How to Use pH and EC "Pens" to Monitor Greenhouse Crop Nutrition

A number of inexpensive pen-like instruments are available which can be used in the greenhouse for assessing pH and soluble salts. The cost of the individual pH and electrical conductivity (EC) "pens" ranges from $50 to 60 and a combination pH/EC pen costs about $80. Pens are available from most greenhouse, agricultural, and forestry supply houses. Proper use of these instruments provides accurate pH and EC measurements which a grower can use to make immediate crop management decisions or to seek further in-depth testing by a commercial soil test lab. The objectives of this fact sheet are to discuss the equipment and supplies needed to maintain and use the pens.

Supplies

In addition to the pens the following items are needed to take care of the pens and to do pH and EC tests. Many of the items can be obtained for free from home or inexpensively from the grocery store. Of course more expensive and professional looking supplies can be purchased from a science lab supply company, but the tests won't turn out any better than using the cheaper alternatives. Here is the basic list with common source in parentheses:

1. pH 4 and 7 buffer solutions to calibrate the pH pen (greenhouse supply).
2. EC standard solution to calibrate EC pen (greenhouse supply).
3. Plastic funnel (5-6" top dia.) (grocery).
4. Distilled water (grocery).
5. Basket-style coffee filters (grocery).
6. Clean 15 oz. or 1 qt. wide mouth jars (home).
7. 3 oz. waxed paper cups (grocery).
8. Plastic colander (6" dia. min.) (grocery).
9. Shallow baking pan (grocery) or 8-10" dia. plant saucers (greenhouse supply).

Calibration of Pens

All of the commonly available pens and more expensive types of pH and EC meters work on the same basic principles and if they are calibrated properly should give the same readings. All pens and meters must be calibrated or standardized to give consistent and dependable readings each time they are used. If a pen or meter has no means of being calibrated it is probably not going to give good results.

Calibration procedures differ somewhat depending on the brand of pen. On some you push a button, on others you turn a small screw to set display at the proper value. For pH pens, calibration is done with the pH 7 buffer solution or by a "two point"calibration using the pH 4 and pH 7 buffers. Calibration involves placing the pH pen in a 3 oz. cup of buffer solution, allowing a stable reading to develop, and then, if necessary, adjusting the displayed value to the pH of the buffer. The EC standard solution is used in the same way to calibrate the EC pen. After calibration the used solutions should be discarded.

Calibration is a must to get any useful information from pens and meters! How often it needs to be done depends on the type of meter and frequency of use. The readings of even the most expensive laboratory meters tend to "drift" over time and must be brought back to to the proper reading fairly often. When you first start using the pens, plan on calibrating at the beginning of every testing session until you find out how much the readings drift between sessions.

Direct Measurements Using the Pens

On certain types of materials pens can be used directly without any special sample preparations.

pH pens can be used directly to measure the pH of irrigation water, hydroponic solutions, and pesticide solutions. Calibrate the pen first according to the instructions, rinse off the buffer, and then place the pen directly into a sample large enough to completely immerse the sensor. Agitate the pen slightly in the sample to dislodge any air bubbles and then allow a stable reading to develop. Checking the pH of irrigation water is useful, but remember that an alkalinity test is needed to get a complete picture on how water pH might be affecting your crop.

The EC pens can be used to measure the EC of fertilizer solutions to check the operation of fertilizer injectors. The EC pen is used in the same way as the pH pen. To check the operation of an injector determine the EC of water without fertilizer and then check the fertilizer solution after the injector has run for several minutes. Subtract the EC of the water from the fertilizer solution EC. Compare the results to the table on the fertilizer bag or product literature. This will tell you whether or not you are getting the ppm you think you are.

Testing Growth Media

Greenhouse growth media are tested by extracting the sample with distilled water and measuring the pH and EC of the filtered extract. Some low-priced testing meters claim that you can stick the sensor probes directly into the growth medium and take readings. This approach has no basis in scientific soil testing and it is not recommended for professional growers.

Growth medium samples. Take samples from the root zone or use all of the material in a container. Never sample from the surface because nutrients and soluble salts are always highest here and do not represent the fertility status of the root zone. Sampling is a good time to inspect the roots - a small or diseased root system can often be the best explanation of apparent fertility problems.

Its is best to air-dry the sample at room temperature or below 80 F on a greenhouse bench. Spread the sample out in the baking pan or plastic saucer and remove any large pieces of root and other debris. Unless the sample is very wet it should be dry enough in 24 hours to test. Screen the sample using the colander or similar sieve. The screened sample is ready to test.

Extraction. The extraction procedure described here is known as the "1:2 dilution method."

Follow these steps:

1. Combine one volume of air-dried growth medium with two volumes of distilled water. Using the items listed earlier, this means fill one 3 oz. cup with growth medium and two 3 oz. cups with distilled water and mix them together in the 15 oz. jar.
2. Mix the sample and distilled water thoroughly by swirling the jar and then allow it to stand for 30 minutes.
3. After 30 minutes pour the mixture into the funnel supporting the coffee filter (I find two filters put together best). Catch the filtered extract in another clean 15 oz. jar. The objective is to separate the liquid extract from the solids which are discarded. The extract is now ready to test for pH and EC.
4. Properly calibrate pens.
5. Pour enough extract into a clean 3 oz. cup so that the sensor of the pen will be completely immersed in the extract. The pen should be swirled in the extract to dislodge any air bubbles and then leave the pen still until a stable (unchanging) reading appears. The stable pH or EC reading is your result.
6. Compare your EC reading to **Table 3.** ***This EC table is specific to the 1:2 dilution method. Do not use any other table unless it states "1:2 method."*** The pH tables in this fact sheet or pH information from other sources can be used to interpret data.

Leachate Pour-through Method

An alternative to the 1:2 dilution method is the "Leachate Pour-through Method," a procedure by which the pot leachates are analyzed for pH and EC. This procedure was developed at Virginia Tech nearly 20 years ago. It is a rather controversial method and so far has not been widely adopted except in the nursery industry in the southern U.S. where it works very well. Greenhouse growers can expect to hear more about this method as researchers at N.C. State are recommending it as a simpler alternative to the 1:2 dilution method. You can use the pens for this test, but you must follow the sampling and interpretative methods carefully.

Interpreting Test Data

pH - soil acidity. Most greenhouse crops can grow satisfactorily over a fairly wide pH range. However, optimum pH ranges have been established for some crops and soilless media and mixes containing field soil. The optimum pH range for soilless media and for mixes containing 20% or more field soil is shown in **Table 1**. The difference in optimum pH between the two types of growing media is related to pH effects on nutrient availability in each.

Table 1. Optimum pH values

Growth Medium	pH
Soilless media	5.5 - 6.0
Media with 20% or more field soil	6.2 - 6.5

Low pH (values below the optimum range) is probably the most common pH problem found in New England greenhouses. At low pH, Ca and Mg may be deficient. Low pH is also part of the cause of molybdenum (Mo) deficiency in poinsettia. Other trace elements such as iron (Fe) and manganese (Mn) may reach phytotoxic levels when pH is low (<5.8). Excess Fe and/or Mn can be toxic to geraniums, New Guinea impatiens, and many bedding plants. The pH requirements for a number of bedding plants and the reasons why are shown in **Table 2**.

Table 2. pH ranges for bedding plant seedlings [z]

Plant	pH	Why?
Most bedding plants	5.4-6.8	pH tolerant
Celosia	6.0-6.8	Prevent Fe/Mn toxicity
Dianthus	6.0-6.8	Prevent Ca deficiency & NH4 toxicity
African marigolds	6.0-6.8	Prevent Fe/Mn toxicity
Geranium	6.0-6.8	Prevent Fe/Mn toxicity
Pansy	5.4-5.8	Prevent B and Fe deficiency
Petunia	5.4-5.8	Prevent B and Fe deficiency
Salvia	5.4-5.8	Prevent B deficiency
Snapdragon	5.4-5.8	Prevent B and Fe deficiency
Vinca	5.4-5.8	Prevent B and Fe deficiency

[z] North Carolina State University Plug Research Group

What action to take on pH depends on the specific requirement of the plants being grown and a knowledge of the factors which interact to affect the pH of greenhouse media. Limestone (rate, type, neutralizing power, particle size), irrigation water pH and alkalinity, acid/basic nature of fertilizer, and effects of mix components are the major influences on pH. Also, some plants are known to change the pH of the growth medium; geranium is the best example - the activity of its roots can significantly lower pH.

Soluble salts. Measuring soluble salts (SS) provides a general indication of nutrient deficiency or excess. Excess SS is very common and generally results from too much fertilizer in relation to the plant's needs, but inadequate watering and leaching, or poor drainage, are other causes. Sometimes high SS levels occur when root function is impaired by disease or physical damage. ***Again, always check the condition of the root system when sampling soil for testing.***

Seedlings, young transplants, and plants growing in media containing 20% or more field soil are less tolerant of excess SS. SS ***above*** the normal range for prolonged periods may cause root injury, leaf chlorosis, marginal burn, and sometimes, wilting. SS ***below*** the normal range may indicate the need for increased fertilization.

Table 3. Soluble salts levels by the 1:2 dilution method and associated interpretation.

EC (dS/m) [y]	Interpretation
0-0.25	Very low - indicates probable deficiency.
0.25-0.75	Suitable for seedlings and salt-sensitive plants.
0.75-1.25	Desirable level for most plants.
1.75-2.25	Reduced growth, leaf marginal burn.

[y] 1.0 mmhos/cm = 1.0 dS/m = 1.0 mS/cm.