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Correcting Iron Deficiencies in Grain Sorghum

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Understanding the Problem

Until grain sorghum develops an extensive root system, young plants may not be able to obtain enough ferrous iron to maintain normal growth on some Texas soils. Although iron is not a part of the chlorophyll molecule, it is required to supply enough chlorophyll to support the growth of new leaf tissue.

High-pH, calcareous soils not only reduce the availability of soluble iron in the soil; they also change the soil's cation-exchange capacity so that less iron is present and available for exchange overall. The result is a more slowly growing plant and subsequent uneven flowering dates. This not only delays ripening of grain and harvest, but the uneven pollination undermines an effective insecticide spray program for controlling sorghum midge. The distribution of soils having a potential for iron chlorosis is shown in Figure 1.

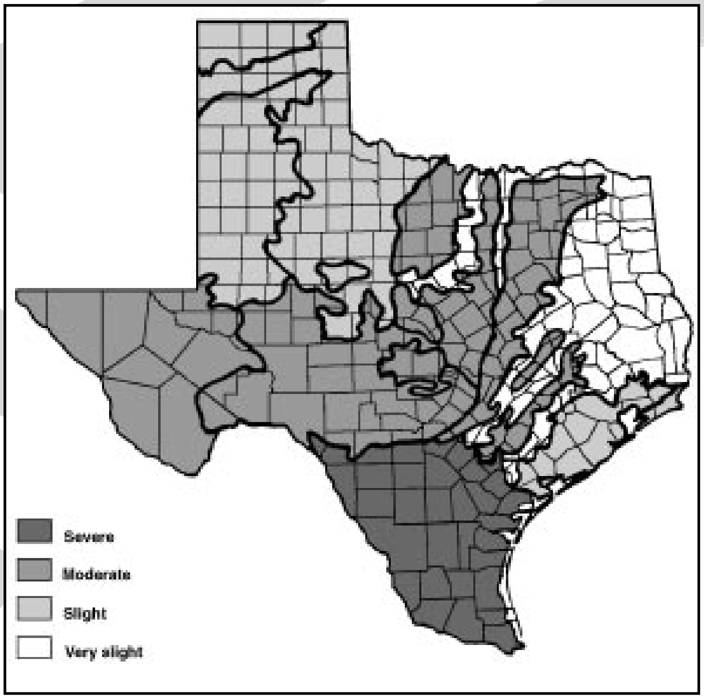

Figure 1. Degree of iron deficiency in land resource areas.

Visual Symptoms

Mild chlorosis ranges from a lighter green leaf color that progresses to increasing interveinal striping, to almost no visual symptoms. New leaves may appear normal as the sorghum outgrows the deficiency. In some cases, the rate of growth may be so close to normal that no difference in flowering date is observed; while in other deficient plants treated sorghum may flower 2 to 3 days earlier than untreated plants.

Moderate chlorosis is seen where sorghum plants are yellow or yellow-green in strips, or irregularly shaped areas of the field. Fields may have intermittent blotches of chlorotic plants scattered in a salt-and-pepper (random) arrangement. Iron chlorosis is often sporadic throughout the field, or it may be associated with some land-moving event. Often the higher ground in a field will exhibit greater chlorosis, while terracing and land leveling may also result in new chlorotic zones. Since available ferrous iron is responsible for this anomaly, both pH change and available soil moisture influence the iron concentration in soil solution. If not treated with ferrous sulfate, some hybrids may yield less grain. Losses result from both uneven midge control and lost yield potential.

Severe chlorosis occurs when tissue develops a very pale yellow to almost white coloration. Some hybrids are more sensitive than others. Leaves of affected plants are thinner and narrower and tend to injure more easily. Shallow, calcareous outcrops; sandy lenses of high-pH soil (8.0+); and shells of land snails are usually associated with these sites. By the time severe chlorosis is observed, it may already be too late to restore even-flowering dates, or to escape

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some yield reductions. The earlier the treatments are made, the greater the effect of the applications. Treatments with ferrous sulfate could result in yield differences of 800 to 2,000 pounds per acre with some chlorosis-sensitive hybrids. Severe chlorosis may kill young sorghum plants or cause stunting so severe that flowering is prevented.

Diagnosis of Problem

Visual symptoms are often the best indicator of whether or not to treat chlorotic fields or parts of fields for iron chlorosis. A simple test area treated with an application of soluble iron in a hand sprayer is sufficient.

One of the simplest methods for confirming iron deficiency is to apply a 1- to 2$^1/_2$-percent solution of iron sulfate (copperas) on some chlorotic leaves. This solution may be prepared by dissolving 1 tablespoonful of iron sulfate and $^1/_2$ teaspoonful of detergent in 1 gallon of water. Apply the solution by spraying, dipping individual leaves in the solution, or painting a portion of the chlorotic leaf.

If the chlorosis is caused by iron deficiency, a darker green color should be noticeable on treated plants in 4 to 7 days under favorable growing conditions. Young or recently matured leaves should be used for this test since old, severely chlorotic leaves tend to lack the ability to form chlorophyll, even when supplied with iron.

Correcting Iron Deficiency

Several products are available for field use to correct iron chlorosis. While a number of attempts have been made with iron-containing slags and acidic byproducts to supply iron to the soil, these have never proven effective because of an almost immediate oxidation of the soluble ferrous iron, converting it to the less-soluble ferric state.

Attempts to correct iron deficiency by applying acidifying materials to calcareous soils generally have not been successful or practical on a field basis because of the large amount of acidifying material required. For example, it would take 5 tons of sulfuric acid per acre to neutralize 1 percent calcium carbonate in a 6-inch layer of soil. Many iron-deficient soils contain as much as 10 percent free calcium carbonate, which represents 50 tons of sulfuric acid. If elemental sulfur were used, it would require one-third that amount to give the equivalent acidifying effect. Products of acidifying reactions may greatly increase soil salinity. Localized acidification through banding or using pelleted sulfur has been successful in some situations.

For the past several decades, producers have had to rely on foliar amendments to place available iron into the plant. If early deficiency symptoms are observed or occur every year on certain fields, banded foliar treatments should begin as early as sufficient leaf area is present to intercept the material used. This is usually 10 to 14 days after the sorghum has emerged. A common mistake is not starting ferrous applications soon enough and then failing to follow-up with subsequent needed applications.

A spray solution can be prepared using 20 pounds of iron sulfate (copperas) in 100 gallons of water, plus a spreader sticker, and spraying the solution over the crop row at 5 gallons per acre (10 to 14 days after emergence). After the first treatment, products should be applied as required at 7 to 10 day intervals using the same solution concentration, but increasing application rates to 10 to 15 gallons per acre.

Potential for Damage

If sorghum is under stress, foliar applications of ferrous sulfate can result in a net yield reduction. Applications made early in the morning or late in the afternoon may reduce risks, but ferrous applications in hot, dry weather may only aggravate an already failing yield potential. This is more likely to occur on plants that really had no need for additional iron. Some iron-chlorosis-tolerant hybrids have been observed to produce less grain when normal plants were sprayed with chlorotic ones. Because entire sorghum fields seldom require iron applications, some producers have installed solenoid valves with a pressure switch to selectively apply ferrous iron while cultivating.

Iron sprays require a spreader-sticker or detergent in order to be effective. If a commercial spreader-sticker is not available, ordinary household detergent may be used at rates of $^1/_4$ to $^1/_2$ pint per 50 gallons of solution. Thorough coverage and wetting of the entire leaf surface is necessary for good results. Avoid too much detergent to minimize the chances of leaf burn.

Yield reductions can also occur if foliar iron is sprayed directly onto large sorghum as the heads are exposed. Application should be discontinued when the sorghum plants reach boot stage. Flowering parts of any exposed heads will be damaged if the iron product is applied at this time.

Other Conditions Causing Chlorosis

Large phosphorus corrections banded next to the seed row may also intensify iron deficiencies. Since iron phosphate is one of the less-soluble phosphates, already low levels of iron in soil solution may become worse during dry, wet, or cold weather when root uptake is less or root systems are damaged. If phosphorus applications greater than 30 pounds per acre are planned on potentially chlorotic fields, growers should be prepared to apply foliar iron as required.

Formulations Available

Dry ferrous products have a long shelf life so long as they are stored properly. Copperas is the least expensive form of ferrous sulfate, but contains sand and impurities that must be filtered. Otherwise, copperas is very abrasive to nozzles. Vitatone is a dry product containing 3 percent ammoniacal N and 1 percent chelated iron from ferrous sulfate and citric acid. It is slightly more expensive than the copperas. PenGreen iron is a highly soluble, 5 percent iron sulfate that is easy to handle and requires no agitation. PenGreen II contain an addition of 3 percent N.

Several manufacturers of foliar products have constructed iron materials that also contain nitrogen, phosphorous, zinc, magnesium, and manganese, as well as other micronutrients. These additions are usually not recommended by soil or tissue test, and while they do not injure the sorghum and may be needed occasionally, they may increase product cost.

Since nitrogen can also effect plant color, urea-based nitrogen may also be added. This small nitrogen addition is useful in that it corrects chlorosis that might have been due to low N levels. Iron reactions will be observed as dark green blotches on leaves where spray droplets fell.

Except on low-fertility or sandy soils, the addition of micronutrients may neither help nor hurt sorghum, but provide insurance against possible deficiencies. The manganese is particularly prone to precipitate from solution with time. Unless the overall pH of the product is kept low enough to maintain solubility, settling occurs to where shelf life seldom spans more than two growing seasons. The pH and salt content of the amendment has much to do with its potential for foliar burn and subsequent leaf damage.

In selecting foliar iron products, consider product efficacy, safety from leaf burn, cost, ease of application, and shelf life.

Product	Rate Per Acre	Form	Agitation Required
Copperas	4-5 lb.	dry, coarse	yes
Vitatone	1.5-3 lb.	dry, fine	yes
Chelate	1-2 lb.	dry, fine	yes
PenGreen	3-6 qt.	liquid	no

Using Chlorosis-Tolerant Hybrids

Over the last several years, grain producers, universities, and seed companies have been observing advantages in selecting certain sorghum hybrids for planting on high pH soils along the Texas Gulf Coast. On the worst of soils, chlorosis continued to be expressed; but on soils with light or moderate chlorosis, some of these hybrids retain a green color throughout the growing season or required fewer applications to sustain normal growth. This small group of hybrids was identified as “iron chlorosis tolerant hybrids” in that the plants still require additional iron, but do not require the intensive number of applications required by sensitive hybrids. One or two iron applications may be sufficient to correct chlorosis problems.

The hybrid response is thought to be due to a greater solubility and uptake of ferrous iron at the root surface rather than a greater proliferation of root surface area. There is insufficient research to fully explain these observed differences in performance beyond the fact that they do exist. Several of the hybrids studied have already been replaced by other commercial hybrids having greater iron utilization efficiency. The following Gonzales County data (see Table 1) are typical of results obtained on high-pH soils.

Product-Sensitive Hybrids

Hybrids respond favorably to iron applications only if iron is deficient in the plant. Some sorghum hybrids may be sensitive to specific foliar iron products. Two years out of three, Pioneer 8313 produced less grain when treated with PenGreen, with no merited increase in the third year. A 1,280 pound yield increase was achieved with copperas in a fourth year of evaluation. It is suspected that this hybrid is sensitive to foliar burn from the pH of the PenGreen solution.

Chlorosis-Sensitive Hybrids

A number of sorghum hybrids have shown a greater potential for chlorosis when grown on high-pH soils. These hybrids lack the ability to fully assimilate iron from the soil. Several of the food-grade white and cream-colored sorghums have been observed to lack this tolerance and should be further evaluated before large acreages are grown. Except for the weakest hybrids of this group, most commercial hybrids will respond to multiple applications of product if properly applied according to time of need.

Soil Testing Concerns

If a soil test is being requested for iron considerations, air drying of the sample should be specified and the iron should be determined by atomic absorption or a method that best indicates available iron in production fields.

The ICAP (Inductive Coupled Argon Plasma) method of analysis is prone to evaluate some of the iron on the clay structure as well as suspended iron. Therefore, adequate (but false) values are sometimes reported. One way to avoid this problem is to air-dry the samples instead of oven-drying them. Oven-drying shrinks the clays, drives off the water, and sometimes doubles the iron and potassium values. For iron testing, the soil samples should be evaluated by atomic absorption spectrometry.

Laboratories using the DTPH method of analysis, developed at Colorado State University, will encounter problems in obtaining accurate iron levels on soils with recent phosphorous amendments. The phosphorus will precipitate the low amounts of available iron. While some laboratories suggest adequacy with iron levels of 4.5 ppm or higher, the level should be moved to 10 or 15 where high levels of phosphorous were added recently.

Table 1. Grain yields and economic relationships observed with the application of PenGreen 25% ferrous sulfate to iron-chlorosis-tolerant and conventional sorghum hybrids on a high-pH soil, Walter and Michael Kuck Farm, Gonzales County, Texas, 1992.

	(Grain lb./A)			Dollars			
Hybrid	w/o Fe	w/Fe	Grain	Untreated Grain Value	Treated Grain Value	Value Added Fe	Fe Benefit/Cost Ratio[2]
Chapparal	3078	3570	492	113.89	132.09	18.20	4.85
Cargill 837	2770	3241	471	102.49	119.92	17.43	4.65
NK KS 737	2851	3282	431	105.49	121.43	15.94	4.25
Cargill 857	2397	2790	393	88.69	103.23	14.54	3.88
DPL 1552	2047	2330	283	75.74	86.21	10.47	2.79
Rustler	2371	2593	222	87.73	95.94	8.21	2.19
DK 50	2726	2917	191	100.86	107.93	7.07	1.89
Pioneer 8313	2667	2133	<534>	98.68	78.92	<19.76>	<5.27>

[1]Sorghum grain value used was $3.70/cwt (Jul 92).

[2]Product cost fixed at a value of $1/gallon.
Application cost estimated @ $2.75/acre.

Note: Fe = iron.

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