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Iron Deficiency Chlorosis

on Woody Landscape Plants in Wyoming

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Soils in the Rocky Mountain West developed under arid conditions from materials that contain limestone. These soils are typically high in free lime (calcium carbonate), which causes them to be alkaline. In addition, many of our soils do not allow good movement of air and water within the root zone due to their high clay content and low organic matter levels. These factors, which are products of the area climate and geology, may limit the availability of certain soil nutrients and cause nutrient deficiencies. The most common of these is iron deficiency.

What causes iron deficiency?

Iron (chemical symbol Fe) is one of 16 chemical elements essential for plant growth. Known as a micronutrient, iron is required by plants in small amounts (relative to other nutrients such as nitrogen (N), phosphorus (P), and potassium (K)). Other micronutrients include boron (B), chloride (Cl), copper (Cu), manganese (Mn), molybdenum (Mo), and zinc (Zn). Iron is abundant in most soils, but as with other micronutrients, its availability is greatly influenced by soil conditions. Soil pH is one characteristic that has a considerable influence. Iron availability is lowest between pH 7.5 and 8.5. It becomes more available as soil pH decreases.

The pH of a soil is a measure of its alkalinity or acidity and is measured on a scale of 1 to 14, where a value of 7 is neutral, values less than 7 are acid, and those greater than 7 are basic or alkaline (Table 1). Wyoming soils usually have pH values between 7.0 and 8.5, with some greater than 9.0. When alkalinity is this high, the availability of iron is greatly reduced. This effect is aggravated by cool, wet soils that can occur during the spring. Heavy soils, high in clay content and low in organic matter, are more susceptible to iron deficiency than soils containing more silt or organic matter.

Table 1. pH values of some common materials.

pH	Material	Acid or alkaline
14.0	Sodium hydroxide	Alkaline
13.0	Lye	Alkaline
12.4	Lime	Alkaline
11.0	Ammonia	Alkaline
10.5	Milk of magnesia	Alkaline
8.3	Baking soda	Alkaline
7.4	Human blood	Alkaline
7.0	Pure water*	Neutral
6.6	Milk	Acid
4.5	Tomatoes	Acid
4.0	Wine and beer	Acid
3.0	Apples	Acid
2.2	Vinegar	Acid
2.0	Lemon juice	Acid
1.0	Battery acid	Acid
0.0	Hydrochloric acid	Acid

** Pure water is very rare; most supplies will have at least some impurities.*

Figure 1. Iron chlorosis on Kentucky coffeetree (*Gymnocladus dioicus*).

The type of plant influences whether or not iron deficiency chlorosis will be a problem. Some plant species can extract enough iron for growth from high-pH soils. Plants that are native to areas with acid to neutral soils are more likely to exhibit iron deficiency when grown in alkaline soils. There are even differences among varieties of the same species.

What are the symptoms of iron deficiency?

Plants suffering from iron deficiency show distinct symptoms; the most obvious is interveinal chlorosis. Chlorosis is a general term used to describe leaves that are abnormally yellow. Chlorosis caused by iron deficiency is usually restricted to the leaf tissue between the veins, while the veins themselves remain green (Figures 1, 2, and 3).

The yellowing develops because iron is used in the production of chlorophyll (the pigment that gives leaves their green color). Iron doesn't move within plants, and even healthy plants cannot take iron from older leaves and send it to younger leaves. In iron deficient plants, the levels of iron in younger leaves are too low for normal chlorophyll production, and chlorosis first appears on new growth. As the deficiency progresses, it may also affect older leaves.

In severe cases of iron deficiency, leaves will be smaller than normal, will turn pale yellow, and will develop angular brown spots between the veins. Leaf margins may also turn brown. If the condition is not corrected, the entire leaf may die prematurely. On some broadleaf trees, the ends of the branches also die back. In general, plants affected by iron deficiency will be stunted and weak. This condition makes them more susceptible to disease and insect damage. Symptoms will often be more pronounced on the sun-stressed side of a tree (south or west exposure) and on plants near areas of newly-poured concrete.

How can iron deficiency chlorosis be prevented?

The best strategy for preventing iron deficiency chlorosis is the proper selection of plant material. All too often, plants are chosen with little thought about the sites where they are to be planted. Plant species differ widely in their tolerance of soil conditions that cause iron deficiency. Although plant species that are susceptible are numerous and cross all plant families, tolerant plant species are also available (Table 2). As a general rule, most of the plant species that are native to our region will have some tolerance to iron deficiency chlorosis. (See University of Wyoming Cooperative Extension Service Bulletin B-1090, *Landscaping: Recommended Trees for Wyoming*.)

Table 2. Plants susceptible to or tolerant of alkaline pH conditions in the soil.

Susceptible to iron chlorosis in alkaline soils	Tolerant of alkaline soils
Maples	Catalpa
Oaks	Hackberry
Aspens	Many ash trees
Cottonwoods	Lilacs
Rose family (Rosaceae)	Many prunus species
Pines	Viburnums
Ohio buckeye	Caragana (peashrub)

Once the appropriate plant material has been selected, it is important to use good planting procedures. Follow the recommended planting methods for any new plants, whether woody or herbaceous. Finally, water and fertilize according to the needs of the plant. Inadequate water will cause drought stress and limit the effectiveness of fertilizer materials, as nutrients must be dissolved in water in order for the plant to absorb them. Conversely, overwatering will cause the soil to remain waterlogged and will reduce air exchange between the atmosphere and the root zone, a condition that will aggravate iron deficiency problems.

What are the best strategies for treating iron chlorosis?

When iron deficiency chlorosis is caused by cool, wet weather or by improper watering, the symptoms will usually disappear when the weather improves or when the watering problem is corrected. Often, a chlorotic plant can manage for an extended period of time without treatment. If the condition does not worsen over time and the plant's appearance is acceptable to its owner, treatment may not be necessary.

Severe iron deficiency is rarely reversible. In more moderate cases, treating iron chlorosis requires an integrated approach. Adequate levels of other nutrients in proper balance must be present for the plant to efficiently utilize any applied iron fertilizer. A soil test will identify nutrient needs and other soil factors important in determining how to deal with an iron problem.

Soil treatments: Soils pH 6.8-7.2

Most Wyoming soils will *not* fall into this category. When the soil pH is in the 6.8 to 7.2 range and the free lime (calcium carbonate) content is low, the soil will often respond to an annual broadcast treatment of 10 pounds of ammonium sulfate per 1000 square feet *or* 25 pounds of sulfur per 1000 square feet. This treatment will temporarily lower the pH and make the iron in the soil more available to the plants. Liquid fertilizers applied to the soil will be taken up by the plant more quickly.

Figure 2. Iron chlorosis on ponderosa pine (*Pinus ponderosa*).

Figure 3. Iron chlorosis on crabapple (*Malus* sp.).

Soil treatments: Soils pH > 7.2

Most Wyoming soils *do* fall into this category. Broadcast application of iron sulfate is often ineffective on soil with a pH above 7.2. However, for use with trees and shrubs, the availability of this form of iron can sometimes be improved by inserting plugs of iron sulfate and sulfur in holes, spaced about 2 feet apart, along the drip line of a tree. The holes should be approximately 2 inches in diameter and 6 to 9 inches deep. Mix equal amounts of iron sulfate with sulfur, place ¼ pound of the mixture into the hole, and then cover with soil.

Even this method may not be effective with high-pH or high-lime soils. Chelated iron should be used for these soil types. Chelating combines iron with an organic compound that keeps it available to plants when applied to the soil. There are many different chelated fertilizers on the market. Chelated iron in the form of FeEDDHA is effective across the entire pH range of Wyoming soils. Other types of chelated iron are less effective at higher pH levels. Again, the plant will take up liquid fertilizers more rapidly than those in a dry form. Always read and follow the label directions carefully.

Foliar applications

Soil applications of iron fertilizers usually require some time to become effective. This means the plant continues to be under nutrient stress, which increases its susceptibility to drought, disease, and insect damage in the interim. Iron can be sprayed on the foliage (either as inorganic ferrous sulfate or as a chelated iron) at 10-day intervals during the active growing period.

To use iron sulfate, mix 1.25 ounces of iron sulfate with one gallon of water. A wetting agent, available from many horticultural supply houses, should be added to the mixture. Follow the wetting agent product directions for the appropriate amount. Thoroughly wet the foliage with the mixture. Chelated iron can also be sprayed on the foliage. Follow the product directions on the label. *Never* apply a foliar spray when the temperature is likely to exceed 90 degrees Fahrenheit within 24 hours of the application. Foliar application should stop when chlorosis disappears. Leaf damage can occur even when all the proper precautions are taken. Iron sprays can also leave an orange or rust-colored residue on foliage, sidewalks, driveways, and buildings. Always mix up only the amount of fertilizer needed, use all of the mixture, and never store leftover fertilizer mixture. High-pH water may decrease the effectiveness of the fertilizer if it is not used right away.

Injections

Occasionally, soil fertilization and foliar application will not alleviate iron chlorosis symptoms in woody plants. In these cases, it may be necessary to consider direct trunk injection of iron on 3-inch or larger diameter trunks. Since creating an open wound in a woody plant increases the potential for disease or insect damage, this should be done by a Certified Arborist who has training in the use of appropriate fertilizers and injection equipment.

Finally, if the plant does not respond positively, consider replacing it with a species that is tolerant of alkaline or high-pH soils. Contact your local University of Wyoming Cooperative Extension Service office or your nursery professional for plant suggestions.

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