Iron Deficiency Chlorosis in Soybean

KEY POINTS

- Iron deficiency can be a yield-limiting problem in some soybean production areas.
- The availability of iron to soybeans is affected by many factors, including soil chemical characteristics, field topography, and environmental conditions.
- Soybean product selection is one of the best management options in fields where iron deficiency chlorosis may be an issue.

Symptoms and Impact on Yield

Iron deficiency chlorosis (IDC) can reduce plant growth and have a negative effect on soybean yield potential. Substantial yield reductions from IDC have been reported throughout the north central United States. IDC does not always affect an entire soybean field at one time, but the areas where IDC is present can show up to a 30% yield loss.

Iron (Fe) is one of the necessary micronutrients for soybean plant growth and development and is important for the following:

- The development of chlorophyll, the green pigment in the plant which is critical for photosynthesis. If Fe is deficient, chlorosis (yellowing) occurs and growth and yield potential can be negatively affected.
- Involved in energy transfer, plant respiration, and plant metabolism.
- A constituent of many enzymes and proteins in the plant.
- Necessary for soybean root nodule formation and has a role in nitrogen fixation; thus, low Fe availability in the soil, and as a result lower uptake by the plant, can lead to a reduction in nitrogen fixation.

Soybean IDC symptoms usually first appear on the youngest of the uppermost leaves. Symptoms typically occur between the first and third trifoliate stage of soybean development. The distinctive symptom of Fe deficiency is the development of an interveinal chlorosis, while the veins of leaves remain dark green (Figure 1). The chlorosis is the result of low chlorophyll formation due to Fe deficiency. Under severe deficiency, leaf edges and the plant growing point may become necrotic (tissue death). Necrosis may progress and eventually leaves may fall off the plant and the growing point can be killed, reducing the amount of plant tissue available for photosynthesis. If the deficiency is not too severe and environmental conditions improve so that the root system is able to absorb sufficient Fe, plant may recover from IDC symptoms.

IDC symptoms are similar to that of manganese (Mn) deficiency. Therefore, a soil and tissue analysis may be necessary to confirm the deficiency.

Causes of IDC Development in Soybean

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

Soil Characteristics and Topography - Soils usually have adequate amounts of Fe but it may not be in the soluble form needed and ready to be absorbed by the soybean plant. The most soluble form in oxidized or aerated soils is Fe(OH)$_3$ where Fe is in the Fe(III) form. However, this form is less soluble and thus less available for plant uptake in high pH soils which have high levels of calcium carbonate.

Figure 1. Soybeans showing iron deficiency chlorosis and the distinctive symptom of interveinal chlorosis on leaves.
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Soil nitrate affects the development of IDC symptoms. When roots take up nitrate, they release bicarbonate. Over time, free bicarbonate levels can increase in the soil, which increases the soil pH surrounding the roots and may decrease the availability of Fe, and therefore IDC symptoms may develop.

IDC is often associated with shallow depressions in a field (Figure 2). 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** - Soybean plants prefer to take up the reduced Fe(II) form. The roots have mechanisms to excrete chemicals that can help reduce the soil pH slightly to improve Fe uptake. Due to these mechanisms, soybean plants can usually take up an adequate amount of Fe when the soil pH is 7.5 or less. However, high levels of calcium carbonate in the soil can neutralize the excreted chemicals and may decrease the plant’s ability to take up adequate Fe.

**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 and increases the potential for IDC. In addition, research has shown that IDC can be more severe at cool temperatures.

In areas where IDC is more common, the amount of water lost to evapotranspiration (ET) 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. 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 Fe chelate products, planting cover crops, and adjusting planting rates.

**Product Selection** - Careful selection of soybean with tolerance to IDC is the most important step to protect yield potential against IDC. This is particularly important for fields with a history of IDC or soil with high levels of salts and carbonate. Your local agronomist of seed brand representative can assist you in understanding the IDC ratings of the soybean products available for your area and determining the appropriate product(s) for your fields.

**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. Minimize compaction and reduce operations that may damage soybean roots.

**Iron Chelate Products** - Use seed placement of an Fe chelate product that is in the ortho-ortho form. Using other Fe chelate products and application methods have shown inconsistent yield benefits. Maximum return on investment has been found to occur when these products are used in areas moderately to severely affected by IDC. Always consult the product label for rates and application information.

**Additional Considerations** - Other management considerations include minimizing nitrate carryover from year to year and targeting soybean crops to low nitrate soils. Additionally, a companion crop, such as oats, can absorb excess nitrate-N and soil moisture, reducing bicarbonate build up to keep soil Fe available to the soybean crop. Higher seeding rates of soybeans planted in wider rows may also result in less severe IDC.

Some postemergence (POST) herbicides, such as ALS and PPO inhibitors and potentially others, may result in greater injury to soybeans stressed by IDC, resulting in reduced yield potential. POST herbicide applications are generally made in the growing season when IDC stress is most severe. Herbicide selection may need to be based on weed spectrum and injury potential in areas with IDC. Always read and follow label directions for product use and consult with your local brand representative for additional use information.