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Nutrient Deficiencies in Trees

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Our knowledge of the nutrition of ornamental trees is sparse. Most research has been conducted on juvenile plants or seedlings that are grown for a few weeks or months in greenhouses, growth chambers or even in nurseries where the controlled conditions are quite different than the environmental conditions encountered in nature and those found in larger, developing trees. Furthermore, most of the literature on nutrient deficiencies is from crop science or horticultural plants, not trees. The information available for trees is at best fragmentary. This fact sheet provides information on some of the nutritional deficiencies found in urban trees in Tennessee and the responses of trees to those deficiencies.

Most of our native soils in Tennessee do not have nutrient deficiencies. Total elemental analysis of 13 soil profiles representing six of the eight major land resource areas in Tennessee established that elemental concentrations were well within the normal ranges for plant growth (Ammons et al. 1997). However, deficiencies do occur in highly altered soils of urban landscapes where topsoil has been removed, soil has been compacted, drainage altered or unconsolidated soil fill material has been added. Deficiencies can also occur in many unaltered soils.

Sixteen essential elements are required for plant growth. An element is considered essential if plants cannot complete their life cycle without it, and if the element is directly involved in the metabolism of the plant. Three elements, carbon, hydrogen and oxygen, are readily available from air and water. The remaining 13 elements are obtained from the

Alan S. Windham

Iron chlorosis of pin oak (*Quercus palustris*) leaves.

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Healthy and manganese deficient leaves of cottonwood (*Populus deltoides*).

Macronutrients

Mineral Element	Plant Process	Visual Symptoms of Deficiency
Nitrogen (N)	Production of amino acids and protein. Synthesis of chlorophyll. Growth regulator. Nucleic acids.	Chlorosis of older leaves progressing from pale green to yellow. Colors may mottle. Occasionally, scorching of leaf tips and margins.
Phosphorus (P)	High-energy bonds (ATP - adenosine triphosphate) associated with energy transfer. Nucleic acids.	Accumulates anthrocyanins, a leaf color pigment causing a blue-green or a red-purple coloration. Flowering and fruiting reduced. Lower leaves tend to turn yellow.
Potassium (K)	Opening and closing of stomata, enzyme activity, protein synthesis, photosynthesis and cell growth.	Leaf margins become scorched, turn brown or mottled and curl downward. Chlorosis first begins at the tips and margins of leaves and progresses toward the base.
Calcium (Ca)	Meristematic tissues of the root tips, bud elongation and development of fruits. Pectin synthesis and cell wall elasticity.	Chlorosis and necrosis of leaves, distorts growth of root tips and shoots.
Magnesium (Mg)	Enzyme systems and chlorophyll synthesis.	Chlorosis of leaves followed by a brilliant yellow color between the leaf veins.
Sulfur (S)	Plant hormones. Three amino acids in synthesis of proteins.	Similar to N deficiencies. Yellowing and necrosis of young leaves resulting from inhibition of protein synthesis. Some stunting of shoot and root tips.

Micronutrients

Mineral Element	Plant Process	Visual Symptoms of Deficiency
Iron (Fe)	Synthesis of chloroplast proteins and various enzymes.	Veins of leaves remain dark green while the interveinal tissues become chlorotic turning light green to yellow. Dieback of shoots is also common. Easily confused with Mn and Mg deficiencies because chlorosis symptoms are similar.
Manganese (Mn)	Photosynthesis, respiration, enzyme reactions	Similar to iron symptoms. Older leaves develop pale, brownish or purple spots.
Boron (B)	Sugar translocation, nucleic acid synthesis and pollen formation.	Death or rosetting (witches broom) of apical shoots. Leaves are dwarfed and discolored, becoming chlorotic or necrotic. Terminal and lateral buds and root tips eventually die.
Zinc (Zn)	Plant growth regulators, particularly auxin and indoleacetic acid (IAA). Enzyme reactions.	Chlorosis, bronzing, or mottling of younger leaves. Abscission of older leaves. Terminal nodes have dwarfed or rossette leaves that are closely spaced (short internodes), small and discolored.
Copper (Cu)	Enzymes	Permanent wilting of leaves. Cu deficiencies difficult to visually detect.
Molybdenum (Mo)	Enzymes in nitrogen fixation.	Few symptoms. Pale color with some scorch on margins of lower leaves. Interveinal chlorosis similar to symptoms of N deficiencies.
Chlorine (Cl)	Photosynthesis	No visual symptoms.

Table 1. Sources of fertilizer amendments and application methods to control nutrient deficiencies.

Mineral	Source	Application
N	Ammonium, urea, nitrates	Ground
P	Superphosphate, rock phosphate	Ground
K	Potassium salts (KCl) and sulfate	Ground
Ca	Lime	Ground
Mg	Dolomitic limestone, epsom salts	Foliar spray (salts) or ground
S	Various sulfates, soil organic matter	Ground
Fe	Iron sulfate	Foliar spray (sulfate) or ground
Mn	Sulfates	Ground
B	Borax or boric acid	Ground or foliar spray
Mo	Sodium molybate	Ground or foliar spray
Zn, Cu	Sulfate	Ground or foliar spray

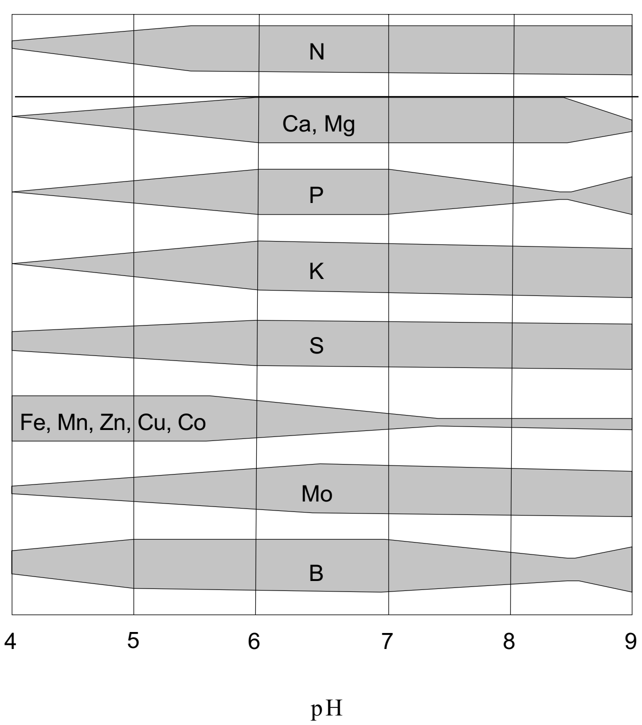

Figure 1. The relationship between soil pH and the availability of plant macro- and micronutrients. Modified from Barnes et al. 1998.

soil complex. Six of these elements, called macronutrients, are required in fairly large quantities in plants, usually in excess of 1,000 parts per million (ppm). These are nitrogen, phosphorous, potassium, sulfur, calcium and magnesium. The other mineral nutrients, including iron, boron, manganese, zinc, copper, chlorine and molybdenum, are known as micronutrients and are required in smaller quantities of usually <200 ppm.

Damage by insects and disease can mimic nutrient problems resulting from **chlorosis**, an abnormal yellowing of plant tissues that results from inadequate chlorophyll synthesis, or **necrosis**, death of plant tissue. Herbicide toxicity can also mimic nutrient deficiency. Your local county Agricultural Extension office can assist you with problem identification.

A few common visual symptoms of nutrient deficiencies are small chlorotic leaves, dead areas of leaf tips and margins or between veins, dieback of stem tips and twigs, bark lesions and excessive gum formation.

If you suspect a nutrient deficiency, the first step is to have your soil tested. Soil tests will give you baseline information on the probability of response to fertilizer and the amount of fertilizer to add. Even though nutrients may be present in sufficient elemental quantities, they may be in a form that is unavailable to plants. In general, pH affects the solubility of several elements (Figure 1). For example, iron and manganese precipitate in high pH, alkaline soils, decreasing their solubility, and thus their availability to plants.

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Healthy (left) and magnesium deficient foliage of *Quercus* spp.

Mark Halcomb

Nutrient deficiency in river birch (*Betula nigra*) due to an acidic pH level.

Phosphorus also becomes more unavailable in alkaline conditions, because it forms complexes with calcium to form insoluble calcium phosphates. Alternatively, calcium and magnesium are frequently deficient in acidic, lower pH soils. Nutrients such as sulfur tend to be deficient in soils with low organic matter.

Once the soil test results are obtained, they should be interpreted professionally at the Extension office or by other knowledgeable professionals to prescribe treatments that rectify the nutrient deficiency. Most prescriptions will be to modify the pH of the soil to make certain nutrients more available (such as adding lime to increase alkalinity or acidifying agents to lower pH) or to add fertilizers by ground applications or foliar sprays (Table 1). With more than 2,000 different formulations of fertilizers available, these professionals can recommend the formulation and amount that will best satisfy your specific soil situation. Generally, the addition of fertilizer as nutrient amendments is a temporary rather than a permanent cure for nutrient deficiencies and should be re-applied periodically.

The role of each of these nutrients in plants and the visual symptoms if that nutrient is deficient are reviewed in the accompanying table.

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