Fertilizing with Sulfur and Putting Together a Corn/Soybean Fertility Program

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Sulfur Response

• Yield responses are increasing-Why?
  – Sulfate deposition have decreased
  – Sulfur in fertilizer sources (other than S fertilizers) and pesticides have decreased
  – Less manure
  – More crop residues

• What is the most important factor?
### Corn Yield Response to Sulfur Fertilizer
20 Trials in Northeast IA, 2007 (Sawyer and Lang)

#### Sulfur Fertilizer Rate
- **10 lbs S/ac**
- **20 lbs S/ac**
- **40 lbs S/ac**

#### Soil Texture:
- **ls** = loamy sand
- **sl** = sandy loam
- **l** = loam
- **sil** = silt loam

#### Soil Organic Matter, %
- **Sp**
- **Sp**
- **F**
- **Di**
- **O**
- **O**
- **CF**
- **K**
- **S**
- **R**
- **K**
- **K**
- **Dr**
- **F**
- **F**
- **F**
- **D**
- **D**
- **D**
- **D**
- **F**

#### Soil Texture
- 0.8
- 0.9
- 1.4
- 1.1
- 1.1
- 0.9
- 2.5
- 2.0
- 2.6
- 2.7
- 2.0
- 3.4
- 1.5
- 2.1
- 2.1
- 2.3
- 2.9
- 2.8
- 2.7
Sulfur Recommendation Update
When SOM(0-6") $\leq 2.57$: $20.7 + 62.3x - 12.1x^2$

$r^2 = 0.38$, $P \leq 0.0001$

These points deleted

Albert Lea 2009
Clarkfield 2008
Clarks Grove 2008
Renville, MN: June 3, 2009
3rd year corn no current manure or S history
Harps/Okaboji Complex: 5.1% SOM (0-6”)
Source: Google Earth
**Response to 10 lbs is significant at \( P \leq 0.10 \).
Sulfur Timing and Rate Study 2010

Otisco MN 2010
Corn Following Corn

Sulfur Applied Broadcast at Planting and at V3-V4

Kaiser U of M 2011
Renville 2010 Data
Corn Yield Data

Relative Corn Yield (%)

2009 Sulfur Application Rate (lbs. S ac\(^{-1}\))

RelYLD = 82.9 + 1.42(rate) - 0.0258(rate)\(^2\)

\(R^2=0.98\ P<0.02\)

Plateau ~ 25 lbs

SoilS = 4.42 + 0.04x

\(R^2=0.89\ P<0.02\)
2008-2010 U of M Studies

• Sulfur may be available for more than 1 years crop
  – Soil texture is important for carryover

• Rate data has been inconclusive
  – 10-15 lbs has been adequate
  – 20-25 lbs has been needed at times

• Sulfur can be applied up to V3-V4
  – Grain moisture may be affected

• Guidelines may vary by previous crop!!!
## N, P & S fertilization of continuous corn

<table>
<thead>
<tr>
<th>No.</th>
<th>APP, 10-34-0 Rate gal./A</th>
<th>Placement</th>
<th>UAN, 28-0-0 Rate gal./A</th>
<th>Placement</th>
<th>ATS, 12-0-0-26 Rate gal./A</th>
<th>Placement</th>
<th>N+P+S Application rate lb N+P₂O₅+S</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>---</td>
<td>0</td>
<td>---</td>
<td>0</td>
<td>---</td>
<td>0+0+0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>---</td>
<td>0</td>
<td>---</td>
<td>2</td>
<td>Surface dribble</td>
<td>3+0+5.8</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>---</td>
<td>0</td>
<td>---</td>
<td>4</td>
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<td>5+0+11.5</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>---</td>
<td>8</td>
<td>Surface dribble</td>
<td>0</td>
<td>---</td>
<td>24+0+0</td>
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<tr>
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<td>0</td>
<td>---</td>
<td>8</td>
<td>Surface dribble</td>
<td>2</td>
<td>Surface dribble</td>
<td>27+0+5.8</td>
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<tr>
<td>6</td>
<td>0</td>
<td>---</td>
<td>8</td>
<td>Surface dribble</td>
<td>4</td>
<td>Surface dribble</td>
<td>29+0+11.5</td>
</tr>
<tr>
<td>7</td>
<td>4 In furrow</td>
<td>0</td>
<td>---</td>
<td>0</td>
<td>---</td>
<td>5+16+0</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>4 In furrow</td>
<td>0</td>
<td>---</td>
<td>2</td>
<td>Surface dribble</td>
<td>7+16+5.8</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>4 In furrow</td>
<td>0</td>
<td>---</td>
<td>4</td>
<td>Surface dribble</td>
<td>10+16+11.5</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>4 In furrow</td>
<td>8</td>
<td>Surface dribble</td>
<td>0</td>
<td>---</td>
<td>29+16+0</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>4 In furrow</td>
<td>8</td>
<td>Surface dribble</td>
<td>2</td>
<td>Surface dribble</td>
<td>31+16+5.8</td>
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<tr>
<td>12</td>
<td>4 In furrow</td>
<td>8</td>
<td>Surface dribble</td>
<td>4</td>
<td>Surface dribble</td>
<td>34+16+11.5</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>4 In furrow</td>
<td>0</td>
<td>---</td>
<td>1</td>
<td>In furrow</td>
<td>6+16+2.9</td>
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<tr>
<td>14</td>
<td>4 In furrow</td>
<td>8</td>
<td>Surface dribble</td>
<td>1</td>
<td>In furrow</td>
<td>30+16+2.9</td>
<td></td>
</tr>
</tbody>
</table>

Funding provided by AFREC and Fluid Fertilizer Foundation
June 21, Waseca

193 bu/A, 21%

209 bu/A, 16%
0 gal/A 10-34-0
8 gal/A UAN S. band
4 gal/A ATS S. band
Corn grain moisture and yield, plant height at V7 and relative leaf chlorophyll at VT at Waseca

<table>
<thead>
<tr>
<th>Trt</th>
<th>Rate / placement of fert.</th>
<th>Grain H₂O</th>
<th>Grain Yield</th>
<th>Plant height</th>
<th>Leaf Chloro</th>
</tr>
</thead>
<tbody>
<tr>
<td>#</td>
<td>------ gal / acre ------</td>
<td>%</td>
<td>bu/A</td>
<td>inch</td>
<td>%</td>
</tr>
<tr>
<td>1</td>
<td>0, In-F 0, SB 0, SB</td>
<td>20.7</td>
<td>202</td>
<td>28.4</td>
<td>90</td>
</tr>
<tr>
<td>7</td>
<td>4, In-F 0, SB 0, SB</td>
<td>19.0</td>
<td>207</td>
<td>32.9</td>
<td>92</td>
</tr>
<tr>
<td>13</td>
<td>4, In-F 0, SB 1, In-F</td>
<td>18.6</td>
<td>219</td>
<td>34.7</td>
<td>94</td>
</tr>
<tr>
<td>8</td>
<td>4, In-F 0, SB 2, SB</td>
<td>18.2</td>
<td>223</td>
<td>35.0</td>
<td>95</td>
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<tr>
<td>10</td>
<td>4, In-F 8, SB 0, SB</td>
<td>18.8</td>
<td>212</td>
<td>34.9</td>
<td>92</td>
</tr>
<tr>
<td>14</td>
<td>4, In-F 8, SB 1, In-F</td>
<td>17.9</td>
<td>209</td>
<td>35.0</td>
<td>93</td>
</tr>
<tr>
<td>11</td>
<td>4, In-F 8, SB 2, SB</td>
<td>16.8</td>
<td>210</td>
<td>37.1</td>
<td>97</td>
</tr>
</tbody>
</table>

Average LSD (0.10): 1.1 10 1.4 2

Funding provided by AFREC and Fluid Fertilizer Foundation
Corn grain moisture and yield, plant height at V7 and relative leaf chlorophyll at VT at Waseca

<table>
<thead>
<tr>
<th>Main effects of trts 1-12</th>
<th>Grain H₂O %</th>
<th>Grain Yield bu/A</th>
<th>Plant height inch</th>
<th>Leaf Chloro %</th>
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</thead>
<tbody>
<tr>
<td><strong>APP (10-34-0) in-furrow</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>18.6 a</td>
<td>214 a</td>
<td>32.7 b</td>
<td>95 a</td>
</tr>
<tr>
<td>4 gal/A</td>
<td>17.7 b</td>
<td>214 a</td>
<td>35.3 a</td>
<td>96 a</td>
</tr>
<tr>
<td><strong>UAN (28-0-0) surface dribble band</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>18.6 a</td>
<td>216 a</td>
<td>32.4 b</td>
<td>95 b</td>
</tr>
<tr>
<td>8 gal/A</td>
<td>17.7 b</td>
<td>212 a</td>
<td>35.5 a</td>
<td>96 a</td>
</tr>
<tr>
<td><strong>ATS (12-0-0-26) surface dribble band</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>19.5 a</td>
<td>209 b</td>
<td>32.5 b</td>
<td>91 c</td>
</tr>
<tr>
<td>2 gal/A</td>
<td>18.0 b</td>
<td>218 a</td>
<td>34.6 a</td>
<td>96 b</td>
</tr>
<tr>
<td>4 gal/A</td>
<td>17.0 c</td>
<td>215 a</td>
<td>34.8 a</td>
<td>99 a</td>
</tr>
</tbody>
</table>

Funding provided by AFREC

J. Vetsch – U of M SROC
2010 N, P & S for cont. corn summary

• One year (two site) data
• Excellent visual (early growth, vigor, and color) response to treatments at Waseca
• Sulfur fertilization alone increased yield 6–9 bu/A at Waseca.
• N, P, and S fertilizers enhanced early growth and decreased grain moisture at Waseca.

J. Vetsch – U of M SROC
Corn grain moisture and yield as affected by S source, rate, and timing at Waseca in 2010.

<table>
<thead>
<tr>
<th>Sulfur Source</th>
<th>S timing</th>
<th>S rate per acre</th>
<th>Placement</th>
<th>APP rate</th>
<th>Grain H₂O</th>
<th>Grain Yield</th>
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</thead>
<tbody>
<tr>
<td>Control</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>no</td>
<td>21.0</td>
<td>181</td>
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<tr>
<td>APP Control</td>
<td>planting</td>
<td>none</td>
<td>In-furrow</td>
<td>4 gal</td>
<td>19.9</td>
<td>183</td>
</tr>
<tr>
<td>ATS (2.8-lb)</td>
<td>planting</td>
<td>1 gal</td>
<td>In-furrow</td>
<td>4 gal</td>
<td>18.2</td>
<td>188</td>
</tr>
<tr>
<td>ATS (5.6-lb)</td>
<td>planting</td>
<td>2 gal</td>
<td>In-fur.&amp;SB</td>
<td>4 gal</td>
<td>16.9</td>
<td>205</td>
</tr>
<tr>
<td>AMS/Gypsum</td>
<td>PP</td>
<td>10-lb</td>
<td>Broadcast</td>
<td>no</td>
<td>16.4</td>
<td>210</td>
</tr>
<tr>
<td>AMS/Gypsum</td>
<td>PP</td>
<td>20-lb</td>
<td>Broadcast</td>
<td>no</td>
<td>16.0</td>
<td>226</td>
</tr>
<tr>
<td>Gypsum</td>
<td>V5</td>
<td>10-lb</td>
<td>Broadcast</td>
<td>no</td>
<td>18.1</td>
<td>222</td>
</tr>
<tr>
<td>Gypsum</td>
<td>V5</td>
<td>20-lb</td>
<td>Broadcast</td>
<td>no</td>
<td>17.2</td>
<td>224</td>
</tr>
<tr>
<td>ATS (10-lb)</td>
<td>V5</td>
<td>3.5 gal</td>
<td>Injected</td>
<td>no</td>
<td>17.3</td>
<td>209</td>
</tr>
</tbody>
</table>

LSD (0.10): 1.5 18

J. Vetsch – U of M SROC
Residue Levels and Sulfur Response

• Does the type of residue matter?
• C:S ratios (source Soil Fertility and Fertilizers 7th ed.)
  – <200:1 – mineralization
  – 200-400:1 no change
  – >400:1 - immobilization
• 2008 data – crop stover
  – Albert Lea, MN R6 Corn: 333:1
  – Clarkfield, MN R6 Corn: 151:1
  – Lewiston, MN R8 Soybean: 123:1
  – Hanska, MN R8 Soybean: 125:1
  – Strathcona, MN Wheat: 286:1
  – Perley, MN Wheat: 291:1
Residue and Response

- Amount and type of residue is important
- Residue likely is the reason for sulfur responses increasing
  - Corn and wheat residue may not mineralize S
  - Soybeans likely will
- Soil organic matter is important in S mineralization
  - In cont. corn thing become fuzzy
  - Clearly the important factor in SB rotations
Where Should I Apply?

• Broadcast has the least risk of damage
• Ammonium Thiosulfate can be banded
  – Better if placed away from the seed
• Am Thio placed with UAN may have some inhibition effects for nitrate conversion
  – Not as big as other N inhibitors
  – Ammonium thiosulfate is not the same as ammonium sulfate (dry)
In-Furrow ATS - Corn Emergence
14 days after initial emergence

Nitrogen Rate Applied (lbs N/ac)

Percent Corn Emergence (% of total)

Soil Type
- Le Sueur CL
- Zimmerman FSL
- Port Byron SL

Kaiser  U of M 2011
Le Sueur CL – 13 DAE
Zimmerman FSL – 13 DAE

- 0 gal/ac
- 0.76 gal/ac
- 1.89 gal/ac
- 3.79 gal/ac
- 7.58 gal/ac
- 15.1 gal/ac
In-Furrow ATS - Corn Dry Matter Produced
14 Days After Emergence

Nitrogen Rate Applied (lbs N/ac)

Total Above Ground Plant Weight
(mg per flat)

Soil Type
- Le Sueur CL
- Zimmerman FSL
- Port Byron SL

Kaiser  U of M 2011
ATS Applied In-Furrow

- Low rates of ~1gpa (3 lbs S) may be okay
  - Still risk some damage
- Emergence data say that higher rates can be used
- Effect on plant growth increased as rates increased
- You can use some in-furrow but you do accept some risk
Current U of M Recs

Where are we at??

- Recommend sulfur on fields with eroded knobs or organic matter <2% and sometimes when <4%
- 10-15 lbs of S was the optimum rate broadcast for 2009
  - Still unsure of this
- Corn on corn we are seeing situations where the organic matter level recs do not hold
  - Recommending S for these fields regardless of soil organic matter levels
- Keeping older guidelines on sandy soils
- No clear recommendation on soil testing for S
Proposed Corn Sulfur Guidelines for Southern Minnesota

<table>
<thead>
<tr>
<th>Broadcast sulfur to apply (lbs S per acre)</th>
<th>0-6” Soil Organic Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation</td>
<td>0-2</td>
</tr>
<tr>
<td>Corn-Corn</td>
<td>20-25??</td>
</tr>
<tr>
<td>Corn-Soybean</td>
<td>10-15??</td>
</tr>
<tr>
<td>Sandy Soils</td>
<td>25</td>
</tr>
</tbody>
</table>

** ??, denotes where we have limited data on response and need more data
Fertilizer Sources

• Any sulfate source should act the same
• Elemental sulfur takes time to become available
  – Better the farther south you go
• Apply the source that makes the most sense
  – Corn – N+S may be a good fit
• Keep on-seed rates low
Can Soybeans Benefit From Sulfur?

Wabasha Co. 2009

20 lbs of N at Planting

20 lbs of N + 25 lbs S at Planting
* Increase was not significant over the control
* Increase was not significant over the control
Plant Early Growth

- Soybean Growth differences were still apparent at the end of the season
  - Corn was not
- The combination of N + S greatly increased growth
- At Hanska all starter treatment advanced maturity
Sulfur Starter Experiment Strip Means
Soybean Sites 2008-2009

Yield Increase Over the Control (bu/ac)

-4 -2 0 2 4 6 8

-4

**Vertical Bars Represent Standard Errors of Treatment Means**
Sulfur and Soybean

• Potentially could see an yield increase when organic matter <2.0%
• Yield increase may be related to growth increases
• Too much growth may be bad
• Additional nutrients may still come into play
  – K is critical for soybeans
  – Responsive areas are also natively low in K
Sulfur Strategy

• Focusing on corn is the best strategy
• A single year application may have multiple years’ benefits
  – Both for corn and soybeans
• Residue is likely the reason for increasing responses
• Large yield benefits may only be temporary
  – Still need to consider some application in following years
Thank You

Questions?

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