Soil Tests - Sampling and Interpreting the Results of Greenhouse Soil Tests

Video of ufRSgzvSm5E

Soil testing is the most common way of determining the nutritional status of plants used by greenhouse operators. In my experience, the usual reason for testing is to diagnose a suspected fertility problem, but soil tests can be run on a regular basis, along with plant tissue tests, to monitor the nutrition of crops and prevent problems from developing.

Soil testing is an important part of IPM and integrated crop management programs. Regular testing can alert the grower to potential nutrient leaching and runoff problems caused by applying too much fertilizer or too much water. So tests not only help with crop health but with environmental health as well!

Most greenhouse soil tests measure pH (acidity), soluble salts, and specific major and minor elements. A soil test is designed to extract plant available nutrients for analysis. This accomplished by using an **extracting solution** which mimics the root systems in terms extracting nutrients from the soil. Nowadays, for greenhouse soilless media, the most common extracting solution is distilled water and the standard test is the **saturated media extract (*SME*)** method. In this procedure a paste is formed by mixing the sample with distilled water and, following an equilibration period, the liquid portion is analyzed for its nutrient content. Two other methods are used by some labs - ***1:2 dilution*** and ***1:5 dilution***. These involve mixing the sample with larger volumes of water then equilibrating, filtering and analyzing the extract. All three are accepted methods, but ***SME*** is used by most commercial and many state labs.

This article is about interpreting test results, but I hope you will learn that interpretation is more than just trying to figure out what the numbers mean. It starts with taking a good sample.

The Sample

Sampling The goal of sampling for a soil test is to efficiently take a sample which best represents 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, 10 pots or flats should be chosen at random from each unit to sample. The "subsamples" from the 10 are then mixed into one sample and sent to the lab. Sampling in this fashion is important because a sample from one pot or flat could be an anomaly (too high or too low) which does not represent the crop as a whole.

The actual sample is taken by either a core or composite sample from all depths in the pot or a sample from the root zone (i.e., portion where roots are most active). Never sample from just the surface one-third of the pot - nutrient and soluble salts levels will be always be much higher here than in root zone and composite samples and will overestimate fertility.

Sample about 4 hours after fertilizing or at least the same day. If slow-release fertilizer pellets are present pick them out. If the pellets are left in and they break during testing this will result in a test which overestimates 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 to track fertility.

Information Be sure to collect and record a practical amount of information describing the sample. This should be sent along with the sample to the lab (keep a copy for yourself!) and is particularly important if you expect useful, specific recommendations from someone associated with the lab who has not seen your plants or may not have talked to you.

You should answer the following questions:

- What is the crop?
- What is the age or stage of development?
- What is the growth medium (soil or soilless, commercial brand)?
- What is the fertilizer program (i.e., specific fertilizer, rate [ppm], frequency of application)?
- Is there a problem and if so what is it?

Having answers to these questions provide a framework for interpretation of the test results later on.

The Laboratory

Always choose a lab which specializes or least has extensive experience in analyzing greenhouse media samples. Ideally the lab should provide some sort of support service to help you interpret the results and return the results quickly. Once you have chosen a lab stick with it, particularly if you are going to develop a soil test "history" of your crops over the years.

The importance of not using different labs cannot be emphasized enough. Even minor differences in testing procedure and technique can result in big differences in the "numbers" between labs. For example, results using the ***SME*** method generally show much higher soluble salts and nutrient levels compared to test results from the ***1:2*** and ***1:5 dilution methods***. Also, some labs determine pH and soluble salts by testing the unfiltered slurry instead of the filtered extract. The pH is lower and the soluble salts are higher in the slurry than the filtered extract. These differences in procedure and technique cause great confusion to growers who try to compare results from two labs. My advice is simple: don't try to compare results from different labs!

Interpretation

Interpreting soil tests involves comparing the results of your test with the normal ranges of pH, soluble salts, and nutrient levels set by your laboratory. Normal ranges are often printed on the soil test report or are available in accompanying information sheets and are specific to the lab and its method of testing. Some interpretation may be done for you, often by a computer program. Best interpretations take into account the answers to the five questions about your sample discussed earlier in this article and other information you give.

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 is 5.5-6.0 and for a mix containing 20% or more field soil the range is 6.2-6.5. The difference in optimum pH between the two types of growing media is related to pH effects on nutrient availability in each.

Low pH (values below the optimum range) is the most common pH problem found in Massachusetts 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 1**.

Table 1: pH ranges for bedding plant seedlings

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 & NH_4 toxicity
African marigolds	6.0-6.8	Prevent Fe/Mn toxicity
Geranium	6.0-6.8	Prevent Fe/Mn toxicity

Table 1: pH ranges for bedding plant seedlings

Plant	pH	Why?
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. ***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 2** shows the SS ranges and their interpretation for the SME, 1:2 dilution, and 1:5 dilution methods of analysis. This comparison clearly shows the large differences in the "numbers" between testing methods!

Table 2: Soluble salts levels (dS/m)[z] as affected by soil test method

Saturated media extract	1:2 dilution method	1:5 dilution method	Comments
0-0.7	0-0.25	0-0.12	Very low - indicates probable deficiency
0.7-2.0	0.25-0.75	0.12-0.35	Suitable for seedlings and salt-sensitive plants
2.0-3.5	0.75-1.25	0.35-0.65	Desirable level for most plants
3.5-5.0	1.25-1.75	0.65-0.90	Slightly high, too high for seedlings

Table 2: Soluble salts levels (dS/m)[z] as affected by soil test method

Saturated media extract	1:2 dilution method	1:5 dilution method	Comments
			and salt-sensitive plants
5.0-6.0	1.75-2.25	0.90-1.10	Reduced growth,leaf marginal burn.

[z]1.0 mmhos/cm = 1.0 dS/m = 1.0 mS/cm

Actual Tests

Below are some actual test results from the UMass Soil Testing Laboratory. The first table shows the standard values for comparison to the tests and the following tables are accompanied by my interpretations of the results:

Normal ranges for soilless media
(UMass Saturated Media Extract)

***Crop* : Bedding plants and potted crops**		***pH* : 5.5-6.0** ***Soluble salts:* 1.5-3.0**	
Nutrient normal ranges			
Macronutrients (ppm)		***Micronutrients (ppm)***	
Nitrate (NO3-N)	60-175	Zinc (Zn)	0.5-2.0
Ammonium (NH4-N)	0-10	Boron (B)	0.1-0.5
Phosphorus (P)	5-15	Manganese (Mn)	0.5-3.0
Potassium (K)	75-200	Copper (Cu)	0.1-0.5
Calcium (Ca)	75-250	Iron (Fe)	0.5-3.0
Magnesium (Mg)	40-75		

Test 1: *Excess nutrients - cause?*

***Crop:*h Impatiens** **(June 17, 1998)**		***pH:* 6.2** ***Soluble salts:* 6.06**	
***Problem:* Not specific - "suspect salts."**			
Macronutrients (ppm)		***Micronutrients (ppm)***	
NO3-N	620	Zn	2.0
NH4-N	200	B	0.4
P	92	Mn	2.9
K	552	Cu	0.7
Ca	123	Fe	1.3
Mg	128		

Test 1 This test was taken from impatiens late in the growing season and SS level is high. SS level is often high when NO3-N is high, as it is in this test. Little information was provided by the grower. Perhaps the plants were showing symptoms of high SS. The plants were probably overfertilized, but a root disease or lack of adequate drainage could also account for high SS.

Test 2: *High soluble salts and low pH, Ca, & Mg*

***Crop:* Zonal geranium May 1, 1998)**		***pH:* 4.5** ***Soluble salts:* 6.36**	
***Problem:* None stated.**			
Macronutrients (ppm)		***Micronutrients (ppm)***	
NO3-N	475	Zn	0.9
NH4-N	1	B	0.4
P	55	Mn	1.4
K	384	Cu	0.1
Ca	58	Fe	5.9
Mg	19		

Test 2 It is early May and the geranium test reveals high SS and low pH. I am less concerned about SS here because the plants are probably large and well-established. Low pH concerns me more because it is accompanied by low Ca and Mg and it also leads to Fe/Mn toxicity in geranium.

Test 3: *Low pH - potential toxicities?*

***Crop:* Seed geranium (April 23, 1998)**		***pH:* 4.8** ***Soluble salts:* 3.74**	
***Problem:* Lower leaves show edge necrosis and many small brown spots. 150 ppm N 15-16-17**			
Macronutrients (ppm)		***Micronutrients (ppm)***	
NO3-N	280	Zn	0.1
NH4-N	1	B	0.2
P	3	Mn	1.3
K	74	Cu	0.1
Ca	354	Fe	4.3
Mg	263		

Test 3 These are seed geraniums about a month before sale. Nutrient levels are high, but SS level is close enough to normal to not be a concern. The grower gave an indication of the problem and the symptoms suggest Fe/Mn toxicity. Toxicity

would be favored by the low pH and the moderate to high Fe and Mn shown in the test.

Test 4: *General nutrient deficiency*

***Crop:* Poinsettia (Late December)**	***pH:* 5.4**
	***Soluble salts:* 0.61**
***Problem:* Leaf yellowing, small bracts. Fertilizer (200 ppm N) stopped in late November**	

Macronutrients (ppm)		***Micronutrients (ppm)***	
NO3-N	35	Zn	0.1
NH4-N	1	B	0.1
P	4	Mn	0.1
K	5	Cu	0.0
Ca	25	Fe	0.2
Mg	7		

Test 4 Too late for these poor poinsettias! They have an overall nutrient deficiency - they simply need more fertilizer. SS and nutrient levels are all below normal to the point where bract size was reduced and the plants developed chlorosis. Don't stop fertilizing poinsettias until about two weeks before sale and do a soil test first.

Test 5: *Low, but O.K. for New Guineas*

***Crop:* New Guinea impatiens (February 20, 1998)**	***pH:* 6.7**
	***Soluble salts:* SS: 1.38**
***Problem:* None stated - routine test**	

Macronutrients (ppm)		***Micronutrients (ppm)***	
NO3-N	45	Zn	0.8
NH4-N	1	B	0.0
P	8	Mn	0.1
K	111	Cu	0.0
Ca	141	Fe	0.2
Mg	25		

Test 5 This test is a good illustration of how important it is to consider crop and stage of development in soil test interpretation. This test would be too low for most crops but not young New Guinea transplants in February. On the other hand, if this was late May and the plants were large and well-developed, I would say this test was too low for New Guineas also!

I hope these examples give you some idea of the approach and factors to be considered when interpreting soil tests for greenhouse crops.
