by Dr. Bert Cregg

CONIFER NUTRITION

LIKE ALL PLANTS, CONIFERS REQUIRE ADEQUATE NUTRITION TO STAY HEALTHY AND GROW PROPERLY. HOWEVER, SOME ASPECTS OF CONIFER NUTRITION DIFFER FROM THOSE OF BROAD-LEAVED, DECIDUOUS TREES. THIS EDITION OF *CONIFER CORNER* DISCUSSES THE BASICS OF PLANT AND SOIL NUTRITION AND HIGHLIGHTS SOME WAYS IN WHICH CONIFERS DIFFER FROM BROAD-LEAVED TREES.

Bare Essentials

Over the years, scientists have identified the chemical elements that are needed for plant growth. These 16 elements are referred to as essential elements. In addition to the essential elements, nickel (Ni) and silicon (Si) have been identified as beneficial to plant growth. Three of the essential elements (carbon, hydrogen and oxygen) are derived from air and water. The remaining elements are supplied by the soil (see Table 1).

(Photo credit: Ronald Hallett, Canadian Forest Service)

(Photo credit: Ronald Hallett, Canadian Forest Service.)

(Far left): Test, don't guess. Soil and tissue sampling are critical managing nutrition and diagnosing nutritional problems. Be sure to request pH along with any soil analysis. (Above left to right): Needle twisting induced by copper deficiency; Yellow tipping of conifer needles associated with magnesium deficiency; Phosphorus deficiency symptoms may include a purple cast to needles, often referred to as "purple heart."

Typically, essential elements are divided into those needed in the largest amounts (macronutrients) and those needed in relatively small amounts (micronutrients). In analyzing plant tissues for nutrients, analytical labs usually report macronutrients in percent (%) dry weight, whereas micronutrients are usually expressed in parts per million (ppm).

The likelihood of a nutrient element becoming limiting depends on plant uptake relative to soil supply. In most situations, nitrogen is the element most likely to become limiting. This is due to two factors: (1) nitrogen is the element required by plants in the largest amounts and (2) soil nitrogen is highly dynamic and subject to losses through microbial activity. The growing environment (field versus container) also impacts conifer nutrition. Aside from nitrogen, most field soils are able to supply adequate nutrients for plant growth. Key exceptions are sandy soils, which have low ability to supply cations such as potassium and magnesium, and high pH soils that limit uptake of iron, manganese and magnesium. Growing trees in containers provides an additional challenge since most container media has low inherent fertility, and all nutrients must be supplied either through a constant-feed program or through controlled release fertilizers.

Nutrients: Conifers vs. Broad-Leaved

In designing a nutrition program for conifers, it is important to remember that there are several key differences in nutrient relations between conifers and broad-leaved trees.

Foliar nutrient levels and nutrient requirements. In general, foliar nutrient levels are lower in conifers than in broad-leaved trees. For example, adequate foliar N levels in conifers are usually around 1.5–2.2 percent dry weight, whereas foliar levels in broad-leaved trees usually range between 2–4 percent. Compared to broad-leaved trees, conifers have relatively low nutrient requirements. This make sense when we consider that broad-leaved trees need to 'rebuild' their entire photosynthetic factory each spring, while most evergreen conifers retain three to six years' worth of needles. In fact, ecologists suggest that their low nutrient requirement is one of the key traits that enable evergreen conifers to dominate vast portions of cold, boreal regions of the world where nitrogen availability is limited.

Soil pH. With a few exceptions, conifers grow best on soils that are more acidic than optimum soil pH for deciduous trees. For example, Fraser fir is native to sites in North Carolina with soil pH as low as 3.5. The optimum pH for most conifers is around 5.5; most broad-leaved trees grow best a pH 6.5. This phenomenon is due largely to reduced ability of conifers to take up nutrients as pH increases.

In some of our recent research on exotic firs, we found that needle chlorophyll content and photosynthetic efficiency of container-grown firs dropped rapidly as pH increased above 6. The overriding effect of soil pH on conifer nutrition is difficult to overstate. Anytime a nutrient problem is suspected in conifers, soil pH heads the list of factors to investigate. If soil pH is higher than 5.5–6, consider applying elemental sulfur or fertilizing with ammonium sulfate to reduce soil pH. Note that the effect of sulfur on pH is transitory. To avoid over-correcting pH, limit sulfur applications to 400 lbs per acre per year (see Table 2). Approximately 2.6 lbs of ammonium sulfate is needed to provide the same acidifying effect as 1 lb of sulfur. Remember that ammonium sulfate also contains 21 percent N that needs to be included in your nitrogen management program.

Symptoms. Diagnosing nutrient deficiencies in conifers can present unique challenges. For instance, many standard symptoms used to diagnose broad-leaved plants, such as inter-venal chlorosis or marginal necrosis, do not apply. Nevertheless, certain nutrient deficiencies often result in symptoms in conifers that may aid in diagnosing nutrient problems:

- **Nitrogen deficiency—**general chlorosis (yellowing) of the entire plant. Since N is mobile within the plant, deficiency may show up in older foliage first.
- **Phosphorus deficiency—**may show variable symptoms, but one of the most diagnostic is a purplish cast to foliage sometimes referred to as "purple heart."

- **Magnesium deficiency**—conifers deficient in magnesium may show a pronounced chlorosis on the tips of the needles.

Micronutrients can sometimes be deficient to the point of causing visible symptoms. Among the most common micronutrient problems in conifers are iron, manganese, copper and boron. Like N deficiencies, iron deficiencies cause needle chlorosis; however, iron is less mobile and symptoms may appear on new foliage first. Manganese is sometimes deficient in conifers in Michigan, especially on high pH sites. Copper deficiency can lead to a distinctive symptom of twist needles near the shoot apex, Boron deficiencies may be indicated by soil or foliar analysis. Conifer growers and landscapers should remember that boron has a narrow window between sufficiency and toxicity. If boron is recommended for your site, fertilize carefully, double check equipment calibration and consider split application to allow time to observe response to the initial application.

Table 1. Sufficiency concentrations for essential macronutrient and micronutrient in conifers

Macronutrient	Chemical symbol	%
Nitrogen	N	1.4–2.2
Phosphorus	P	0.2–0.4
Potassium	K	0.4–1.5
Calcium	Ca	0.2–0.4
Magnesium	Mg	0.1–0.3
Sulfur	S	0.2–0.3

Micronutrient	Chemical symbol	Parts per million (ppm)
Iron	Fe	60–200
Manganese	Mn	100–250
Zinc	Zn	30–150
Copper	Cu	5–20
Boron	B	20–100
Chlorine	Cl	2–20
Molybdenum	Mo	0.25–5

Source: US Forest Service Container Nursery Manual

Diagnosis of Conifer Nutrient Problems

As noted previously, managing nutrition in conifers is quite different from the nutrition of broad-leaved trees and shrubs. One characteristic that is similar in both cases, however, is the process for identifying and diagnosing suspected nutritional problems.

Identifying nutrient problems in nurseries or in landscape plants can often be a difficult chore and can involve significant detective work. Although many nutrition guides and extension publications imply that nutrient deficiencies can be diagnosed from visible symptoms, in reality the situation is rarely that simple. If you suspect a nutritional problem, the following steps should be useful in sleuthing the problem.

(1) **Eliminate other causes.** Some nutrient deficiencies can look like other biotic or abiotic injuries. For example, needle scorch caused by drought or high temperature may result in needle browning that may suggest a nutrient problem. Eliminating environmental causes will require knowledge of the history of the site. Has the site been flooded recently? Has rainfall or irrigation been adequate or has the planting been subjected to drought stress? Is there evidence of insects or disease? Remember, many insect pests are extremely small and may require a hand-lens to see. Also, the pest organism may have moved on and left only its damage behind.

(2) **Consider cultural history.** What has been done on the site recently? Has fertilizer been applied? Remember, some fertilizers such as ammonium nitrate have a relatively high salt index and can cause salt injury. Some elements like boron or chloride can cause a direct toxicity injury, while others can interfere with uptake of other elements (e.g., potassium-induced magnesium deficiency). Have there been any grade changes on the site? Raising a grade can deprive roots of oxygen whereas reducing grades can remove surface feeder roots and lead to drought injury. Have any herbicides been applied recently? Some herbicides that are safe to use over conifers when they are dormant may injure shoots during active growth.

(3) **Check visible symptoms.** As indicated earlier, many nutrient deficiencies have characteristic symptoms that can aid in diagnosis. Also, certain trees are prone to specific nutrient disorders (e.g., pH-related nutrient problems in firs). However, many nutrient disorders and abiotic or biotic stresses have similar symptoms. Therefore, visible symptoms alone may not be sufficient to diagnose a nutrient problem.

(4) **Test, don't guess.** Soil and foliar analysis are usually required to make a complete diagnosis of a nutrient problem, and even these techniques have limitations.

(5) **Sample the soil.** Numerous private labs and the MSU Soil and Plant Nutrient lab conduct soil nutrient analyses. To collect a soil for analysis, use a soil probe, shovel or trowel to collect 10 to 15 samples

Table 2. Approximate pounds of sulfur per acre to lower soil pH by 1 pH unit

Soil Texture	Pounds per acre
Sand (CEC = 5)	435 to 650
Loam	870 to 1300
Clay (CEC = 25)	1300 to 1750

Source: Whitworth, 1995

in the area of interest. Scrape away surface mulch and organic matter and sample to depth of seven inches. Mix the samples together in a large, clean bucket and pour the samples into a soil test box (available from county extension offices or the MSU Soil and Plant nutrient lab) or use a plastic zip-lock bag. If only part of a planting is showing problems, collect a separate set of samples in the affected and unaffected areas. Label one sample as 'good' and the other as 'bad'. Depending on the lab, results for a standard soil test will usually include soil pH, available phosphorus, potassium, calcium and magnesium and lime and fertilizer recommendations. Additional elements can also be determined, if requested. While soil sampling is useful and necessary, it is important to realize there are limitations. First, nitrogen, the element that is used in the largest amounts and the most limiting, is difficult to assess in soil samples because N is dynamic in the soil and is constantly being converted among various fractions. Therefore, N is not reported on standard nutrient tests. Secondly, a nutrient test may not reflect availability of certain elements. For example, a soil may have adequate levels of iron or magnesium, but plant availability may be limited due to high soil pH.

(6) **Sample the foliar.** In theory, analysis of foliar nutrition provides the best means to assess the nutrient status of plants in a nursery or landscape. Foliar sampling integrates soil supply and availability with plant uptake factors. The limitation for foliar sampling in nurseries and landscapes is that a large number of different species are dealt with. Unlike agronomic crops such as corn or wheat, good reference guidelines do not exist for the various elements for all landscape plants. Foliar nutrition of conifers is further complicated by the fact that nutrient levels vary with needle age class and with time of year. The most common reference point for conifer nutrition is to sample current-year needles in the fall. A brown paper lunch bag about half full will provide an adequate amount of material for sampling. One of the most effective ways to use foliar sampling is to collect separate samples from 'good' and 'bad' plants. This will allow a side-by-side comparison when the results are returned.

Summary

Plant nutrition is critical to overall plant performance and health. Conifer nutrition is determined by complex and dynamic interactions between the soil and the plant. Likewise, diagnosing plant nutrition problems is often a complex process. This requires gathering information on the history of the site—especially recent cultural treatments—and careful observation of potential abiotic or biotic problems. Because reference information on nutrition of landscape conifers is often sketchy, the best approach for soil and foliar sampling is to collect separate samples of areas and plants that are growing well and those that are having problems. By comparing nutrient status of 'good' and 'bad' samples, the nutrients that are limiting will often become evident. In addition, underlying causes such as high soil pH may also become evident.

For more information on soil and plant sampling, contact your county extension office or the MSU Soil and Plant Nutrient Laboratory, A81 Plant and Soil Science Building, East Lansing, MI 48824-1325.

Dr. Bert Cregg is an associate professor at the Michigan State University Department of Horticulture and Department of Forestry.