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PLANT TISSUE TESTING

PLANT TISSUE ANALYSIS COMPLEMENTS SOIL TESTING

By Garn A. Wallace, Ph. D.

Various tools are available for enhancing growth and reducing plant problems. Each tool has it strength and limitations. Soil testing is not always 100% adequate in resolving plant nutritional needs. It is estimated by some to be only 75% accurate. Soil testing is valuable in resolving major problems but does not do well with minor adjustments nor does it perform as well in soils which have poor physical properties.

Soil tests can be valuable when calibrated for a specific plant in a specific soil. Since there are thousands of soil types and numerous plant species which differ in their responses to soils and nutrition, this is difficult.

The most efficient procedure to assess plant nutritional requirements is with the use of various combined analyses. Visual symptoms, the result of plant growth to different treatments as well as soil and tissue testing need to be used. It is best to have a second opinion before applying nutrients which can not be readily removed from the soil.

The micronutrients are needed in very low amounts. Boron for instance has a very fine line between optimum levels for good growth and the toxic level. Poorly buffered soils such as sandy soils can be adversely effected with the application of an essential trace metal. A little too much zinc or copper can induce an iron or manganese deficiency.

Since the root systems of plants assimilate the nutrients, the availability of nutrients present in the soil depends upon the size and status of the root system. A very invasive root system in an infertile, loose, friable soil can give good growth as well as a more restrictive root system in a fertile soil. Most nutrients move with the flow of water to the roots. Low levels of nutrients over a large root system are just as effective as higher levels of nutrients in a smaller system. The proper evaluation of soil when using soil testing should include fertility as well as physical evaluations. Otherwise, plants can be used as a bioassay to determine what is really available. The measurement of nutrient uptake by plants eliminates all the complex interactions of soil and gives a picture of what is available.

RESPONSE OF PLANT GROWTH TO NUTRITIONAL STATUS

Generally, as the concentration of a nutrient present in tissues increases, the growth rate is found to be faster as shown in figure 1. The greatest increase in growth occurs when the plant is highly deficient but not severely deficient. The curve is steepest in the highly deficient zone meaning that a small increase of a nutrient in the tissue gives a large increase in the growth rate. When mineral content of the tissue is sufficient, there is little change in the growth rate with additional fertilizers. As the concentration of nutrients increases even higher, toxicity occurs with a decreased growth rate.

The shape of the growth curve in the severely deficiency range is "C" shaped. As the growth rate becomes extremely slow, the production of biomass is too low to cause much dilution of the absorbed minerals. The concentration of the minerals could be on the curve in the moderately deficient range or on the lower curve in the severely deficient range. It is best to interpret the data in conjunction with regards to several elements. For example with iron deficiency, phosphorus and calcium are also depressed. It is wise to evaluate the results as a whole and not rely on absolute values.

Frequently, laboratories will use a critical value for an elements. Normally the "critical value" for the deficient nutrient level is the concentration present for 90% of the optimum growth rate. The "critical toxicity level" is the concentration present where the growth rate is depressed 10% from the optimum growth. More reliable recommendations are made within a range of concentrations.

Optimum growth occurs over a range of nutrient contents. Deficiency also occurs over a range of concentrations. In lieu of a "critical value", it is more accurate to use a "critical nutrient range" for diagnostic needs. As with all organisms, variation occurs from individual to individual. What is optimum for one differs a little for another.
Guidance with the use of critical values can cause poor growth if multiple elements are deficient. If just one nutrient were slightly deficient and results in a 10% decrease in growth while all of the other nutrients were in the optimum range, total growth would be 90% of maximum if all cultural practices and other factors were also at optimum. Seldom are all factors perfect. If two nutrients were present at 90% of optimum levels, the total growth rate is 90% times 90% or 81% of optimum. For three factors at 90%, the result is 73% (90% x 90% x 90%) and 10 factors at 90% would be 35% of optimum. It is important to correct all factors to near 100% if the goal is to have good growth.

Some experts believe that the ratio of the concentration of one nutrient relative to the concentration of another element is more important than the absolute concentration of either. This concept has led to a method for the interpretation of multi-element analyses of plant nutrients often called by the acronyms such as DRIS or TEAM. The method has given some success. Its main advantage is that it organizes the nutrients into a series from mostly likely deficient to least likely deficient (or most toxic).

Tissue Analysis as a Forensic Tool

Some plants suffer from stress from excess salts which result in damaged leaves and roots. Necrotic leaves can be analyzed to determine the source of the stress. Excess salts in the plant are extruded on the margins of leaves causing a marginal burn. Analyses of leaves can determine the actual salts causing the problem.

Moisture stress can cause the nutrients to be recycled from leaves prior to leaf loss. These leaves lose nitrogen, potassium, phosphorus and carbohydrates. The leaves become thinner than normal. With a reduced tissue weight, the nonmobile elements remaining in the tissue will have high concentrations based upon tissue mass.

Toxicity from heavy metals such as nickel, chromium, cadmium, vanadium, arsenic, silver etc. can be detected in leaf tissue analyses. For some elements such as silver, nickel, chromium and others, the root system is a barrier to the movement of the metals into the upper parts of the plants. Root analysis is more reliable in detecting these possible problems.

Multiple Testing approach to Nutritional Status

Soil testing is helpful to determine broad problems such as salinity, acidity and major problems with deficiencies. Soil testing can not provide precise answers for nutrient needs. Soil testing data are used to predict that there may be a probability of a increased growth response to the application of a nutrient in question. It is not uncommon in relying on soil data predicting that a nutrient is low that one finds upon supplying an element in large amounts that there is no response to increased growth. Thus the test can be considered as inaccurate. In reality, the test is accurate but the interpretation is inadequate. The same problem occurs with tissue analysis.

When several different methods of assessing nutritional status are combined, the results are more dependable. Evaluation methods are soil testing, tissue testing, visual symptoms and responses to the testing of nutrient application - typically foliar application.

Soil properties can vary from spot to spot. The manner in which plants grow is the total sum of the differences for each spot. Soil testing may not give a true picture of the soil properties in a particular location but plant appearances reflect these problem areas.

Tissue content varies within the plant. Leaves from the same age vary. Also tissues change with age. The newest growth has higher levels of nitrogen, potassium and phosphorus than do older leaves. As the tissue ages, mobile elements such as nitrogen, potassium and phosphorus are transported to new tissues and the concentrations are lowered. Nonmobile elements such as calcium, magnesium increase with age. The selection of tissue for testing needs to be selective.

Visual Indications OF DEFICIENCIES

Visual interpretation of the nutritional status of plants can help diagnose problems. The following symptoms are helpful if only one element were deficient. With multiple deficiencies or toxicities in addition to deficiencies, the use of visual signs is difficult

Nitrogen	Low nitrogen causes a pale green coloration. Since the nitrogen is mobile, new growth is greener than the older growth.
Iron	The old growth versus new growth symptoms for low iron are reversed for nonmobile elements such as iron. The newest growth is yellower for iron. In addition, iron deficiency, if not too deficient, will have green veins in the leaves with yellowness in between the veins.
Manganese	Manganese deficiency is similar to iron. However, the width of the green veins is greater.
Phosphorus	Phosphorus deficiency causes slow, weak growth. Newer leaves may be dark green while the older leaves have a purple pigmentation.
Potassium	Potassium deficient plants are sensitive to disease infestation. Older leaves will be as if they had been burned along the edges, a deficiency known as “scorch.” Plants deficient in potassium may become sensitive to ammonium toxicity.
Calcium	The growing tips of plants turn brown and die with calcium deficiency. Leaves curl and their margins turn brown with newly emerging leaves sticking together at the margins, leaving the expanded leaves shredded on their edges.
Zinc	Zinc deficiency causes a chlorosis of the interveinal areas of new leaves. The chlorosis is mosaic. With increasing severity of deficiency, growth is stunted and leaves die and abscise. Excess phosphorus can induce zinc deficiency. Excess zinc can induce iron deficiency.

Tissue analysis is a valuable tool to aid those growing, establishing or maintaining vegetation. As with all tools, the proper ones are needed at the appropriate time. With the correct interpretation and recommendations, valuable plantings can be maintained for many years.

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