MASTER GARDENER
COLORADO STATE UNIVERSITY
EXTENSION

CMG GardenNotes #223

Iron Chlorosis of Woody Plants

Outline:

Symptoms

The term ***chlorosis*** means a general yellowing of the leaves. Many factors contribute to chlorosis.

Iron chlorosis refers to a yellowing caused by an iron deficiency in the leaf tissues. The primary symptoms of iron deficiency include ***interveinal chlorosis***, i.e., a general yellowing of leaves with veins remaining green. In severe cases, leaves may become pale yellow or whitish, but veins retain a greenish cast. Angular shaped brown spots may develop between veins and leaf margins may scorch (brown along the edge). [Figure 1]

Figure 1. Symptoms of iron chlorosis include yellowing of the leaf with veins remaining green.

Iron is necessary for the formation of chlorophyll, which is responsible for the green color in plants and necessary for photosynthesis (sugar production in plants). Any reduction in chlorophyll during the growing season reduces plant growth, vigor, and tolerance to stress conditions. Plants with reduced vigor from iron chlorosis are more prone to winter injury and winter injury may aggravate an iron chlorosis problem. Weakened plants also are more susceptible to other diseases and insect infestations

Iron is not very mobile within plants. Plants use their stores of iron in new leaves as they create them so iron chlorosis shows first and more severely on the newer growth at branch tips. Leaves may be smaller than normal. Leaves may eventually curl, dry up, and fall. Fruits may be small with a bitter flavor. Mildly affected plants become unsightly and grow poorly. In severe cases individual limbs or the entire plant may die.

It is common for iron chlorosis to show on a single branch or on one side of a tree. This is particularly common for plant species with marginal winter hardiness following winter injury. Plant species and varieties vary greatly in their susceptibility to iron deficiency.

Chlorosis usually develops as an overall yellowing of needles on junipers, pines, and other evergreens.

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Similar Symptoms

Iron chlorosis symptoms can be confused with other problems. In the high pH soils of Colorado, an iron chlorosis problem may actually be a combination of iron and manganese deficiencies. It is common for chlorotic trees to show a response to both iron and manganese treatments.

Zinc and manganese deficiencies result in similar leaf symptoms. Iron chlorosis appears first on the younger or terminal leaves. Under severe conditions, it may progress into older and lower leaves. By comparison, zinc and manganese deficiencies typically appear first on older, interior leaves.

Nitrogen deficiency shows as a uniform yellowing of the entire leaf (including the veins). Nitrogen deficiency shows first in the older leaves, while iron chlorosis shows first in the newer growth.

Damage from soil sterilants (i.e., Pramitol, Atrazine, Simazine, Ureabor, and Diuron) used to prevent weeds result in similar symptoms. With these weed killers, the leaf tissue along the vein remains green. With iron chlorosis, just the vein itself remains green.

Natural aging of tissues may create similar symptoms in some plants. Root and trunk damage and some virus, phytoplasmas, and vascular wilt diseases may cause similar leaf symptoms.

Causes and Complicating Factors

The factors leading to iron chlorosis are complex and not fully understood. A number of chemical reactions govern iron availability and contribute to the complexity of iron chemistry in soils.

Many environmental factors also create or contribute to iron deficiency. These factors need to be evaluated and alleviated to the extent possible. In many situations, attention to watering and soil conditions will satisfactorily correct minor iron chlorosis problems.

Calcareous Soils

Many Colorado soils are naturally high in lime (calcium carbonate and other calcium compounds) which raise the soil pH above 7.5. In these *calcareous* soils, iron chlorosis is common on susceptible plants.

Colorado soils are abundant in iron, as evidenced by the common "red rock" formations. In alkaline soils (pH above 7.0), iron is rapidly fixed through a chemical reaction into insoluble, solid forms that cannot be absorbed by plant roots. Such iron will be tied up indefinitely unless soil pH changes. Soil applications of iron alone are ineffective, as the applied iron will quickly be converted to these unavailable solid forms.

Over-Watering

Iron chlorosis is a common generic symptom of over-watering.

Overly wet or dry soils predispose plants to iron chlorosis. Iron chlorosis is more prevalent following wet springs, and where gardeners over-water in the spring. In western calcareous soils, iron chlorosis can be moderated by eliminating springtime over-watering. Dry soils can also lead to nutrient deficiencies as nutrients are absorbed in solution with water. Severe cases of iron chlorosis involving "acid-loving" loving plants may not be corrected through improved irrigation practices.

It is common for gardeners to allow sprinkler control settings to remain unchanged from the high summer water needs to the lower water needs of spring and fall. In this situation, the yard receives as much as 40% more water than is needed in the spring and fall. Such over watering can contribute to iron chlorosis.. For details, refer to *CMG GardenNotes* on irrigation management.

Soil Compaction

Soil compaction and other conditions that limit soil air infiltration (like surface crusting and use of plastic mulch) predispose plants to iron chlorosis by limiting effective rooting area and soil oxygen levels. Plants that have smaller root systems have less chance of "finding" available iron. These are key contributing factors in clayey soils. Using organic mulch (like wood or bark chips) helps prevent and reduce soil compaction. Avoid the use of plastic under rock mulch around landscape plants. For details on mulching and soil compaction, refer to *CMG GardenNotes* #215, **Soil Compaction**, and #245, **Mulching with Wood/Bark Chips, Grass Clippings, and Rock**.

Trunk-Girdling Roots

Iron chlorosis is a common early symptom of trunk girdling roots in trees. The primary cause of trunk girdling roots is planting trees too deep. Trunk girdling roots can lead to decline and death some 20 years after planting.

In tree planting standards, the top of the root ball should rise slightly above grade (i.e., 1-2 inches above grade) for newly planted trees. At least two structural roots should be located in the top 1-3 inches of the root ball. For additional information on tree planting, refer to *CMG GardenNotes* #633, **The Science of Planting Trees**.

On established trees, the trunk-to-root flare should be noticeable. If the trunk goes straight into the ground, suspect planting problems and possible development of trunk girdling roots over time. To check, perform a root collar excavation (carefully removing the soil around the base of tree) and examine the trunk/root flare.

Other Contributing Factors

Plant competition – In susceptible plants, competition from adjacent lawns or flowers may aggravate iron chlorosis. Replace the grass under the tree canopy with wood/bark chip mulch.

Winter injury – Trees with cankers and other winter injuries are prone to iron deficiency. (Winter bark injury on tree trunks is caused by winter drought.)

Soil organic matter – Organic matter is a key to successfully gardening in Colorado's soils. Ideally, the soil's organic content should be increased to 5%. However, excessive amounts may aggravate iron problems.

Excessive salt levels – High soil salt levels adversely affect uptake of water and nutrients, including iron. For details, refer to *CMG GardenNotes* #224, **Saline Soils**.

Soil temperature and light intensity – Extreme soil temperatures and high light intensity may increase iron chlorosis problems. Use an organic mulch to moderate soil temperature. Shading may help some crops.

Acid-loving plants – Acid loving plants are highly susceptible to iron chlorosis and not suited to Colorado's soil conditions. These include blueberries, azaleas, rhododendron, flowering dogwood, and heather.

Nutrients – Excessive levels (from over-application) of phosphate, manganese, copper, or zinc may aggravate iron chlorosis.

Plant Selection – Right Plant, Right Place

In Colorado's high pH soils, the best method to prevent iron chlorosis is to select plant species tolerant of high soil pH and less affected by low iron availability. Avoid planting the more susceptible species (Table 1) on soils prone to iron chlorosis problems (pH above 7.5, compacted, clayey, or wet soils).

Table 1. Examples of Plants with High Susceptibility to Iron Chlorosis

Amur maple	Dawn redwood	Northern red oak
Apple	Douglas-fir	Peach
Arborvitae	Elm	Pear
Aspen	Flowering dogwoods	Pin oak
Azalea	Grape	Pine
Beech	Honeylocust	Raspberry
Birch	Horse chestnut	Red maple
Boxelder	Juniper	Rhododendron
Bumald spiraea	Linden	Silver maple
Cherry	London plane tree (sycamore)	Spruce
Cotoneaster	Magnolia	
Crabapple	Mountain-ash	

Iron Additives

Unfortunately, there is no easy, inexpensive, or long-term correction for iron chlorosis. Treatments may be rather expensive and give disappointing results.Plant and soil conditions vary greatly so there is no single approach that is consistently best. Focusing on reducing springtime over-watering, soil compaction and other contributing factors is can be effective in mitigating iron chlorosis in some situations.

The first step in using iron additives is to know the soil *pH* and *free-lime* (calcium carbonate) content. These soil factors directly affect the success of any approach. Determine soil pH by soil test. When the pH is above 7.5, effective approaches are limited.

To check for ***free-lime***, place a rounded tablespoon of dry crumbled soil in a small cup. Moisten the soil with vinegar. (The soil needs to be thoroughly moistened, but not swimming in vinegar.) If the soil-vinegar mix fizzes or bubbles, it has free-lime. High lime content is typical of soils with a pH above 7.5. A standard approach in treating iron chlorosis is to lower the soil's pH. **Lowering the pH is impractical to impossible if the soil contains *free-lime***.

There are four general approaches to iron treatments: 1) lowering the soil's pH, 2) soil iron treatments, 3) foliar sprays, and 4) tree injections. Each has advantages and disadvantages. Each procedure gives variable results depending on plant species and soil conditions.

The two principal types of iron-containing products used for iron application include iron chelates and inorganic iron compounds (such as iron sulfate, ferrous sulfate). Several types of iron chelates are marketed under a variety of trade names. Soil pH dictates the type of chelate to use. Treatment of any iron product made mid-season may not produce satisfactory results.

Lowering Soil pH with Sulfur Products

A standard approach used in many products is to lower the soil pH. This approach merits consideration only if the soil does NOT have "free-lime" (high calcium carbonate**)**, and may show effectiveness over a period of years.

Due to the high pH and lime content of many Colorado soils, this approach seldom merits consideration. If irrigation water is hard, the calcium carbonate (lime) in the water will counter any acidifying effect. (As a side note, it has been observed that in some older gardens the pH has dropped below natural levels as the lime content is slowly leached out with decades of irrigation.)

The pH is lowered by soil applications of sulfur products. See the product labels for specific application rate. (Use of aluminum sulfate to lower soil pH is not recommended due to a potential for aluminum toxicity.) For details on lowering pH, refer to the *CMG GardenNotes* #222, **Soil pH**.

Soil Applications of Iron Sulfate Plus Sulfur

A simple approach is to apply a mixture of equal amounts of iron (ferrous) sulfate and sulfur to the soil. Examples of products include Copperas, Jirdon Super Iron Green, HiYield Soil Acidifier Plus Micros, and Fertilome Soil Acidifier Plus Iron. Over a period of months to years, an improvement may be noticed. When it is effective, treatments may last up to three or four years, depending on soil conditions.

This approach merits consideration only on soils without "free-lime".

For trees, apply the mixture in holes around the drip-line of the tree, as described for chelates (see below). Over time, the sulfur reacts to lower soil pH in a localized area. Broadcast applications, that dilute the material over a larger area, are less likely to give satisfactory results. Treat rows of berries or small shrubs by placing the mix in a furrow four inches deep and 12-24 inches away from the plant. See specific label directions for application rates. For best results, treat the soil in spring.

Soil Applications of Iron Chelates

Soil application of iron chelates may give a rapid response if the correct chelate is used and other contributing factors are minimal. Applications after May 1st are less likely to show results. Treatments may last less than a season to a couple of years.

Treat trees by placing the iron product in rings of holes in the ground beneath the dripline (outer reaches of the branches). Make holes 1½ to 2 inches in diameter, 6 inches deep and 12 inches apart in rings 2 feet apart. For smaller trees, make 2 to 3 rings of holes. For large trees, create four to five or more rings of holes, and rings may need to extend beyond the drip line. No holes should be made within 2½ to 4 feet of the tree trunk on established trees. [Figure 2]

Drill holes in the soil with a power or hand auger, bulb planter, or small trowel, removing the soil core. Using a punch bar that makes holes by compacting the surrounding soil may be less effective. To avoid damage to shallow utility lines, have the area utility-staked before starting. [Figure 2]

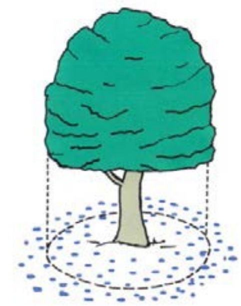

Figure 2. Place soil additive in a ring of holes around the drip line of the tree.

In soils with a pH above 7.5, only special chelates formulated for a high pH are effective. Examples include EDDHMA (Miller's Ferriplus) or EDDHA (Fe Sequestrene 138). Due to its higher cost, these products have limited availability. See product label for specific application rates.

In acid to slightly alkaline soils, try other chelates like EDTA (Fe Sequestrene 330, Fertilome Liquid Iron) and DTPA (Miller's Iron Chelate DP). They lose effectiveness quickly as the pH rises above 7.2 to 7.5. See product label for specific application rates.

Soil Applications of Iron Sucrate

Iron sucrate, a relatively new iron source, is manufactured from iron oxide and molasses to form an iron-containing organic complex with limited water solubility. It is less prone to staining due to its very low solubility.

Iron sucrate merits consideration in high pH soils, and additional scientific evaluation is warranted for Colorado soils. It is marketed as Lilly Miller Iron Safe.

Foliar Sprays

Foliar sprays of iron sulfate or iron chelates may provide quick response, often in a matter of days. However, the treatment is often spotty and only temporary. Multiple applications per season may be needed. Effects will not carry over into subsequent years.

Both types of products are equally effective, but iron chelates are more expensive. See product labels for specific application rates and instructions. With foliar applications, spray in the evening or on cloudy days when drying time is slower. A few drops of liquid dishwashing soap or commercial wetting agent will enhance sticking properties.

Foliar applications are generally not recommended due to application limitations. Complete coverage of all leaves is essential. Individual leaves not treated may remain chlorotic. Coverage on large trees is impractical to impossible.

There is a small margin between an iron concentration that will green up the leaves and a concentration that will cause leaf burn. Leaf tissues are rather prone to turn black from an iron burn. Following an iron sulfate foliar treatment, it is common to see leaves that remain chlorotic, leaves that green up, and leaves with black burn spots on the same plant. Spray hitting the sidewalk, house, and other objects may leave a permanent rusty discoloration. Chelated iron sprays are inactivated by sunlight.

Trunk Injections

Professional arborists have trunk implant or injection methods available for treating iron chlorosis on large trees. Trunk injections may last from one to five years. Refer to product information for application details. Injections may create pathways for decay organisms to enter a tree.

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