Foliage nutrient levels for three Rocky Mountain tree species

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Foliage nutrient levels of three western conifers are presented for use as reference standards. By comparing nursery stock to these "ideal" seedlings, cultural treatments con be prescribed on a more scientific basis.

Chemical analysis of plant tissue has been widely accepted as a valuable tool for regulating crop nutrition. For agronomic crops, these tests are performed regularly during the rotation and fertilizer applications are scheduled accordingly. Nutritional reference standards have been developed for many agricultural species, providing an easy basis for comparison.

Plant tissue analysis can benefit tree culture in several ways. Visual deficiency symptoms, especially chlorosis, are difficult to interpret. Chemical analysis measures current levels of minerals on a much more sensitive basis. Many deficiencies cause growth loss but exhibit no outward symptoms. Even when symptoms are distinctive, the majority of growth loss occurs before the symptom is expressed. Nutritional analysis of seedling foliage can reveal incipient deficiencies early enough that corrective action can be taken.

Tree seedlings are much less demanding in their chemical requirements than are most agronomic crops. Even so, nutritional deficiencies have caused growth loss in tree nurseries, especially through hidden losses. Below-optimum nutrient levels may also predispose seedlings to attack by biotic pathogens. Maintenance of a proper chemical environment in tree nurseries could feasibly shorten rotations and thus provide considerable savings to nurserymen.

A major roadblock in tree nutrition is the lack of suitable reference standards. Nutrient levels and response curves have been developed for Canadian pulpwood species by Swan 11, 2, 3). Foliar nutrient concentrations for deficient and healthy forest trees were tabulated by Powers (I I and provide relative ranges for macro- and micronutrients.

Many of these studies have been conducted under laboratory conditions and do not reflect field conditions. Because of chemical differences in the soil environment, seedlings may contain varying amounts of plant nutrients. Ideally, reference standards should be determined at each tree nursery. The purpose of this study was to calculate foliage nutritional standards for the three principal tree species grown at Mt. Sopris Tree Nursery, Carbondale. Colorado.

Methods

Tree foliage samples were collected from commercial size seedlings of ponderosa pine *(Pinus ponderosa* Laws.), lodgepole pine *(P. contorta* var. *latifolia* Engelm.), and Engelmann spruce *(Picea engelmannii* Parry). Seedlings were chosen by the nurseryman for qualities of form, color, and caliper, they represented the "ideal" seedling desired at the end of rotation. The sample consisted of various seed sources from over the region to account for ecotypic variation. Pines were 2-0 whereas the spruce were 3-0 in age.

The seedling samples were wrapped in plastic and stored at temperatures slightly above 0°C to minimize losses due to respiration or biological decomposition. As soon as possible after collection, these seedlings were taken to a private chemical laboratory where the analysis was to be done.

The nutritional analyses were performed by Agricultural Consultants Laboratory of Brighton, Colorado. This laboratory was recommended for quality work and proved to be professional and reliable. Duplicate samples were used to test their precision and the results were very satisfactory. Seedling foliage was washed and oven-dried in preparation for analysis.

All standard macronutrients and micronutrients were measured in the seedling foliage. On the recommendation of a plant nutrition specialist, nitrogen and sulfur were measured as nitrate nitrogen and sulfate sulfur instead of their total amounts. These ions constitute the mobile form in the plant, providing a more sensitive indicator of the current status of these elements.

When the sample analyses were complete, results were tabulated by tree species and averaged to yield a mean for each element by species. These values were then compared to those reported in the literature.

Results and Discussion

Compared to the literature, macronutrient concentrations are similar to those reported for other species

(table 1), except for nitrate and sulfate for which there are no data. In forestry nutrition studies, these elements are usually reported as total nitrogen or total sulfur. Standards are needed for these two elements if they are to be used in forestry nutrition studies. Ideally, nitrogen and sulfur should be analyzed for both total values and those of the specific ion.

Micronutrient levels are extremely difficult to interpret and only wide ranges are provided as adequate levels (table 1). One interesting point disclosed by these tests is that iron levels are high for all tree species. Soils at Mt. Sopris are slightly alkaline and iron is usually not available under alkaline conditions (5).

Soil tests have traditionally been the diagnostic procedure for detecting nutrient deficiencies at Mt. Sopris Nursery. Soil analyses were performed every 2 years and fertilizer recommendations were based on these tests. Soil testing often does not accurately reflect plant nutrient status. An element may be present at adequate levels in the soil but may exist in chemical forms which are not available for uptake by plants. Soil chemicals may exhibit an antagonistic effect on each other which may also induce deficiency (5). Because of these problems with soil testing, an annual program of seedling foliage analysis has been initiated at Mt. Sopris Nursery to detect nutrient deficiencies or toxicities.

We hope that these results will encourage other persons involved in tree nutrition to have nutritional analyses performed. Every nursery should develop foliage nutrition standards for its particular site. These standards could then he used as references for cultural treatments, especially fertilizer applications. Foliage analysis should become a regular feature of nursery procedure

Table 1.—Plant nutrient concentrations in seedling foliage of three Rocky Mountain tree species

Elements	Units	Ponderosa pine	Lodgepole pine	Englemann spruce	Adequate levels [1]
MACRONUTRIENTS					
NO_3-N	ppm	20	89	252	unknown
P	pct.	0.16	0.17	0.22	0.10–0.30
K	pct.	0.43	0.34	0.37	0.50–1.60
Ca	pct.	0.32	0.64	1.50	0.12–0.70
Mg	pct.	0.14	0.14	0.15	0.07–0.20
SO_4-S	ppm	197	518	105	unknown
MICRONUTRIENTS					
Fe	ppm	222	381	415	50–100
Mn	ppm	161	702	1108	100–5000
Zn	ppm	90	265	105	10–125
Cu	ppm	10	6	7	4–12
B	ppm	21	51	38	10–100

[1] From R. F. Powers. See literature citation 4.

because these values provide the most comprehensive index of plant "health" available.

Summary and Conclusions

Chemical analysis of foliage from "ideal seedlings" can provide useful reference standards of seedling nutrition in tree nurseries. Through comparisons with annual tests of foliage nutrient status, fertilizer applications and other cultural treatments can he made on a scientific basis. This technique is a considerable improvement over the use of visual deficiency symptoms, which can he easily misinterpreted. Use of relevant ionic forms of certain elements, such as nitrate and sulfate, will provide a more meaningful index of current plant nutrition.

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