Micronutrient Management

Dorivar Ruiz Diaz
Soil Fertility and Nutrient Management
Essential Nutrients

- Thirteen essential nutrients
  - Nitrogen, phosphorus, potassium, calcium, magnesium, sulfur
  - Iron, manganese, boron, molybdenum, copper, zinc, and chlorine
    - Nickel has recently been added

- By definition, micronutrients are needed in small amount to achieve optimum plant growth.
Essential Micronutrients

- Minor elements or trace elements
- Increased interest in micronutrients
  - Higher crop yields and micronutrient removal rates
  - Declining soil organic matter, a major source of most micronutrients
  - N, P and K fertilizers contain lower amounts of micronutrient impurities
- Excessive levels can cause toxic effects on plants
- In Kansas: Fe, S, Zn, and Cl.
- Other micronutrients: B, Mg, Cu, Mn, and Ni.
## Total Micronutrient Levels in the Soil Surface

<table>
<thead>
<tr>
<th>Micronutrient</th>
<th>Lb/Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>70,000</td>
</tr>
<tr>
<td>Manganese</td>
<td>1,000</td>
</tr>
<tr>
<td>Boron</td>
<td>40</td>
</tr>
<tr>
<td>Chlorine</td>
<td>20</td>
</tr>
<tr>
<td>Zinc</td>
<td>20</td>
</tr>
<tr>
<td>Copper</td>
<td>10</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>2</td>
</tr>
</tbody>
</table>
Organic Matter

- Important source of most micronutrients.
- Simple organic compounds as chelates.
- S, Zn and B deficiencies are more likely to occur in soils low in O.M.
- Deficiencies of Cu and Mn are most common in peat soils.
Soil pH and micronutrient availability

- Soil pH affects availability of micronutrients.

- In general the solubility and availability of micronutrients are greatest in acid soils and lowest in high pH calcareous soils.

- Exception is Mo.

- In some soils, high levels of soluble Fe, Al and Mn may be toxic to plants.
Iron (Fe)

- Iron in the plant
  - Catalyst in the production of chlorophyll
  - Involved with several enzyme systems

- Deficiency symptoms
  - Yellow to white leaf color
  - Symptoms first appear on the younger leaves
  - Wide range of susceptibility of different crops
    - Sorghum, field beans and soybeans are more sensitive than corn and alfalfa
    - Varieties differ within crops
Iron deficiency
Factors Affecting Iron Availability

- High soil pH.
- Soils with high salt and carbonate contents.
- Cool, wet springs.
- Poor soil drainage and aeration.
- Susceptible crops/varieties.
- High concentrations of nitrate-N inhibit conversion of Fe$^{+++}$ to Fe$^{++}$, increasing severity of iron chlorosis.
Soybean Fe Study - 2009

• Varieties (2): high and low IC tolerance.
• Seed treatment: with and without 0.6 lb/acre of EDDHA Fe (6%).
• Foliar treatments:
  – 0.1 lb/acre EDDHA Fe (6%)
  – 0.1 lb/acre HEDTA Fe (4.5%)
  – No foliar trt
• 4 locations with 5 replications
Objectives

• Evaluate fertilization strategies.
• Determine soil parameters (diagnostic):
  – Fe, Mg, P, K, Ca, OM, OC, TN, pH, EC, Carbonates, nitrate-N.
• Determine “optimum” plant tissue level.
• Evaluate possible interaction of parameters, both in soil and plant.
  – Possible Fe-Mn interaction?
Effect of soil nitrate?
The nitrate theory

• Iron is part of the chlorophyll molecule
• Iron taken up as Fe+++ (ferric)
• Iron in chlorophyll exists as Fe++ (ferrous)
• High concentrations of nitrate-nitrogen inhibit conversion of Fe+++ to Fe++
• Reduce nitrate in soybean plants with the use of a competition crop
Soybean seed treatment with Fe chelate
Seed treatment
Chlorophyll meter readings

SPAD Values

<table>
<thead>
<tr>
<th>Treatment</th>
<th>SPAD Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>foliar 6%</td>
<td>32.5</td>
</tr>
<tr>
<td>foliar 4.5%</td>
<td>32.0</td>
</tr>
<tr>
<td>No</td>
<td>31.5</td>
</tr>
<tr>
<td>foliar 6%</td>
<td>33.0</td>
</tr>
<tr>
<td>foliar 4.5%</td>
<td>33.0</td>
</tr>
<tr>
<td>No</td>
<td>32.5</td>
</tr>
</tbody>
</table>

No seed trt

Yes seed trt
Plant height at maturity

- Foliar 6%
- Foliar 4.5%
- No

Inches

<table>
<thead>
<tr>
<th>foliar 6%</th>
<th>foliar 4.5%</th>
<th>No</th>
<th>foliar 6%</th>
<th>foliar 4.5%</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No seed trt</td>
<td>Yes seed trt</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Soybean yield: seed and foliar treatment

Var AG2906: Very Good IC tolerance
Soybean yield: seed and foliar treatment

Var AG3205: Low IC tolerance
Are these yield values significantly different?

<table>
<thead>
<tr>
<th>Effect</th>
<th>F Value</th>
<th>Pr &gt; F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
<td>2.11</td>
<td>0.1487</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Seed trt</strong></td>
<td>69.6</td>
<td>&lt;.0001</td>
<td>S</td>
</tr>
<tr>
<td>Foliar</td>
<td>0.05</td>
<td>0.9553</td>
<td>NS</td>
</tr>
<tr>
<td>Var*Seedtrt</td>
<td>0.19</td>
<td>0.6616</td>
<td>NS</td>
</tr>
<tr>
<td>Var*Foliar</td>
<td>2.1</td>
<td>0.1268</td>
<td>NS</td>
</tr>
<tr>
<td>Seedtrt*Foliar</td>
<td>0.1</td>
<td>0.9004</td>
<td>NS</td>
</tr>
<tr>
<td>Var<em>Seed</em>Foliar</td>
<td>0.27</td>
<td>0.7631</td>
<td>NS</td>
</tr>
</tbody>
</table>
Some soil parameters

Soil pH

Soil Fe

EC

Soil OM
Foliar Applications

- Applications must be done before plants are severely damaged by chlorosis and may need to be repeated.

- One of several iron chelates/complexes may be used. Economical benefit need to be evaluated.

- Critical timing
  - By the first or second trifoliate leaf
Fertilizer Sources of Iron

- Deficiencies occur more frequently than most other micronutrients in Kansas
- Patchy or irregular appearance in the field
- Success with iron fertilization is difficult
  - Difficulty in correcting Fe deficiency with soil-applied fertilizer
    - Iron quickly converted to unavailable form.
## Common Iron Fertilizers

<table>
<thead>
<tr>
<th>Fertilizer Source</th>
<th>Fe (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron Sulfate</td>
<td>19-40</td>
</tr>
<tr>
<td>Iron Chelates</td>
<td>5-12</td>
</tr>
<tr>
<td>Other Organics</td>
<td>5-11</td>
</tr>
<tr>
<td>Manure - best</td>
<td>??</td>
</tr>
</tbody>
</table>
## Average animal manure micronutrient content of different animal sources

<table>
<thead>
<tr>
<th>Manure source</th>
<th>Iron (lb/wet ton)</th>
<th>Manganese (lb/wet ton)</th>
<th>Boron (lb/wet ton)</th>
<th>Zinc (lb/wet ton)</th>
<th>Copper (lb/wet ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy solid</td>
<td>0.5</td>
<td>0.06</td>
<td>0.01</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Swine solid</td>
<td>19.0</td>
<td>1.09</td>
<td>0.04</td>
<td>0.79</td>
<td>0.50</td>
</tr>
<tr>
<td>Poultry</td>
<td>3.0</td>
<td>0.61</td>
<td>0.08</td>
<td>0.48</td>
<td>0.66</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Manure source</th>
<th>Iron (lb/1000 gal)</th>
<th>Manganese (lb/1000 gal)</th>
<th>Boron (lb/1000 gal)</th>
<th>Zinc (lb/1000 gal)</th>
<th>Copper (lb/1000 gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy liquid</td>
<td>0.9</td>
<td>0.11</td>
<td>0.03</td>
<td>0.11</td>
<td>0.12</td>
</tr>
<tr>
<td>Swine liquid</td>
<td>2.5</td>
<td>0.23</td>
<td>0.06</td>
<td>1.03</td>
<td>0.62</td>
</tr>
</tbody>
</table>
Manure/Biosolids as source of micronutrients

- Biosolids/manure can be excellent sources of Fe and micronutrient nutrition for higher plants.
- Soils with application histories can show higher micronutrient availability levels than those receiving commercial fertilization.
- Maintaining adequate soil pH for crop production should ensure good micronutrient availability.
Summary - Fe

- Fe deficiency potential can not be explained well by a single soil parameter.

- Development of an “index” may be the best alternative.

- Foliar treatment seems to increase the “greenness” effectively. But seed coating provides higher yield increases.
Summary – other micros

- The ability to coat seed with micronutrient is a concept that deserve further investigation.
- There is again a recent interest for foliar application of nutrients.
- Increased interest for mixing micronutrients with fluid fertilizer for band application.
- Several nutrients in each dry fertilizer granule uniform distribution of nutrients?
Questions?

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