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Know Your Micronutrients

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Macro and Micronutrients

- C, H, O – Water and carbon dioxide
- N, P, K – Primary macronutrients supplied by fertilizer or soil
- Ca, Mg, S – Secondary macronutrients mostly supplied by the soil
  - Except for S in some cases
- B, Cu, Fe, Mn, Zn, Mo, Cl, Ni – micronutrients mainly soil supplied
Background

- With high commodity prices the tendency is to chase these small, ~2 bu/ac yield increases

- Micros have been increasingly scrutinized
  - Little known response to them
  - Poor predictors of response

- Research has shown a link between Glyphosate tolerant soybean and reduced micronutrient uptake and translocation
Micronutrient

• Nutrient essential for crop growth but taken up in small quantities
  – Typically less than one pound per acre
• Some nutrients are beneficial but are not considered essential
  – i.e. Cl, Ni
• Uptake is mostly metabolically controlled (active uptake)
• Most are immobile in the plant
## Corn Uptake of Micronutrients

**2008-2009 Data Southern MN**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Plant</th>
<th>Grain</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron</td>
<td>0.09</td>
<td>0.02</td>
<td>0.11</td>
</tr>
<tr>
<td>Iron</td>
<td>2.10</td>
<td>0.22</td>
<td>2.32</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.66</td>
<td>0.04</td>
<td>0.70</td>
</tr>
<tr>
<td>Copper</td>
<td>0.06</td>
<td>0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.14</td>
<td>0.17</td>
<td>0.31</td>
</tr>
</tbody>
</table>
Boron

- Corn: Sufficient ear leaf concentration (R1-R2)
  - 4-15 ppm??
- Soybean: Sufficient trifoliate concentration (R1-R2)
  - 21-55 ppm??
- Taken up as HBO$_4^{2-}$ (Passive Uptake)
- Role in Plant
  - Cell wall development
    - Concentration is higher in dicots than monocots
  - Meristem development
Boron (B)

- Deficiencies in soils
  - Droughty soils
  - Sandy soils with low organic matter
  - High soil pH – but should not be an issue if SOM is high enough
Copper

- Corn: Sufficient ear leaf concentration
  - 3-15 ppm
- Soybean: Sufficient trifoliate concentration (R1-R2)
  - 10-30 ppm
- Taken up as Cu$^{2+}$, Cu-Chelates (active)
- Role in Plant
  - Promotes seed production and formation
  - Plays an essential role in chlorophyll formation
  - Is essential for proper enzyme activity
Copper (Cu)

- Deficiencies in soils
  - Organic soils
  - High soil pH (<7.5)
  - Unlikely in mineral soils
Iron

- Corn Sufficient ear leaf concentration
  - 50-200 ppm
- Soybean sufficient trifoliate concentration
  - 51-350 ppm
- Plants are easily contaminated by soil Fe
  - Soybean with IDC can have more Fe
- Take up as Fe$^{2+}$, chelated-Fe (phytosiderophores) (active)
- Role in Plant
  - Chlorophyll synthesis
  - Enzymes for electron transfer
Iron (Fe)

Deficiencies in soils
High soil pH and free lime
Calcareous soils
High soil moisture
Manganese

- Corn: Sufficient ear leaf concentration
  - 20-250 ppm
- Soybean: Sufficient trifoliate concentration
  - 21-100 ppm
- Taken up as Mn$^{2+}$, Mn-Chelates? (active)
- Role in Plant
  - Photosynthesis
  - Oxidation-reduction system control

Soil Fertility
Manganese (Mn)

- Deficiencies in soils
  - High soil pH
  - Sandy soils high in organic matter
  - Peat or muck soils
Manganese (Mn)

- Any soil that is deficient can be a problem
- Research at Purdue (Huber, 2003) found a relationship between glyphosate resistant soybeans and Mn deficiency in the plant
- Glyphosate resistant soybeans appeared to have problems in Mn uptake and efficiency in the plant
- Plant were exhibiting “Glyphosate Flash” a few days after application
- Problem was worse after over application of glyphosate
- Actual yield loss from this problem has been debated
  - Application of Mn has been shown to increase yields in irrigated soybeans (Kansas)
  - Other research has not shown a positive response to Mn fertilization (Ebelhar, 2007 Illinois)
Zinc

- Corn: Sufficient ear leaf concentration
  - 20-70 ppm
- Soybean: Sufficient trifoliate concentration
  - 20-50 ppm
- Taken up as Zn$^{2+}$, chelated-Zn (active)

Role in Plant
- Enzymes
- Metabolic reactions
  - Formation of chlorophyll and carbohydrates
  - Conversion of starches to sugars
Zinc (Zn)

- Deficiencies in soils
  - High soil pH
  - Low soil organic matter with high pH
  - Cool, wet soils
  - High phosphorus fertilizer rates on marginal Zn soils

Soil Fertility
Zinc (Zn)

- Deficiencies in soils
  - High soil pH
  - Low soil organic matter with high pH
  - Cool, wet soils
  - High phosphorus fertilizer rates on marginal Zn soils
  - Not known to be deficient in soybean
### 2009-2010 Zinc for Corn: Red River Valley

<table>
<thead>
<tr>
<th>Zinc Rate</th>
<th>0</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>LSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polk ’09</td>
<td>171</td>
<td>164</td>
<td>169</td>
<td>167</td>
<td>ns</td>
</tr>
<tr>
<td>Mahnomen ’10</td>
<td>168</td>
<td>169</td>
<td>179</td>
<td>191</td>
<td>13</td>
</tr>
<tr>
<td>Red Lake ’10</td>
<td>211</td>
<td>199</td>
<td>195</td>
<td>194</td>
<td>ns</td>
</tr>
<tr>
<td>Marshall ’10</td>
<td>134</td>
<td>132</td>
<td>143</td>
<td>135</td>
<td>ns</td>
</tr>
</tbody>
</table>

**Soil test Zinc (DTPA): Polk ’09 1.36ppm; Mahnomen ’10 0.37 ppm; Red Lake ’10 0.65 ppm; Marshall ’10 0.55 ppm.**

***Zinc rates applied as broadcast Zinc Sulfate (36% zinc)***
Chelated Zinc With 10-34-0 - Corn

<table>
<thead>
<tr>
<th>Site</th>
<th>Control</th>
<th>10-34-0</th>
<th>10-34-0 + Zn</th>
<th>ST – Zinc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>---------</td>
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<td>-----------</td>
</tr>
<tr>
<td>Murdock '12</td>
<td>194</td>
<td>192</td>
<td>192</td>
<td>2.8</td>
</tr>
<tr>
<td>Waseca '12</td>
<td>188</td>
<td>189</td>
<td>200**</td>
<td>1.4</td>
</tr>
<tr>
<td>St Charles '13</td>
<td>204</td>
<td>198</td>
<td>197</td>
<td>1.7</td>
</tr>
<tr>
<td>Willmar '13</td>
<td>159b</td>
<td>173a</td>
<td>172a</td>
<td>1.0</td>
</tr>
<tr>
<td>Prinsburg '14</td>
<td>200</td>
<td>209</td>
<td>204</td>
<td>2.6</td>
</tr>
<tr>
<td>Stewart '14</td>
<td>162</td>
<td>167</td>
<td>162</td>
<td>1.3</td>
</tr>
<tr>
<td>Becker '15</td>
<td>179</td>
<td>192</td>
<td>184</td>
<td>1.1</td>
</tr>
<tr>
<td>Lamberton '15</td>
<td>214</td>
<td>213</td>
<td>212</td>
<td>0.6</td>
</tr>
</tbody>
</table>

- 2.5-6 gpa + 1 qt/ac Blue Tsunami (10% fully chelated zinc with citric acid/EDTA)
- **Indicates a potential response to Zn. Individual plot yield was highly variable for the treatment (min 168 and max 228), no response for treatment with Zn only.
Take Home Message on Zn

• We have not seen hard evidence that Zinc deficiencies in corn are occurring in situations not traditionally responsive to Zn
• Rate and critical soil test level (0.75 ppm) seem to still hold – better response when <0.5 ppm
• The current research on Zn-chelates do not overwhelmingly support application in starter to all acres
• Recommendation – Target low testing field areas with broadcast zinc for the highest return
Other Micros

• Molybdenum (MoO$_4^-$)
  – Nitrogen fixation
  – Transforming nitrate to ammonium

• Chlorine (Cl$^-$)
  – Oxygen production in photosynthesis
  – Plant water relations

• Nickel
  – Seed germination
  – Urease activity
### What Crops are Sensitive to Deficiency

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Sensitive crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron</td>
<td>Alfalfa, Clover, Sugar Beet</td>
</tr>
<tr>
<td>Copper</td>
<td>Small Grains, Corn</td>
</tr>
<tr>
<td>Iron</td>
<td>Soybeans</td>
</tr>
<tr>
<td>Manganese</td>
<td>Alfalfa, Small Grains, Soybean, Sugar Beet</td>
</tr>
<tr>
<td>Zinc</td>
<td>Corn, Edible Bean</td>
</tr>
</tbody>
</table>

*Source: University of Minnesota Extension*
<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Sensitive crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boron</td>
<td>Corn, Edible Beans, Soybean</td>
</tr>
<tr>
<td>Copper</td>
<td>Cereals, Legumes</td>
</tr>
<tr>
<td>Iron</td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td>Cereals</td>
</tr>
<tr>
<td>Zinc</td>
<td>Cereals</td>
</tr>
<tr>
<td>Nutrient</td>
<td>Toxicity Symptoms</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Boron</td>
<td>Burning on leaf margins, leaves look scotched and fall off</td>
</tr>
<tr>
<td>Copper</td>
<td>Suppressed root growth, may induce Fe deficiency</td>
</tr>
<tr>
<td>Iron</td>
<td>Not known</td>
</tr>
<tr>
<td>Manganese</td>
<td>Brown spots on older leaves surrounded by chlorotic circles</td>
</tr>
<tr>
<td>Zinc</td>
<td>Chlorosis in plants sensitive to Fe, most crops are tolerant to high Zinc</td>
</tr>
</tbody>
</table>
Boron Toxicity in Soybeans
5 lb/ac B broadcast preplant
Sandy soil – Dry spring
How to Differentiate

• It can be hard to tell a deficiency from a toxicity
  – Some mimic or may induce symptoms
  – Dig up plants and look at the roots
    • Some toxicities will severely impact the roots
    • Over application may result in salt damage on roots

• Take plant and soil samples
  – Need to know what you are looking for
Tissue Testing for Micros

• Do we know if the current data actually has any yield data to back it up
• Responses are not as likely to some nutrients, where did the sufficiency data come from?
• When do you take the sample, early in the season the total amount of nutrients taken up is low
• Micros are immobile – sample new tissue
• Tissue concentration may vary over time – sufficiency levels will vary with growth stage

Soil Fertility
# Hybrid Differences - 2012

## 6 Southern MN locations – 34 hybrids

<table>
<thead>
<tr>
<th>Hybrid</th>
<th>N (%)</th>
<th>P (%)</th>
<th>K (%)</th>
<th>Zn (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agrigold 6252 VT3 Pro</td>
<td>2.69</td>
<td>0.24</td>
<td>1.39</td>
<td>15.9</td>
</tr>
<tr>
<td>Dairyland DS9501 SSX</td>
<td>2.83</td>
<td>0.30</td>
<td>1.36</td>
<td>16.9</td>
</tr>
<tr>
<td>DKC 48-12</td>
<td>2.86</td>
<td>0.31</td>
<td>1.59</td>
<td>18.7</td>
</tr>
<tr>
<td>DKC 52-04</td>
<td>3.09</td>
<td>0.27</td>
<td>1.36</td>
<td>18.7</td>
</tr>
<tr>
<td>G2 5X-0004</td>
<td>2.80</td>
<td>0.33</td>
<td>1.38</td>
<td>14.6</td>
</tr>
<tr>
<td>Pioneer 0062 XR</td>
<td>2.64</td>
<td>0.28</td>
<td>1.59</td>
<td>15.6</td>
</tr>
<tr>
<td>Pioneer 9917 AM1</td>
<td>2.79</td>
<td>0.29</td>
<td>1.58</td>
<td>17.9</td>
</tr>
<tr>
<td>Renk RK629VT3P</td>
<td>2.84</td>
<td>0.25</td>
<td>1.66</td>
<td>16.4</td>
</tr>
<tr>
<td>Titan Pro X2M00-SS</td>
<td>2.84</td>
<td>0.25</td>
<td>1.47</td>
<td>18.3</td>
</tr>
<tr>
<td>Wensman W9288 VT3PRO</td>
<td>2.85</td>
<td>0.25</td>
<td>1.43</td>
<td>17.8</td>
</tr>
</tbody>
</table>

Hybrids represent a subset of the 34 hybrids sampled, LSD=0.30 from analysis of all 34 hybrids.
Tissue Sampling

• Tissue sufficiency levels were not made with the intention of using them for predicting where fertilizer is needed
• Early season samples are worthless, especially if you are only taking one sample from a field
• Foliar application may work better for perennial crops versus annual crops
  – Uptake may still be through the plant root
Corn Summary

• Targeting zinc is the best approach
  – Yield increase is still not guaranteed

• Corn can be sensitive to copper deficiency
  – Right now I’m not convinced we see Cu deficiency unless on high organic soils.

• I don’t trust the boron soil or tissue test
  – I don’t think B is a problem for corn

• Corn should not be sensitive to manganese deficiency
Soybean Summary

• We have not seen any micro-nutrients become more deficient due to higher commodity prices

• Manganese is not any more deficient now than before in Minnesota

• Do not apply boron to fields going to soybean
  – Recent research – Yield reduction at 1 of 6 sites

• Glyphosate has not tied up all the micros!
Thank You
Questions?

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Soil Fertility