# TISSUE ANALYSIS

By

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Nurserymen in the Northeast are faced with the problem of producing seedling stock of plantable size and good quality during the growing season found at their own nursery. Thus, those of us in the far North find some of our stock too small at 2 years old, but too big at 3 years or perhaps out of balance. Those with nurseries a little farther south or at lower elevations are somewhat less troubled with this problem, but they also may have the same difficulties between one and two year old stock.

There isn't much we can do about the length of the growing season or its average temperature, but we can manipulate the plant's environment in many ways which will affect the growth pattern and the shape and size of the seedlings produced. Remember that the growing season for conifers is not the one used by agronomists for annual plants, but a much longer one extending for some species, almost from spring thaw to fall soil freeze up.

Over the years nurserymen have developed reasonably successful techniques for growing seedlings. Seed testing, seed sizing, seeding timing, soil fumigation, pest control, weed control, fertilization, irrigation, mulching, top and root pruning and more recently soil testing have been used by nurserymen to help them to control the size and quality of the seedlings they produce. Of equal importance to the morphological quality, is the physiological quality of the stock which strongly influences survival of plantations, but which remains hidden in a cloak of roots, stems, and foliage.

Of all the environmental conditions under our control, assuming adequate soil moisture, fertilization probably exerts the greatest effect on the stock. For this reason, testing soil for nutrients has become an increasingly

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popular tool to help predict the outcome of a particular planting in the nursery. Even without soil testing, attempts by the nurseryman to recognize soil fertility by experience has resulted in the designation of "spruce blocks" or "pine blocks" in the nursery.

Soil tests have not always been of as much help to nurserymen as they had hoped. This is not only the fault of soil tests, but of a combination of our too high hopes for a simple panacea and the great difficulty of interpretation of chemical data in a complex biological system. In this system we have a very imperfectly defined "ideal plant" as our end product.

The following quote from Soil and Plant Analysis for Tree Culture by Wilde, Voight, and Lyer states the problem very clearly.

> "The determination of the fraction of nutrients which is available to plants represents the most difficult problem of soil analysis. Regardless of the nature and strength of extracting solutions, chemical analyses provide only an approximation of the dissolving ability of root systems, especially roots of woody plants endowed with mycorrhizal fungi. This discrepancy has ledto the idea of utilizing the root systems of living plants as the natural extracting agent and determining the available nutrients by analysis of either entire tissues of plants or their foliage. On first sight this approach seemed to provide a simple solution to the problem of nutrient deficiencies and the use of fertilizers. Subsequent research of the last three decades, however, has disclosed that plant tissue or foliar analyses involve considerable complications."

Based on our limited experience at Saratoga with several years of soil testing and one year of tissue testing, I can tell you that I agree completely with that statement. However, the picture is not all black. We have several examples of the successful use of tissue analyses in New York. Heiberg and White 1951 used foliar analysis to detect potassium and magnesium deficiency in plantations of red and white pine and white and Norway spruce growing on a sandy outwash plain. More recently, E.L. Stone at Cornell University has used foliar analysis to help solve nursery problems. Phosphorus deficiency was twice diagnosed with the help of foliar analysis. The first time in 1958 at our Oak Orchard Nursery in western New York, the deficiency resulted from the destruction or lack of mycorrhizal fungi, and the second at Saratoga where we know that the mycorrhizal fungi were destroyed by the fumigants Vapam and Trizone. In neither case would soil analyses have revealed the cause of the trouble, since adequate amounts of phosphorus were present for growth

of seedlings with mycorrhizal root systems. This spring Stone found toxic levels of arsenic in 3-0 red pine foliage from our Lowville Nursery. Only this month, he also reports confirmation by foliar analysis of a magnesium deficiency in an oat crop at this nursery.

Tissue tests as a tool for diagnosis or confirming a visual diagnosis of crop ailments has so far been the main use made of these tests at our nurseries. There is, however, the possibility of using foliar analyses for the regulation of nutrient applications on seedling crops. The pomologists are leading the field in this use of foliar analysis. In a long term crop like fruit trees this seems to be working quite well. It is more like the kind of thing Heiberg and White did with plantation trees. Pomologists sample tree foliage during the period of slow nutrient change between bud set and the beginning of leaf dormancy. This slow period is about the last of July or the first part of August in New York. Fertilizer applications can be made at this time to assist the tree with the crop already on it, and to insure good bud development for the next year.

It seems unlikely that the late season sampling of conifer seedlings recommended by most investigators would yield much information that could be used to direct a nutrient application to our short term crop. So much depends on our first year growth, that we can't wait long to find out how we are doing. On Saratoga's sandy soil we must start nitrogen and potassium fertilizer applications a couple weeks after seedling emergence if we are to get maximum first year growth. We are concerned with only nitrogen and potassium because phosphorus is placed by the seeder at sowing.

To find out if we can make use of the results of tissue analysis made at short intervals during the growing season, we have started a tissue testing program, along with our soil testing. We hope eventually to quantify the nutrient requirements of our species and to develop a fertilizer program based on these requirements. A measure of the effectiveness of these applications may be possible by routine analysis of stock for height, weight, form and nutrient content.

Stock of various ages and treatments is being analyzed for nitrogen, phosphorus, potassium, calcium and magnesium. Sampling is at two week intervals. Plants are sorted into two groups, the largest and the smallest by weight and analyzed separately. Plant parts are also analyzed separately. The analyses, which are not very difficult, are made by standard volumetric, colorimetric or flame photometric methods.

The large university laboratories use spectrographic analysis for all except nitrogen.

We don't have all our analyses finished yet. The analysis for total nitrogen by the Kjeldahl method is so slow that we won't have those results before late winter. However, a few observations based on the results so far are justified.

1. We find that the ranges in nutrient content of red pine foliage agree with those published by Armson & Carman in Ontario. That is, .6 – .9% potassium for 2-0 stock.

2. Red pines from the same bed showing a five fold difference in seedling weight have about the same % content of phosphorus and potassium. It seems that factors other than nutrients are involved here.

3. Foliage phosphorus on 2-0 red pine is only about half that found by Armson and Carman. This may be a dilution effect. Soil fumigation has created a serious phosphorus deficiency at Saratoga which has been overcome by phosphate applications. It is possible that the effect may last into the second year. No phosphorus deficiency symptoms are visible on these seedlings.

It is increasingly apparent that the complexity of interpretation referred to by research workers is going to make formulation of simple recommendations a difficult task.

The use of tissue analysis to determine the physiological grade of seedlings may some day be of great importance. The tests used to determine the physiological condition of stock may measure the common nutrient elements, but they will surely measure the complex organic compounds which control the plant's reaction to its environment. This is a complex subject best investigated by a research organization. About the only thing of this kind that we plan at Saratoga is the study of changes in the sugar and starch quantities in seedlings during trials of packaging materials. We hope to discover whether changes in the amounts of these compounds can be correlated with seedling survival in plantations, thus giving us a screening tool for packaging trials.

To summarize: (1) Tissue tests can be a useful tool when used with other observations and tests to diagnose seedling ailments. (2) These tests appear not very satisfactory for short term regulation of nutrient applications, but may be useful to establish a fertilizer prescription. (3) In the future, tests may be our only way to identify the various physiological grades of nursery stock.

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