

**CHECKLIST
SOIL TESTING**

- ✓ Conduct pre- plant media analyses to provide an indication of potential nutrient deficiencies, pH imbalance or excess soluble salts. This is particularly important for growers who mix their own media.
- ✓ Conduct media tests during the growing season to manage crop nutrition and soluble salts levels.
- ✓ Always use the interpretative data for the specific soil testing method used to avoid incorrect interpretation of the results.
- ✓ Take the soil sample for testing about 2 hours after fertilizing or on the same day. If slow-release fertilizer pellets are present, carefully pick them out of the sample.
- ✓ In a greenhouse where a variety of crops are grown, take soil samples from crops of different species.
- ✓ If a problem is being diagnosed, take a sample from both normal and abnormal plants for comparison.
- ✓ Be consistent in all sampling procedures each time you sample.
- ✓ ***Do not*** compare soil test results from one lab to those obtained from another. Testing methods may vary. ***How the soil test is interpreted is the key to what action you should take based on the soil test!***

SOIL TESTING

A soil test is important for several reasons: to optimize crop production, to protect the environment from contamination by runoff and leaching of excess fertilizers, to aid in the diagnosis of plant culture problems, to improve the nutritional balance of the growing media and to save money and conserve energy by applying only the amount of fertilizer needed. Pre-plant media analyses provide an indication of potential nutrient deficiencies, pH imbalance or excess soluble salts. This is particularly important for growers who mix their own media. Media testing during the growing season is an important tool for managing crop nutrition and soluble salts levels. To use this tool effectively, you must know how to take a media sample to send for analysis or for in-house testing, and be able to interpret media test results.

Determining the pH and fertility level through a soil test is the first step in planning a sound nutrient management program. Soil samples from soilless mixes are tested differently than samples from field soil. There are three commonly used methods of testing soilless media using water as an extracting solution: 1:2 dilution method, saturated media extract (SME), and leachate Pour Thru. The values that represent each method of testing are different from each other. For example, 2.6 would be “extreme” (too high) for the 1:2 method, “normal” for SME, and “low” for leachate Pour Thru. Likewise, values for specific nutrients are likely to differ with testing methods. Always use the interpretative data for the specific soil testing method used to avoid incorrect interpretation of the results. See Table 2, Soluble salts levels determined by different methods of soilless media analysis.

Most fertilizers (except urea) are salts and when placed in solution they conduct electricity. Thus, the electrical conductivity (EC or soluble salts) of a substrate solution is indicative of the amount of fertilizer available to plant roots. In addition to carrying out a complete soil test, growers should routinely check the EC and pH of their growing media and irrigation water. These checks can be done onsite using portable testing meters, or samples can be sent to the University of Massachusetts soil test laboratory. Depending on the crop, and fertilizer practices, growing media should be tested at least monthly.

Sending the leachate solution collected from the Pour Thru method for laboratory analysis at least once during the growing season is a good idea, so that actual nutrient levels in the container can be determined and corrected if needed. The accuracy of EC and pH meters can also be checked by sending a leachate sample to the laboratory at least once during the growing season.

pH and EC Monitoring Equipment

Many horticulture supply companies carry pH and EC testing equipment, usually in the form of pens or meters. Most pens and meters are temperature-compensating; however, the instructions that come with the equipment will help growers determine if any adjustments are necessary related to environmental conditions. A buffer (standardizing) solution (pH 4 or 7) should be purchased with pH meters or pens. A standard solution should also be purchased with EC pens and meters to assure that equipment is calibrated and working properly.

Saturated media extract (SME)

SME is currently "the" method of testing soilless greenhouse media and it is almost universally done by commercial and university labs, including the UMass Soil and Plant Tissue Testing Lab. In this test a paste is made using soil and water and then the liquid portion (the extract) is separated from the solid portion for pH, soluble salt, and nutrient analysis. Special skills and laboratory equipment are required to perform this test. SME is probably not suitable for a grower to use unless the greenhouse operation is large enough to support a lab, a technically trained person is hired to carry out the tests, and there is a commitment to frequent testing and tracking of the results.

1:2 dilution method

This method has been used for many years and has good interpretative data to back it up. In this test an air-dried sample of soil and water are mixed together in the volume ratio of 1 part soil to 2 parts water (e.g., using a measuring cup, 1 fl. oz. of soil + 2 fl. oz. of water). The liquid extract is then separated from the solids using laboratory grade filter paper or a common coffee filter. The extract is then ready for analysis. This is a very easy test to master and quite suitable for on-site greenhouse testing of pH and soluble salt using meters available from greenhouse suppliers. The 1:2 method is a very good choice for occasional pH and soluble salts testing by growers on-site.

Leachate Pour Thru Method

In addition to collecting a soil sample to test, growers can collect leachate from container grown plants using the Pour Thru method. One of the major advantages to leachate pour thru is that there is no media sampling or preparation. Unlike SME and 1:2 methods, plants do not have to be sacrificed or disturbed for testing because the extract is the leachate collected from the container during routine irrigation. The leachate can be analyzed on-site using the pH and EC pens or it can be sent to a commercial laboratory for a complete nutrient analysis. In the reference section there is a fact sheet from North Carolina State University which provides detailed information on the leachate pour thru method or see:

<http://www.ces.ncsu.edu/depts/hort/floriculture/Florex/PourThru%20Handout%20123s.pdf>

Leachate pour thru is best used for continuous monitoring and graphical tracking of pH and soluble salts. To make this method work best an irrigation and leachate protocol must be established and carefully followed when sampling takes place. Leachate pour thru is not a good choice for casual checks (use 1:2 method for this). Unfortunately, with casual use, the "numbers" are often quite variable, inconclusive, and probably unreliable.

Sampling Instructions for Media Testing

A soil test can aid in the diagnosis of plant problems and in quality plant production. Sampling can be done at any time; but if pH adjustments are necessary, test as early as possible prior to planting. Avoid sampling soils that have been fertilized very recently. Follow instructions for specific testing methods.

Sampling for 1:2 and SME testing methods

The goal of sampling for a soil test is to efficiently collect samples which best represent the nutrient status of the crop or the problem to be diagnosed. The first step is to identify the crop unit(s) to be sampled - bench, greenhouse, etc. In a mixed greenhouse, crops of different species

must be sampled separately for the tests to have any value. If a problem is being diagnosed, it is best to have a sample from both normal and abnormal plants for comparison.

After selecting and recording the crop unit, take several samples of soil at root depth from several pots or from several areas of bag culture or bed (cut flowers, greenhouse vegetables) and mix it together in a clean container. Sampling in this fashion is important because a sample from one pot or flat could be an anomaly (values too high or too low) which does not represent the crop as a whole. Sampling and analyzing soil *separately* from 10 *different* pots would be the best way but also the most expensive way!

For the 1:2 and SME tests the actual soil sample is taken by either a core or composite sample from all depths in the pot or from the root zone only (i.e., portion where roots are most active). Never sample from just the surface 1-2" of the pot - nutrient and soluble salts levels will be always be much higher here than in the root zone and composite samples and, as a result, will overestimate fertility.

Sample about 2 hours after fertilizing or at least on the same day. If slow-release fertilizer pellets are present, carefully pick them out of the sample. If the pellets are left in, they can break during testing and this may result in an overestimation of fertility.

Finally, be consistent in all sampling procedures each time you sample. A lot of variability can be introduced to tests due to inconsistent sampling and this diminishes the value of testing especially if you are trying to track fertility.

Take about one cup of the soil mixture and dry at room temperature. Put the dry soil in a sandwich size zip-type bag and close it tightly. Identify each sample on the outside of the bag for your use. Complete and attach the "Greenhouse Media Submittal Form" available from http://www.umass.edu/umext/floriculture/grower_services/soil_testing.html with the following information:

- Name, address and phone number
- Is the sample from a newly-prepared mix or from a mix where a crop is currently being grown?
- Crop being grown, and crop age or development
- Is the sample a soilless mix? If so, what is the commercial brand?
- Does the sample have field soil in it?
- What fertilizer is in use, and what is the rate and frequency of application?
- Is this a routine sample to determine nutrient status or is it for a problem diagnosis?

Label the outside of the bag clearly with your name, address, and your name for the sample (ID).

Send the sample with payment to the University of Massachusetts Soil and Tissue Testing Laboratory, West Experiment Station, 682 North Pleasant Street, UMass, Amherst, MA 01003. For more information, see link to Soil and Tissue Testing Service under Resources.



Soil samples from container crops can be tested onsite for pH and EC. For information, access the online fact sheet “How to Use pH and EC ‘Pens’ to Monitor Greenhouse Crop Nutrition”

http://www.umass.edu/umext/floriculture/fact_sheets/greenhouse_management/phecpens.html

Photo: Douglas Cox, UMass

Procedure for Collecting and Testing Leachate from Containers for Pour Thru Method

1. Irrigate your crop one hour before testing. Make sure the substrate is saturated. If the automatic irrigation system is variable, water the pots/flats by hand. If using constant liquid feed, irrigate as usual. If using periodic feeding (weekly, etc.): a) irrigate with clear water, b) test a day or two before you are to fertilize, and c) test on the same day in the fertilizing cycle each time. *Consistency is very important!*

2. Place saucer under container. After the container has drained for an hour, place a plastic saucer under the container

3. Pour enough distilled water on the surface of the substrate to get 1.5 oz of leachate. The amount of water needed will vary with container size, crop and environmental conditions. Use values in Table 1 as a guide.

Table 1. Amount of water to apply to various container to obtain 1.5 ounces (50 ml) of leachate		
Container Size	Water to Add: milliliters	Water to Add: ounces
4 inch	75	2.5
5 inch		
6 inch		
6.5 inch azalea	100	3.5
1 quart	75	2.5
1 gal.	150	5.0
Flats	50	2.0
606 (36 plants)		
1203 (36 plants)		
1204 (48 plants)		
<i>Containers should be brought to container capacity 30 to 60 minutes before applying these amounts.</i>		
<i>**These amounts are estimates. Actual amounts will vary depending on crop, substrate type, and environmental conditions.</i>		

4. Collect leachate for pH and EC. Make sure to get about 1.5 oz (50 ml) of leachate each time. Leachate volumes over that amount will begin to dilute the sample and give you lower EC readings.

Either, send the leachate to a soil test laboratory or test the leachate on-site using a meter and following steps 5 and 6.

5. Calibrate your pH and EC meters prior to testing. The test results are only as good as the last calibrations. Calibrate the instruments every day that they are used. Always use fresh standard solutions. Never pour used solution back in the original bottle.

6. Measure pH and EC of your samples. Test the extracts as soon as possible. EC will not vary much over time provided there is no evaporation of the sample. The pH will change within 2 hours. Record the values on the charts specific to each crop.

Interpretation of a Soil Test Report

Interpreting a soil test involves comparing the results of a test with the normal ranges of pH, soluble salts, and nutrient levels set by the testing laboratory. Normal ranges are specific to the lab and its method of testing (Table 2). Some interpretation may be done for you, often by a computer program. Best interpretations take into account the crop, its age or stage of development, the growth media (soil or soilless media), the fertilizer program (specific fertilizer, rate, frequency of application) and any problems with the crop.

If used correctly, the three methods of soil testing outlined here give valuable and useful results for greenhouse crops. To optimize the value of soil tests, care in taking and describing the samples is very important.

1:2	SME	PourThru	Indication
0-0.03	0-0.8	0-1.0	Very low
0.3-0.8	0.8-2.0	1.0-2.6	Low
0.8-1.3	2.0-3.5	2.6-4.6	Normal
1.3-1.8	3.5-5.0	4.6-6.5	High
1.8-2.3	5.0-6.0	6.6-7.8	Very high
>2.3	>6.0	>7.8	Extreme

pH or Soil Acidity

Most greenhouse crops can grow satisfactorily over a fairly wide pH range. What action to take on pH depends on the specific requirements of the plants being grown and knowledge of the factors which interact to affect the pH of the media. Limestone (rate, type, neutralizing power,

particle size), irrigation water pH and alkalinity, acid/basic nature of fertilizer, and effects of mix components (container plants) are major influences on pH.

Optimum pH values have been established for soilless media and media with 20% or more field soil. Optimum pH values are shown in Table 3. The difference in optimum pH between the two types of growing media is related to pH effects on nutrient availability in each.

Table 3. Optimum pH Values	
	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 the most common pH problem found in greenhouse growth media in Massachusetts. 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 and manganese may reach phytotoxic levels when pH is low (<5.8). Excess iron and/or manganese can be toxic to geraniums, New Guinea impatiens, and many bedding plants. Proper liming prior to planting is the best way to avoid low pH problems. As a general recommendation, growers should add no less than 5 lbs. of dolomitic limestone per yd³ of growth medium. Greater amounts (8 to 10 lbs. per yd³) of limestone may be needed depending on the materials used to make the medium, irrigation water pH and alkalinity, and acid forming tendency of the fertilizer in use. ***Do not add limestone to commercial brands of growth medium.*** It is much more difficult to raise pH after planting. To raise pH, try irrigating with a commercial “liquid limestone” product.

Electrical conductivity (EC)

Soluble salts are the total dissolved salts in the root substrate (medium) and are measured by electrical conductivity (EC). Measuring EC or soluble salts provides a general indication of nutrient deficiency or excess. A high EC reading 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 EC levels occur when root function is impaired by disease or physical damage. ***Always check the condition of the root system when sampling soil for testing.***

The accompanying table shows the "normal range" of soluble salts levels for common greenhouse crops using the SME (saturated media extraction) method. Seedlings, young transplants, and plants growing in media containing 20% or more field soil are less tolerant of excess soluble salts. Soluble salts **above** the normal range for prolonged periods may cause root injury, leaf chlorosis, marginal burn, and sometimes, wilting. Soluble salts **below** the normal range may indicate the need for increased fertilization.

Soluble Salts Levels (mS/cm)	
	Normal range
Seedlings and young transplants	0.7-1.0
Established plants	
Soilless growth media	1.5-3.0

Growth media containing 20% or more field soil	0.8-1.5
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Ammonium

Some ammonium in the fertilizer program is beneficial, but ammonium and urea should not exceed 50% of the total N supplied in soilless growing media. Excess ammonium can cause injury to most greenhouse crops and the occurrence of injury is highest in soilless growth media.

Calcium and Magnesium

In general the major source of calcium (Ca) and magnesium (Mg) is limestone, therefore low pH is often accompanied by low Ca and Mg. Many commercial water-soluble fertilizers supply no Ca and very little Mg. If the soil test indicates low Ca, levels can be increased by alternating application of calcium nitrate and the usual N fertilizer. If Mg is low, apply a solution of Epsom salts every 2 to 3 weeks. This solution is prepared by dissolving 2 to 3 lbs. of Epsom salts in 100 gallons of water.

Common Nutrient Problems

Excess soluble salts

High growth medium electrical conductivity (EC) can injure or inhibit the growth of young transplants. Use low rates (50-100 ppm N) for slowing-growing species in the one to two weeks following transplanting. Whenever a high EC problem occurs, check for root disease.

Iron/manganese toxicity

Some crops, especially zonal geranium, and all types of impatiens are the most susceptible plants to iron (Fe)/manganese (Mn) toxicity. This disorder is sometimes called "bronze speckle" due to the appearance of numerous small brown spots on the leaves. Growth medium pH should be maintained in the recommended range by adequate liming prior to planting, careful selection of fertilizers with low potential acidity, pH monitoring, and the use of liquid limestone Preparations to raise pH after the plants are established in their containers. Some growers make a routine liquid limestone treatment once the plants are established after transplanting. Raising the pH (6.2-6.5) limits the availability of Fe and Mn and prevents toxicity. Consult the "iron out" nutrient management fact sheet from the University of New Hampshire, <http://extension.unh.edu/Agric/AGGHFL/IRONOUT.pdf> for more information on this problem.



Fe/Mn Toxicity on Geraniums

Photo: Douglas Cox, UMass

Iron deficiency

Iron deficiency symptoms generally show up as an interveinal chlorosis, normally starting at the shoot tips, but often they occur throughout the entire plant. Sometimes the leaves of some Fe deficient plants turn almost white. Calibrachoa, scaevola, snapdragons, and petunias are the vegetative annuals most susceptible to iron deficiency. Preventing Fe deficiency can be accomplished by maintaining a low pH and using an iron chelate fertilizer.



Iron Deficiency on Petunia

Photo: Douglas Cox, UMass

Acid pH favors the availability of Fe to plants, therefore the target pH range for crops susceptible to Fe deficiency is fairly low, 5.5 to 6.0. Most commercial soilless media have pHs in this range and the use of an acid-forming fertilizer like 20-10-20 may be enough to keep the pH in this range. A major exception would be if the irrigation water is highly alkaline and then acid injection would be needed. If a grower mixes his/her own sphagnum peat-based growth medium dolomitic limestone should be added at a rate of no more than 5 lbs./yd. Too much limestone is an aggravating factor contributing to Fe deficiency.

Probably the least complicated way of preventing Fe deficiency is to fertilize with Fe chelate fertilizer from time to time. Most greenhouse supply companies carry Sprint 330® (10% iron), Sprint 138® (6% iron), or similar iron chelate products. Sprint 138®, however, is the preferred chelate if it is available. Sprint is generally applied as a soil drench at the rate of 8 oz./100 gal. (½-¾ tsp. gal.). The chelate is also soluble enough to make a concentrated solution for injection and low rates can be mixed and injected with other fertilizers. At the rate recommended here, Fe chelate can be applied every 3 or 4 weeks if desired.

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