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Measure to Manage – Lab Testing for Growers

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Summary

There are multiple laboratory test options available to nurseries, turf managers and plant growers to help manage their unique production systems. Most of these tests are complementary, in that they each provide a piece of valuable information that may not be entirely useful on its own but when used in conjunction can give confidence in any management change practices, and help with environmental stewardship. Lab testing can also help direct management decisions that may be needed to deal with climate change challenges and regional or national regulation. The sampling protocol used is critical, to guide interpretation and to realise the benefit of testing. Using an expert advisor is highly recommended. Field observations supported by test result data provides a framework to guide decisions, removing guesswork and uncertainty.

INTRODUCTION

Successful growing systems require water, light, heat, air and adequate amounts of essential nutrients throughout the growing cycle of the crop. As well, growers want to protect the environment they live in and be sustainable through an ever-changing world of climate uncertainty and regulation. Laboratory testing can play an important role in achieving successful growing and production systems to manage at least some of these critical elements. Having real data provides assurance to the grower around management decisions and can be useful to help diagnose problems. Lab testing is a risk-management tool to provide confidence of crop supply (in-time), prevent crop losses and to minimize nutrient losses to waterways as well as to protect soil health. Testing is often used for monitoring or else for diagnostic purposes. This paper describes some of the tests available for growers and has commentary on how these tests can be helpful along with some limitations.

Soil Testing

Soil samples are usually collected from the growing zone of plants, and sent to the laboratory to measure the plant-available nutrients. Several samples should be collected from a growing area, as there is often large spatial variability to consider. The bulked sub-samples from an area are analysed as a single sample to provide an average nutrient status for that area. Different crops need to be sampled separately, as they may have different pH and nutrient needs.

In New Zealand the standard tests carried out are pH (water); Olsen Phosphorus, Exchangeable Cations (Ca,K,Mg,Na); Cation Exchange Capacity (CEC); Base Saturation; Volume Weight and sometimes available sulphate-S (SO4) and Soluble Salts (EC). Additional soil tests may include Boron and other Trace Elements where special investigation are needed.

Testing for Organic Matter, Total Carbon, Total Nitrogen, the CN ratio, Mineralisable Nitrogen and Hot Water Extractable Carbon are also carried out routinely, as growers look to monitor soil health using easy tests on the sample already submitted for fertility monitoring.

The soil pH test can help with understanding nutrient availability, as shown for a mineral soil diagrammatically below. Fig 1 is for a mineral soil and organic soils behave a little differently.

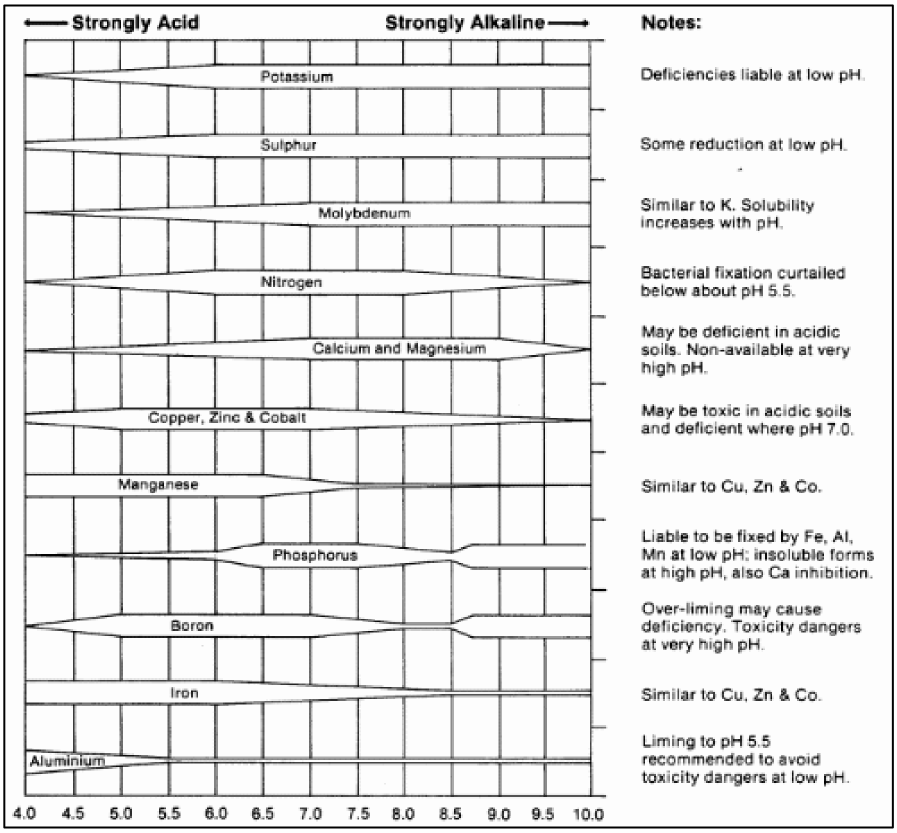

Figure 1. Soil pH effects on plant availability of nutrients (Truog, 1948)

A soil pH range of 5.8-6.5 is considered ideal for most plants (lower range for organic soils) although some plant species prefer more acid soils e.g. potatoes, camellia. A soil pH near to 6 is considered desirable for earthworm populations to thrive.

Acidification of soil is a natural process under growing plants. As cations are taken up, H^+ ions are released and other processes such as microbial respiration, the release of organic acids by plant roots and use of NH4-N fertilisers all contribute to acidification.

Soil pH can be altered by use of appropriate rate and form of liming product, but it should be noted that plants may grow well in soil or media that doesn't fit the ideal range – provided adequate nutrients are supplied directly to the plant and the plant is reasonably pH-tolerant.

Soil tests can be variable as referred to earlier, both spatially and temporally (over season and years). Sampling consistently from an area and depth will help to minimize variability, but not remove it entirely. Table 1 describes how nutrients in an uncultivated soil may vary in the soil profile with most of the valuable plant-nutrients in the top few centimeters. This will of course be different in soils that are regularly turned over, but highlights the need for sampling at a consistent depth (often 0-150mm for most crops, 0-75mm for turfs).

Table 1. Example of change in nutrient with soil depth (uncultivated soil) from an in-house study by Hill Laboratories.

Soil Depth	pH	Olsen P (mg/L)	Calcium (MAF Units)
0-1"	7.0	60	20
1-2"	6.2	24	10
2-3"	5.8	9	6
3-4"	5.7	7	4
4-5"	5.6	4	3
5-6"	5.6	2	3
Effect of Sampling Depth			
0-3" (0-75mm)	**6.3**	**31**	**12**
0-6" (0-150mm)	**5.9**	**18**	**8**

Growing Media Testing

Although there are some similarities with soil analysis, testing potting media (media) presents some special challenges. In the early 1970s, a 1:1.5 media to water extraction was developed and remains as the standard method for New Zealand and Australia (refer Australian Standard for Potting Mixes AS3743). Testing potting media provides an analysis of immediately available nutrient as well as pH, and is a snapshot in time. Typically, tests carried out from this water extract are pH and Electrical Conductivity (EC), and the immediately available nutrients ammonium-nitrogen, nitrate-nitrogen, phosphorus, sulphur, potassium, calcium, magnesium and sodium.

As for soil tests, the pH of media is important for the availability of nutrients. The EC provides an overall measurement of the dissolved salts, and is important in diagnosing problems such as salt stress in crops.

It is important to realise that a media test measures the nutrients that are immediately plant available. It does not include nutrients that may become available over time (e.g. from slow release fertiliser prills). Consequently it is possible that a Potting Media analysis shows only low levels of nutrients present, even though the crop is apparently growing well. When this is the case, the crop is taking up these nutrients at the same rate as they are being released by slow-release fertilizers.

Heavy watering/leaching of the media just prior to testing may also result in low nutrient levels. The treatment given to the media before or after analysis must be taken into account when interpreting the analysis results. If diagnosing a specific problem, select the sample from the pots showing the most prominent symptoms.

The trace elements iron, manganese, zinc, copper and boron are analysed from a DTPA (Diethylenetriamine pentaacetate) extraction. As with soil trace element testing, there are limitations to the reliability of the test, and in most instances suspected trace element problems should be confirmed with plant tissue analysis.

Desirable pH, soluble salts and nutrient levels vary with the glasshouse crop being grown and management practices. General guidelines are suggested in the table below:

Table2. Table showing general analysis guidelines for potting media of different types (as used for different growing rates).

	Low	**Fairly Low**	**Broad Range**	**Medium**	**High**
pH	5.2 - 6.5	5.2 - 6.5	5.2 - 6.5	5.2 - 6.5	5.2 - 6.5
Conductivity (mS/cm)	0.3 - 0.8	0.5 - 1.2	0.5 - 1.8	1.0 - 1.8	1.0 - 2.5
Nitrate-N (mg/l)	15 - 35	20 - 50	20 - 80	40 - 80	40 - 120
Ammonium-N (mg/l)	1 - 10	1 - 15	1 - 20	3 - 20	1 - 30
Phosphorus (mg/l)	4 - 15	5 - 15	5 - 20	10 - 20	10 - 30
Potassium (mg/l)	10 - 35	20 - 50	20 - 80	40 - 80	40 - 120
Calcium (mg/l)	10 - 20	15 - 40	30 - 70	30 - 70	30 - 100
Magnesium (mg/l)	8 - 15	6 - 15	7 - 25	12 - 25	12 - 35
Sodium (mg/l)	3 - 25	5 - 30	5 - 40	10 - 40	5 - 10

Compost Testing

Compost is most useful in growing systems as a soil amendment, to improve water holding capacity and as a supply of slow-release nutrients. As plants are not usually grown directly in compost, an extractable or plant-available nutrient test is of limited use, apart from pH and conductivity (EC). Analysis of compost is generally carried out using a hot acid digest to measure the total recoverable nutrients along with a Carbon to Nitrogen (CN) ratio, measured by combustion analyser. The CN ratio is important as an indicator of the rate of compost decomposition, and will assist with nitrogen fertiliser decisions. Compost with a high CN ratio (>30) may immobilize soil nitrogen and create a plant "nitrogen-hunger".

Interpretation of compost analysis can be difficult, due to the variety of raw materials in the starting ingredients, but a test can be helpful where heavy metals or other contaminants are suspected. In New Zealand, laboratory methods should align closely with the NZ Standard 4454 - Composts, Soil Conditioners and Mulches.

Plant Testing

Plant testing (also known as plant analysis or tissue testing) is a useful tool for growers, often carried out as complementary to soil or media testing. An analysis should include all of the major and trace elements required by growing plants. Methods used are most often hot acid digestion followed by inductively-coupled-plasma optical emission spectroscopy (ICP-OES) and also combustion analyzer for nitrogen. Extractable methods for chloride and nitrate-N may also be used.

Interpretation can be difficult, as many factors affect the nutrient content of plants, with some of these listed below.

Plant uptake of nutrients may be affected by variables such as:

- Moisture
- Temperature
- Air
- Soil/Media pH
- Physical conditions of the growing media
- Light
- Salinity
- Disease/Pests
- Root Injury
- Residues, toxins

Plant analysis for nutrient content can be a successful tool if an appropriate sampling protocol is used to align with available interpretive ranges. In fact plant sampling is critical, as stage of growth, plant part and plant variety will all impact on interpretation of nutrient levels. One of the reasons for this is to do with nutrient mobility within the plant. *Mobile* nutrients such as nitrogen, phosphorus, magnesium and potassium are redistributed from older leaves to the growing points so that deficiency will be apparent in the older leaves first. *Immobile* nutrients such as calcium, boron and zinc are incorporated into older plant tissue and are not available for subsequent redistribution within the plant. Deficiency of these elements will therefore appear in the growing points of the plant first.

Most reputable laboratories will be able to provide guidance on how to sample, to align with any interpretive ranges in their library. Unique plant varieties should be sampled separately, and most often this is done in a period of active growth. In most cases the sampling part is the youngest mature leaf (YML) to avoid some of the nutrient mobility differences described earlier. Some conventions also suggest sampling the plant petiole only, and this is particularly valid to do for the mobile nutrients.

An alternative approach, especially when there are no reference ranges available, is to sample plants that appear to be in good condition, compared to their same-stage neighbours growing poorly in apparently similar conditions. A “good” versus “bad” set of samples can be helpful, especially when non-nutritional factors are suspected.

Nutrient Solution testing (Hydroponics)

Drip type systems are sampled to compare the feed solution with the drainage solution. Nutrient Film Technique (NFT) and Ebb and Flow systems are sampled to determine the nutrient composition and any changes in the balance of nutrients that occur in the recycled solution.

Interpretation of a nutrient solution analysis is influenced by the choice of crop grown, environmental variables such as light and temperature, the type of hydroponic growing system and how the sample is taken. A typical hydroponic solution test will include the following tests:

- pH as a measure of the acidity (and alkalinity) of the nutrient solution. This should be appropriate for the plants grown and also suitable for maintenance of the solubility of all nutrient components.
- Electrical Conductivity representing the total concentration of dissolved salts (includes nutrients) and is commonly reported as the Conductivity Factor (CF) units.
- Nitrate-Nitrogen and other elements are reported as concentrations of elemental equivalents reported as mg/l which is ‘parts per million’ on a weight/volume basis.
- The sum of anions and sum of cations which is a comparison of the chemical equivalents of negatively charged ions (anions including P, S, NO3, Cl) with positively charged ions (cations including K, Ca, Mg, Na). These two sums should be similar if the analysis conducted has reported the entire major element components, as the components of a nutrient solution should theoretically be a balance of cations and anions.

Measurements of ammonium-N, molybdenum and silica may also be useful for particular investigative purposes.

Water Testing

The pH, alkalinity, hardness, salts (sodium and chloride) and trace element (boron, iron, manganese) content of the feed water should be researched before commitment to using it in any hydroponic growing system. The simple rule is that the best results are obtained from using ‘pure’ water. Any dissolved impurities in the water should be present at levels that are lower than the nutrient solution specifications. Treatment options are available to reduce levels of potentially insoluble iron and manganese and to correct pH, alkalinity and hardness. Impurities that are most difficult to manage are dissolved sodium, chloride and boron.

Town water supplies are not always appropriate for hydroponic growing systems without further treatment. Where surface water (river, lake) is used, investigate the risk of contamination from all possible sources within the catchment, such as herbicide applications.

Water used to irrigate container or soil-grown plants may also be less than ideal, depending on its source and other environmental effects. A simple analysis can fore-warn of any potential problems and give confidence in an investment dependent upon supplies of clean water.

Chemical factors affecting the suitability of a water supply for irrigation relate to the presence of a number of potentially undesirable or hazardous features. These include:

• dissolved salts
• chemical toxicities
• the level of sodium and its effect on soil structure

In New Zealand there are several public data sources available, to view regional or local trends in water quality from various water-quality monitoring programs.

Useful websites can be found at:

- LAWA website (Land, Air, Water Aotearoa) www.lawa.org.nz
- Regional Councils – state of the environment reporting e.g. www.waikatoregion.govt.nz/environment (river & stream monitoring)
- MPI website e.g. www.mpi.govt.nz/agriculture (farm management/waterways)

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The information in this article is largely sourced from Hill Laboratories proprietary technical notes and crop guides, available on their website www.hill-laboratories.com

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