PLANT PATHOLOGY IN THE LANDSCAPE SERIES

Iron Chlorosis of Trees and Shrubs

Authors:
Dr. Janna Beckerman,
Botany & Plant Pathology
Lindsey Purcell, M. Ed,
Forestry & Natural
Resources

Many trees, shrubs, and other ornamental plantings in Indiana and throughout the Midwest suffer from iron deficiency caused by high pH (alkaline) soil (Fig. 1). Soil pH affects plant growth directly and indirectly by affecting availability of essential nutrients and microbial activity. One of these nutrients is iron, an essential plant nutrient that is required for the production of chlorophyll. Chlorophyll is necessary for photosynthesis and gives plants their green color. Iron (and manganese) deficiency results in leaf yellowing (chlorosis); over time, scorching of foliage, dieback and even death of the tree or shrub can result (Fig. 2).

Figure 1. Pin oak leaves with typical symptoms of iron chlorosis. The leaf veins remain green while the tissue between the veins turns a pale yellow.

Symptoms

Chlorosis is one of the earliest observed symptoms of this disorder and first appears on the newest growth. Leaves reveal a network of darker green veins as a result of the light-green or yellow background (Fig. 1). If severe, the entire leaf may become cream-colored (Fig. 3), while the tips and margins of leaves turn brown. Eventually, numerous brown, dead spots speckle the leaf surface. Branches may begin to die back when leaves are no longer capable of producing food by photosynthesis. Plants severely affected will be stunted, have poor root development, and may eventually die. Upon excavating the crown of the affected plant, a mineral ring may be observed (Fig. 4)

Figure 2. Dieback of oak due to iron chlorosis

Figure 3. Azalea is highly susceptible to iron chlorosis.

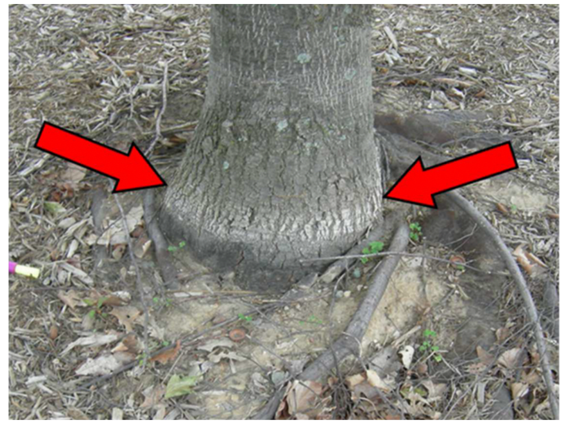

Figure 4. Lime and other salts build up at the crown of this tree. Photo by Phillip Kurzeja.

Chlorosis is especially a problem with trees and shrubs that are planted along streets and around homes where the original topsoil was removed or mixed with subsoil. The lime (calcium carbonate, which raises soil pH) content of many of these subsoils is high. Irrigating over several years with hard water provides additional lime, intensifying the problem. In Indiana, pin oak, holly, river birch, red maple, sweet gum, tupelo, white oak, white pine, rhododendron/ azalea, and yew frequently show symptoms of iron chlorosis in the landscape.

Cause

Iron chlorosis is a problem that results from multiple factors, including (but not limited to) host genetics, site pH, compaction, competition, soil quality, and plant maintenance practices, to name a few factors. In Indiana, plants that exhibit these chlorotic symptoms are usually deficient of one or more essential micronutrients (e.g., iron, manganese, and occasionally magnesium) that occurs not because the nutrients are lacking in the soil but because they are insoluble and unavailable to the plant due to the high-pH soil (Fig. 5, 6). At these higher soil pH levels (6.5 and above) many trees and shrubs are incapable of taking up adequate amounts of iron or manganese. Though iron deficiency is the most common problem, manganese, magnesium and zinc deficiencies may occur as well and mimic the symptoms of iron deficiency. Maple trees, especially red maples, are especially sensitive to manganese deficiency (Fig. 7).

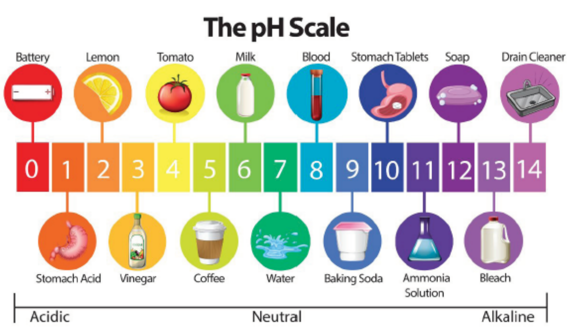

Figure 5. The relative acidity or alkalinity of soil is commonly expressed in terms of the symbol "pH". The neutral point in the pH scale is 7. Soil below a pH of 7 is acid; soil above a pH of 7 is alkaline

Figure 6. Early and late manganese deficiency in maple

A quick method to conclusively diagnose which micronutrient deficiency a plant has involves spraying solutions of iron, magnesium, manganese and zinc sulfate (approximately 5% weight/volume or approximately 1 ½-2 tablespoons per quart of distilled water on separate branches of an affected tree, and observing which, if any of the treatments correct the chlorosis.

Managing Iron Chlorosis

Severe chlorosis that has resulted in the dieback and decline of mature trees is rarely reversible. The following treatments are useful for cases of moderate deficiency, and depending on the treatment selected, may need to be repeated yearly or every few years. Before treatment, consider that any treated tree will only get larger and more costly when removal is required, and the most economical solution is to remove the problem plant or tree and replant with a suitable species which tolerates the existing pH. The most effective way to prevent iron chlorosis is to plant species or varieties that can do well in your soil conditions without special treatments. For example, northern red oak is very similar to pin oak, but tends to be less prone to iron chlorosis. See Table 3 for additional suggestions.

For those trees and shrubs that are highly valued, four commonly used methods to treat for iron chlorosis in plants are: (1) altering soil acidity; (2) applying a chelated iron compound directly to the soil; (3) spraying the foliage with a solution of iron (ferrous) sulfate or iron chelate; or (4) introducing iron salts into the main stem or trunk of affected plants by implantation, infusion or injection.

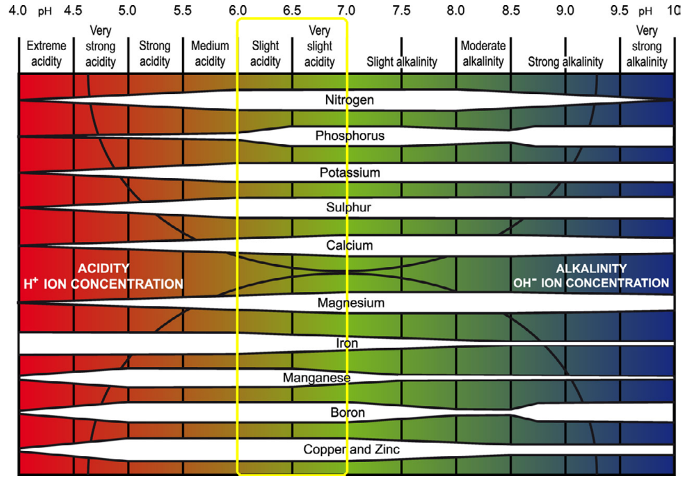

Figure 7. Redrawn for Potash Development Association from Truog, E. (1946). Soil reaction influence on availability of plant nutrients. Soil Science Society of America Proceedings 11, 305-308.

Increasing Soil Acidity

Sulfur

Soil acidification with elemental sulfur is most practical for annuals and perennials, along with shrubs, such as azaleas, rhododendrons, and yew. Before attempting to alter the soil pH, determine what your existing soil pH is. Collecting Soil Samples for Testing is available to help in this process.

The addition of elemental sulfur to soil produces hydrogen that causes soil pH to decrease (Havlin et al., 1999). Soil pH is, after all, simply a measure of the hydrogen ion concentration in soil solution, and the higher the concentration of hydrogen, the lower the soil pH. The soil temperature should be above 55F when treating the soil. Avoid treating saturated or flooded soil to prevent the soil microbes from converting the sulfur to hydrogen sulfide (rotten egg smell) under flooded (anaerobic) conditions. At extremely high pH, elemental sulfur has limited value in acidifying high pH (calcareous) soils because the sulfur cannot be converted to sulfuric acid by soil microbes.

Table 1. Pounds per 1000 square feet of elemental sulfur required to decrease soil pH to a depth of 6 inches.

Desired change in pH	Application rate based on soil texture[1]		
	Sand	Silt loam	Clay
8.5 to 6.5	8.5	16.8	33.5
8.0 to 6.5	7.8	15.4	30.8
7.5 to 6.5	6.9	13.8	27.5
7.0 to 6.5	4.1	8.3	16.5
8.5 to 5.5	19.1	38.1	76.0
8.0 to 5.5	18.4	36.7	73.2
7.5 to 5.5	17.4	35.1	70.0
7.0 to 5.5	14.7	29.6	59.2

These numbers assume the cation exchange capacity (CEC) of the sandy loam, silt loam, and clay soil are 5, 10 and 20 meq/100 g (which assumes soils are not calcareous). Most alkaline soils in Indiana are calcareous; as such, these numbers serve only estimates and starting points to begin the acidification process.

It can be difficult, if not impossible, to acidify large areas of soil such as found within a tree's root system: It takes about 32 lb of finely ground elemental sulfur to reverse the soil pH change obtained with 100 lb of lime. Most urban landscape soils require between 35 and 56 lbs sulfur/1000 sq. ft. to lower the soil pH by 0.5. Do not use more than 20 lbs of sulfur per 1000 sq. ft. at any one time. If greater acidification is required, use split applications of 20 lb and apply in succeeding years. Check the soil pH before making a second application in order to see how much change has taken place. The amount of material required per unit area will depend upon soil type, existing pH, calcium level, and the presence of other bases in the soil. Topdressing sulfur is not as effective as incorporating sulfur into the soil. Tree or shrub response will take time and is dependent upon soil moisture, timing of application and tree growth. Remember that several applications may be necessary over several years to change soil pH. Sulfur treatments will increase the availability of all micronutrients and not just iron, and may provide additional benefits to plants by freeing up additionally unavailable nutrients.

Iron (ferrous) sulfate is an expensive way to decrease soil pH, and requires approximately eight times more product. The ferrous sulfate reaction is quicker, since this salt disassociates sulfuric acid and iron. The iron ends up binding to the clay or precipitates out of the soil solution and may not be available. Unfortunately, soil application of ferrous sulfate to supply iron is not effective in high pH soils (above 7.2). because the iron is rapidly oxidized to unavailable form.

Iron Chelates

Where it is not feasible or possible to acidify soil, iron chelates can be applied to the soil as a liquid solution. The only chelate that works well under high pH soil conditions contain the FeEDDHA molecule. Chelated materials are less affected by soil pH, and work within a range of pH4-pH10. Work the chelate into the top 1-2 inches of soil around the base of the tree or shrub and water it in well. There are several formulations of chelated iron marketed under various trade names (e.g., Chelated Liquid Iron). Follow directions on the package label for rates of use and methods of application (Fig. 8).

Figure 8. The addition of chelated iron to the soil will temporarily suppress syptoms of iron chlorosis.

Aluminum sulfate also acidifies soils, and its effect is nearly immediate, but phytotoxicity (plant damage) has been reported if higher rates are applied and is not recommended.

Foliar Sprays

Symptoms expressed from iron chlorosis can be corrected by spraying the foliage with an iron chelate or with ferrous sulfate solution. Spraying usually results in a quicker, but temporary, response and several sprays may be required. Follow the manufacturer's direction for the particular iron chelate formulation used. Ferrous sulfate may be substituted for chelated iron. To mix ferrous sulfate, use two ounces in three gallons of water plus 1-2 drops (but no more) of mild detergent. Use a very fine mist so that the leaves will not be burned by the solution. The leaves should green up in about 10 days if the treatment is successful. The application of chelated iron sprays can reveal greening response sometimes in hours, but it is temporary and often gone within a few weeks, with the treated plant returning to its chlorotic appearance. Immediately after application, rinse equipment and hose off any spills to avoid stains. Foliar nutrient applications produce quick results, but the improvement is temporary. New growth emerging after the treatment will be chlorotic because the iron will not be able to move into the plant. Repeated applications may be necessary as new foliage appears, or chlorosis persists.

Trunk Injections

When trees are growing in well-buffered alkaline soils (pH above 7), trunk injection offers one of the most effective semi-permanent treatments available to correct iron or manganese chlorosis in trees and large shrubs. Several treatments are available to arborists (A), landscape professionals (LP) and homeowners (H). All of these treatments require drilling into the tree to treat it. When drilling into a tree, always use sharp drill bits of the recommended size to create 'clean' holes. Unless otherwise stated, injection into the root flare is recommended.

Microinjection

The implant method using Medicap FE provides an iron sulfate product by 1/2" diameter holes drilled in the lower trunk at 4 to 6 inch spacing. Implants are inserted into holes using a hammer and bolt or dowel. The cartridge head plugs the wound made to the tree trunk, and the cambium layer will compartmentalize the injection site. Medicap FE iron capsules are available in two sizes, for shrubs and for larger trees. Available to A, LP, H.

Inject-A-Min Iron/Zinc and Inject-A-Min Manganese Hp are microinjection systems for use on palms, maples, citrus and other tree species growing in alkaline soils. Treatment rate is determined by the diameter at breast height (dbh),. After drilling, a pressurized capsule (microinjector) injects the fertilizer into the tree. (https://mauget.com/applying-mauget/). Available to trained A and LP.

Table 2 - Advantages and disadvantages of iron chlorosis control methods.

Method	Advantages	Disadvantages
Foliar application: Chelates or iron sulfate	• Quick response • Fairly simple, easy procedure (except for large trees)	• Phytotoxicity (leaf burning) • Requires seasonal application • Impractical on large trees
Soil application: Elemental sulfur	• Lasts 4-6 years • Relatively inexpensive • Simple procedure	• Effective for only small areas • Slow plant response • Results variable • Too expensive for large areas • Impractical for larger established plantings or on high pH soils
Soil application: Iron sulfate-elemental sulfur	• Lasts up to several years • Relatively inexpensive • No injury to plant • Simple procedure	• Slow response • Results sometimes variable • Can be labor-intensive on high pH soils • Ineffective for high pH soils
Soil application: Iron chelates	• Simple procedure • Little risk of plant injury • Quick response	• May last less than one season • Expensive
Trunk implantation MediCap FE	• Lasts up to several years • Available for homeowner use • Variable expense depending upon treatment	• Injures tree's trunk • Can't be used on small shrubs • Variable results • Phytotoxicity • Efficacy trials lacking in larger trees
Trunk injection Inject-A-Min Iron/Zinc	• Lasts up to several years	• Injures tree's trunk • Limited efficacy data available • Questionable use on small shrubs • Variable results • Phytotoxicity • Requires pesticide applicator's license and additional training
Trunk infusion: Verdur	• Provides longest lasting results • Works for larger trees	• Injures tree's trunk • Can't be used on small shrubs • Variable results • Phytotoxicity • Requires pesticide applicator's license

Newer technology has emerged with delivering nutrition and pesticides into trees. The microinfusion devices available now include low pressure hydraulic systems for moving the nutrient solution into the tree's vascular system. These include the ArborJet system and the Rainbow Q-Connect system. Both systems are very effective devices for improving nutrient deficiencies with minimal invasive procedures from drilling. Available to qualified A and LP.

Macroinfusion

Verdur is a macroinfusion technique with a rate that varies depending when in the growing season the product is applied. Care must be taken to use the appropriate rate at the appropriate time to reduce the risk of phytotoxicity, foliar burn and defoliation. (https://www.treecarescience.com/pdf/Nutrients/Verdur_Specimen_Label.pdf). Available to A and LP.

The greatest disadvantage of any trunk injection/infusion/implantation methods is the wounds that are necessary for treatment provides opportunity for pathogens, particularly oak wilt (see BP-28 Oak Wilt in Indiana) and other pests and pathogens. However, for most trees, benefits far outweigh the potential for tree damage (Doccola et al, 2011).

Other Causes of Chlorosis

Iron deficiency is not the only cause of leaf yellowing. Abiotic causes of iron chlorosis, such as excessive planting depth, soil compaction, construction damage, stem and root-girdling roots, should also be ruled out prior to treatment. Herbicide damage or other mineral deficiencies, such as nitrogen, manganese, boron or zinc, may also result in chlorosis symptoms. Signs of manganese deficiency, in particular, may be similar to those of iron deficiency. The two can be distinguished by the broad bands of normal green color that remain next to the major veins if manganese is lacking. Leaves on the ends of the branches of manganese-deficient trees generally are not affected until late in the summer after growth has stopped. However, visual identification is not a clear diagnostic process. A tissue analysis will provide the best results for determining elemental deficiencies. In most cases, a foliar application of the deficient mineral early in the summer will cause a temporary green-up of the leaves. If application of the mineral thought to be deficient does not cause a temporary correction of the chlorosis, some other mineral deficiency is causing the problem. Other possible causes should be investigated, including root rot.

Table 3. A few recommended trees, shrubs, and perennials for alkaline, clay soil.

Trees	Shrubs	Perennials
Arborvitae (*Thuja spp.*)	American smoketree (*Cotinus obovatus* and *C. coggygeria*)	Aster
Bald cypress	Carolina allspice (*Calycanthus spp.*)	Beautyberry (*Calicarpa spp.)*
Gingko	Chokeberry (*Aronia spp.*)	Bluestem, big (*Andropogon spp.*)
Juniper (*Juniperus spp.)*	Spicebush (*Clethra spp.)*	Butterfly bush (*Buddleia spp.*)
Basswood, linden (*Tilia spp.*)	Bush-honeysuckle (*Diervilla spp.*)	Coneflower (*Echinacea spp.)*
Crabapple (*Malus spp.*)	Flowering quince (*Chaenomeles spp.*)	Clematis
Elm (*Ulmus spp.*)	Forsythia	Coreopsis
Fringe tree (*Chionanthus spp*).	Sweetspire (*Itea spp.)*	Daylily
Northern red oak (*Quercus rubra*)	Lilac and tree-lilac	Hardy hibiscus
Redbud (*Cercis spp.*)		Hosta
Shagbark hickory (*Carya ovata*)	Rose	Obedient plant (*Physostegia spp.*).
Swamp white oak (*Q. bicolor*), white oak (*Q. alba*), bur oak (*Q. macrocarpa*)	Viburnum	Switchgrass (*Panicum spp.)*
Zelkova	Weigela	Yucca or Adam's needle

Reference to products in this publication is not intended to be an endorsement to the exclusion of others which may be similar. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

References:

- Doccola, J.J., Smitley, D.R., Davis, T.W., Aiken, J.J. and P.M. Wild. 2011. Tree wound response following systemic insecticide trunk injection treatments in green ash (Fraxinus pennsylvanica Marsh.) 2011. **Arboriculture & Urban Forestry 37: 6–12.**
- Havlin, J. L., Beaton, J. D., Tisdale, S. L., & Nelson, W. L. (eds.). 1999. Soil Fertility and Fertilizers: An Introduction to Nutrient Management. (6th Ed.). Upper Saddle River, NJ: Prentice Hall.
- Kurzeja, P.S. 2015. Determining the cause of abiotic leaf scorch: Getting to the root of the problem. Master of Science thesis, Michigan State University.
- Truog, E. 1946. Soil reaction influence on availability of plant nutrients. Soil Science Society of America Proceedings 11, 305-308.

Revised from the original: Iron Chlorosis of Trees and Shrubs by Paul C. Pecknold, Extension Plant Pathologist

PURDUE UNIVERSITY Extension

purdue.edu/extension

Find out more at THE EDUCATION STORE edustore.purdue.edu

EXPERT REVIEWED

An Equal Access/Equal Opportunity University

March 2020