NITROGEN: A Challenge for Modern Agriculture

Nitrogen provides robust growth in crops
Nitrogen has serious environmental issues
MN agriculture has a “leaky” nutrient system

“Troubled Waters” Larkin McFee

N transfer to surface and ground water: a matter of how we manage our soil
Taking Care of the Land?

• “Nobody cares about good soil and clean water more than farmers”
• “Farmers are the original environmentalists”
• “Farmers produce more by using less”
• “Minnesota farmers are the best”
• “Farmers have a moral obligation to feed the world”
John Deere 3710 moldboard new plow sales, 8-10 bottom

- 2006  2
- 2007  6
- 2008  7
- 2009  3
- 2010  11
- 2011  15
- 2012  15 plows on order

(8 SEMA dealers, sales data, new plows)
Salford 12 and 14 bottom plows

<table>
<thead>
<tr>
<th>Year</th>
<th>12 bottom</th>
<th>14 bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>2011</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>2012</td>
<td>1</td>
<td>4, 2 on order</td>
</tr>
</tbody>
</table>

(SEMA equipment data)
Every gallon of diesel burned emits 22.4 lb. of CO2.
Soil Warrior with dry fertilizer system  $84,354
Trimble Auto Steer with cellular correction  $20,322
WHAT IS SOIL QUALITY?

AIR

ORGANIC MATERIAL (HUMUS) 1% TO 11%

BIOTA: BUGS, WORMS, BACTERIA,

WATER HOLDING CAPACITY

AGGREGATE STABILITY

Soil scientists agree that less tillage builds soil quality.
St. Olaf Nitrogen Rate Trials 2011

Ryan Lemickson
And
Rachel Weime ’12 St. Olaf College

Preliminary
Corn/Soybean Site

Corn Price: $6.01/bushel      N Price (UAN): $448/ton ($0.80/lb) (.13 ratio)

Iowa N Rate Calculator MRTN: **103 lbs N** (96 – 110 lbs N/acre)

**Corn Nitrogen Rate Calculator**

Finding the Maximum Return To N and Most Profitable N Rate
A Regional (Corn Belt) Approach to Nitrogen Rate Guidelines

State: Minnesota
Number of sites: 60
Rotation: Corn Following Soybean
Non-Responsive Sites Not Included

Nitrogen Price ($/lb): 0.80
Corn Price ($/bu): 6.01
Price Ratio: 0.13

<table>
<thead>
<tr>
<th>MRTN Rate (lb N/acre)</th>
<th>Profitable N Rate Range (lb N/acre)</th>
<th>Net Return to N at MRTN Rate ($/acre)</th>
<th>Percent of Maximum Yield at MRTN Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>103</td>
<td>96 – 110</td>
<td>$221.51</td>
<td>98%</td>
</tr>
</tbody>
</table>

UAN (28% N) at MRTN Rate (lb product/acre): 368
UAN (28% N) Cost at MRTN Rate ($/acre): $82.40

Most profitable N rate is at the maximum return to N (MRTN).
Profitable N rate range provides economic return within $1/acre of the MRTN.

http://extension.agron.iastate.edu/soilfertility/nrate.asp
Basal Stalk Nitrate Testing

- Sample points built in ArcGIS
  - Trimble GPS Unit to navigate to points in the field
- 10 Stalks Per Strip = 1 Sample
  - 8 inch Section
  - 6” off the ground
- Ear Samples as Visuals
Basal Stalk Nitrate Testing

- After Black Layer (Maturity)
  - 2 Dominant Soil Types
    - Merton Silt Loam 377 (1-3 % Slope)
    - Moland Silt Loam 376B (1-4% Slope)
  - Each Individual Strip Sampled
    - Rest of field sampled
Methods: Sampling

• Soil Samples – 2 samples per replicate
  – Test for % Soil Moisture, SOM, NO$_3$-N, NH$_4$, PO$_4$-P

• Stalk Nitrate
  – Mature Corn -> Black layer
  – 6-14” above ground

• Soil Respiration & Corn Moisture

• C:N and Stable Isotope

• Yield Data
## Results (Averages)

<table>
<thead>
<tr>
<th>Strip ID (sidedress)</th>
<th>Total N (lbs)</th>
<th>Moisture (%)</th>
<th>Test Weight</th>
<th>Yield (Bu/ac)</th>
<th>BSNT (ppm)</th>
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</thead>
<tbody>
<tr>
<td>30</td>
<td>75</td>
<td>14.2</td>
<td>57.0</td>
<td>159</td>
<td>79</td>
</tr>
<tr>
<td>60</td>
<td>105</td>
<td>14.3</td>
<td>57.1</td>
<td>175</td>
<td>167</td>
</tr>
<tr>
<td>90</td>
<td>135</td>
<td>14.3</td>
<td>57.1</td>
<td>179</td>
<td>900</td>
</tr>
<tr>
<td>120</td>
<td>165</td>
<td>14.2</td>
<td>57.3</td>
<td>185</td>
<td>404</td>
</tr>
</tbody>
</table>

**Rest of Field**
- BSNT: 97 ppm
- Yield: ??
## Results

<table>
<thead>
<tr>
<th>Total N (lbs)</th>
<th>Sidedress (lbs)</th>
<th>Strip Yield (Avg)</th>
<th>*Yield Increase (bushels)</th>
<th>Yield Benefit</th>
<th>N cost</th>
<th>Return to N (Yield Increase x Corn $) - (SD increase x N cost/lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>75</td>
<td>NA</td>
<td>159</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>105</strong> (BMP Rate)</td>
<td><strong>30</strong></td>
<td><strong>175</strong></td>
<td><strong>17</strong></td>
<td><strong>$102</strong></td>
<td><strong>$24</strong></td>
<td><strong>$78</strong></td>
</tr>
<tr>
<td>135</td>
<td>60</td>
<td>179</td>
<td>20</td>
<td>$120</td>
<td>$48</td>
<td>$72</td>
</tr>
<tr>
<td>165</td>
<td>90</td>
<td>185</td>
<td>26</td>
<td>$156</td>
<td>$72</td>
<td>$84</td>
</tr>
</tbody>
</table>

*Based on difference from 75 lbs Strips (No 0 Checks)

- Significant responses to additional Nitrogen up to 105 lbs Corn/Soybean
- 105 vs 135: No difference
- 135 vs 165: No difference
Iowa On-Farm Network Trials

Grain Yield (Bu/Ac)
- 10.0 - 171.0
- 171.1 - 188.9
- 189.0 - 200.6
- 200.7 - 211.8
- 211.9 - 225.6
- 225.7 - 399.1

Strip Trial Soils
2013 St. Olaf Research

Professor Kathleen Shea
Ellen Squires, Nitrogen research
Megan Exner, Nitrogen research
Alex Bauch, Soil quality/macroinvertebrates
2013 Corn Field Study

Field 1
Conservation/Conventional tillage
Most crop residues left on field

Field 2
Strip tillage
Crop residues left on field

Both applied
1 flat rate and 1 variable rate of nitrogen
Objectives

1) Compare tillage methods in terms of soil characteristics

2) Compare nitrogen application in terms of yield, soil characteristics, and stalk nitrate levels
Soil Characteristics

Average % Moisture

Field 1: 25%
Field 2: 30%

Average % Organic Matter

Field 1: 5%
Field 2: 8%
Conservation/Conventional Tillage Yield and Stalk Nitrates

Graph showing the relationship between treatment group (variable lbs of N added) and average dry yield vs stalk nitrates.
Strip Tillage Yield and Stalk Nitrates

- Average Dry Yield (bu)
- Stalk Nitrates (ppm)

Graph showing the relationship between variable rate of nitrogen applied (lbs) and average dry yield (bu) and stalk nitrates (ppm).
Summary

• Strip tillage had higher % moisture and organic matter
• The conservation/conventional tillage field may have applied more than the necessary amount of nitrogen in all treatment plots
• Possibly, the strip tilled field lost some nitrogen due to heavy rains
• Difficult to set appropriate nitrogen targets
Understanding Potential Impacts to Groundwater

**How?**

- Deep Nitrate Soil Testing
  (In Season & After Harvest)
  (4 ft.)

- Suction Tube Lysimeters
  (In Season)
  (Pull water from 4-6 ft.)

Comparing Crop Nitrogen Rates, Responses, and the associated Leaching losses to Groundwater
Lysimeter Outline

- Vacuum applied and draws water out of the soil
- Ceramic Tips (porous)
- Below the crops root zone (subject to leaching)
- Water sample is collected through sample line and analyzed for Nitrate levels

Hach UltraViolet Spectrophotometer for nitrate analysis
Water Samples Collected Weekly under each N Rate

Sample lines coming out of ground.
How do we bring about change in agriculture?

Minnesota Discovery Farms: Centralized research done by U of M, MN Dept of Agriculture, Sponsored by commodity groups and agriculture agencies. Excellent science but remote from individual farmers.
Decentralized research

• Scientific research done on individual farms.
• Resource issues are chosen by each farm operator.
• Economic outcomes may drive decision making.
• Environmental benefits can be proven.
• Each producer “owns” his/her data.
• Data proves the effectiveness of practices.
• Authentic results on “my soil”.
• Who can make this happen?

COLLABORATIVES
Drainage Water Management

Diagram showing the water table and drain levels throughout the year.
Subsurface Drainage Practices

- Drainage water management
- Better drainage design
Mower County Surge Basin Near Grand Meadow.
Mower County Site Retention Basin Near Ostrander
Tile flow from subsurface drainage diverted into a trench of woodchips. Routed in and out with one structure.

Site, one month after construction.
Bioreactor receiving 66 acres, 10 by 75 ft excavated area.
How do we value good groundwater in agriculture?

Well water for ag uses.
Fertilizer efficiency relates to less groundwater pollution.

$ Better bottom line $
The Learning Curve

On-farm research promotes producers improving practices.

Look at other state’s initiatives and learn from them.

As aid from government programs retracts, build collaboratives, seek support from a wide variety of sources.