IRON DEFICIENCY CHLOROSIS OF SHADE TREES

by Dan Neely

All healthy trees with a few prominent exceptions are green in color. Many factors may interfere with normal plant metabolism and result in failure of the plant to produce the usual amount of green pigment known as chlorophyll. When chlorophyll production is below normal, the yellow pigment present in all green tissue becomes evident, giving the plant a yellowed appearance which is called chlorosis.

Although chlorosis may be the result of unfavorable environmental conditions, it is most often due to a deficiency, or in rare cases an excess, of some nutrient such as nitrogen, calcium, magnesium, manganese, iron, boron, or zinc in the soil. All deficiencies eventually result in chlorosis symptoms.

Iron deficiency chlorosis has been recognized in various parts of the world for over a hundred years. It was established in France in 1843 that plants which are deprived of an adequate supply of iron failed to develop chlorophyll and became chlorotic. A German in 1886 established that iron is an essential element for growth of higher plants. A South African in 1912 related iron chlorosis to an excessive amount of calcium carbonate in the soil. "Lime-induced" chlorosis is the term often used to denote iron chlorosis that develops in plants grown on naturally calcareous soils.

The symptoms of iron chlorosis in trees are a yellowing of the leaf blade in the areas most removed from the veins. The yellowing may range from a yellow green to a lemon yellow or nearly white in the extreme. Any green present in the leaf will remain along the veins. In early stages of deficiency the leaves may be normal in size and yet be definitely yellow. This frequently is the case when only a portion of the tree is chlorotic. Leaves that emerge and expand late in the growing season tend to be more yellow than leaves that emerged earlier. This often results in green leaves on the early part of the current season shoot growth and leaves progressively more yellow toward the twig tip.

As the deficiency becomes more severe, results of the shortage of chlorophyll and food production in the leaf become evident. Leaves become progressively smaller. Necrotic areas are observed between the veins similar to that found in leaf scorch due to a shortage of water. Shoot growth is stunted. Trees chlorotic for two or more years frequently develop dieback of twigs. In larger trees yellowing of leaves and dieback occur first in the tree top or at the ends of long branches. Apparently normal primary buds often fail to open. Secondary and adventitious buds closer to the trunk produce short compact, pale green shoots. Over a period of years, unless treatment is given, the trees die.

In areas where lime-induced chlorosis occurs, a nonavailability of iron is noted both in the soil and in the plant. Chemical tests often reveal as much or more iron in chlorotic plants as in green plants. Unfortunately the iron is firmly bound and cannot be used. Another factor that makes a constant supply of available iron essential is the failure to iron to be translocated or exchanged in the areas of physiological activity. Once used, iron is bound. Other nutrients are constantly mobile and are found primarily in the growing parts of the plant.

Several genera and species of shade trees and woody ornamentals suffer from iron deficiency, oaks and maples are by far the most susceptible, with oaks heading the list. Jacobs (2) list of susceptible trees include: pin oak, red oak, black oak, swamp white oak, white oak, willow oak, mossy cup oak, yellow birch, canoe birch, wild black cherry, mazzard cherry, red maple, silver maple, sugar maple, sweet gum, flowering dogwood, American elm, American holly and white pine. I can add horse chestnut, Norway maple, London plane, cottonwood, walnut, eucalyptus, yellowpine, Jackpine, and bald cypress. The susceptible shrubs listed by Jacobs are forsythia, rhododendron, azalea, magnolia, hydrangea, and rose.

Since man learned over 100 years ago that the addition of iron to plants would often correct chlorosis, many studies on control measures have been published. Although materials and methods have improved over the years, perhaps the most practical solution to lime-induced chlorosis is learning to live with it. We know that most naturally calcareous soils are inherently soils which will induce iron chlorosis in plants. The causative factors of iron chlorosis must be recognized and alleviated, not aggravated. Plant species must be selected and developed which are resistant to iron chlorosis.

When iron chlorosis can not be avoided it can be corrected. The iron source first and most often used in treatment of deficiency is iron sulfate. It is abundant, cheap, and readily available. Unfortunately it is not the most effective. The development of synthetic iron chelates in the 1950's has improved control recommendations greatly. Iron chelates are water soluble forms of iron that do not precipitate from solution once added to the soil or tree. Iron thus becomes mobile in the soil and in the plant. The iron attached to metal chelates can be absorbed by plant roots. Specific chelates have been developed for use on alkaline soils and for use on acid soils. Wallace (6) recommends FeEDDHA, commercially available as Sequestrene 138Fe, for use in correcting lime induced chlorosis.

Lime induced chlorosis was first identified as an iron problem following a foliar application of iron sulfate to grapes in 1854. Correction of chlorosis by iron sprays has been through the years usually only moderately successful. An example of widespread and quite effective use of iron sprays is in the pineapple industry where plants are sprayed weekly or biweekly with iron sulfate. More often than not with other species of plants spraying has resulted in green spots or speckling of leaves with only a partial correcting of the iron chlorosis. Although some iron chlorosis problems are being satisfactorily solved with chelate sprays, reputedly effective sprays have not always proven to be consistent. There is not sufficient basic information on either the behavior of iron in leaves or on the penetration of iron into leaves to permit formulation of a completely satisfactory cure by foliage sprays for iron chlorosis.

Since iron chlorosis is often caused by alkalinity, it would seem that acidifying the soil would correct the problem. Changing pH of soil in pots can be done; changing pH of soil in the field is difficult and expensive, if not impossible. Addition of sulfur, aluminum sulfate, ammonium sulfate, and sulfuric acid to soil along with iron sulfate have decreased deficiency symptoms in some tests. Scientific results are inconclusive. Results in trials by arborists are inconsistent.

Iron chelates for use in soil treatments have been given much attention in recent years. Expense has limited use of chelates to high value crops and ornamental plantings. There are some plant species, however, for which iron chelates have not satisfactorily corrected chlorosis by soil applications. New chelates are being evaluated each year.

The remaining control measure for correcting iron chlorosis involves injection of iron suspensions or solutions or implantation of iron salts into the trunk of affected trees. Injection and implantation have both been used effectively in trees for 75 years. Treatment in this way corrects chlorosis within 2 to 4 weeks. Recovery is temporary, however. Trees remain green for 2, 3, or more years, then must be retreated. Once the implanted or injected iron is depleted, the tree reverts to the chlorotic condition. An implantation procedure was proved effective on thousands of fruit trees in California by Bennett (1) and described in 1931. Ferric citrate, a natural chelate, was the most effective iron compound tried.

Although injection and implantation treatments have consistently given the most prompt and thorough correction of iron chlorosis in scientific studies, some authorities are hesitant to recommend this method. Objections center on the numerous holes that must be routinely drilled into the trunk, sap leakage from the holes, toxicity to the cambium where iron salts are inserted and toxicity to leaves when too much iron is applied at the wrong time to sensitive plants. In my experiments on pin oak, no plant injury symptoms were observed on treated trees regardless of time of treatment, source of iron, or quantity of iron implanted. Plastic cartridges containing iron effectively sealed the implantation holes and prevented sap leakage on to the bark surface. Callus tissue closed most implantation holes within 1 year.

Complaints from nurserymen, arborists, and homeowners concerning the lack of consistent success in correcting iron chlorosis in trees prompted further work by Schoeneweiss (4) and Neely (3) at the Illinois Natural History Survey and Smith (5) at Ohio State University.

Recommendations

Soil treatment.—Excellent results without foliar burn have been obtained with feEDDHA at a rate equivalent to 10 pounds of Sequestrene 138Fe per 200 gallons of water per 1000 square feet of soil. This should be considered the maximum rate for highly alkaline soil, and a lower dosage may be sufficient in soils which are neutral or slightly alkaline. The material is injected into soil to a depth of 12-15 inches with a root needle and hydraulic pump or hydraulic sprayer operating at 150-200 psi pressure. Injection sites are placed at intervals of 2½ feet in a series of parallel lines 2½ feet apart throughout the area to be treated. There should be approximately 160 injection sites in each 1000 square feet. Each injection site should receive 1.2 gallons of water. Treat all the soil beneath the branch spread of the chlorotic tree. Best results are obtained from April, May, or June treatments. Treatments remain effective 2, 3, or more years.

Trunk implantation (for pin oaks only.)—Treat trees with gelatin capsules containing ferric citrate or ferric ammonium citrate in April, May, or June. Trees may be treated while still dormant or after leaves appear. The dosage is based on tree size, as is given in this table.

Trunk (dbh) *(in.)*	**Capsule size** *(filled w/iron salts)*	**Distance between holes** *(circumference in.)*
1-4	No. 2	2
4-12	No. 000	3
12 and up	1/8 oz.	4

Implantation holes are placed in the trunk at different heights (1-3 feet above the soil) around the entire circumference. Hole size and depth must be sufficient to place the iron-containing capsule entirely in the wood of the trunk (not in the bank). Properly installed MEDICAPS (which contain iron citrate salts) will seal the implantation holes. Otherwise close the holes with doweling discs, corks, grafting wax or asphalt to prevent sap leakage. Water the trees thoroughly immediately after treatment and during dry periods in the summer.

Literature Cited

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ABSTRACT

Tinus, R.W. 1975. **Growth retardants control development of deciduous nursery stock.** Tree Planters' Notes 26(1):5-7.

Many nurseries growing deciduous tree seedlings find that their stock reaches the desired size at mid-growing season. It would be valuable to have a means to prevent it from growing larger. Unsold stock that grows an additional full season may become so large that it must be destroyed. In this study two growth retardants were tested for nursery use to control size of five hardwood species. Alar slowed growth of lilac and cotoneaster. Slo Gro stopped growth of Siberian elm, and slowed growth of honeysuckle and cotoneaster. Chemicals were less effective than undercutting on green ash.