University of Minnesota Extension

Nutrient Management

AG-FO-08672-A (2011)

Managing Iron Deficiency Chlorosis in Soybean

Daniel E. Kaiser, John A. Lamb, and Paul R. Bloom

WHAT IS IDC?

Iron Deficiency Chlorosis in soybean otherwise known as IDC or iron chlorosis is a problem for soybean production in South Central, Southwest, West Central, and Northwest Minnesota. The symptoms are interveinal chlorosis of the leaves with the leaf veins remaining dark green. When active iron (Fe) is low in leaves chlorosis occurs because Fe is required by several enzymes involved in the formation of chlorophyll. The soil usually has a large amount of iron but it is not in the soluble form needed by the plant. The most soluble form in oxidized (aerated) soils is $Fe(OH)_3$, where Fe is in the Fe(III) form This iron becomes less soluble at higher soil pH and especially when the soil has large amounts of calcium carbonate.

Plants prefer to take up the reduced form of iron (Fe II). Plants have adapted mechanisms to help extract iron from the soil. Type I plants, such as soybean, azaleas, and blueberries, excrete acids and chemical reductants from their roots. The acids make the $Fe(OH)_3$ more soluble and the reductants change insoluble Fe(III) to more soluble Fe(II). Type II plants such as corn and grasses excrete iron chelators that bind Fe(III) and the plants are able to absorb the iron through the root. Plants do vary in their ability to get Fe out of the soil. Azaleas and blueberries only survive in acid soils where $Fe(OH)_3$ is more soluble. Because of this, Azaleas and blueberries are chlorotic in soils with a pH greater than 5.5 while soybeans can adequately grow when pH is less than 7.5.

Type I plants and high lime (calcium carbonate) IDC: High lime IDC is quite common for soybean, peanut, grapes, citrus and peaches. The use of a soil test for iron will generally not indicate these problems. High lime IDC is more severe in soils with finely divided lime (calcium carbonate). The fine calcium carbonate particles contact the soybean root and slowly neutralize the excreted acid that is meant to solubilize iron in the soil. The effect is that the plants cannot take up iron that is in the soil.

Wet soils also aggravate IDC: When soils are wet, there is limited air exchange with the atmosphere which causes a buildup of carbon dioxide in the soil. The carbon dioxide is produced by roots and soil microbes through respiration. The amount of bicarbonate in the soil is proportional to the amount of carbon dioxide and as carbon dioxide increases so does bicarbonate. This increase will rapidly neutralize the acidity around the soybean root. Research in the greenhouse has shown that increased soil moisture increases IDC and that increased severity is greater at very low temperatures. The amount of bicarbonate in the soil has been correlated with IDC in soybean in the field, so the more bicarbonate in the soil the more IDC will occur. In wet soil conditions, it may be useful to consider cultivation to speed the release of carbon dioxide from the soil.

Addition of fresh organic matter: Decaying organic matter, whether it is from crop residues or manures, adds to the amount of carbon dioxide in the soil. The microbes that are breaking the organic matter down release carbon dioxide as part of the process. If soils are wet, then diffusion of the carbon dioxide out of the soil will be limited which increases the risk for buildup of bicarbonate in the soil and therefore increases the severity of IDC.

Nitrate in the soil: Soil nitrate in the field can increase the chlorosis intensity. Field and greenhouse studies have shown the addition of nitrate increases the severity of chlorosis in soybean (**Table 1**). When a plant root takes up nitrate it must exchange with a bicarbonate ion. In addition, nitrate taken up into the plant has to be converted to ammonium within the leaves which increases pH in leaf sap and decreases the rate of reduction of Fe III to Fe II that is necessary for leaf cells to have usable Fe. When taking plant samples from chlorosis fields, iron in leaflets can be greater in the chlorosis affected plants than non-chlorotic plants because of an accumulation of iron in the leaves and the plants inability to reduce the iron III into an available form. Both cases increase IDC.

Differences in soil nitrate may explain why we often see less chlorosis in the wheel tracks of the secondary tillage in a soybean field, **Figure 1**. The soil under the tractor wheels is more compacted. This causes the compacted area to be more anaerobic (low air), but not low enough to reduce much Fe III to Fe II . These slightly anaerobic soil conditions can cause denitrification of nitrate to N_2 and thus reducing the amount of nitrate in the soil and reducing the amount of IDC.

Table 1. The effect of soil nitrate-N on IDC and soybean grain yield.

N rate lb/A	Oat Companion crop	C06	YM06	K07	YM07
		-- Grain yield (bu/A) --			
0	No	42.1	52.0	3.6	51.7
100	No	28.5	32.2	0.3	46.5
200	No	25.3	19.1	0.1	40.2
0	Yes	42.5	52.4	52.4	50.7
100	Yes	20.5	42.6	42.6	43.4
200	Yes	18.9	25.9	25.9	33.7

Figure 1. Green wheel tracks of the secondary tillage operation through an IDC affected area of the field

Plant Stress: Finally, any production practice that can cause stress to the plant also will cause problems with iron uptake by the plant. Examples include herbicide injury which has been reduced with the use of glyphosate, plant disease pressure, and nematodes.

WHERE DO WE FIND IDC IN MINNESOTA FIELDS?

Soybean IDC generally occurs in shallow depressions. The IDC is generally worse on the rims of the potholes where higher concentrations of calcium carbonate have been deposited**, Figure 2**. The calcium carbonate deposits were caused by conditions that existed when the soils were wet prairies (before tile drainage and farming).. The intensity and extent of IDC depends on the soybean variety and factors that affect soil nitrate and bicarbonate contents.

WHAT CAN BE DONE?

Table 2. Effect of oat or 3 lbs of an in-furrow ortho-ortho chelate (IF-Fe) on the yield of a IDC susceptible (V1) and tolerant (V2) soybean variety grown on soils with low, moderate, or high IDC pressure

		Chk	IF-Fe	Oats	Oat+Fe
		---- Grain yield (bu/A) ----			
Low	V1	47.2	50.9	42.8	48.8
	V2	46.0	49.5	42.7	46.7
Mod.	V1	30.6	38.7	26.9	41.7
	V2	42.5	46.0	32.1	43.6
High	V1	6.6	15.3	26.6	28.5
	V2	16.6	26.5	23.2	31.8

1) Soybean variety selection is important. If you have a field with a large amount of IDC in it, choose the most tolerant variety possible. Recent field research indicates that tolerant varieties have greater yield were IDC is problem but even higher yields can be achieved when combined with treatments used to decrease the severity of IDC (**Table 2**). A tolerant variety, however, should be the first line of defense against IDC.

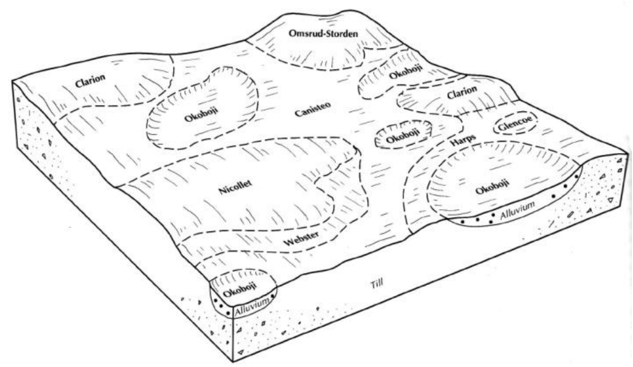

Figure 2. Pictorial representation of a typical Clarion-Nicollet-Webster-Okoboji soil association from the prairie pothole area of western Minnesota. IDC typically is found on the low lying area (Okoboji and Harps soils) where salts and carbonates have accumulated over time.

2) Use a companion crop, particularly where soil nitrate can be high. The companion crop in these situations can use the excess soil nitrate and also dry a moist soil to reduce bicarbonate build up. The use of a companion crop such as oat seeded at a 1.5 bushel per acre rate at or before soybean planting has been shown to increase soybean grain yield in IDC affected areas of the field. This practice does require extra management. Oat must be killed by the time it is at the 10 to 12 inch height. Later than this causes drought and earlier does not allow for the nitrate uptake or soil moisture use (**Table 3 and Figure 3**).

Table 3. The effect on soybean grain of oat companion crop killing time.

Stage of oat growth	K07	C09	R09
	----- Grain yield (bu/A) ----		
No oats	17	51	36
6 inches tall	14	52	40
12 inches tall	35	53	41
Heading	24	49	34

Figure 3. The effect of nitrate-N and companion crop on IDC severity and soybean growth. Upper left corner has no nitrogen applied and no companion crop, Upper right corner has 200 lb N/A applied and no companion crop, lower left has no nitrogen applied and oat companion crop, and lower right has 200 lb N/A applied and a companion crop

3) Reduce stress to the plant as much as possible. The use of glyphosate herbicide for weed control is less stressful to the plant compared to some of the preplant and in-season choices used before glyphosate tolerant varieties were available. Reduction of root damage from cultural practices such as excessive and deep cultivation is also useful. Beware of soil conditions that cause compaction during the tillage and planting operations. Compaction of surface soil at planting can stress a plant for the whole growing season. Be sure to treat plant diseases and pest according to accepted thresholds.

4) Use a seed placement of an iron chelate product that has a majority of its iron in the ortho-ortho form. Research has shown great success with the use of ortho-ortho chelated iron with the seed, **Table 4**. Use of other products and application methods has not produced consistence results. Most research data suggests a rate of 1-3 lbs of dry product per acre of the ortho-ortho chelate will be enough to increase yield. The research data also suggests that areas moderately or highly affected by IDC are where these chelates are best used to return a maximum profit potential in the field.

Table 4. The effect of seed placed ortho-ortho iron chelate on soybean grain yield.

	K07	YM07	C08	R08	C09	R09
	------- Grain yield (bu/A) ----------					
No	21.8	53.6	30.0	30.2	48.0	43.0
Yes	41.5	55.3	44.2	29.5	49.0	42.0

Research involving the combination of tolerant variety, companion crop, and seed placed ortho-ortho chelate is currently being conducted. Preliminary results indicate that all three practices can be used together and each can reduce the effect of IDC on soybean growth independently. The amount of reduction of IDC effects from the above practice are ranked with variety selection first, followed by the use of a seed placed ortho-ortho chelate, and finally the companion crop.

Additional Publications

FO-03813 - Fertilizing Soybeans in Minnesota

UNIVERSITY OF MINNESOTA | EXTENSION

© 2011, Regents of the University of Minnesota. University of Minnesota Extension is an equal opportunity educator and employer. In accordance with the Americans with Disabilties Act, this ublication/material is available in alternative formats upon request. Direct requests to the Extension Store at 800-876-8636.

Printed on recycled and recyclable paper with at least 10 percent postconsumer waste material.