SOILS AND CHRISTMAS TREE PRODUCTION—PART 8
FOLIAR NUTRIENT ANALYSES

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(Reprinted from Michigan Christmas Tree Journal, Fall 1996)

The objective of ail Christmas tree producers should be to maximize production of high quality trees in the shortest time frame possible. There are several factors which contribute to attaining this objective. These include matching species to site, size and quality of planting stock, intensity of cultural practices such as weed control and trimming, and evaluation and maintenance of adequate soil fertility levels. In previous articles in this series emphasis has been placed on understanding soils and the many contributions they make to the production of quality trees. Several physical characteristics and factors have been considered. Additionally, the several nutrients essential for plant growth have been identified and characterized. In this part of this continuing series the use of foliar sampling and analysis as a means of assessing and evaluating nutrient regimes within growing trees will be considered.

WHAT IS FOLIAR SAMPLING?

Simply defined foliar sampling consists of collecting a representative foliage sample (needles) from one or more trees in a plantation and analyzing this sample for the presence and amount of one or more of the several nutrients which have been determined as being essential for plant growth. Foliar sampling is based on the premise that the amount of a particular nutrient in plant tissue (foliage) is indicative of the concentration in the entire plant. Nutrient concentrations in plant tissue are believed to more accurately reflect the nutrient needs and balances of the plant than are soil analyses for the same nutrient. This is based on the fact that tissue concentrations reflect nutrients present in an available form in the soil. Total soil concentrations may be indicative of what is present, but do not necessarily represent what is present in an available form. Nutrient availability is dependent on several factors, including soil pH value, cation exchange capacity, and chemical form of the nutrient in the soil.

WHY USE FOLIAR SAMPLING?

The primary reason for completing a foliar tissue analysis is to obtain an indication of the nutrient status of a particular tree or plantation. As indicated, foliar nutrient concentrations reflect the availability status of soil nutrients, and better reflect what the tree is able to absorb. Soil testing is an excellent way of evaluating the total amount of essential nutrients present in the soil. Soil testing is particularly useful in evaluating nutrient concentrations and making general adjustments by adding appropriate fertilizer materials before trees are planted. By making additions of fertilizer materials which are only slightly or slowly soluble, or of compounds which do not readily move once in the soil, treatments such as tillage to incorporate these materials into the soil can be completed.

Foliar sampling is often viewed as a means of "fine tuning" plant nutrient needs. This is especially true for micronutrients which are required in very small or trace amounts. Foliar concentrations may indicate deficiencies exist although no visible external symptoms or other

indications are present. The results of foliar tissue analysis can also be helpful in evaluating nutrient balance or imbalance within the tree. In addition to being present in concentrations sufficient for normal growth to occur, the relative relationships between and among different nutrient concentrations are also important.

WHEN SHOULD FOLIAR SAMPLING BE DONE?

The results of several different studies conducted in the past indicates considerable variation in plant nutrient concentrations exist within an individual plant depending on the time of year the analysis is conducted. In perennial plants (trees) in temperate regions, plant nutrient concentrations are normally lowest during the dormant season. Early in the growing season most nutrient concentrations increase and will remain relatively high during the period of active growth. Towards the end of the period of active growth, concentrations for some nutrients such as nitrogen, phosphorus and potassium decrease as a percent of total needle weight, however, concentrations of other nutrients such as calcium and magnesium will actually increase. This increase reflects the accumulation of these minerals in structural components of needles such as cell walls.

Because of seasonal variations in nutrient content it is necessary to collect foliage samples at a time of the year when nutrient concentrations are relatively stable. Results from research studies indicate late summer-early fall foliar nutrient concentrations meet this concern and are indicative of the general nutritional status of the tree. Accordingly, in Michigan it is recommended that samples be collected in early to mid-September.

HOW SHOULD FOLIAGE SAMPLES BE COLLECTED?

In addition to the seasonal variations in tissue nutrient concentrations, variations also exist with respect to age of the tissue being sampled. Concentrations of nutrients such as nitrogen will be higher is younger tissue as opposed to older. In contrast nutrients such as calcium, on an ovendry-weight percentage basis, may be present in higher concentrations in older foliage. Variations have also been determined to exist between foliar nutrient concentrations at different locations throughout the tree. To obtain standardized results it is recommended that needles of the current growing season be taken from a location near the top of the tree. Usually twigs 3 to 5 inches in length are collected from an area located immediately beneath the top whorl of foliage. Two to three ounces of tissue should be collected from each tree. These twigs should be collected from trees which reflect the average condition in the plantation. If particular trees have been identified due to "off-color", reduced growth, or other symptoms, they should be sampled separately and a separate analysis completed. Following clipping, twigs should be placed together and a representative sample taken from all twigs collected in the plantation. The composite two to three ounce sample should be placed in a ice chest or similar container and mailed or taken to the analytical laboratory as soon as possible. It is necessary to keep the twig samples cool to minimize metabolic processes which may change after collection thereby possibly altering nutrient concentrations.

WHAT RESULTS WILL BE OBTAINED?

It is possible to have either a partial or complete nutrient analysis completed on foliage samples. If a partial analysis is done, usually the presence and amount of major or

will be determined. However, it is also possible to have an analysis for the minor or trace nutrients (micro-nutrients) as well. Usually for higher site demanding species such as Fraser fir, it is recommended that a complete analysis be completed. This enables actual concentrations to be determined and is also helpful in looking at nutrient balance.

Results from foliar analyses are usually presented in percentages based on an oven dry weight basis, or in parts per million. Most laboratories will report nitrogen, phosphorus, potassium, calcium, magnesium, arid sulfur concentrations as percentages of dry matter, while concentrations of zinc, iron, manganese, boron, copper, and molybdenum are reported in parts per million. In that 10,000 parts per million are equal to 1 percent, it is possible to convert either measurement from one form to the other.

HOW ARE THE RESULTS INTERPRETED?

The results of a foliar analysis, whether it is partial or complete, must be interpreted before they are meaningful to the grower. Interpretation is assisted by comparing the obtained results with results from other studies, or from "standards" which have been developed from research studies of the same species. For many species the availability of guidelines which reflect normal or acceptable foliar nutrient levels is limited. Very few studies are available which have specifically examined both major and micronutrient levels in Christmas tree species. Some studies have reported on nitrogen, phosphorus and potassium levels, and there is limited published information on acceptable micronutrient levels as a function of nitrogen content.

Results of a three-year study examining total foliar nutrient concentrations at both adequate and optimal levels were recently published (Fisher, 1996). A portion of the results of this study are presented as follows:

FOLIAR NUTRIENT CONCENTRATIONS
FRASER FIR

	Macro-nutrients (% odw)	
	adequate	optimal
Nitrogen	1.50-1.80	1.80-2.20
Phosphorus	0.14-0.24	0.24-0.33
Potassium	0.50-0.90	0.90-1.30
Calcium	0.20-0.40	0.40-0.65
Magnesium	0.04-0.10	0.10-0.20
Sulfur	0.10-0.17	0.17-0.22
	Macro-nutrients (% ppm)	
	adequate	optimal
Iron	30 - 80	80-120
Manganese	50-250	250-500
Zinc	20 - 45	45 - 65
Copper	10 - 15	15 - 30
Boron	10 - 40	40 - 60

No data is reported for molybdenum since it is essential only in extremely small concentrations and is rarely in deficient supplies in most soils.

These data provide a means of comparing individual nutrient concentrations with data obtained from a designed, replicated study. Differences between an individual analysis and these Michigan values can provide a basis for assessing existing nutrient levels, and for designing fertilization treatments to correct apparent deficiencies, it should be noted that results from a foliar nutrient analysis do not provide a ready recommendation for fertilizer additions. Rather, these data simple assess the nutrient status of an individual tree or a plantation at a point in time. It is obvious that fertilizer supplements should be considered when nutrients are present at levels below "adequate". However, the amount and form of fertilizer to apply should be influenced by factors such as soil texture and soil pH in addition to existing foliar nutrient levels. This is particularly true with micro-nutrients since soil chemistry exerts a significant affect on the availability of these nutrients to the tree.

One of the difficulties associated with interpretation of a foliar analysis and correction of observed deficiencies is the fact that data are not available which indicate how much of a particular fertilizer product should be added to change foliar concentrations of individual nutrients from one level to another. Research studies to evaluate changes in foliar nutrient concentrations as a result of different fertilization levels are being conducted. A few commercial laboratories and nutrient suppliers do make recommendations based on limited testing and grower experience. Because the difference between sufficiency and toxicity for many micro-nutrients is relatively narrow, it is recommended that growers be conservative in making applications to correct deficiencies or generally increase foliar nutrient levels.

SUMMARY

Foliar analysis can be an excellent means of assessing nutrient content and availability in Christmas trees It is complementary to soil testing, yet offers the advantage of being indicative of what nutrients are present in a form available to the tree. To obtain maximum benefit from such analyses it is essential that specific procedures be followed in collecting and handling foliage samples to minimize variation. Where samples of the same trees are made over an extended period of time, it is important that the same laboratory complete the analyses as well.

The results obtained from a foliar analysis do not readily translate to fertilization recommendations. However, it is possible to compare results with standards developed from research studies and to determine which nutrients are present in an inadequate supply. The need for supplemental fertilization treatments can be observed based on this information. Growers are urged to exercise caution in making fertilizer applications, especially of micro-nutrients since imbalances in nutrient concentrations may result. Such imbalances may actually be harmful to the tree since differences between sufficiency and toxicity are often quite small. As the results of continuing research studies become available, it is expected specific fertilization recommendations can be made which will result in changes of foliar nutrient levels from existing to desired concentrations.

Foliar Testing and Nutrient Analysis in Christmas Tree Production - Handout

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Why foliar testing?

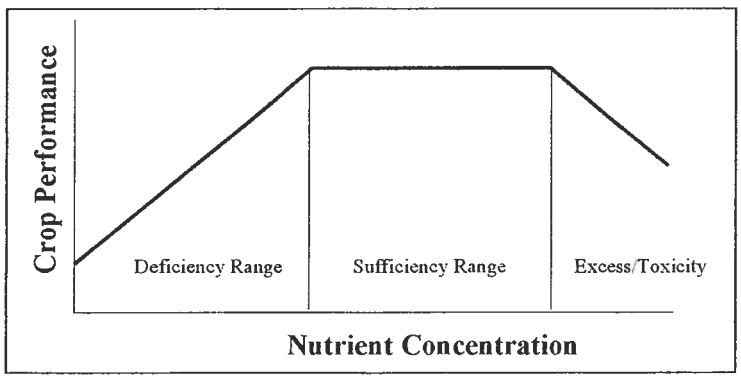
Foliar nutrient levels reflect what tree has actually absorbed from soil.
Foliar testing can indicate a problem before visual symptoms or growth reduction is evident.
Foliar analysis can be used to optimize nutrition and push production.

How to sample:

Collect separate "good" and "bad" samples to diagnose problems
Use composite samples for regular monitoring/optimization.
Sample in late fall: mid October through December.
Collect current years foliage (2-3 oz of needles).
Always sample from the same whorl (upper 1/3 of crown)
Never sample from the leader.
Always sample from the same cardinal direction (N).
Pluck needles (no bark or twig material!).
Mix composite samples thoroughly.
Assign sample name/number for identification.
Take detailed notes!!!
Minimize time between collection and shipping.
Keep samples cold and/or dry
Avoid contamination (perspiration, fertilizers, dirt, dust).

Results

Lab reports will give individual concentrations of nutrient elements on a dry weight basis.
Macronutrients will be reported as %, micronutrients as parts per million (ppm).
1% = 10,000 ppm
Many reports will rate the deficiency/sufficiency/excess of each element.
Interpret these with caution – be sure to ask testing lab what criteria they use to evaluate concentrations.



Interpreting results – individual nutrients

Compare concentrations of individual nutrients to established sufficiency ranges.

For Fraser fir there are several data sets to choose from:

Nutrient	NC State[1]	SAPMA Study (MI)[2]	GREEEN Study (MI)[3]
N	1.5 – 2.0	1.5 – 1.8	1.65 – 2.05
P	0.2 – 0.6	0.14 – 0.24	0.18 – 0.24
K	0.6 – 0.8	0.5 – 0.9	**0.6 – 0.8 (note change)**
S	0.08 – 0.2	0.1 – 0.17	0.11 – 0.14
Ca	0.45 – 0.6	0.2 – 0.4	0.33 – 0.55
Mg	0.1 – 0.2	0.04 – 0.1	0.08 – 0.11
Fe	40 – 300	30 – 70	45 – 60
Mn	30 – 300	100 – 300	100 – 600
Zn	18 – 75	25 – 50	No Data
Cu	5 – 10	3 – 15	No Data
B	18 – 30	10 - 30	No Data

[1] North Carolina State Extension. http://www.ncagr.com/agronomi/saaesd/fir.htm

[2] Fisher, J.H. 1996. Adequate nutrient ranges for scotch pine, Douglas-fir and Fraser fir Christmas trees in Michigan. Michigan Christmas Tree Journal. 42: 25-27.

[3] Rothstein, DE, and N Lisuzzo. 2003. Optimal foliar nutrition of Fraser fir Christmas trees in Michigan. Pages 19-21 In *Nursery, Landscape and Christmas Tree Research Projects and Educational Programs Bulletin.* Michigan State University.

Interpreting results – nutrient ratios

Balance, or ratios, among foliar nutrients, can be as important as individual concentrations, particularly important if you are trying to push growth.

Most important nutrient ratios related to N.

To calculate nutrient ratios simply divide concentrations from lab report, i.e. N/P = %N ÷ %P.

Make sure units are the same when comparing macro- and micronutrients.

Here is our best estimate of target N ratios for Michigan Fraser fir.

N/P	**less than 10**
N/K	**less than 2.8**
N/S	less than 15
N/Ca	4 - 6
N/Mg	20 - 25