Fertility Management for Corn on Corn Systems

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The Mosaic Company
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Outline

- Nutrient Stewardship
- Corn on Corn Fertility Considerations
- Primary Nutrients Management
  - Nitrogen
  - Phosphorous
  - Potassium
- Other Nutrients Considerations
  - Sulfur
  - Zinc
- Mosaic Products and Research
Performance indicators

- Resource use efficiencies: Energy, Labor, Nutrient, Water
- Nutrient balance
- Yield
- Return on investment
- Profit
- Soil productivity

Economic

- Quality
- Working conditions
- Nutrition security

Social

- Biodiversity
- Nutrient loss
- Water & air quality
- Soil erosion
- Adoption
- Ecosystems services
- Food security

Stakeholder input

Mosaic
Right Source

**Scientific Principle:**

- Ensure a balanced supply of each of the essential nutrients in plant-available form, utilizing all available sources.

**Practices:**

- Credit nutrients from manures and composts
- Credit N from previous crops
- Assess use of enhanced-efficiency sources
Right Rate

Scientific Principle:
• Assess soil nutrient supply and plant demand.

Practices:
• Soil test
• Balance crop removal
• Determine crop yield potential
• Assess price ratios
Right Time

Scientific Principle:
• Assess timing of crop uptake, soil nutrient supply, weather, loss risks and field operation logistics.

Practices:
• Split-application for sandy soils
• Scouting and tissue sampling
• Cover crops to capture nutrients
• Suit tillage and planting operations
Right Place

**Scientific Principle:**
- Place nutrients where they are accessible to the crop.

**Practices:**
- Placement near seedlings
- Within-field management zones
- Apply soil survey information (drainage, etc.)
- Band, inject, or incorporate
- Precision RTK-GPS
Corn on Corn Fertility Considerations
Fertility implications

What do I need to do differently to grow continuous corn?

- Transport of nutrients in corn
- Nutrient removal
- Nutrient tie up
- Use of starter fertilizers
- P & K management
- N-timing
- Starter placement
- Sulfur/zinc needs
How do plant roots take up nutrients?

<table>
<thead>
<tr>
<th>Mass Flow</th>
<th>Diffusion</th>
<th>Interception</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfur</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Marschner, 1995
### Nutrient removal by cropping system

<table>
<thead>
<tr>
<th>Cropping System</th>
<th>N (lbs)</th>
<th>P2O5 (lbs)</th>
<th>K2O (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn (180 bu/a)</td>
<td>215</td>
<td>70</td>
<td>50</td>
</tr>
<tr>
<td>Soybean credit</td>
<td>-45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybeans (55 bu/a)</td>
<td>10</td>
<td>45</td>
<td>75</td>
</tr>
<tr>
<td>C-S total</td>
<td>180</td>
<td>115</td>
<td>125</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cropping System</th>
<th>N (lbs)</th>
<th>P2O5 (lbs)</th>
<th>K2O (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st year Corn (180 bu/a)</td>
<td>180</td>
<td>70</td>
<td>50</td>
</tr>
<tr>
<td>2nd year Corn (162 bu/a)</td>
<td>190</td>
<td>65</td>
<td>45</td>
</tr>
<tr>
<td>Organic matter tie up</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-C total</td>
<td>400</td>
<td>135</td>
<td>95</td>
</tr>
</tbody>
</table>
Nutrient tie up from corn on corn system

- OM shift can cause N, P, S & Zn deficiencies in the short term
- Corn residues tie up more N than soybeans
- Compensate by increasing N fertilizer 30-50#/a
- If using yield-based calculations of N requirements, adjust yield goals downward 5-8% for C/C
- More early N is needed until organic N pool becomes available
P & K management in continuous corn

- Cooler, wetter soils can cause P/K problems
- Soils with low/deficient soil P & K levels can be a problem
- Banding preplant P & K is more advantageous in C/C, especially if soils have a higher pH
- Starter application more advantageous in C/C
- K levels need to increase as yield potential increases – starting to see more stalk lodging problems that could be K deficiency coupled with weaker genetic stalk strength
Starter placement

- Traditional 2 x 2 is very effective on low P soils, but many growers do not have the equipment
- 2 x 0 (or drip surface) placement produced similar results in many university studies
- Fertilizer needs to be applied at least 2” away from the seed row when nitrogen levels in the starter increase
- Rain is required to move fertilizer into profile
Nitrogen
Nitrogen application timing

- Need a pool of N early in corn’s lifecycle – preplant N is beneficial
- N supplied by previous soybean crop in season must be replaced
- Very high yielding corn may require additional N prior to tasseling
- Use of controlled released N products or high clearance N applications prior to tasseling may become more common as growers push for upper level yields
Nitrogen response by corn in different rotations: Eudora silt loam

Corn grain yield (bu/acre) vs. N rate (lb N/acre)

Maddux and Barnes, 1998

Eudora silt loam
Average: 1979-1987
Summary

• Nitrogen requirements
  – Corn following soybean usually requires the least amount of nitrogen
  – Continuous corn usually requires the most amount of nitrogen
  – Nitrogen requirements of second year corn following soybean are somewhere between these two

• Nitrogen response
  – Corn following soybean is less responsive, allowing a greater margin of error in rate selection
  – Corn following corn is more responsive, allowing a smaller margin of error in rate selection
Phosphorous
The International Plant Nutrition Institute (IPNI) conducts a US Soil Sample Survey every 5 years.

- Conducted periodically by IPNI, current = 10th
- Samples from fall 2009 – spring 2010
- Data reported:
  - Median P, K, and pH values
  - Relative frequency across soil test ranges for P, K, pH, Mg, S, Zn, Cl⁻
- 4.4 million samples
- Data from 63 public and private labs
Figure 5. Median Bray P-1 equivalent soil test levels, 2010.

North America
25 ppm
4.4 million samples
Change in median Bray P equivalent soil test levels from 2005 to 2010.

North America

-6 ppm
Soil test P distribution in 2010 compared to 2005 for the Corn Belt (12 states plus Ontario)

**Corn Belt P**

- **2005**: 2.0 million samples
- **2010**: 3.0 million samples

Median:
- **(2010) 22**
- **28 (2005)**

Bray P1 Equivalent, ppm

- 0.5
- 6-10
- 11-15
- 16-20
- 21-25
- 26-30
- 31-35
- 36-40
- 41-45
- 46-50
- >50
Phosphorus and Nutrient Utilization

• Advantage: Phosphorus improves the ability of plants to use all available nutrients

Benefits:
– Best utilization of all inputs
– Reduced environmental concern

Schlegel, Dhuyvetter, and Havlin, 1996
JPA 9:1
Potassium
K Role in Plants

- Enzyme Activation
- Water Relations
- Energy Relations (ATP)
  - Photosynthesis
  - Translocation
  - Protein Synthesis
- Stress Resistance
Figure 10. Median soil test K levels in 2010.
Figure 13. Change in median soil K level from 2005 to 2010.

*Shifts in laboratories between years and limited sample volume for these states could have inflated apparent changes.

IPNI, 2010
The difference non-limiting levels make to nutrient recommendations

Corn grain yield (bu/A) vs. N rate (lb N/A)

- 139 ppm K (205 lb N/acre optimum)
- 80 ppm K (294 lb N/acre optimum)

Sulfur
Sulfur needs

- 90% of sulfur comes from OM/residue – more S will be tied up with C/C so deficiencies will become more common

*Sulfur in plant needed for:*

- 3 amino acids: methionine, cysteine, cystine
- Chlorophyll production
- Vitamins like thiamine and biotin
- Glucoside oils like glucosinolates
- Ferredoxins for assimilatory reduction of N, dinitrogen fixation
Sulfur Deficiency in Corn
Clean Air Means Less Sulfur in Precipitation

National Atmospheric Deposition Program

Change in Sulfate Ion Concentration In Precipitation from 1985 To 2003

Corn for Grain 2004 Harvested Acres by County

1985

2003

SO_{4}^{2-} (mg/L)

≤ 0.50

0.50 - 0.75

0.75 - 1.00

1.00 - 1.25

1.25 - 1.50

1.50 - 1.75

1.75 - 2.00

2.00 - 2.25

2.25 - 2.50

2.50 - 2.75

2.75 - 3.00

> 3.00
Zinc
Zinc needs

- Zinc is required in cooler soils
- Zinc deficiencies may begin to show up with more than 2 years of corn in a row

**Zinc in plant needed for:**

- Protein synthesis
- Chlorophyll and carbohydrate production
- Auxin synthesis
- A driver of many metabolic reactions
Percent of samples testing < 1.0 ppm DTPA equivalent Zn in 2010.
Micronutrient Deficiencies are Seldom Uniform Across Fields

Zn Deficiency
Zinc deficiency
## Phosphorus & Zinc

- Zn deficiency impairs plant P regulation.
- High soil P or large amounts of applied P can induce Zn deficiency if Zn supply is marginal.

<table>
<thead>
<tr>
<th>P$_2$O$_5$</th>
<th>Zn</th>
<th>Yield</th>
<th>Leaf tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb/A *</td>
<td>bu/A</td>
<td>P, %</td>
<td>Zn, ppm</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>101</td>
<td>0.14</td>
</tr>
<tr>
<td>0</td>
<td>10</td>
<td>102</td>
<td>0.16</td>
</tr>
<tr>
<td>80</td>
<td>0</td>
<td>73</td>
<td>0.73</td>
</tr>
<tr>
<td>80</td>
<td>10</td>
<td>162</td>
<td>0.41</td>
</tr>
</tbody>
</table>

Data source: Adriano and Murphy

* P and Zn band-applied
Mosaic Products and Research
The Next Generation of Fertilizer

MicroEssentials® SZ™ (10-40-0-10S-1Zn)

MicroEssentials combines nitrogen, phosphorus, sulfur and zinc into one nutritionally balanced granule, creating a single source for balanced crop nutrition.

The unique chemistry & precise nutrient ratio of MicroEssentials promotes:

- Uniform Nutrient Distribution
- Increased Nutrient Uptake
- Season-long Sulfur Availability
A Breakthrough in Fertilizer MicroEssentials Fusion™ Technology

• Through our patented Fusion™ manufacturing process, nitrogen, phosphorus, sulfur and zinc are fused into one nutritionally balanced granule, creating a single source for balanced crop nutrition.
Two Forms of Sulfur

- Season-Long Availability
  - 50% Sulfate Sulfur for immediate availability to the plant
  - 50% Elemental Sulfur for availability throughout the growing season, after oxidation
Uniform Nutrient Distribution
Through our patented Fusion manufacturing process:

- Same analysis within every granule
- Nutrients delivered evenly across every field
- Plants have more sites to reach the key nutrients needed for optimal growth
- Get more from every acre
Summary

• Corn on Corn fertility requires more attention
• There is less margin for error.
• Corn on Corn requires more Nitrogen
• Residue management will impact P and K fertility.