SULFUR NUTRITION IN ROW CROPS

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Sr. Agronomist
December 4th, 2018
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GET TO KNOW ROSS…

• Contrasting Cleveland’s…

<table>
<thead>
<tr>
<th></th>
<th>Cleveland, MS</th>
<th>Cleveland, WI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>34.5° Lat</td>
<td>43.5° Lat</td>
</tr>
<tr>
<td>Dec 4th Record Low</td>
<td>16°F</td>
<td>-16°F</td>
</tr>
<tr>
<td>City Population</td>
<td>12,101</td>
<td>1,492</td>
</tr>
<tr>
<td>Bovines in County</td>
<td>?</td>
<td>~110,000</td>
</tr>
</tbody>
</table>

• State Laws:
  • Illegal to serve margarine at restaurant unless requested
  • Cows always have the right of way

Do cows enjoy being treated like royalty or do they have a genius plan to take over WI and if so, why!?
WHO IS MOSAIC?

Who We Are: World’s largest single source supplier of finished phosphates and potash.

Mission: Help the world grow the food it needs.

Premium Products:

MicroEssentials®

MicroEssentials S10: 12-40-0-10S
MicroEssentials SZ: 12-40-0-10S-1Zn

Both products: Sulfur is a 50:50 blend of sulfate and elemental sulfur

Aspire®

Same Analysis: 0-0-58-0.5B
New Formulation of B:
50:50 blend of fast and slow release

K-Mag®

Analysis: 0-0-21.5-10.5 Mg-21 S
TODAY’S OBJECTIVES

• WHAT ARE THE SULFUR BASICS?
• DO CROPS NEED SULFUR?
• WHAT TOOLS ARE AVAILABLE?
• Q&A (TIME PERMITTING)
SULFUR NUTRITION

• Secondary macronutrient.
• 4th most needed nutrient after N, P, and K.
• Atmospheric sulfur deposition has been greatly reduced.
• Required for protein synthesis (2 amino acids).
• Required for nodule formation on the root hairs of legume crops.
• Plants do not mobilize S from older tissues.

Source: www.cropnutrition.com/nutrient-knowledge
### RELATIVE CONTRIBUTIONS OF SULFUR FOR CURRENT PRODUCTION SYSTEMS

<table>
<thead>
<tr>
<th>Source of S</th>
<th>Relative Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Matter</td>
<td></td>
</tr>
<tr>
<td>Atmospheric Deposition</td>
<td></td>
</tr>
<tr>
<td>Plant Remobilization</td>
<td></td>
</tr>
<tr>
<td>Fertilizer</td>
<td></td>
</tr>
</tbody>
</table>

Information expressed here is not based on actual data, and only represents the thoughts of Ross Bender.
**ORGANIC MATTER (OM) MINERALIZATION**

<table>
<thead>
<tr>
<th>Each 1% OM Contains…</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 100 lbs/ac of organic S (unavailable)</td>
</tr>
<tr>
<td>• 2.0-2.5 lbs/ac inorganic S (available)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Key factors influencing availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Moisture</td>
</tr>
<tr>
<td>• Temperature</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Conditions for deficiency?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Vegetative: cool/wet</td>
</tr>
<tr>
<td>• Reproductive: hot/dry</td>
</tr>
</tbody>
</table>

### Recommendations for Sulfur on Corn (Purdue University)

- Low CEC soils: 25 lbs S/Ac annually
- Medium – High CEC Soils: 15 lbs S/Ac annually
- When using elemental sulfur only, combine with sulfate source

REDUCED ATMOSPHERIC DEPOSITION OF S

Data courtesy of National Atmospheric Deposition Program/National Trends Network (http://nadp.isws.illinois.edu)

Data represents annual content of sulfate deposition in precipitation (kg/ha).
WHY IS SULFUR IMPORTANT?

Maximum grain productivity requires season-long S availability, especially for corn and soybean:

Note the limited plant mobility of S in corn to supply intra-seasonal periods of plant stress.
SOYBEANS NEED SEASON-LONG SULFUR

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Yield Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Yield (bu/ac)</td>
<td>54</td>
</tr>
<tr>
<td>S Uptake (lbs/ac)</td>
<td>13.3</td>
</tr>
<tr>
<td>S Removal (lbs/ac)</td>
<td>9.1</td>
</tr>
<tr>
<td>Root Uptake (%)</td>
<td>50</td>
</tr>
<tr>
<td>Remobilization (%)</td>
<td>50</td>
</tr>
</tbody>
</table>

Adapted from Gasper et al., 2018.
### RELATIVE CONTRIBUTIONS OF SULFUR FOR CURRENT PRODUCTION SYSTEMS

<table>
<thead>
<tr>
<th>Source of S</th>
<th>Relative Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Matter</td>
<td>Medium</td>
</tr>
<tr>
<td>Atmospheric Deposition</td>
<td>Low</td>
</tr>
<tr>
<td>Plant Remobilization</td>
<td>Low</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>High</td>
</tr>
</tbody>
</table>

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# MASS BALANCE OF SULFUR

<table>
<thead>
<tr>
<th></th>
<th>Corn (230 bu/Ac)</th>
<th>Soybean (60 bu/Ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Need:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uptake</td>
<td>23</td>
<td>17</td>
</tr>
<tr>
<td>Removal</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td><strong>Supply:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Atmospheric Deposition</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Organic Matter (2% * 2.5 lbs S/Ac)</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Previous ES Application</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td><strong>Deficit:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suggested application rate (based on 60% efficiency)</td>
<td>20 lbs</td>
<td>10 lbs</td>
</tr>
</tbody>
</table>

*Hypothetical scenario only*

Higher yields and lower amounts of S from acidic rainfall continue to encourage S fertilization on corn and soybean!
DUAL SOURCES FOR MAXIMUM AVAILABILITY

MicroEssentials has both fast (Sulfate) and slow-release (Elemental S) sulfur sources for season-long S availability.

MicroEssentials S10 Analysis:
- Total Nitrogen 12%
- Total P$_2$O$_5$ 40%
- Total Sulfur 10%
  - Sulfate Sulfur (5%)
  - Elemental Sulfur (5%)
OXIDATION 101: FORMATION OF PLANT AVAILABLE SULFATE

Oxidation:
Conversion of plant unavailable elemental sulfur to plant available sulfate:

\[ 2 \text{ S} + 3 \text{ O}_2 + 2 \text{ H}_2\text{O} \rightarrow 2 \text{ SO}_4^{2-} + 4 \text{ H}^+ \]

(bacteria in soil)

Model Assumptions:
- pH: 6.8; OM: 1.5%; Cleveland, MS
- *Using S Oxidation Model from University of Adelaide.
Granular Elemental S (20 lbs ES)

MicroEssentials SZ (10 lbs SO$_4^{2-}$ + 10 lbs ES)

Model Assumptions:
- pH: 6.8; OM: 1.5%; Cleveland, MS
- Using S Oxidation Model from University of Adelaide.
WHAT IS BALANCED CROP NUTRITION?

Providing the right mixture of nutrients in a ratio that optimizes yield and profitability.

Analysis:

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>MicroEssentials S10</th>
<th>MicroEssentials SZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Nitrogen</td>
<td>12%</td>
<td></td>
</tr>
<tr>
<td>Total Phosphate (P₂O₅)</td>
<td>40%</td>
<td></td>
</tr>
<tr>
<td>Total Sulfur</td>
<td>10%</td>
<td></td>
</tr>
<tr>
<td>Sulfate Sulfur</td>
<td>(5%)</td>
<td></td>
</tr>
<tr>
<td>Elemental Sulfur</td>
<td>(5%)</td>
<td></td>
</tr>
<tr>
<td>Total Zinc</td>
<td>1%</td>
<td></td>
</tr>
</tbody>
</table>

FUSION TECHNOLOGY
MICROESSENTIALS ON CORN

MicroEssentials® S10™ vs. DAP

Trial Details

Locations and Crop Management:

CROP: Corn (Zea mays)

YEARS: 2008–2013

DATA SOURCE: Field studies conducted by university and/or third-party, independent researchers.

CROPPING CONDITION:

• P Rate: 65–90 lbs P₂O₅/ac
  – Balanced across all treatments

5.4 bu/ac

MicroEssentials® SZ™ vs. DAP

Trial Details

Locations and Crop Management:

CROP: Corn (Zea mays)

YEARS: 2004–2013

DATA SOURCE: Field studies conducted by university and/or third-party, independent researchers.

CROPPING CONDITION:

• P Rate: 65–90 lbs P₂O₅/ac
  – Balanced across all treatments

8.8 bu/ac
MICROESSENTIALS ON COTTON

Trial Details

Locations and Crop Management:
CROP: Cotton (Gossypium hirsutum L.)
YEARS: 2016–2017
LOCATIONS: 8 trials across the United States – GA, MS, NC, SC, TN, TX

CROPPING CONDITIONS:
All trials conformed to local cropping practices.

- **P Rate:** 50 lbs P₂O₅/ac applied as DAP (18-46-0), MicroEssentials S10 (12-40-0-10S) or MicroEssentials SZ (12-40-0-10S-1Zn)
- **S Rate:** 12.5 lbs S/ac from the MicroEssentials treatments
- **K Rate:** As required by soil test
- **Application Timing:** Preplant
- **Application Method:** Broadcast incorporated

**Cotton Lint Yield**

<table>
<thead>
<tr>
<th></th>
<th>DAP</th>
<th>MicroEssentials S10</th>
<th>MicroEssentials SZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (lbs lint/ac)</td>
<td>1,241</td>
<td>1,284</td>
<td>1,292</td>
</tr>
</tbody>
</table>

Increase with MicroEssentials SZ over DAP

51 lbs lint/ac

Increase with MicroEssentials S10 over DAP

43 lbs lint/ac
**TRIAL OBJECTIVE**
Evaluate MicroEssentials S10 (12-40-0-10S) fertilizer vs. MAP (11-52-0) vs. MAP + AS (21-0-0-24S) with a base application of MOP (0-0-60).

**TRIAL DETAILS**
- **CROP:** Soybean
- **YEAR:** 2016
- **LOCATION:** 8 trials (IL, IN, MI, IA, OH, ON, MO)
- **DATA SOURCE:** Small-plot (RCBD) trials conducted by university and third-party contract researchers.
- **P RATE:** 40 lbs P$_2$O$_5$/ac
- **K RATE:** 60 lbs K$_2$O/ac
- **S RATE:** 10 lbs S/ac
- **CROPPING CONDITIONS:** All trials conformed to local cropping practices.

Source: Data from 8 trials during 2016 by university and independent, third party researchers.
**MicroEssentials® on Rice**

**Objective**
- Improve yield response and micronutrient uptake in rice (Oryza sativa) compared to conventional practices.

**Introduction**
- Zinc (Zn) deficiency is a common issue in rice, affecting yield and quality. Adding MicroEssentials® can help supplement Zn levels in the soil.

**Trial Details**
- **Location and Crop Management:** Field trials conducted in the U.S. and Asia.
- **Zinc Treatment:** Application of Zn by spraying or incorporation into the soil.
- **Yield Data:** Based on multiple replicates over several seasons.

**Summary**
- MicroEssentials® treatments led to significant yield increases compared to controls.
- Zinc rates above 0.5 lb Zn/ac were particularly effective in improving yield.

**Graph:**
- **Rice Yield at Varying Zinc Rates**
  - DAP + AS + ZnSO₄
  - MicroEssentials® SZ™
- Yield increases are demonstrated across different zinc rates, with notable gains at higher zinc applications.

*Graph data and images courtesy of Mosaic.*
KEY TAKEAWAYS ON SULFUR

- Sulfur management is a system. We receive less S from “acid rain” today.

- Plants require more S (in part due to high yields) which needs to be available for longer for maximum grain yield.

- Significant University research has been done on soybean nutrition. Current data shows they stand to benefit from S, even if only 5-10 lbs S/ac.

- MicroEssentials has two forms of S, sulfate and elemental S, for season long availability.
For more information, please visit…

Twitter: @RossRBender
K-Mag: www.KMag.com
Aspire: www.AspireBoron.com