Management of Iron Deficiency Chlorosis of Soybeans

Soybean "iron deficiency chlorosis" (IDC) is a nutrient deficiency with general symptoms of chlorosis (yellowing) of the soybean foliage and stunting of the plant. This condition is yield-limiting in many soybean fields in the northern and western Corn Belt including western Minnesota, the Dakotas, Nebraska, Iowa and other states. Some experts estimate that losses in income from this problem exceed $100 million. Because soybean acres are increasing in regions at risk to IDC, losses could become even higher unless management practices are implemented to reduce iron deficiency occurrence.

Typically, IDC symptoms begin to appear a few weeks after soybean emergence as interveinal chlorosis on the first trifoliate leaves. Because iron does not translocate in the plant, new growth will be most affected if the deficiency intensifies. Leaves may eventually turn yellow with dark green veins and the plants may be stunted. Under severe iron deficiency, plant leaf edges become necrotic (turn brown), and the necrosis may progress until entire leaves or even plants are dead. The symptoms tend to show up in irregularly shaped spots randomly distributed across a field.

Interveinal chlorosis due to iron deficiency.

Several management practices have been evaluated to address iron deficiency chlorosis in soybeans. These include variety selection; increased soybean seeding rate; use of interseeded, small-grain crops; delayed planting; avoidance of herbicides that slow growth or cause leaf area loss; and seed-applied, foliar-applied and in-furrow-applied iron. This article will discuss some of these management practices.

Environmental Factors Causing IDC

The factors that may cause chlorosis are complex and interact with each other to intensify the level of chlorosis. The most dominant factors are carbonate levels, salts and depressional field areas with poor drainage. Results of past research suggest that free calcium carbonate levels higher than 5% and/or soluble salts values greater than 0.5 mmho/cm indicate a high probability of soybeans expressing iron deficiency chlorosis and reduced yields. Research studies have suggested that decreased temperature, reduction in air-filled soil porosity, increased soil moisture, soil pH > 7.8 and residual nitrogen may also increase IDC symptoms.

Franzen and Richardson (1999) studied the relationship between soil pH, soluble salts (EC), soil Fe, Na and calcium carbonate equivalent (CCE) within gradients of chlorotic to green soybeans at various locations over three years. These results suggested EC and CCE were the best indicators of the potential for developing iron deficiency chlorosis. Soil Fe, Na and soil pH did not consistently predict the potential for developing chlorosis.

Managing Iron Deficiency Chlorosis

Variety Selection and Plant Population – Because soybean varieties vary widely for tolerance to IDC, variety selection is the first and most important step in managing this problem. Pioneer Hi-Bred has a significant research effort to screen its varieties in areas with IDC. This screening effort is critical to understand and report current variety response to IDC, as well as identify new varieties that can help growers overcome yield losses to IDC.

Pioneer® brand varieties are rated on a 1 to 9 scale where 1 indicates poor tolerance and 9 indicates excellent tolerance. If growers are planting into an area with a history of IDC, they should select varieties with an IDC score of 6, 7 or 8. Along with improving chlorosis tolerance, Pioneer soybean breeders have been able to stack other defensive traits such as SCN resistance, phytophthora and brown stem rot tolerance.

Another management practice that has resulted in increased yields in IDC areas is increased plant population. Scientists suggest increasing plant density to 200,000 plants/acre in 30-inch rows in chlorotic field areas. Using GPS systems to map affected fields and variable-rate seeding equipment to vary seeding rates in affected vs. non-affected field areas could increase the efficiency of this management strategy.

Cover Crop and Nitrogen – Pioneer and the University of Minnesota have conducted studies evaluating the use of competition crops such as oats or wheat to help reduce IDC. Early work suggested additional roots from oats may reduce soil pH and increase iron availability. However, this did not explain an observation that soybeans in a wheel track were typically healthier than those outside the wheel track. To help understand this phenomenon, George Rehm (Extension Soil Fertility Specialist for the University of Minnesota) collected soil samples from the wheel track area and soil adjacent to the wheel track (Rehm, 2008). Rehm identified lower levels of soil nitrate nitrogen in wheel tracks and in the plants grown in the soil from the wheel track in a greenhouse experiment.

To confirm greenhouse results, an N rate by competition crop study was conducted at two locations in Minnesota. The results suggested N rate had a very negative impact on yield and the use of oats reduced the impact of N (Table 1). At the Kandiyohi County site, yields were near zero when a competition crop was not used vs. 40 bu/acre with oats planted. In these locations, oats were seeded at a rate of one bu/acre and killed with glyphosate when they reached 12 inches tall.

Table 1. Influence of N fertilizer and a competition crop on soybean yield when IDC is a problem. Source: U. of MN.

Nitrogen Rate	Oats Planted?	Yellow Medicine County	Kandiyohi County
lb/acre		bu/acre	
0	no	52.0	3.6
100	no	32.2	0.3
200	no	19.1	0.1
0	yes	52.4	40.2
100	yes	42.6	24.5
200	yes	25.9	7.2

Iron Chelate Treatments – Investigators have looked at various methods of addressing iron chlorosis with an iron chelate, including seed-, foliar- and soil-applied treatments. Using chelates can be cost-prohibitive, but applying chelates as seed treatments is an efficient means of getting iron to the soil for plant uptake. One such chelate is Fe-EDDHA, a dry powder that can be mixed with water and applied to the seed.

Seed and Foliar Treatments – To determine the value of seed-applied iron, the University of Minnesota and Pioneer conducted a three-year study. Fe-EDDHA was applied on the seed at a rate of 0.06 lb Fe per acre. These treatments tended to improve early plant health at V3, but their effect diminished by V6. The seed-applied Fe did not significantly increase grain yield. Another treatment in the experiment was foliar application of ferrous sulfate (0.5 lbs/acre) at V3 and V6. These applications, when used alone or in combination with seed-applied Fe-EDDHA, significantly improved plant health but not grain yield.

In another study conducted by Rehm in 2004, seed-applied Fe-EDDHA significantly increased soybean yields, but foliar applications did not increase yields above the seed-applied treatments. Based on this work and Pioneer research, the value of seed and foliar applications of Fe has been questionable.

Soil-applied treatments – Iron uptake from the soil occurs primarily at the root tips. This would suggest delivery of Fe in-furrow would be advisable. Historically, soil-applied iron chelates were very expensive and could not be justified. However, Soygreen®, a new Fe-EDDHA that entered the market in 2006, could change the cost/benefit equation. Soygreen is a dry, water-soluble powder with 6% Fe-EDDHA chelate that costs about $10.00 to $14.00/acre.

In field observations by Pioneer agronomists, Soygreen applied in-furrow has shown some promise. In 2007 and 2008, Dr. John Lamb at the University of Minnesota evaluated Soygreen. He reported Soygreen increased soybean yields from 30 bu/acre to 49 bu/acre when it was applied at 3 lbs/acre. He also found that when Soygreen was used in combination with a competition crop (oats), additional improvements in yield may be achieved.

In 2008 and 2009, Pioneer Agronomy Sciences evaluated Soygreen at four locations with high, moderate or low chlorosis pressure. The average response across varieties with poor to high chlorosis tolerance is shown in Figure 1.

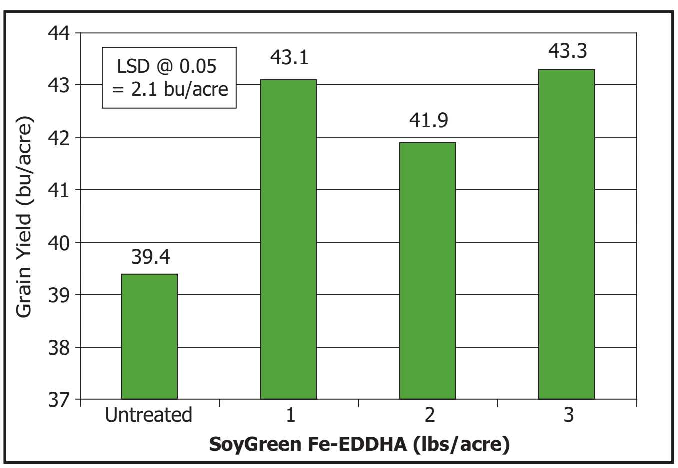

Figure 1. Effect of Soygreen Fe-EDDHA on soybean grain yield, averaged across varieties. Four locations, 2008-2009.

A significant variety by Fe-EDDHA treatment interaction was found in this study (Figure 2). The three Pioneer® brand varieties with an iron chlorosis score of 7 or 8 did not respond to the applications of Fe-EDDHA. The varieties with a Fe-EDDHA score of 2 had an average grain yield response of 9.6 bu/acre. At some locations yield increases were as high as 13 bu/acre.

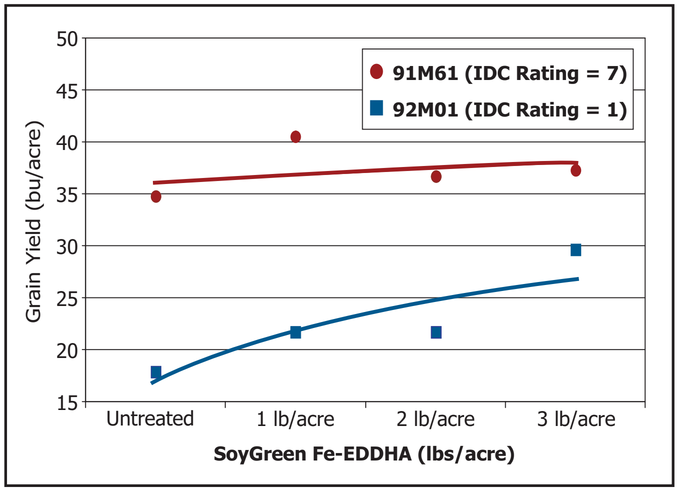

Figure 2. Response of an IDC-tolerant vs. non-tolerant soybean variety to Soygreen treatment, Bird Island, MN, 2009.

Note that although Soygreen treatment greatly improved the yield of Pioneer 92M01(RR), the tolerant variety 91M61(RR) was still much higher-yielding.

Pioneer 92M01 (iron chlorosis rating = 1, non-tolerant), shows significant improvement from Soygreen treatment.

Summary

This recent research suggests growers may have some new tools to manage iron deficiency chlorosis. Soygreen and interseeding competition crops have provided the most consistent means of improving yields in fields with a history of chlorosis. However, the first step to success involves the selection of Pioneer soybean varieties with very good tolerance to iron chlorosis (Figure 2). When considering these management options, contact your local Pioneer sales professional to assist in the selection of the best Pioneer products and management practices for your field.