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CONTROL OF IRON CHLOROSIS IN ORNAMENTAL AND CROP PLANTS

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INTRODUCTION

Iron deficiency (iron chlorosis) affects many desirable landscape and crop plants in Utah. The primary symptom of iron deficiency is *interveinal chlorosis*, the development of a yellow leaf with a network of dark green veins (photo 1). In severe cases, the entire leaf turns yellow or white and the outer edges may scorch and turn brown as the plant cells die. It is common for an individual branch or one half of a tree to be chlorotic while the remainder of the tree appears normal (photo 2). In some areas vegetation from the entire landscapes may be affected, while in others only the most susceptible plants show deficiency symptoms.

Photo 1. Interveinal chlorosis on silver maple leaves.

Yellow leaves indicate a lack of chlorophyll, the green pigment responsible for photosynthesis (sugar production) in plants. Any reduction in chlorophyll during the growing season can reduce plant growth and vigor. In addition, chlorotic plants often produce smaller fruits of poor quality with bitter flavor. In severe cases, or if iron chlorosis persists over several years, individual limbs or the entire plant may die.

Photo 2. Chlorotic silver maple in Smithfield, Utah, City Park. Note that the left side of the tree is severly chlorotic while the right side is only slightly affected.

CAUSES OF IRON CHLOROSIS

The causes of iron chlorosis are complex and not entirely understood. Many reactions govern iron availability and contribute to the complexity of iron chemistry in soil. Iron chlorosis frequently occurs in soils that are alkaline (pH greater than 7.0) and that contain lime; conditions that are common in Utah. Most soils contain abundant levels of iron; however, deficiencies develop because soil chemical reactions render this iron unavailable to plants. At high pH, iron rapidly forms solids in combination with oxygen, and hydroxide and carbonate ions. These forms of iron are not water-soluble and cannot be absorbed by plant roots. Such iron will be tied up indefinitely unless soil conditions change. This also explains why rusty nails or iron shavings do not correct iron deficiency in Utah: iron released by these materials immediately forms solids that are unavailable to plants.

Iron chlorosis is known to be aggravated by cool soil temperatures and conditions that restrict air movement into soil: plastic sheet mulching, compaction, and water-saturated conditions. Chlorosis is often more severe where topsoil has been removed exposing lime-enriched subsoil. Examples are eroded soils or soils subjected to land leveling for agricultural irrigation or new housing developments.

Prevention and Control of Iron Chlorosis

Control of iron chlorosis is not easy and can be expensive. Therefore, one of the best methods is to select plant species and cultivars that are tolerant of high soil pH and less likely to be affected by low iron availability. Table 1 describes the susceptibility of common landscape and crop plants to iron chlorosis. Planting selections from the highly susceptible column should be avoided in Utah, since recurring chlorosis problems will weaken the plants, predisposing them to other problems and/or shortening their life span.

Table 1. Susceptibility of plants to iron deficiency.*

Fruits, vegetables and flowers		
Highly susceptible	**Moderately susceptible**	**Moderately tolerant**
Berries Grapes	Corn Turf grasses Flowers (some) Vegetables (some)	Alfalfa Wheat, barley, and oats Potatoes Flowers (most) Vegetables (most)
Trees and shrubs		
Highly susceptible	**Moderately susceptible**	**Moderately tolerant**
Red maple Silver maple Pin oak Sweetgum Dawn redwood Amur maple Bumald spiraea Azalea Rhododendron	Aspen Beech Birch Cherry Peach Magnolia Most conifers Mountain-ash London planetree Horsechestnut	Ash Boxelder Catalpa Kentucky coffeetree Cottonwoods Poplars Ginkgo Hackberry Hawthorn Honeylocust Linden Norway and Canyon maples Elms Most oaks

*Some plants are listed under two categories because of differences among varieties and growing conditions.

Plant culture is also important in the control of iron chlorosis. Avoid saturated soil conditions by reducing watering or by installing drainage systems, especially with susceptible trees and shrubs. Aerate compacted areas around the base of affected vegetation. Also, avoid using plastic sheeting as a mulch for susceptible plants, since it restricts oxygen movement into the soil.

Several methods are available for treating iron deficiency. These are: 1) soil application of elemental sulfur combined with ferrous (iron) sulfate; 2) soil application of iron chelates; 3) foliar sprays containing ferrous sulfate or chelated iron; or 4) trunk injection of ferric ammonium citrate or iron sulfate (trees only). Foliar treatments produce a rapid but incomplete response, while a soil or trunk treatment will last longer. Soil treatments are not economical for large areas of relatively low-value crops such as corn. Iron chlorosis in field crops should be treated with a foliar spray. Table 2 lists some advantages and disadvantages of different iron chlorosis control methods. Often, one method will work well in one area but not in another due to variations in soil conditions and species susceptibility. Try different methods until you find the one that works in your situation.

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

Method	Advantages	Disadvantages
Soil application of iron sulfate-elemental sulfur combination	●Lasts up to several years ●Relatively inexpensive ●No injury to plant ●Simple procedure	●Slow response ●Results sometimes variable ●Too expensive for large areas of low-value crops ●Can be labor-intensive
Soil application of iron chelates	●Simple procedure ●Generally no injury to plant ●Relatively quick response	●May last less than one season ●Expensive ●Results sometimes variable
Foliar application of chelates or iron sulfate	●Quick response ●Fairly simple procedure (except for large trees) ●Only practical method for field crops	●Expensive on trees ●Can cause temporary leaf burning ●Often lasts less than one season ●Provides only partial control
Trunk injection or implantation	●Lasts up to several years ●Moderate expense	●Injures tree's trunk ●Can't be used on shrubs or non-woody plants ●Results sometimes variable ●Can cause temporary leaf burning ●Somewhat complicated procedure

Soil treatment. Use soil applications to treat individual trees and shrubs, or small areas in a landscape, in the fall or early spring. A mixture of equal parts iron sulfate (Table 3) and elemental sulfur can produce lasting results and is relatively inexpensive. Select an inorganic iron source with a high concentration of iron and one that is derived from iron or ferrous sulfate. Read labels to determine iron concentrations and forms in different products.

It is not practical or desirable to blanket an entire landscape with the elemental sulfur-ferrous sulfate combination. Instead, treat small areas by making holes 1 to 2 inches in diameter and 12 to 18 inches deep. Space the holes 18 to 24 inches apart around the area within the drip line (outer edge of crown) of affected trees and shrubs. Fill each hole with the iron sulfate-elemental sulfur mixture to within 4 inches of the soil surface. Table 4 provides recommendations for the number of holes and quantity of the ferrous sulfate-elemental sulfur mixture required to treat plants according to their size. Make holes with an auger or soil probe that *removes* soil to reduce compaction. Avoid damaging large, woody roots when making holes. Also, check with local utility companies if making holes in the vicinity of underground utility lines.

Photo 3. Treatment of pin oak with soil application of sulfur and iron sulfate into augered holes.

Rows of berries or small shrubs can also be treated with equal parts ferrous sulfate and elemental sulfur. Use a hoe to excavate a small trench approximately 4 inches deep, 12 to 24 inches away from the base of plants. Apply one inch of the ferrous sulfate-elemental sulfur combination to the bottom of the trench and then fill in the remainder of the trench with soil.

Table 3. Commonly available forms of iron and sulfur.

	Trade name	**Content**
Inorganic iron:		%iron
Ferrous sulfate	Iron sulfate	20.5
Ferrous sulfate	Ironite	4.5
Iron Chelates:		
FeDTPA	Sprint 330	10.0
FeEDDHA	Sprint 138	6.0
FeEDDHA	Millers Ferriplus	6.0
FeEDTA	Hampene Iron	9.0
FeHEDTA	Che-Gro Iron	5.0
FeHEDTA	Versonol Ag Fe	5.0
Sulfur:		%sulfur
Elemental sulfur	Elemental sulfur (powder form)	99.0
Elemental sulfur	Degra-Sul (prill form)	90.0
Elemental sulfur	Agri-Sul (prill form)	90.0

Table 4. Combined iron sulfate and elemental sulfur requirements for the treatment of individual trees and shrubs by the soil application method.*

Trunk diameter (inches)	Number of 1 - 2 inch diameter holes made in soil within the drip line	Pounds of elemental sulfur + iron sulfate
1	4	0.5 - 1.0
2	6	1 - 2
4	8	3 - 6
6	12	8 - 12
8	16 - 24	12 - 16
10	25 - 30	16 - 20
15	30 - 40	20 - 30
20	40 - 50	30 - 40

* Holes should be made 12 -18 inches deep by *removing* a soil core.

Over time, the concentrated sulfur reacts to form acid which neutralizes lime and lowers soil pH in a small zone around the treated areas. The acidification of soil in combination with the iron sulfate maintains iron in a form that can be absorbed by plant roots.

Certain iron chelates provide excellent results when used as a soil treatment. The effect usually lasts only one year and chelates are relatively expensive. The only chelate that works consistently under high soil pH conditions is one containing the EDDHA molecule (Table 3). All other chelates currently on the market are ineffective at pH greater than 7.2, and therefore are not very effective for treating typical soils in Utah.

Use chelates in spring before growth begins. Sprinkle dry chelate on the soil surface and irrigate in, or dissolve in water and apply to soil around the base of plants. Chelates can also be applied in holes around the drip line of affected vegetation.

Foliar treatment. Foliar applications are made directly on the leaves of affected plants during the growing season. These treatments produce a quick response, often in a matter of days. Response to foliar sprays, however, is often incomplete (spotty control) and temporary. Repeated applications of foliar sprays may be required if chlorosis symptoms persist or as new foliage appears.

Chelates (Table 3) also control chlorosis when applied as a foliar spray. Follow label recommendations that come with these products. A 0.5% solution of ferrous sulfate applied to foliage also provides some control and is less expensive. A 0.5% solution is formulated by dissolving 2 ounces of ferrous sulfate (20 to 22% iron) in 3 gallons of water. Foliage should be sprayed in the evening or on a cool, cloudy day to prevent leaf burning. Add a few drops of liquid soap or wetting agent (available at farm supply stores) to help the solution wet the leaves.

Foliar-treat large acreages of field crops only if symptoms are severe. Treat field crops with a 2% ferrous sulfate solution formulated by dissolving 17 pounds of ferrous sulfate in 100 gallons of water. Add a wetting agent to the mixture and apply at the rate of 15 to 30 gallons of solution per acre. This treatment will need to be repeated if chlorosis persists.

 

Photo 4. Severely chlorotic pin oak before (left) and six weeks after (right) June trunk injection of ferric ammonium citrate liquid.

Trunk injection or implantation. Iron compounds in dry or liquid form can be placed directly into holes drilled into the lower trunk. Systems also are available that use plastic tubing and tees, capsules of various types, or a hypodermic-like tool to place iron materials into the tree. Though these techniques can be quite effective, they injure the trunk and should be used with care. Minimize injury by using methods and formulations that require small holes (some systems use holes as small as 1/8 inch diameter), and avoid any treatments that would require injecting a tree more than once every few years.

Commercial formulations are available as liquids or powders and should be used according to directions. Look for formulations that contain ferric ammonium citrate (iron citrate) or ferrous sulfate. Holes should be made with a sharp brad-point bit to ensure quick uptake and reduce injury. Pay particular attention to manufacturer recommendations on hole placement, angle, depth and diameter. Studies have shown that uptake is better and more evenly distributed if holes are drilled near the soil surface on the outside of root flares. Covering or capping holes can be done for cosmetic reasons, but will not reduce the chance for decay or speed healing. Wound dressings should not be used.

Injection treatments are most effective if applied in the early spring during bud break. Treatments later in the year will not be as effective and may not last as long. Effects can be expected to last for two or more years, after which time retreatment may be necessary. Avoid injecting materials on hot, dry, windy days since leaves may blacken or "burn," though such damage is usually temporary and not serious. Make sure the tree is well-watered for several days before and several weeks after injection treatments.

Product availability. Ferrous sulfate, iron chelate and elemental sulfur products can be purchased at larger garden supply stores or from agriculture chemical dealers. Chemicals and apparatus for injecting trees can be found at, or may be ordered by, nurseries and garden centers.

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