications in this series, visit the Purdue Extension Education Store, www.extension.purdue.edu/store.*

*Reference to products in this publication is not intended to be an endorsement to the exclusion of others that may be similar. Persons using such products assume responsibility for their use in accordance with current directions of the manufacturer.*