iGrow Soybean

BEST MANAGEMENT PRACTICES

Chapter 26:
Management Recommendations for Soybean Fe, K, Cl, and S

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Iron is an essential plant nutrient and in certain soils, Fe deficiencies can reduce South Dakota soybean yields. In the soybean plant, Fe deficiencies appear as the yellowing of new trifoliate. The symptoms for Fe deficiencies generally first appear within several weeks of emergence. This is most often observed in high pH soils containing lime. In soybean, Fe deficiencies have been named iron (Fe) deficiency chlorosis (IDC). Tips to reduce IDC risks are available in Table 26.1. The purpose of this chapter is to discuss management recommendations for Fe, K, Cl, and S. In South Dakota, consistent benefits in soybean production from K, Cl, and S fertilization have not been observed.

Figure 26.1. Iron deficiency chlorosis (IDC) in soybean in the plant and in a field. (left, John Sawyer, Iowa State; right, Ferguson et al., 2006). Available at http://www.agronext.iastate.edu/soilfertility/photos/secmicro/4ironchjs.html and http://www.ianrpubs.unl.edu/pages/publicationD.jsp?publicationId=146

Table 26.1. Tips to reduce the risk of iron deficiency chlorosis. (Ferguson et al., 2006; Kaiser et al., 2011; Rehm, 2012)

1. Plant tolerant varieties.
2. Use management strategies that minimize nitrate-N carry over.
   a. Seed a winter cover crop.
   b. Reduce the N rate to the prior crop.
3. Apply EDDHA-Iron fertilizer on the seed.
   a. EDDHA is a compound that reduces Fe reactions with soil, which thereby increases its availability to the plant.
   b. Target Fe seed treatments to soil zones with soils containing high calcium carbonate concentrations (Chapter 19).

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Iron Chlorosis Deficiencies

Impact on the plant

Iron (Fe) plays an important role in plant respiration, nitrogen fixation, and photosynthesis. If soybean plants are not able to take up the required amount of Fe, yields can be reduced. The common symptoms for IDC are chlorosis (yellowing) of younger leaves, while the veins remain green (Figure 26.1). In severe conditions, the leaves can appear yellow for the entire season. IDC may reduce N fixation. Deficiency symptoms may be increased by low temperatures in the spring. One solution to IDC is to plant appropriate cultivars. IDC-tolerant varieties are available from most soybean seed companies. In addition, soybean cultivars entered in the North Dakota crop testing program are assessed for IDC tolerance. http://www.ag.ndsu.edu/varietytrials/soybean

Soil characteristics

Iron deficiency has been identified in some poorly drained South Dakota soils that have high pH (7.4 or higher) and calcium carbonate concentrations (Bly and Woodard, 2007). Rehm (2008) notes: "The problem is always associated with calcareous soils (soil pH>7.4). But IDC is not found on all calcareous soils." According to Rehm (2008), the extent of the problem is related to the relative amount of free calcium carbonate and soluble salts. He suggests that IDC risk increases with free calcium carbonates.

It has been hypothesized that soils with high nitrate concentrations will have a greater risk for IDC (Kaiser et al., 2011). This hypothesis is based on the plant releasing the negatively charged biocarbonate ion (HCO_3-) when it takes up the negatively charged nitrate ion (NO_3-) (Kaiser, 2011). The biocarbonate ion then reacts with iron to form a relatively insoluble complex.

Kaiser et al. (2011) suggest applying EDDHA chelated Fe to the seed or adopting management practices such as planting an oat cover crop to reduce nitrate concentrations, as well as IDC risk. EDDHA is chelate that reduces Fe reaction to soil and increases its availability to the plant. If Fe is applied without the chelate, it would not be available to the plant. In some situations, seed treatment with EDDHA-Fe can increase yields even if tolerant varieties are selected (Rehm, 2012).

IDC recommendation summary

Research conducted across the United States North Central region suggests that IDC yield losses in calcareous soils can be reduced by seed treating with Fe chelated EDDHA (Table 26.2). In some situations, yields can be increased even if tolerant cultivars are seeded. The fertilizer rate depends on the degree of iron deficiency, but most data suggest that the rate should be between 1 to 4 lbs product per acre (Ferguson et al., 2006). Fe-EDDHA is a dry product that can be mixed with water (Ferguson et al., 2006). Table 26.3 shows popular EDDHA iron products available in South Dakota. At this point, a soil test for available Fe is not a reliable predictor for the Fe-EDDHA requirement.

Table 26.2. The effect of EDDHA (ortho-ortho) chelated iron seed treatment on soybean yield at Brookings, SD, in 2007. (Modified from Bly and Woodard, 2007)

Iron Treatment (lb/acre)	Grain Yield (bu/acre)
Check	40.0
1 lb EDDHA Fe + 4 lbs gypsum	49.0
$LSD_{(0.05)}$	3.7

Table 26.3. Current available EDDHA (ortho-ortho) chelated iron seed treatments.

Product	Manufacturer/ Distributor	Website
Soygreen	West-Central Inc.	http://www.westcentralinc.com/Product/Soygreen.aspx
Ironworks	AG Specialties	http://www.fertilizerandchemicals.com/ironworks.html
Ferrilene 6	Helena Chemical	http://www.pacgro.co.nz/ProductDetails/40-3080.html
6% EDDHA Iron	Winfield Solutions	http://www.winfield.com/search/default.aspx

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Potassium (K)

Deficiency symptoms

Soybeans require potassium (K) for protein synthesis, photosynthesis, water regulation, disease resistance, vegetative growth, drought tolerance, and lodging control. For K deficiencies, yellowing starts on the margins of older leaves (Fig. 26.2). In severe cases, most of the affected leaf edge may turn brown and die. A good approach to confirm K deficiencies is to use soil and plant analysis. Details on soil sampling are provided in Chapter 18 and details on plant sampling are provided in Chapter 17.

Figure 26.2. Potassium deficiency in soybean. (Source: John Sawyer, Iowa State University. Available at http://www.agronext.iastate.edu/soilfertility/photos/potassium/2potjs.html)

K recommendations

Soybean typically utilizes and requires more K than corn (Table 26.4). Around 65 lb of K_2O per acre (1.3 lbs K_2O/bu) are removed in a 50 bu/acre soybean crop. Even though soybeans use relatively large quantities of K, South Dakota agricultural soils seldom need K fertilizer. However, K responses may be observed in:

- Sandy and/or eroded soils.
- Soils with low K values.
- No-till systems. (Gelderman et al., 2002-2005)

Table 26.4. Potassium recommendations for soybean in South Dakota. (Gerwing and Gelderman, 2005)

	Soil Test Potassium (ppm)				
Yield	**VL**	**L**	**M**	**H**	**VH**
	0-40	**41-80**	**81-120**	**121-160**	**161+**
bu/acre			K_2O (lbs/acre)		
30	55	33	11	0	0
40	73	44	15	0	0
50	92	55	19	0	0
60	110	66	22	0	0
70	128	77	26	0	0
80	147	88	30	0	0

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Table 26.5. Sample calculations for soybean K fertilizer recommendations.

K_2O recommendation

Lbs K_2O/acre = (2.2 - 0.0183 x soil test k) x yield goal

Sample calculation

Soil test K	= 150 ppm and the yield goal is 50 bu/acre
	= (2.2 - 0.0183 x 150)
	= 18.5 lbs K_2O/acre

K deficiencies may be more apparent during springs that are cool and wet. A soil test (of the top six inches of soil) is the best way to determine the need for K fertilizers. K fertilizer recommendations are based on yield and soil test K values (Table 26.5).

K fertilizer type and placement

Potassium chloride or muriate of potash (0-0-60) is the primary K fertilizer available in South Dakota. Potassium sulphate can be used if S is needed and/or if chloride toxicity is a concern (discussed below). Potassium fertilizer can be broadcasted or banded at seeding. If K fertilizer is banded at seeding, it should be located at least two inches away from the seed to avoid seed injury. To avoid seedling salt injury, do not band more than 75 lb K_2O per acre. Broadcasting and incorporating K prior to planting is also a good application method. The banded and broadcast placements have been compared and Rehm et al. (2001) concluded that the placement methods are not consistently superior if adequate K rates are used.

Chloride (Cl-) Fertilizer Recommendations

Soybean yields generally are not limited by too little chloride (Table 26.6). However, too much chloride can reduce yields under some situations. High soil Cl- concentrations can result when high rates of KCl are applied. When chloride toxicity is a concern, producers should consider applying K_2SO_4.

Table 26.6. The effect of chloride on soybean yield at Aurora, SD. Chloride applied as $CaCl_2$ or KCl as surface broadcast after planting. Soil test Cl (0-24" depth) is 28 in 2005 and 16 lb/acre in 2006. (Bly et al., 2005 and 2006)

Chloride treatment (60 lb/acre)	Grain yield (bu/acre)	
	2005	2006
Check	47.2	26.5
$CaCl_2$	46.3	23.7
KCl	45.2	24.3
LSD $_{(0.05)}$	1.4	0.8

Sulfur (S)

In South Dakota, S deficiencies in soybean typically are not a problem (Gelderman et al., 2000). However, soybeans may respond to sulfur:

1. if no-tillage is used,
2. if the crop residues are routinely harvested and manure is not applied,
3. if soybeans are seeded in sandy and eroded soils, and
4. if the climatic conditions are cool and wet. (Gelderman et al., 2000; Bly et al., 2001)

Sulfur deficiency symptoms include stunted growth and the yellowing of younger leaves (N typically is observed on older leaves first). Sulfur responses are most likely when the surface two feet of soil contain less than 30-35 lb SO_4-S per acre (Table 26.7). Check Chapter 21 for fertilizers containing S.

Other nutrients

South Dakota soils typically contain adequate amounts of boron, zinc, and manganese (Bly et al., 2005; Bly et al., 2006; Bly and Gelderman, 2007; Gerwing et al., 2005). Therefore, application of these micronutrients for soybean production is not recommended.

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Table 26.7. Sulfur recommendations based on the amount of S contained in the surface two feet of soil.

Soil Test S	Coarse Textured		Medium/Fine Textured	
	Tilled	No-till	Tilled	No-tilled
lbs S/2 ft soil			lbs S/acre	
0-9	25	25	25	25
10-19	25	25	15	25
20-29	15	25	0	15
30-39	15	15	0	15
>40	0	0	0	0

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