Greenhouse
FACTSHEET

BRITISH COLUMBIA | Ministry of Agriculture

July 2015

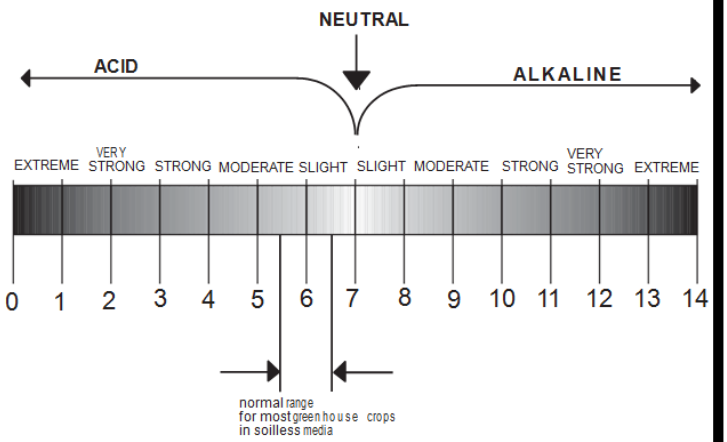
On-site Testing of Growing Media and Irrigation Water

Nutritional problems are a primary cause of economic losses associated with poor crop quality and yield. Two of the most important indicators of nutrient availability and water quality are pH and total soluble salts. These are easily monitored under greenhouse conditions. With routine testing of salts and pH, and occasional complete laboratory analyses, it is possible to eliminate almost all nutritional problems associated with the production of greenhouse crops.

pH

The pH of the growing medium and the irrigation water can affect the availability of nutrients in solution, and the health of root systems. Most plants have a relatively narrow range of preferred pH levels. Figure 1 shows the pH scale and the preferred range (5.5 - 6.5) for most greenhouse crops grown in organic substrates. Acid tolerant crops, such as azaleas, are usually grown at pH 5.0 - 5.5.

Figure 1. The pH Scale*



* **pH is a log scale. There is a tenfold difference between each pH number, i.e. pH5 is 10x more acidic than pH6.**

Some crops are tolerant of a wide range of pH values, while others, such as geraniums require a relatively narrow range (pH 5.8 - 6.2). Although pH can be measured by chemical titration and with the use of color indicating litmus papers, an electronic pH meter provides the most accurate and practical means of on-site testing.

pH Meters - Portable pH meters that are suitable for greenhouse use range in price from $150 to $1000. In general, the accuracy and longevity of the meter increases with the amount paid. Most meters use a remote semi-permeable glass electrode filled with a solution of mercury or silver chloride. In some cases the electrodes are refillable, which extends their useful life. Whenever an electrode cannot be accurately calibrated between two standard buffer ranges, there is usually a problem with the electrode, or the batteries are low. These instruments must be handled and stored carefully, and the electrode end must usually be kept immersed

in a liquid according to manufacturer's directions. Some newer pH meters use a flat electrode which does not require wet storage. Other features to look for in a pH meter are automatic temperature compensation and calibration. Digital readouts are now standard in most meters. The level of accuracy needed for horticulture is to one decimal point, i.e., pH 6.2.

Electrical Conductivity (EC)

Fertilizers and other dissolved salts change the ability of a solution to conduct electricity. Pure water is not a particularly good conductor, but as the salinity level increases, its conductance also increases. Salt meters (conductivity meters) are used to measure the electrical conductivity of a solution, which provides a rough idea of its fertilizer content. One factor that must be kept in mind is not all salts are fertilizers. Some water sources are high in non-fertilizer minerals that tend to increase the overall conductivity. So while EC measurements are a good indicator of relative fertility levels, particularly if measured regularly and tracked over time, it is important to establish the non-nutritional background content of irrigation sources. Occasionally have a complete mineral analysis performed by a testing laboratory to determine the balance of nutrients in the irrigation water.

EC Meters - Portable EC meters for use in horticulture range in price from about $150 to $1000. The more expensive meters should last many years, although the electrode sensors may need replacement periodically. There are a variety of inexpensive pen type meters that are quite accurate and convenient to use for spot checking irrigation solutions and soilless media. Standard solutions are available for calibrating the meters. Some features to look for are auto calibration, auto temperature compensation, easy to read displays and replaceable probes. EC meters usually provide a readout in millimho's (mmho) or millisiemens (mS). They are numerically identical units. Some auto-ranging meters may provide a readout in micromho's (μmho) or microsiemens (μS). These units are $1/1000^{th}$ of a millimho or millisiemen.

Testing Methods

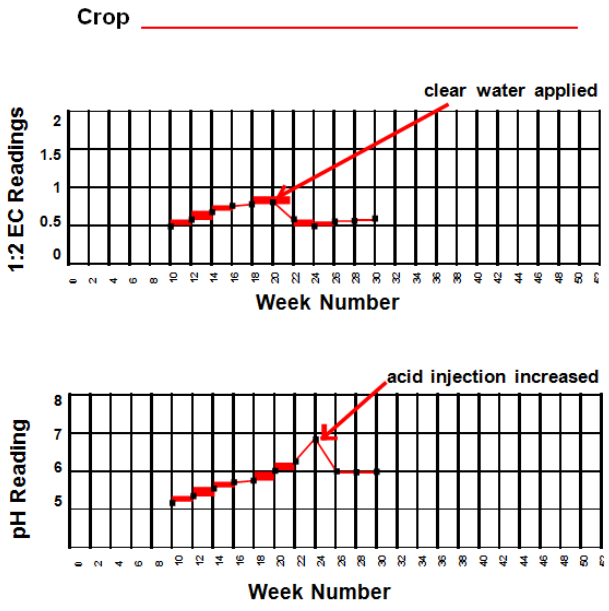
For irrigation water and fertilizer solutions, testing is a straightforward matter of monitoring the pH or EC directly. Follow the instructions provided with the meter and be careful to rinse the electrode surfaces after use and store the instruments properly. Buffered calibrating solutions are usually supplied with pH meters and standard salt solutions are available to check and adjust the accuracy of EC meters. These calibrations should be performed often.

Water and Nutrient Solutions - Well or tap water should be checked before fertilizers are added to determine any background levels of salinity and the initial pH. It is important to allow tap water to sit for about 60 minutes when measuring pH. This allows any $C0_2$ dissolved in the water to come to equilibrium with the air. Dissolved $C0_2$ will tend to lower pH readings. If the water shows any substantial salt content (0.5 mS or above), an irrigation water quality analysis should be performed by a testing laboratory to determine the background mineral content. The report should include the elemental content, including the level of bicarbonates. Once a background EC is known, it must then be taken into account when measuring fertilizer content with a salt meter. For instance, if your water has an initial EC of 0.8 mS, then you will need to subtract this amount from your fertilizer solution readings to determine the actual fertilizer content of your nutrient solution. This is important when you check the accuracy of injectors. Most commercial soluble fertilizers will indicate the EC values on the bag for various feeding concentrations. In order to check the calibration of your injectors, you must subtract the background EC levels from your measured fertilizer EC values after injection.

Media Testing

Record Keeping - Growing media should be tested for salts and pH on a routine basis. Testing should begin before the crop is planted and be performed at least every two weeks. It is important to keep records so that you can chart pH and EC levels over time. (See Figure 2.) Graphically charting your pH and EC values will provide you with a trend of timely information on whether the pH and EC are rising, falling or stable. This is at least as important as the actual reading. It will enable you to make informed decisions about fertilizer concentrations, watering frequencies and leach rates. Very often, growers who use routine media testing find they can produce superior crops with less fertilizer and lower leaching rates, thereby reducing waste and the possibility of environmental contamination. You can post the EC and pH tracking graphs to inform staff of current fertilizer conditions in the crop.

Figure 2. Tracking EC and pH Values



Collecting a Media Sample - There are two strategies available for media sampling. First, you can take several samples and measure them individually. This will provide you with a good indication of the uniformity of your watering and fertilizing program. If the results are dramatically different between pots or locations, it might provide a clue to uneven growth or other crop problems. However, collecting and individually measuring 10 or more separate samples can be very time consuming, and may not provide information that is any more useful than a representative or average sample. In any case, it isn't practical to water and fertilize each plant individually. For these reasons the representative sample method is usually the one to use.

To obtain a representative sample it is necessary to combine several sub samples in order to obtain an average value. Depending on the size of the crop, samples from about 10 different pots or growing bed locations are usually required. Combined samples should always be from within one distinct growing unit, environment, irrigation method etc. The samples should be obtained from uniform plants that are the same type, age and in the same size container. Try to collect your samples at the same time between irrigations, i.e., just before the next watering. Avoid sampling the top 2 cm of media since there are usually very few roots in this zone, and the salts tend to be higher due to evaporation of water from the soil surface. The latter point is especially true if the crop is subirrigated. Collect samples from the mid-range of the pot, making sure to include more than just the soil at the outside edge of the container. You can usually remove about 10% of the media without harming the plant.

Use fresh, moistened growing media to replace the soil removed by your sample. Follow the same procedure for

growing beds, by avoiding the top 2 cm and making sure that your sample is from the area of most active root growth. It is very important to be consistent in your sampling methods, so that your results will be accurate when tabulated over time. When all the sub samples have been collected, place them in a clean container or bag, and mix thoroughly. Take care not to crush any prills of controlled release fertilizer.

Extraction Methods - Only the media solution can be tested, and there is usually not enough of it to sufficiently immerse the EC or pH probes without adding water. Also, the EC in the growing media changes with moisture content, becoming more saline as the media dries. It is therefore necessary to add enough water to the sample to immerse the electrodes and to have comparable readings from one sampling date to another.

Over the years, several dilution and extraction methods have been devised. All have advantages and disadvantages, and all may provide different instrument readings. This often leads to confusion when trying to discuss or compare values obtained from different extraction methods. Three methods are described in this factsheet: the 1:2 extraction, the saturated media extraction (SME) and the pour- through method. Other methods such as the 1:5 and 1:1.5 dilution methods are described briefly, although they are not as commonly used.

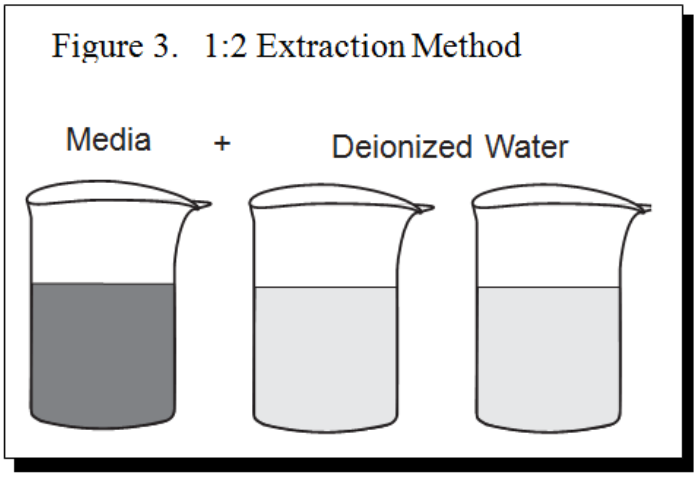
1) **1:2 Media Extraction** is probably the fastest and easiest method, and has been used for many years. Although easy to perform, it may be slightly less accurate than the saturated media extract due to differences in the amount of moisture in the media at sampling time and the degree to which the media is compressed to measure the sample. If you can be consistent in the volume and compression of your samples, and if you always sample at about the same degree of wetness, you can achieve fairly uniform results when tracking EC over time. pH is relatively unaffected by the amount of moisture present, but to obtain greater accuracy in EC measurement using this method, you could air dry your samples for a few days before measuring. However, this defeats the purpose of a fast, on site test from which to make immediate fertilizer and watering decisions.

The 1:2 method uses 1 part soil to 2 parts distilled or deionized water. (See Figure 3.) It is important **not** to use tap water, particularly if your water source is highly buffered or saline, as this will affect your test readings.

Equipment needed:

- ✔ 1 bucket or bag for mixing the samples
- ✔ 1 standard measure (either 50 ml, 100 ml, 1/4 cup, 1/2 cup etc.)
- ✔ 1 large container to hold the water and soil mixture
- ✔ 1 plastic mixing spoon or spatula
- ✔ distilled or deionized water
- ✔ filter paper or sieve
- ✔ EC meter (properly calibrated)
- ✔ pH meter (properly calibrated)
- ✔ record book or recording sheets
- ✔ small beaker for sieved solution

Figure 3. 1:2 Extraction Method



Method:

1. Mix growing media subsamples thoroughly to prepare a representative sample.
2. Using the standard measure, obtain 1 level volume of media, compressing it slightly. Be sure to always use a consistent pressure when packing the measure. Try to duplicate the same degree of media compaction as in the crop.
3. Empty the measured media into the large container.
4. Add 1 measure of deionized water to the large container and mix with the soil.
5. Let the mixture stand for at least 15 minutes.
6. This is now a 1:1 soil/water mixture.
7. If the media is largely organic, immerse the electrode directly into the slurry and record the pH. For mineral or sandy media, read the pH after sieving to avoid damaging the glass electrode. After removing the probe from the media, rinse it according to manufacturer's instructions.
8. Add another volume of water, stir, and wait 5 minutes. You now have a 1:2 soil/water mixture.
9. Sieve enough of the slurry into a clean beaker to immerse the EC probe and record the reading.

Interpretation of Results: See Table 1 (page 7) for EC values and comparisons.

2) Saturated Media Extract (SME) is a method to extract a solution from a saturated 'paste' made by wetting the sample media until it is thoroughly saturated, but with little or no free water. Unlike the 1:2 method or other multiple dilution methods, the volume of test media and the amount of moisture in the sample prior to collection are not important to the accuracy of the SME reading. All that is required is a sufficient amount of the representative sample to produce enough liquid for an EC reading after extraction.

Two types of extraction are possible: vacuum and squeeze. Vacuum extraction is the recommended method for all growing media and particularly for media that consists primarily of soil. Although it involves some additional cash outlay for the vacuum system, you will be able to achieve EC readings comparable to a commercial laboratory if you use this method. Carefully spread saturated samples onto a filter paper in a Buchner funnel taking care to fill the entire funnel and not to leave any open areas for air to channel. Mount the funnel directly onto an Erlenmeyer vacuum flask and apply a vacuum to the flask. The water in the media is drawn downward through the filter paper and into the Erlenmeyer flask. Measure the EC and pH of this vacuum leachate.

Many peat based media can be direct squeezed at the saturated stage with good results. Wear rubber gloves when squeezing a sample. This prevents any salts on your skin from interfering with the accuracy of the EC reading. Some good sieving materials include fine mesh nylon stockings, heavy duty cellulose cleaning cloths, and filter bags for making jellies. Special filter bags are also available from companies supplying the new flat electrode type 'Cardy' meters. If you use an improvised filter, you must take care to thoroughly rinse and wring it out before and between readings. The mesh size should stop all but the finest particles from passing through. If desired, you can filter the extract further through a coffee filter or other funnel type filter. Media containing controlled release resin coated fertilizers should never be squeezed, since the pellets may be

broken, releasing large amounts of fertilizer into the solution and providing a false indication of fertility levels. You must also take care when pre- paring the saturated paste for the vacuum method not to damage any controlled release fertilizer beads.

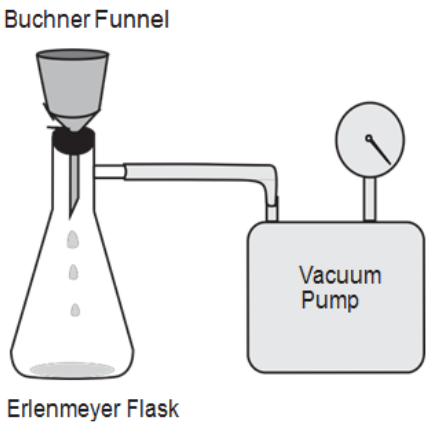
Equipment Needed:

- ✔ clean beakers or cups for preparing the saturated extract (about 500 ml or 2 cup capacity)
- ✔ plastic spatula or spoon for mixing the media and water
- ✔ small beaker(s) for collecting and reading the extract.
- ✔ a) vacuum option (parts available from scientific supply houses):
  - 500 ml Erlenmeyer vacuum flask(s) with side spout for vacuum attachment
  - Buchner funnel(s) with multiple sieve holes
  - drilled rubber stopper for the funnel end of the Buchner funnel to fit the Erlenmeyer vacuum flask
  - filter paper to fit the Buchner funnel
  - vacuum pump
  - vacuum hose (about 1 meter)
- ✔ b) squeeze option:
  - suitable filtering mesh material or special filter bags. Note: do not use this method for media containing controlled release or resin coated fertilizers.
- ✔ EC & pH meters (calibrated)
- ✔ record book or recording sheets

Method:

1. Fill the sample container about 2/3 full with media from a blended representative sample.
2. Add distilled or deionized water slowly, while mixing with a spoon or spatula.
3. The sample is the correct consistency when the surface just glistens but there is no free water (puddles) on the surface. A small portion of the sample should remain more or less solid without dripping but should slide easily from the spoon.
4. Wait at least 15 minutes. Stir and add more water if required.
5. Read and record the pH directly from the saturated sample if the media is organic or peat based. For mineral or sandy media, record the pH after extraction to avoid damaging the electrode.
6. Extract the sample by vacuum or squeeze methods.
7. Read and record the EC.

Figure 4. Saturated Media Extract



3) **Pour-Through Method** is a quick and reasonably accurate method to test fertility of container-grown plants. The use of resin coated controlled release fertilizers made it necessary to investigate new methods to measure salts and pH on-site. Since these fertilizers tend to be quite fragile, even removing the sample from the container can result in broken prills that release all of their fertilizer salts, artificially elevating the subsequent EC readings. For this reason, many outdoor container nurseries are now using the pour-through method to test fertility. Extracts from pour- through samples can be read directly for salts and pH, or they can be combined to form a representative sample. In practice, growers often do both, since several containers must be extracted in any case.

   Pour-through extraction is a two-step process. First, the media is progressively wetted until just saturated and left to stand for about two hours (or the extract can be collected 2-4 hours after irrigation). Second, a volume of water sufficient to produce about 100 ml of leachate (depending on container size) is drenched onto the surface. Care must be taken so that the water does not channel down the sides of the container. If applied carefully, the water does not immediately mix with the container solution, but evenly displaces it, driving it down into the lower root zone where some of it drains from the pot and is captured for testing.

   Interpretation of Results: See Table 1 (page 7) for EC values and comparisons.

4) **Other Testing Methods** have been developed, including variations of the 1:2 dilution method (e.g. 1:1.5 and 1:5 methods). The 1:5 method is performed essentially the same as the 1:2 method and can be quite accurate for EC. The relative moisture of the representative sample does not tend to skew the results as much for this method since a lot more water is added. However, since the readings are lower and in a narrower range, a well calibrated, accurate meter is needed. In addition to pH and EC measurement, flat electrode meters can test for nitrates, potassium and sodium.

Table 1. Interpreting On-Site Media Test Results.

EC reading in mS (or mmhos)				Indication
1:5	1:2	SME	Pour-Through*	
0 to 0.12	0 to 0.25	0 to 0.75	0 to 0.9	**Very low**. Nutrient levels may not be sufficient to sustain rapid growth.
0.12 to 0.35	0.26 to 0.75	0.76 to 2.0	1 to 2.6	**Low**. Suitable for seedlings, bedding plants and salt sensitive plants.
0.36 to 0.65	0.76 to 1.25	2.0 to 3.5	2.7 to 4.6	**Normal**. Standard range for most established plants; upper range for salt sensitive plants.
0.66 to 0.89	1.26 to 1.75	3.5 to 5.0	4.7 to 6.5	**High**. Reduced vigor and growth may result, particularly during hot weather.
0.90 to 1.10	1.76 to 2.25	5.0 to 6.0	6.6 to 7.8	**Very high**. May result in salt injury due to reduced water update. Reduced growth rates likely. Symptoms include marginal leaf burn and wilting.
> 1.1	> 2.25	> 6.0	> 7.8	**Extreme**. Most crops will suffer salt injury at these levels. Immediate leaching required.

*** Due to the variability of pour-through results depending upon your methods and media, you should always compare your initial results to other methods before using this technique.**