Iron Deficiency Chlorosis in Soybean: Factors & Management

- Iron deficiency chlorosis (IDC) can be a serious concern for soybean producers.
- Yellowing (chlorosis) usually appears on the youngest of the uppermost leaves in the affected areas of a soybean field.
- Symptoms typically occur between the first and third trifoliate growth stage.

Iron (Fe) is one of the essential micronutrients for soybean plant growth and development. It is needed for the development of chlorophyll, which is the green pigment in the plant and is critical for photosynthesis. If soybean plants cannot absorb enough Fe, chlorosis (yellowing) can develop, which can lead to a potential reduction in yield. Iron is involved in energy transfer, plant respiration, plant metabolism, and is a constituent of certain enzymes and proteins in the plant. Additionally, because Fe is necessary for soybean root nodule formation and has a role in nitrogen (N)-fixation, low Fe availability in the soil, and as a result lower uptake by the plant, can lead to a reduction in N-fixation.

**IDC Symptoms**

Symptoms typically appear on the youngest upper leaves between the first and third trifoliate growth stages. The distinctive symptom of Fe deficiency is the development of an interveinal chlorosis while the veins remain dark green (Figure 1). The chlorosis is the result of low chlorophyll formation due to Fe deficiency. If the deficiency is not too severe and environmental conditions improve so that the root system is able to absorb sufficient Fe, plants may recover from IDC symptoms.

Under severe Fe deficiency, leaf edges and even the growing points become necrotic (turn brown). Necrosis may progress and eventually leaves may die and fall off the plant and the growing point can be killed, reducing the amount of plant tissue available for photosynthesis.

Reduced plant growth due to IDC can have a negative effect on yield potential. Substantial yield reductions from IDC have been reported throughout the north central United States. Iron deficiency does not affect entire soybean fields at a time but the areas where IDC is present could show a 20 to 30% potential yield loss (Figure 2). Iron deficiency symptoms are similar to that of manganese (Mn) deficiency; therefore, only soil and tissue analysis can confirm the deficiency.

![Figure 1. Symptoms of iron deficiency chlorosis (IDC) on newly developed upper soybean leaves. Images courtesy of Daren Mueller, Iowa State University, Bugwood.org.](image)

![Figure 2. Symptoms of iron deficiency chlorosis (IDC).](image)

**Why Leaves Turn Yellow**

Interactions between several factors can lead to IDC in soybean:

**Soil Characteristics and Topography.** Soils usually have adequate amounts of Fe, but it might not be in the required soluble form 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 becomes less soluble, and thus less available for plant uptake, in higher pH soils with higher levels of calcium carbonate.

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

Iron deficiency chlorosis 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 pH slightly to improve Fe uptake. Because of these mechanisms, soybean plants can usually take up adequate amounts of Fe when soil pH is less than 7.5. However, high levels of calcium carbonate in the soil can neutralize the excreted chemicals and 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 IDC. Research has shown that IDC is 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**

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.

**Soybean 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 IDC or soils with high levels of salts and carbonate.

Your agronomist or seed brand representative can assist you in understanding the IDC scores 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.

**Fe Chelate Products.** Use a seed placement method of Fe chelate product that is in the ortho-ortho form. University of Minnesota research has found yield benefits of ortho-ortho chelated Fe with seed; however, using other Fe 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 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, targeting soybean crops to low nitrate soils, and planting a companion crop, such as oats. The companion crop can absorb excess nitrate-N and soil moisture to reduce bicarbonate build-up and keep soil Fe available to the soybean crop.

Adjusting planting rates may also be a management option in some situations. Research has found that a higher seeding rate can result in less severe chlorosis and higher yield; however, this observation is limited to soybeans planted in wider rows, which suggests that spacing is the most influential factor.

In summary, IDC is a common yield-limiting condition in a soybean crop. Iron deficiency occurs due to various stresses and not simply to a low Fe level in the soil. Selecting soybean products with tolerance to IDC is one of the best and most recommended options to protect yield potential against IDC, especially in areas where this issue may be a concern. It is important to match soybean products to your specific soil and environmental conditions.

**Sources:**