

Iron Deficiency Chlorosis in Soybean

- Iron deficiency has been a common, serious, and yield-limiting problem for soybean production in some parts of the U.S.
- The availability of a specific micronutrient, such as iron (Fe), is affected by many factors such as soil characteristics, field topography, environmental conditions, and soybean physiology.
- Careful selection of soybean products with tolerance to iron deficiency chlorosis (IDC) is one of the best and most recommended options to protect yield potential against IDC.

IDC Symptoms

Iron is one of the necessary micronutrients for soybean plant growth and development:

- Needed for the development of chlorophyll, the green pigment in the plant.
- Involved in energy transfer, plant respiration, and plant metabolism.
- Is a constituent of certain enzymes and proteins in the plant.
- Necessary for soybean root nodule formation and has a role in N-fixation; thus, low levels of Fe can lead to reduction in N-fixation.

The most common IDC symptom is interveinal chlorosis of new leaf tissue. Soybean leaves first turn yellow, while the veins remain green. Leaves may develop necrotic spots, which can coalesce. Eventually leaves may die and fall off the plant. In severe cases the growing point can be killed. Iron deficiency symptoms are similar to that of manganese (Mn); therefore, only soil and tissue analysis can confirm the deficiency. Soybean IDC symptoms typically occur between the first and third trifoliate stage. Depending on the severity of the problem, symptoms might improve later in the season.

Reduced plant growth due to any IDC symptoms can have a negative effect on yield potential. Substantial yield reductions have been reported from IDC throughout north central United

States. Yield loss is estimated to be around \$120 million annually.¹

Factors Associated with IDC Development

IDC in soybean is the result of complex interactions among many factors including soil characteristics and topography, soybean physiology, and environmental conditions.

Soil Characteristics and Topography. While soils usually have adequate amounts of iron, it is not in a soluble form that can be directly used by plants, including soybeans. In oxidized or aerated soils, iron exists in the Fe(III) form. This form of Fe becomes less soluble and therefore less available for plant uptake with higher soil pH and when large amount of calcium carbonate exist in soil. High levels of carbonate in the soil can be due in part to the soil parent material. Some combinations of the percentage of free calcium carbonate and soluble salts can cause severe IDC (Table 1).

The presence of soil nitrate can also affect the development of IDC symptoms. While soybeans have the ability to fix nitrogen through root nodules, they will take up nitrate when it is available from soils. When roots take up a nitrate, they release bicarbonate. Over time bicarbonate levels can increase in the soil, which may lead to the development of IDC symptoms.

IDC is often associated with shallow depressions in a field. As water moves to low-lying areas, it carries solutes that collect over time. As the water evaporates, these solutes concentrate along the edge of the low-lying area. Symptoms of IDC may be more pronounced along these edges.

Soybean Physiology. Soybeans are Type I plants, meaning that their roots excrete acids and chemical reductants to help with iron uptake. The acids change iron in the Fe(OH)₃ form to Fe(II), a more soluble form. The reductants change the insoluble Fe(III) to the more soluble Fe(II). Because of these mechanisms, soybeans can usually uptake adequate amounts of iron when soil pH is less than 7.5.³ In soils with high levels of calcium carbonate, these calcium carbonate particles can come in contact with the soybean roots and neutralize the excreted acid, which results in the plants inability to take up adequate levels of iron (Table 1).



Figure 1. Symptoms of iron deficiency chlorosis in a soybean field.

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Environmental Conditions. Weather also plays a role in IDC symptoms. When soils are wet, carbon dioxide can build up in the soil. As the level of carbon dioxide increases, so does the level of bicarbonate, which neutralizes the acid excreted from soybean roots. Research has shown that increased soil moisture results in increased IDC and that IDC is more severe at low temperatures.⁵

In areas where IDC is more common, the amount of water lost to evapotranspiration tends to be greater than the amount of water that leaches through the soil profile. Thus, solutes do not leach through the soil, but instead collect on the soil surface.⁴ A shallow layer of carbonate or salts may be evident in soils where soybean IDC symptoms exist.

Management Considerations

It is difficult to correct IDC, but there are several management options to consider. The most important management consideration is product selection. Other options include the use of iron chelate products, planting cover crops, and adjusting planting rates. Please contact your local Agronomist for help in selecting the right soybean product for your operation and identifying other management steps that may be viable options to minimize IDC in your area.

Product Selection. Careful selection of soybean products with tolerance to IDC is the most important step to protect yield potential against IDC. Product selection is particularly important for fields with a history of Fe chlorosis or soil with high levels of salts and carbonate.

Minimize Plant Stress. Reduce plant stress due to diseases, nematodes, and herbicides. Product selection can be an important factor in minimizing plant stress, particularly when dealing with disease or nematode issues. Avoid compaction and reduce operations that may damage soybean roots.

Iron Chelate Products. Orth-ortho chelated iron products such as Soygreen® may be applied in-furrow at the time of planting. University of Minnesota research has supported the yield benefits of Soygreen when used at planting.² Use of other iron chelate products and application methods has shown inconsistent yield benefits. Maximum return on investment has been found to occur when these products are used in areas moderately to highly affected by IDC.⁵ Always consult the product label for rates and application information.

Additional Considerations. Other management considerations include minimizing nitrate carryover from year to year, targeting soybean crops to soils with low nitrates, and planting a companion crop to use excess nitrate. Adjusting planting rates may also be a management option in some situations.

Table 1. Combination of calcium carbonate and soluble salt levels in the soil that can cause IDC.

Carbonate level (%)	Soluble salts (mmhose/cm)	Risk of IDC
0 – 2.5	< 0.5	Low
0 – 2.5	0.51 – 1.0	Moderate
0 – 2.5	> 1.0	High
2.6 – 5.0	0 – 0.25	Low
2.6 – 5.0	0.26 – 0.50	Moderate
2.6 – 5.0	0.51 – 1.0	High
2.6 – 5.0	> 1.0	Very high
> 5.0	0 – 0.25	Moderate
> 5.0	0.26 – 0.50	High
> 5.0	0.51 – 1.0	Very high
> 5.0	> 1.0	Extreme

Source: Iron Chlorosis: Soybeans. Agvise Laboratories, <http://www.agvise.com>

Sources:

¹ The mysteries of yellow soybeans. 2007. Corn & Soybean. <http://cornandsoybeandigest.com> (verified 7/31/13); ² Rehm, G. 2008. Major progress with iron deficiency chlorosis in soybean. agbuzz.com. Minnesota Farm Guide and University of Minnesota Extension Service; ³ Kandel, H. and Goos, J.R. 2011. Iron deficiency chlorosis in soybean. Crop and pest report. North Dakota State University. <http://www.ag.ndsu.edu> (verified 7/31/13); ⁴ Morgan, J. 2012. Iron deficiency chlorosis in soybeans. <http://www.agronomy.org> (verified 7/31/13); ⁵ Kaiser, D.E. et al. 2011. Managing iron deficiency chlorosis in soybean. University of Minnesota Extension. <http://www1.extension.umn.edu> (verified 7/31/13); Corn & Soybean Field Guide. 2007 Edition. Purdue Pest Management Program. Purdue University; Diaz, D. 2008. Nutrient deficiency symptoms. Agronomy e-Updates, K-State Extension; Common nutrient deficiency symptoms, soybeans. 2007. <http://plantsci.sdstate.edu>; Sawyer, J. 2007. Integrated pest management nutrient deficiencies and application injuries in field crops. Department of Agronomy, <http://extension.agron.iastate.edu> Pedersen, P. 2007. Soybean nutrient requirements. Iowa State University Extension. <http://extension.agron.iastate.edu>; Soybean production handbook. 1997. Kansas State University, C-449.

Individual results may vary, and performance may vary from location to location and from year to year. This result may not be an indicator of results you may obtain as local growing, soil and weather conditions may vary. Growers should evaluate data from multiple locations and years whenever possible. ALWAYS READ AND FOLLOW PESTICIDE LABEL DIRECTIONS. Asgrow and the A Design® and DEKALB® are registered trademarks of Monsanto Technology LLC. Leaf Design® is a registered trademark of Monsanto Company. All other trademarks are the property of their respective owners. ©2013 Monsanto Company. 07312013MEA