ANALYSIS AND INTERPRETATION OF FOLIAGE NUTRIENT LEVELS IN TREE SEEDLINGS

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WHAT IS FOLIAGE NUTRIENT ANALYSIS?

Trees, like all living things, are composed of an assortment of chemical elements which are necessary for survival and growth. The amount of each of these elements varies with the age of the plant and its relationship with the physical environment.

Although numerous chemicals are found in plant tissue, only 16 have been shown to be necessary for plant growth. These essential nutrients are required in varying amounts and can be classified by their source and relative concentration in plants (Table 1). About 96% of the dry weight of plant tissue consists of 3 common elements: carbon, hydrogen and oxygen. These chemicals form carbohydrates which constitute the bulk of plant tissue. They are obtained from water and carbon dioxide and are therefore never considered limiting.

We are more concerned with the remaining 4% of the chemical elements which are supplied by the plant's edaphic environment. The first 6 chemicals are called macronutrients because they are used by plants in large quantities. As Nurserymen, you are familiar with these nutrients because they are commonly supplied to crop lands through fertilizer amendments.

The seven micronutrients are required in very minute quantities, only a few parts per million. Although they are usually present in soil minerals, it is sometimes necessary to supply one or more of these nutrients with fertilizers.

The purpose of foliage nutrient analysis is to measure nutrient levels within a plant and to relate these levels to its overall health. Using modern techniques of analytical chemistry, plant tissue can be separated into its chemical constituents and the exact amount of each plant nutrient determined. The most common procedure involves a mass spectrometer which projects the light from burning plant tissue through a prism to measure individual chemicals. Each chemical element has a characteristic wavelength

TABLE 1

RELATIVE NUTRIENT CONCENTRATIONS
WITHIN HEALTHY PLANT TISSUE 1/

ELEMENT	SOURCE	% or PPM of Dry Weight %	Cumulative%
1. Hydrogen (H)	Water	6	
2. Carbon (C)	Carbon Dioxide	45	
3. Oxygen (O)	Water	45	
			96.0
MACRONUTRIENTS			
4. Nitrogen (N)	Soil	1.5	
5. Potassium (K)	Soil	1.0	
6. Calcium (Ca)	Soil	0.5	
7. Magnesium (Mg)	Soil	0.2	
8. Phosphorus (P)	Soil	0.2	
9. Sulfur (S)	Soil	0.1	
			3.5
		ppm	
MICRONUTRIENTS			
10. Iron (Fe)	Soil	100	
11. Chlorine (Cl)	Soil	100	
12. Manganese (Mn)	Soil	50	
13. Zinc (Zn)	Soil	20	
14. Boron (B)	Soil	20	
15. Copper (Cu)	Soil	6	
16. Molybdenum (Mo)	Soil	0.1	
			0.5
			100.0%

1/ Modified from Epstein, E. 1972. MINERAL NUTRITION OF PLANTS. PRINCIPLES AND PERSPECTIVES. John Wiley and Sons, Inc. New York. 412p.

and the elemental concentration can be obtained by measuring the light intensity within that particular spectral band.

Foliage nutrient analysis is used in plant nutrition to monitor the levels of the 13 macro- and micronutrients within plant tissue. By comparing nutrient levels in a given sample with accepted standards, nutrient deficiencies or excesses can be identified and corrective measures undertaken.

USES OF FOLIAGE NUTRIENT ANALYSIS

1. Nutritional disorders - The most common use of tissue analysis is in the diagnosis of poor seedling growth. After it has been determined that biological pests are not involved, the cause of seedling diseases can often be attributed to nutritional disorders. Tissue samples from diseased seedlings are analyzed to determine if nutrient imbalances are responsible for the disease symtoms.

One of the best uses of foliage nutrient analysis is the confirmation of visual nutrient deficiency symptoms. Very often nutritional disorders are diagnosed based on visual symptoms alone. Common deficiency symptoms, including chlorosis, can be caused by many different factors. Ideally, diagnoses of nutritional imbalances would be based on a combination of visual symptoms, soil chemical tests and foliage nutrient analysis.

2. Monitor the adequacy of fertilizer programs - Most of you, as Nurserymen, regularly add chemical fertilizers to supplement soil fertility. Many of these fertilizer applications are made as a matter of routine policy rather than an actual proven need. Foliage analysis is a convenient way to check on your fertilizer programs and see if they are supplying the proper nutrients, in the proper amounts and at the proper time. Foliage tests are an excellent supplement to soil nutrient tests because they actually measure plant nutrient uptake rather than soil chemical content.

3. Surveys of soil productivity - Every tree nursery has soils of varying productivity and most of these have been identified through soil tests or past production records. Foliage nutrient analysis can be used to confirm field productivity records. Foliage samples from mature seedlings could be collected during tree harvesting; a well-balanced healthy seedling would contain optimum levels of plant nutrients. Seedlings which show poor nutrient levels may indicate areas of low soil fertility.

COLLECTION OF FOLIAGE SAMPLES

Before starting to collect samples, it would be helpful to contact the analytical laboratory that you intend to use and ask about the

kind of sample that they need for your specific tests. Certain tests may require a special sample. Specify the type of analysis that you want. Usually a standard package is offered but make certain that it provides all the information that you need. Certain nutrients, notably nitrogen, exist in several different chemical forms so indicate whether you are interested in total nitrogen, nitrate nitrogen or ammoniacal nitrogen.

Cost will probably limit the kind and number of samples that you will be taking. While talking to the lab,obtain the prices of their various services so that you can budget for the cost of the analysis. Tissue tests range from $7.50 - $20.00 or more, depending on their degree of difficulty.

The actual sample should consist of non-woody portions of seedling foliage. The most recently matured leaves of the current year's growth are the best indicators of overall plant nutrient status. The best sampling technique is to collect an aggregate of seedling foliage from within the area of concern. Make sure that the foliage is clean and keep it cool and shaded. If samples become too warm, the nutrient content of the leaves may change due to respirational losses.

Collect the type of foliage that you are interested in, healthy or unhealthy. If you are testing for nutritional disorders, make sure that you collect some healthy foliage of similar origin as a basis for comparison. Sample diseased foliage as soon as symptoms become evident because a deficiency of one nutrient may upset normal physiological processes and cause other nutrients to accumulate, making test results difficult to interpret.

Concerning the number of sample replications, take as many as you can afford. The reliability of the results will increase with each additional replication. Cost will usually limit the number of sample replications that you can collect for each test.

Finally, get the samples to the laboratory as soon as possible before deterioration occurs. Make sure that samples are clearly labeled. Supply as much additional information about the sample as possible such as fertilizer amendments, cropping history, pesticide applications as well as any other relevant observations.

INTERPRETATION OF RESULTS

Do not be surprised if the analysis report seems confusing at first; nutritional analyses are seldom self-explanatory. Do not be scared away either because,with a little effort, much knowledge can he gained from a few numbers.

Most laboratories supply their own interpretations with the test results; if not, ask for them. If you are working with a nutritional disorder, compare and contrast the diseased sample with the healthy

foliage. Check the literature for nutrient analyses of similar tree species - are your results in the ball park? After searching through many references for comparative test results, I have included the most comprehensive and useful chart in Table 2. This table was synthesized from numerous sources and represents general guidelines rather than absolute values. Note that the nutrient levels for trees do not differ drastically from those for agricultural crops.

Do not jump to conclusions when first analyzing nutrient analysis results. Nutritional imbalances can be caused by many factors, both internal and external. Extremes in soil moisture, plant diseases, weather damage and other injury may upset the normal physiological balance of a tree seedling. Try to eliminate all other possibilities before diagnosing a nutritional problem. Before taking drastic action, collect additional samples to confirm original findings; e.g. do not make huge fertilizer applications based on one test value.

Remember, foliage nutrient analyses are only one weapon in your arsenal. They should be interpreted in concert with soil tests and your own experience as a Nurseryman. Ease of interpretation will come with familiarity so the more exposure you have, the more meaningful the test results will become.

CONCLUSIONS AND RECOMMENDATIONS

1. Foliage nutrient analyses are not a panacea; use them to complement soil tests, visual symptoms and your own knowledge of the problem.

2. Develop your own foliage nutrient standards for the tree species that you are working with before you have a problem. Run tests regularly so that you are familiar with nutrient levels at your own Nursery. Although these tests are relatively inexpensive, it would help financially to budget for these expenses ahead of time.

3. Do not use foliage nutrient tests as a last resort. By the time nutrient deficiency symptoms become evident it is usually too late to correct the problem. Deficiency symptoms take weeks to develop and considerable growth loss may occur in the meantime. A regular battery of foliage analyses should reveal nutritional problems before major damage is done.

TABLE 2

FOLIAR NUTRIENT CONCENTRATIONS REPORTED FOR DEFICIENT AND HEALTHY FOREST TREES AND AGRICULTURAL CROPS 1/

NUTRIENT	Nutrient concentration in leaves when concentration is-- DEFICIENT			ADEQUATE		
	Conifers	Hardwoods	Field crops	Conifers	Hardwoods	Field Crops
	percent of dry weight					
N	< 1.1	< 1.0	< 1.5	1.3-3	1.0-4.0	1.5-5
P	< 0.09	< 0.09	< 0.1	0.1-0.3	0.1-0.28	0.2-0.34
K	< 0.4	< 0.5	< 1.4	0.5-1.6	0.5-1.5	1 - 5
S	< 0.1	< 0.15	< 0.1	0.15-0.3	0.15-0.3	0.1-0.24
Ca	< 0.12	< 0.2	< 0.15	0.12-0.7	0.3-2.2	0.5-7
Mg	< 0.05	< 0.08	< 0.1	0.07-0.2	0.1-0.4	0.15-1.8
	parts per million dry weight					
Fe	< 30	< 30	< 30	50-100	50-100	50-450
Mn			< 10	100-5000	100-5000	25-300
Zn	< 5	< 5	< 13	10-125	10-125	15-95
Cu	< 3	< 3	< 3	4-12	4-12	5-65
Mo			< 0.2	0.05-0.25	0.05-0.15	0.6-5
B	< 3		< 3	10-100	10-100	6-20
Cl			< 100	10-3000		100-4000

1/ Taken from Powers, R.F. 1974: EVALUATING FERTILIZER PROGRAMS USING SOIL ANALYSIS, FOLIAR ANALYSIS AND BIOASSAY METHODS. IN: Service-wide Work Conf. Proceedings, Sacramento, Calif. USDA-FS, Division of Timber management, Washington D.C. p. 124-151.