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Iron Deficiency of Woody Plants

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Introduction

Iron deficiency is a nutritional deficit that can occur in woody and herbaceous plants in landscapes, nurseries, greenhouses, and production fields. It is most often associated with soils that have neutral or alkaline pH (pH 7.0 or above). Plants that grow best in acidic soils are particularly vulnerable to this condition. In Kentucky, iron deficiency is most commonly observed on pin oak, willow oak (Figure 1), azalea, rhododendron, and blueberry, but other woody plants are also susceptible (Table 1).

Table 1. Plants sensitive to iron deficiency

Common name	Genus
Azalea	*Rhodoendron*
Birch (some)	*Betula*
Blueberry	*Vaccinium*
Dogwood	*Cornus*
Holly (American)	*Ilex*
Magonia	*Magnolia*
Oak (black & white groups)	*Quercus*
Pine (white)	*Pinus*
Rhododendron	*Rhodoendron*
Sweetgum	*Liquidamber*

Figure 1. Willow oak with symptoms of iron deficiency (Win Dunwell, University of Kentucky)

Symptoms

The most common and distinctive symptom associated with iron deficiency is leaf discoloration between the veins, especially on younger leaves. In addition, affected leaves are usually abnormally small. Unless the condition is treated, symptom progression typically follows the pattern described below, which can occur over a period of several years.

- Yellow or white (chlorotic) colored tissue between green leaf veins (Figure 2)
- Nearly white leaves as veins lose their green color
- Necrotic (brown) areas along leaf margins and between veins (Figure 3)
- Reddish-brown tint of older leaves
- Leaf drop, beginning at the terminals
- Dieback of twigs and branches (Figure 4)
- Plant death

Figure 2. Yellowing between the veins of rhododendron leaves (Win Dunwell, University of Kentucky)

Cause

Iron availability is a function of soil pH. If a plant is not able to absorb the iron present in soil, then iron is unavailable to the plant. It is not the total amount of iron present in the soil that matters but rather the amount that the plant can take up and utilize. Typically, iron deficiency occurs at a high soil pH and can be accentuated at high soil phosphorus levels. Although the availability of most other plant nutrients is maximized at pH ranges near 6.5, iron tends to become more available for plant uptake at lower soil pH levels (Figure 5).

Figure 3. Necrotic (brown, dead) areas beginning to show up on iron deficient willow oak foliage (Win Dunwell, University of Kentucky)

Figure 4. Dieback in oak tree (Joseph O'Brien, US Forest Service, Bugwood.org)

Optimal soil pH differs among plant species. Most plants favor pH ranges between 5.5 and 6.5, and many acid-loving plants prefer a soil pH of 4.5 to 5.5. Readings above those optimal ranges may result in iron deficiencies.

Note: Soil pH is measured on a scale of 0 to 14. A pH of 7 is considered neutral. Readings below 7.0 are categorized as acidic, and those above 7.0 are classified as alkaline.

Diagnosis

An approximated diagnosis can be made based on foliar symptoms, but soil should be tested to determine soil pH in order to confirm iron deficiency. Commercial growers may also consider a leaf analysis through a private laboratory. Contact your county Extension office regarding the correct sampling procedure and submission requirements for soil samples as well as information on leaf-testing labs.

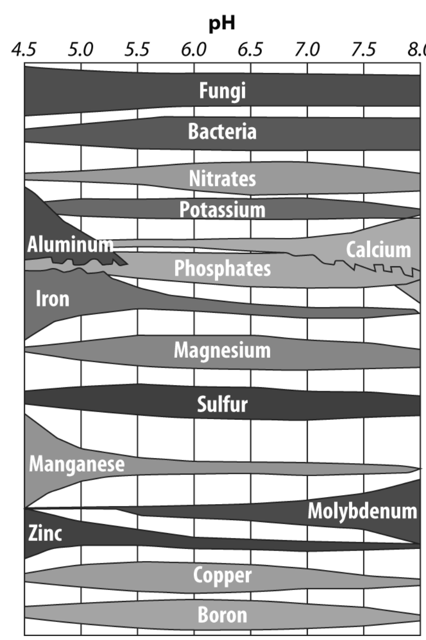

Figure 5. The availability of plant nutrients, toxic elements and microbial activity as influenced by soil pH. Wider bars indicate increased availability (activity).

Correcting Iron Deficiency

Iron deficiency can be treated by one or more of the following methods:

- Acidification of soil
- Addition of iron to soil
- Application of iron directly to plants

Corrective action will be most effective when initiated either prior to planting or at least at the early onset of chlorotic symptoms. Treatments applied during the later stages of symptom development (i.e. after most of the terminal growth becomes chlorotic and twig dieback is prevalent) often are not effective, and plants do not fully recover. However, plant vigor, maintained by timely watering and fertilization for at least one to two years after treatment, will aid in symptom recovery.

Acidification of soil

Acidification of soil is the most effective means of correcting iron deficiencies. Soil amendments may be added anytime, but they are more easily incorporated when applied before planting. To determine application rates, soil tests should precede addition of amendments. High pH is often lowered using elemental sulfur. Incorporation is recommended but may not be possible once plants are established.

Acidification of soil before planting

Elemental sulfur should be incorporated into soil at least one month prior to planting. Refer to Table 2 for amounts of sulfur required to bring about the desired pH change. These amounts will effectively treat an area 100 square feet to a depth of 6 inches. When treating individual plants, amounts of sulfur should be adjusted accordingly.

Note: Acidifying only the soil in the planting hole is not recommended since roots will grow far beyond the original root ball.

Elemental sulfur is the preferred treatment, but aluminum sulfate may also be used for acidification of soil. It reacts faster than elemental sulfur, but effects are not as long-lasting and greater amounts are required for a similar change in pH. Although aluminum sulfate is often recommended to gardeners for increasing the acidity of soil, it has a toxic salt effect on plants if large amounts are used, and precautions are suggested. About 6 pounds of aluminum sulfate provide the same effect as 1 pound of sulfur. If rates greater than 4.5 pounds per 100 square feet of aluminum sulfate are needed, apply half of the required amount in the spring and half during the fall.

Note: Although other sources suggest using sulfuric acid, this chemical is very corrosive and hazardous to handle. Sulfuric acid is not recommended.

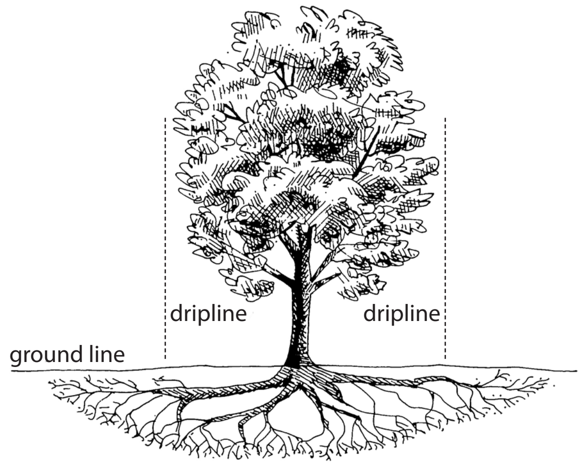

Figure 6. A tree's dripline is the outer edge of the canopy or branch spread (dashed lines). Often, there is more root area extending beyond an established tree's dripline than within it.

Acidification of soil after planting

Spread (broadcast) elemental sulfur evenly on the soil surface over the root zone. Begin approximately 1 foot from the trunk and work outward. Cover a distance equal to twice the distance from the trunk to the dripline (Figure 6). Refer to Table 2 for amounts of sulfur required to bring about the desired change in pH. Do not apply more than 10 pounds of elemental sulfur per 100 square feet. Do not make heavy applications of sulfur to poorly drained soils because toxic hydrogen sulfide can form under these conditions.

Table 2. Amount of sulfur needed to lower soil pH

Original pH of Loam Soil[1]	Pints[2] of sulfur/100 sq ft[3] needed to reach pH of:				
	4.5	5.0	5.5	6.0	6.5
5.0	2	-	-	-	-
5.5	4	2	-	-	-
6.0	6	4	2	-	-
6.5	8	6	4	2	-
7.0	10	8	6	4	2

1 Based on water pH value
2 Since reducing pH is usually attempted on a per plant or small bed basis, pints per 100 square feet (rather than pounds) is generally more useful. One pint is approximately 1 pound.
3 These amounts will treat a surface area of 100 square feet to a depth of 6 inches when incorporated into the soil.

Applying iron to the soil

Addition of iron to soil below trees or shrubs can result in improved foliar color, which may last several months. Results, however, may be inconsistent. Soil treatments for iron deficiency are not effective in soils where high soil pH is also inducing other nutrient imbalances.

The most common iron amendment is water-soluble iron chelate. Chelated iron is sold in many forms, and most brand names have "Fe" or "iron chelate" in them. These materials can be applied during spring to the soil below root zones either as a dry product or dissolved in water. Closely examine the product label prior to purchase and select a product that contains one of the following compounds: DTPA, EDTA, EDDHA, or HEDTA. Follow directions for the specific product being applied.

Soil may also be supplemented with addition of organic matter. Natural chelates can be found in organic matter, so any practice that increases soil organic matter will help maintain iron in soils.

Do not apply inorganic salts, such as iron or ferrous sulfate, as iron supplements. They are relatively ineffective as soil-applied amendments since they are quickly oxidized to an unavailable form.

Application of iron directly to plants

A foliar iron treatment will result in the quickest, most noticeable improvement, but results are often short-term. Because iron is not translocated within plants, the response will be localized to the area of application; new foliage will not benefit from foliar sprays. Leaf burn may occur during hot weather. Apply foliar sprays early in the morning or in the evening to reduce the risk of foliar burn. If treating high-value plants, test a small area for foliar damage. Proceed with treatment of the entire planting only if the test area is not affected within 2 to 3 days.

Follow these recommendations for foliar applications of iron:

- Spray soluble forms of iron, such as iron sulfate (ferrous sulfate) or chelated iron, on foliage in late spring. Iron sulfate is as effective as chelated iron when applied as a foliar spray and is typically less expensive.
- Mix 1 to 4 ounces of iron sulfate into 1 gallon of water. A solution concentration greater than 4 ounces will increase the risk of foliar burn.
- Add a wetting agent to increase the coverage, and therefore the absorption, of the product. Use a commercial wetting agent or a couple of drops of dishwashing liquid.

Maintaining a Low Soil pH

Once soil pH has been adjusted to the desired range, it should be maintained for optimal plant growth, especially for acid-loving plants. Soil pH should be retested every 2 to 3 years. The following suggestions can help maintain acidic soil conditions.

A number of fertilizers specifically designed for acid-loving plants are available and can help maintain low pH. Follow label instructions for application method and rates. One such fertilizer is ammonium sulfate. Use caution when applying fertilizers to turfgrass. Apply 0.3 pound of ammonium sulfate per 100 square feet to the soil surface *within* the dripline and 1.2 pounds per 100 square feet *beyond* the dripline annually. Divide applications over autumn, winter, and early spring.

Avoid the use of:

- Alkaline or "hard" water. Frequent irrigation with water from a public water supply may cause a progressive increase in soil pH. Use rain or well water when possible.
- Limestone or materials containing limestone as mulch around bases of plants.
- Planting near buildings or masonry walls, as concrete and masonry leach lime and can raise pH in nearby soils.
- Phosphorous and potassium-rich fertilizers.
- Nitrate-containing fertilizers.

Summary

Prevention of iron chlorosis can be challenging. Once iron deficiency/chlorotic symptoms develop, they are often difficult to reverse. Potential problems can be avoided by correcting soil pH before planting. Begin with a soil test, then select a proper growing site for desired plants. Slight changes in soil pH are often easy to maintain; drastic changes are more difficult to sustain.

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