Controlling Iron Deficiency in Idaho Plants

Terry A. Tindall, Michael W. Colt,
Danny L. Barney, and Esmaeil Fallahi

Introduction

Iron is essential to the growth and development of all plants. Green and growing plants usually indicate adequate iron. The absorption of iron from the soil by plant roots and iron movement within the plant is genetically controlled. However, this process depends on sufficient levels in the soil. Although Idaho soils do not lack iron, alkaline soils (pH > 7.0) are often insufficient in the availability of ferrous ions Fe^{+++} (the iron form that is utilized most commonly for plant metabolism), resulting in poor plant growth. Free lime ($CaCO_3$) in alkaline soils results in low ferric ion solubility, which can cause an iron deficiency problem. Soils with pH levels above 7.5 indicate the presence of free lime. However, some plants have the ability to grow very well in alkaline soil environments without iron deficiency because of their inherent ability to effectively extract iron from the soil.

Symptoms

One of the most common and frustrating problems for Idaho growers, landscapers, and home gardeners is plant iron deficiency or chlorosis. The symptoms are characterized by perpetual "interveinal" chlorosis: leaves are yellow or yellowish white but the veins remain green (plate 1).

Plants need a continual supply of iron because of their inability to translocate iron from older to newer leaves. This results in the outer portions of the leaf and new leaves becoming yellow first. In more severe cases, with some susceptible plants, the newer leaves lose all of their capacity to produce chlorophyll and the leaf turns black and dies (plate 2). Chlorophyll is the green pigmented material in the plant necessary in carrying out photosynthesis. Any reduction in chlorophyll during plant growth reduces the plant's ability to grow and develop fully. Iron deficiency reduces its ability to produce chlorophyll, resulting in low levels of photosynthesis. In some severe cases, limbs or the entire plant may be affected.

Most southern Idaho soils contain free lime, with related soil pH values often ranging between 7.5 and 8.2. Desert soils often have concentrated layers of free lime or calcium carbonate located just below the original top soil. When these layers of lime are exposed or brought to the surface of the soil through building, land leveling operations, erosion, or other disturbances, it creates an altered environment that promotes iron chlorosis in susceptible plants.

Iron chlorosis problems are intensified with cool, wet soil conditions. Therefore, the most common time to see many of these symptoms is in the early spring on eroded landscapes or where subsoil has been exposed.

Control Practices

There are several management practices that growers or gardeners can use to decrease iron chlorosis, including:

Irrigation

Excessive irrigation or poor drainage magnifies iron chlorosis problems. Growers and home gardeners need to more effectively control the amount of water being applied to susceptible plants. Plants in low lying or poorly drained areas are especially susceptible to iron chlorosis

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because of saturated soil conditions. This is especially important in the spring of the year when cold temperatures also decrease the availability of iron to growing plants. As the soil dries in the spring and temperatures rise, microorganism activity increases releasing natural iron available to growing plants. Therefore, more iron is available because of increased rooting activity and usually a decrease in the yellow or chlorotic symptoms occur.

Planting

Where possible, plant susceptible ornamentals on more southern exposures to take advantage of warmer soil temperatures in the spring. Use plastic mulches (clear, black, brown, or green) in areas where iron chlorosis has been a concern. These tend to increase soil temperatures and decrease iron chlorosis problems.

Variety selection

Plant species vary in their general susceptibility to iron chlorosis (Table 1). Growers and home gardeners can use local sources, such as their local County Extension Educator or their support staff who have gone through the Master Gardener program, to help select plants that might be well suited for specific Idaho growing conditions. Home owners should also seek direction for plant selection from their local nursery or gardening centers. This selection process is important and is determined by soil conditions, including soil pH, levels of free lime, soil texture, and soil drainage conditions.

Plant selection is a good place to begin in managing iron chlorosis problems (Table 1). This is especially true on small berries such as raspberries, blackberries, and grapes. Individual plants that are chlorotic should be removed and replaced with cuttings of adjacent plants that are healthy and green. Trees can also be selected in a similar manner over a period of time.

Soil application of iron

It is much easier to prevent chlorosis than to overcome the problem after the symptoms appear. One way to do this, is to apply iron containing products to the soil in the spring before new leaves appear. Three classes of soil-applied materials are available with different iron chemistry*: inorganic salts, chelates/organic complexes, and acidulated soil amendments.*

The *inorganic salts* are most commonly ferrous or iron sulfate and usually contain about 20 percent iron. They rapidly become unavailable in the soil to most plants with the exception of turf. Ferrous sulfate is effective and recommended on Idaho turf because of the low soil contact and should be broadcast applied yearly. However, soil application of inorganic iron salts should be avoided because ferrous iron is quickly oxidized in the soil to an unavailable iron form.

Iron chelates are synthetically produced organic complexes. Chelates are very large organic molecules resulting in a decrease to oxidation or other chemical alteration. This characteristic allows the iron to remain in a form available to plants for longer periods of time. Chelated forms of iron are by far the most reliable and effective iron materials available for soil application. There are four main iron chelates: DTPA, EDTA, EDDHA, and HEDTA. The most common soil- applied chelate is Fe-EDDHA, manufactured by Ciba-Plant Protection Corporation and marketed as Sequestrene 138 Fe. EDDHA is applied either on a broadcast basis or on a per-unit basis where individual trees are being treated. Growers and homeowners should carefully follow label directions. These applications should be made in early spring and

Table 1. Relative sensitivities to iron deficiency

Susceptible	Moderately susceptible	Relatively resistant
Raspberry	Corn	Wheat
Dry bean	Oats	Peppermint
Proso millet	Barley	Sunflowers
Grape	Peonies	Various grasses
Oak	Various grasses	Amaranthus
Strawberry	Alfalfa	
Peach	Potatoes	
Maple		
Blueberry		
Rhododendron		

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Plate 1. Green veins and yellow interveinal tissue of iron deficient raspberry growing on southern Idaho alkaline soil.

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Plate 2. Severe iron chlorosis causing necrosis (dying) in developing tissue. Continued problems will result in loss of entire limbs or plants.

prior to fully emerged leaves. As a general rule, all iron compounds should be applied with a nitrogen source as well as a small amount of wetting agent ($^1/_2$ tablespoon/1-gallon solution) to increase product efficiency. This will assure quick and rapid uptake of the iron material. Most recommendations for chelates suggest the material be dissolved in water or a solution fertilizer prior to application. Fe- EDDHA should be applied around the drip line of a tree or in a band at the base of small berries (e.g. strawberries).

A more precise application method of Fe-EDDHA used by some growers and home owners is drip irrigation. Effective rates of application through the drip system have been reduced to 0.01 to 0.02 lb of Fe-EDDHA/tree/year (3-to 4-inch caliper). The iron material is mixed in solution and stored in a small plastic tank, then injected into the drip lines (venturi injector costs about $20.00 in 1996). There are a large number of very active roots in a small area under drip systems that increases the efficiency of the chelated iron. Drip irrigation makes chelates more attractive and easier to use. The greatest limitation, however, is its relatively high cost.

Acidulated soil amendments are produced in Arizona under the brand name of Iron-sul. This product has a pH of about 2 and has been moderately effective in controlling iron chlorosis for fairly long periods of time. The Iron-sul material is best applied by shallow trenching around the plants and should be applied in the bottom 1 to 2 inches of the trench. Cover the trench with soil and water thoroughly. Avoid contact with cement work such as driveways or walkways, because the materials will result in iron-colored stains.

Foliar application of iron

Iron compounds that can be sprayed on leaves and tissue respond to iron chlorosis in a matter of days. Repeat applications every 2 to 3 weeks are almost always necessary to treat new foliage because of the limited translocation of iron nutrients within the plant. A 3 percent ferrous sulfate solution is recommended from the inorganic sources of iron. The solution can be made by mixing 4 oz of ferrous sulfate per gallon of water, or 24 to 25 pounds per 100 gallons of water. The first application should be made about

3 weeks after leaves appear. Spray to complete saturation as the tree approaches full leaf. For best results, spray in the early morning hours when the tree is most likely to utilize the material. Applicators should add a few drops of a wetting agent to each gallon of water used. Ferrous sulfate solutions should not be stored after mixing because of the oxidation of the Fe, which results in the iron settling out of solution making it unavailable to the trees.

Chelated forms of iron can also be applied foliarly. The most common foliar-applied chelate is Fe-DTPA, which is manufactured by the Ciba-Plant Protection Corporation and marketed as Sequestrene 330 Fe. All chelated iron materials that are foliar applied will require repeat applications every 2 to 3 weeks. Two products that have proven fairly effective for the control of iron chlorosis in stone-fruit trees are Fe-metalosate and Nutra-phos Fe (3-27-0 with 21% Fe). Fe-metalosate is manufactured by Albion Laboratories, and Nutra-phos Fe is manufactured by Leffingwell Chemical. Nutra-phos Fe should be applied at a rate of 14 to 16 pounds per 100 gallons of water. Apply with a wetting agent 3 to 4 times during the early growing stage of the fruit. Fe metalosate should be used by following the label instructions.

Trunk injection of iron

Trunk injection of ferric ammonium citrate (FAC) and ferrous sulfate ($FeSO_4$) may be the most effective for controlling iron chlorosis. The FAC is available by order from specialty garden stores or through chemical supply houses for approximately $30.00 per 1 pound (1996 cost). The recommended rate is about $^1/_8$ to $^1/_4$ teaspoon per-inch-tree caliper and should be placed into small dissolvable gelatin capsules obtained from local health food stores. Drill holes into the tree trunk deep enough to embed the capsule. The holes should be spaced equally around larger trees and covered with wax or silicone. If these FAC injections are too concentrated, they may discolor leaves. Therefore, a little experimentation may be necessary prior to injection of all trees. This type of injection can last 3 to 4 years.

A 1 percent ferrous sulfate solution can be injected in commercial orchards. Holes should be drilled through the sap wood 2 inches deep, and the material injected with a pressure system not exceeding 300 psi. Also, commercial applicators can inject 100 ml (3 oz) of 1 percent $FeSO_4$ for every 1 inch of caliper for fruit tree management to a maximum of 500 ml. Avoid low-pressure injection (<200 psi). Injections should be made in early spring or after September 30. This injection should last for several years.

Precautions

There are two concerns that need to be discussed related to tree injection of iron-containing materials. Whenever a tree or plant is subjected to drilling through its bark and into meristematic tissue, it becomes susceptible to diseases. Growers need to be aware of this tendency when making injections. Most of the wounds tend to heal themselves over a short period of time and cause no serious damage. When injections occur in mid-summer, foliar burning is a possibility. Therefore, all injections should take place early in the spring or later in the fall.

Summary

Controlling iron chlorosis is a challenge even under the best of conditions. Each environment is unique and will require a little experimentation. Using the information in this guide should provide a starting place and helpful direction for Idaho home owners, consultants and growers.

Authors

Terry A. Tindall is an extension soil scientist at the Twin Falls Research & Extension Center. Michael W. Colt is a horticulture specialist and Esmaeil Fallahi is a fruit tree specialist, both at the Parma Research & Extension Center. Danny Barney is a small fruit specialist at the Sandpoint Research & Extension Center. All authors are faculty members of the University of Idaho.

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