Managing soybean iron deficiency chlorosis (IDC) with soil testing

John S. Breker

AGVISE Soil Fertility Seminar
March 14, 2018

johnb@agvise.com
@jsbreker
IDC Showing up in some soybean fields, not sure the variety, but can see where the water was.

@MbPulseGrowers Saw some unusual soys today. Unifoliates green, trifoliates interveinally yellow. Only hdlnd affected. Any ideas? #scout17

Scouting soybean field with @aggrowconsult
IDC sympomology@saskpulse
Iron deficiency chlorosis of soybean

Older leaves are green

New leaves are yellow with green veins

Iron deficiency chlorosis of soybean
Severe IDC persisting into 5-6 trifoliate stage greatly reduces yield

**IDC rating scale**

1. No chlorosis
2. Slight yellowing
3. Distinct interveinal chlorosis, no stunting
4. Stunting, some necrosis
5. Necrosis of upper leaves and growing point, dead plants

Why is iron deficiency so bad in soybean?

• Soil may contain over 450,000 lb Fe/acre
• Soybean plant only needs a few grams

Not a question of amount, but availability

• Soybean has really, really inefficient iron uptake
• Bicarbonate (HCO$_3^-$) dissolved in soil solution reduces iron availability

Calcium carbonate (lime) reduces iron availability

\[ \text{CaCO}_3 \ + \ \text{H}_2\text{CO}_3 \ \leftrightarrow \ \text{Ca}^{2+} \ + \ 2\text{HCO}_3^- \]

Bicarbonate neutralizes H\(^+\) that the soybean root releases to make iron available
IDC on the glacial till landscape

High IDC risk

On the rolling till plain:
High carbonate and salinity around closed depressions
IDC on the glacial lake plain

On the glacial lake plain:
High carbonate and salinity across entire field
Many plant species that evolved in acidic environments are IDC susceptible:

- Maples
- Pin oak
- Azalea
- Rhododendron
- Rugosa rose

Maples, like soybean, are susceptible to iron deficiency chlorosis (IDC) with interveinal chlorosis in newest leaves.
Soil factors contributing to soybean IDC

The short list

- Carbonate (CCE)
- High soil water content
- Cool soil temperature
- Salinity
- High residual nitrate
- High pH???
Soil factors contributing to soybean IDC

Carbonate (calcium carbonate, lime, CCE)
- Central Corn Belt: 0-5% CCE
- Northern Plains: 0-30% CCE

\[
\text{CaCO}_3 + \text{H}_2\text{CO}_3 \leftrightarrow \text{Ca}^{2+} + 2\text{HCO}_3^-
\]

Soil pH > 7.3 may have carbonate (test needed)
Soil pH < 7.3 likely no carbonate
Soil factors contributing to soybean IDC

Salinity (electrical conductivity, soluble salts)
- Reduced root growth
- Reduced water uptake
- Competing nutrient effects

Residual nitrate (NO$_3^-$)
- Increased bicarbonate (HCO$_3^-$) in rhizosphere
- Affects internal Fe metabolism
Hydrogen consumption increases internal pH, fewer H\(^+\) to acidify root zone

Nitrate must be converted to amino groups by nitrate reductase (Fe,S-containing enzyme)

Bicarbonate released to balance charge, decreases Fe solubility
Soil factors contributing to soybean IDC

Cool soil temperature
• Reduced root activity
• Dissolves more $\text{CO}_2 \rightarrow \text{HCO}_3^-$

High soil water content
• Reduced gas exchange (more $\text{CO}_2 \rightarrow \text{HCO}_3^-$)
• Dissolves more $\text{CO}_2 \rightarrow \text{HCO}_3^-$
• Reduced root development
• Decreased nutrient uptake
Soil samples with soil pH greater than 7.3

Fall 2017 samples (0-6” samples)
Carbonate can be high or low when soil pH is near 8.0. Soil test needed to know.
Iron deficiency chlorosis (IDC)

Carbonate 3.5% Salts 0.7 pH 7.9
No IDC

Carbonate 0.9%  Salts 0.4  pH 7.8
Soil samples with carbonate greater than 5.0%

Fall 2017 samples (0-6” samples)
Soil samples with salts greater than 1.0 dS/m

Fall 2017 Samples (0-6” samples)
# AGVISE – Soybean IDC risk index

Based on observations and soil samples from 103 fields (2001)

<table>
<thead>
<tr>
<th>Calcium carbonate (CCE)</th>
<th>Electrical conductivity (EC)</th>
<th>Relative IDC risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>dS/m (1:1)</td>
<td></td>
</tr>
<tr>
<td>&lt;2.5</td>
<td>&lt;0.5</td>
<td>Low</td>
</tr>
<tr>
<td>&lt;2.5</td>
<td>0.5 – 1.0</td>
<td>Moderate</td>
</tr>
<tr>
<td>&lt;2.5</td>
<td>&gt;1.0</td>
<td>Very High</td>
</tr>
<tr>
<td>2.6-5.0</td>
<td>&lt;0.25</td>
<td>Low</td>
</tr>
<tr>
<td>2.6-5.0</td>
<td>0.26-0.50</td>
<td>Moderate</td>
</tr>
<tr>
<td>2.6-5.0</td>
<td>0.51-1.0</td>
<td>High</td>
</tr>
<tr>
<td>2.6-5.0</td>
<td>&gt;1.0</td>
<td>Very High</td>
</tr>
<tr>
<td>&gt;5.0</td>
<td>&lt;0.25</td>
<td>Moderate</td>
</tr>
<tr>
<td>&gt;5.0</td>
<td>0.26-0.50</td>
<td>High</td>
</tr>
<tr>
<td>&gt;5.0</td>
<td>0.51-1.0</td>
<td>Very High</td>
</tr>
<tr>
<td>&gt;5.0</td>
<td>&gt;1.0</td>
<td>Extreme</td>
</tr>
</tbody>
</table>

TABLE 1. FIELD RISK OF IDC BASED ON CARBONATE AND SOLUBLE SALT SOIL TEST LEVELS

<table>
<thead>
<tr>
<th>SOLUBLE SALTS (mmhos/cm)</th>
<th>CARBONATE LEVEL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0 to 2.5</td>
</tr>
<tr>
<td>0 to 0.25</td>
<td>Low</td>
</tr>
<tr>
<td>0.26 to 0.50</td>
<td>Low</td>
</tr>
<tr>
<td>0.50 to 1.0</td>
<td>Moderate</td>
</tr>
<tr>
<td>&gt;1.0</td>
<td>High</td>
</tr>
</tbody>
</table>

Managing IDC with soil testing

Identify fields with low IDC risk
• Soil test for carbonates and salinity
• Choose low IDC risk fields for soybean

Mitigating moderate to high IDC risk
1. Variety selection
2. Variety selection
3. Variety selection
4. Wider rows (plant closer together reduces IDC)
5. Apply high quality FeEDDHA with seed
6. Plant companion cereal with soybean (uses excess water and nitrate)
You cannot turn a weak variety into a strong variety


Quality matters

Chlorosis ratings
• Seed companies vary greatly, scoring and rigor
• Local trials, neighbor experience, maybe not newest variety
• NDSU soybean IDC variety trials

Iron fertilizer (FeEDDHA)
• Chelate quality (ortho-ortho EDDHA content) varies considerably
Foliar Fe not effective for rescue

Iron does not move to the unsprayed area on the leaf

Iron does not move to the new leaves

R. J. Goos
NDSU
Managing IDC with soil testing

1. Identify fields with low IDC risk
   - Soil test for carbonates and salinity
   - Yes…some fields may not be suitable for soybean

2. Make maps of previous IDC hotspots
   - Aerial or satellite imagery
   - Site-specific mitigation strategies?

3. Choose IDC-resistant varieties, wider rows, FeEDDHA, companion cereal
Tillage influence on IDC?

Chisel plow

Strip-till

Factors: carbonate uplift, soil water evaporation, salt movement, soil structure, gas exchange (carbon dioxide), nitrogen mineralization?

A.F. Wick, North Dakota State Univ. (personal communication, 2017)
Thank you for your kind attention

Questions?

John Breker
@jsbreker

Rome-ing around and found a nutrient deficiency. Any guesses? It isn't potassium! #KFrontiers