Nitrogen Decisions
A Case Study of a Virginia Farm

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Mobile Device Technology - Agricultural Applications

- Identification Tools
- Input Calculators
- News, Weather, Market Updates
- Other Calculators
- Scouting Tools
On-Farm Data Storage

Digitization: Storage and Compute Costs
Exponential Decrease in Storage and Computing Costs

Source: http://www.statisticbrain.com/, The Hamilton Project at the Brookings Institution
Decision Making Process

What was the question in the first place?
Nitrogen Fertilizer Decision Making

- Stanford Equation

\[ N_{\text{fert}} = \frac{(N_{\text{crop}} - N_{\text{soil}})}{e_{\text{fert}}} \]

Douglas Beegle, Penn State University
Scott Murrell, International Plant Nutrition Institute
Nitrogen Fertilizer Decision Making

- $f_{\text{Soil}} \mid f_{\text{Fert}} \mid e_{\text{Fert}}$
- Are the Values Static?
- How Static is the Environment?
Nitrogen Fertilizer Decision Making

\[ N_{\text{fert}} = \left( N_{\text{crop}} - N_{\text{SIN}} - N_{\text{SON}} - N_{\text{CRN}} - N_{\text{manure RON}} - N_{\text{manure IN}} - N_{\text{manure ON}} - N_{\text{leg}} \right) / e_{\text{fert}} \]

- \( N_{\text{fert}} \): Total fertilizer N required
- \( N_{\text{crop}} \): Total N in Crop
- \( N_{\text{SIN}} \): Available soil inorganic N
- \( N_{\text{SON}} \): Available soil organic N
- \( N_{\text{CRN}} \): Available crop residue N
- \( N_{\text{manure RON}} \): Available manure residual organic N
- \( N_{\text{manure IN}} \): Available manure inorganic N
- \( N_{\text{manure ON}} \): Available manure organic N
- \( N_{\text{leg}} \): Available legume N
- \( e_{\text{fert}} \): Fertilizer N efficiency

Diagram showing the total plant uptake and partitions of N.
• The foundation of fertilizer BMPs and efficient nutrient management can be aptly described as following the “4Rs”...

Applying the **Right Source** at the **Right Rate** at the **Right Time** and in the **Right Place**
4R Nutrient Stewardship

1. Supply in plant available forms
2. Suit soil properties
3. Recognize synergisms among elements
4. Blend compatibility

1. Appropriately assess soil nutrient supply
2. Assess all available indigenous nutrient sources
3. Assess plant demand
4. Predict fertilizer use efficiency

1. Assess timing of crop uptake
2. Assess dynamics of soil nutrient supply
3. Recognize timing of weather factors
4. Evaluate logistics of operations

1. Recognize root-soil dynamics
2. Manage spatial variability
3. Fit needs of tillage system
4. Limit potential off-field transport
Implementing precision agriculture technologies within the context of 4R nutrient stewardship is an efficient and effective way to help meet the environmental, economic, and social goals of sustainable agricultural systems.

4R is Precision Nutrient Management
Standard N Management in VA:

Corn: 1) Target 1 lb. N per 1 bu. expected yield
     (takes into account fertilizer N, legume credits, and organic additions)
     (expect yield based soil type, productivity class)

     2) Multiple N applications timed with periods of plant uptake
     (Standard practice includes 1 pre-emerge application, 1 application @ V5-V6)

Wheat: 1) Multiple N applications based on
     a. early plant development (fall)
     b. tiller density (spring)
     c. N in the plant based on tissue tests (spring)
Typical Characteristics of Eastern Virginia Farmland:
1. Soils are variable, Sandy Loam
2. Wooded Field Edges
3. Low Organic Matter
4. Small Field Size, +/- 20 ac avg
Corn
Soybeans
P & K applications were made for the 2015 corn crop, 2015-16 wheat crop, and the 2016 bean crop.
2011 Corn Yield Avg. = 169.2 bu/ac

2013 Corn Yield Avg. = 170.5 bu/ac
2012 Bean Yield Avg. = 58.5 bu/ac

2014 Bean Yield Avg. = 46.1 bu/ac
Crop Years of < 80% of Field Avg.

Crop Years of > 120% of Field Avg.

Analyzed > 90,000 data points over 4 crop years
All points < 80% of Field Avg.

Analyzed > 90,000 data points over 4 crop years
All points > 120% of Field Avg.
Field Name: Wesley's
Field Acreage: 72.2
Basis for Prescription: Yield Data
   Corn - 2011, 2013
   Soybeans - 2012, 2014
   Wheat - 2012, 2014

Recommended Zone Format: 3 Productivity Zones (High, Avg, Low)

<table>
<thead>
<tr>
<th>Zone</th>
<th>2011 Corn Yield</th>
<th>2013 Corn Yield</th>
<th>Yield Goal 2015 (bu/ac)</th>
<th>Yield Target (bu/1,000 plants)</th>
<th>Recommended Seeding Rate for 2015</th>
<th>Amount of Seed Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Productivity Zone - 24.0 acres</td>
<td>194 bu/ac</td>
<td>190 bu/ac</td>
<td>225</td>
<td>6.82</td>
<td>33,000</td>
<td>27 Units</td>
</tr>
<tr>
<td>Average Productivity Zone - 35.4 acres</td>
<td>166 bu/ac</td>
<td>167 bu/ac</td>
<td>175</td>
<td>6.03</td>
<td>29,000</td>
<td></td>
</tr>
<tr>
<td>Low Productivity Zone - 12.8 acres</td>
<td>114 bu/ac</td>
<td>118 bu/ac</td>
<td>125</td>
<td>5.21</td>
<td>24,000</td>
<td></td>
</tr>
</tbody>
</table>

Fertility Management Strategy:
Soil samples were taken on a 2.5 acre grid prior to the 2013 corn crop and again in late 2014 in preparation for the 2015 corn crop.

Lime will be variably applied to a target soil pH of 6.2.

Potash and phosphorus will be variably applied based upon expected crop removal rates within each zone.

Two options exist for nitrogen management: 1) GreenSeeker variable rate application or; 2) application of ~1.2 lbs. of N per expected bushel of yield within each zone.
2015 Actual Corn Yield
High Zone = 228 bu/ac
Avg Zone = 192 bu/ac
Low Zone = 125 bu/ac
Legend
Yield per 1,000 seed
- < 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- > 8

< 5 bu/1,000 seed = management problem
6-8 bu/1,000 seed = wheelhouse
> 8 bu/1,000 seed = population too low
1. Used GreenSeeker since 2007 to variably apply Nitrogen to wheat.

2. Requires reference strip to calibrate = double up on N application at GS 25 for each field and/or variety.

3. VT developed VA intensive wheat algorithm.

4. Uses NDVI photography to read chlorophyll
# Comparison: Year 1 vs. Year 2

## Wheat: Year 1

<table>
<thead>
<tr>
<th>Method</th>
<th>GS 30N Applied</th>
<th>Yield</th>
<th>NUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GreenSeeker</td>
<td>58.1 lbs/ac</td>
<td>77.3 bu/ac</td>
<td>1.8</td>
</tr>
<tr>
<td>Standard</td>
<td>58.4 lbs/ac</td>
<td>76.6 bu/ac</td>
<td>1.9</td>
</tr>
<tr>
<td><strong>Average - All Fields</strong></td>
<td>57.1 lbs/ac</td>
<td>71.8 bu/ac</td>
<td>1.9</td>
</tr>
</tbody>
</table>

## Wheat: Year 2

<table>
<thead>
<tr>
<th>Method</th>
<th>GS 30N Applied</th>
<th>Yield</th>
<th>NUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>GreenSeeker</td>
<td>53.0 lbs/ac</td>
<td>74.4 bu/ac</td>
<td>1.45</td>
</tr>
<tr>
<td>Standard</td>
<td>59.0 lbs/ac</td>
<td>75.5 bu/ac</td>
<td>1.52</td>
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<tr>
<td><strong>Average - All Fields</strong></td>
<td>53.4 lbs/ac</td>
<td>70.3 bu/ac</td>
<td>1.54</td>
</tr>
</tbody>
</table>
Summary on GreenSeeker

• It usually applies less Nitrogen;
• It usually leads to a more efficient use of N;
• It’s not particularly user friendly;
• It is more attractive when grain prices drop and N prices rise;
• It would be more attractive if there was an incentive for better NUE (gov’t. or market)
Drones could potentially provide an alternative to other optical sensor based VR platforms for data gathering...still need to interpret the data and physically make the N application.
Closing Thoughts

• No “right” answer...evolution occurs everyday
• TMDL may offer great opportunities
• It’s really hard to make an informed decision without the aid of information.
Physiographic Region

• Coastal Plain
  – B/t Richmond and Williamsburg, Va
  – Long season, 40+ inches rainfall annually
  – Soils - v.deep, high in sand, low clay and OM, drought prone
  – No tillage in most crops
  – Crops - corn, soybean, small grains, pumpkins
Response to Fertilizer Depends on:

- **Cultural Practices Used**
  - Never Till, Cover Crops

- **Soil Productivity**
  - Conetoe 80 bu - Pamunkey 180 bu

- **Soil Test Level** (OM up to 3%+)
  - Crop Removal, Tissue Samples

- **Method of Fertilizer Application**
  - 2x2, Sidedress, Topdress, Fertigate, Pop-up?
Never Fallow with Winter Annual Cover Crops
Biomass Yield

LSD = 2.1

Biomass Yield, tons/ac

Early  Mid  Late  Early  Mid  Late  Early  Mid  Late  Early  Mid  Late  Early  Mid  Late

Barley  Crimson Clover  Oats  Rye  Rye + Vetch  Vetch  Triticale
WOOLY POD
Historic Corn Yields

\[ y = 1.195x - 2285.6 \]

\[ R^2 = 0.2927 \]
Nitrogen

![Graph showing nitrogen uptake and dry matter accumulation over time. The graph includes stages such as V4, V8, VT, R2, and R4, with proposed N application windows marked. The x-axis represents growing degree units from May to September, and the y-axis represents dry matter accumulation and N uptake in kg ha\(^{-1}\).]
Yetter Sub-Surface Placement

- Yield, bu/ac
- Starter N, lb/ac

60 lb N BC, preplant + 10 lb N starter
Optimum Starter Band and Sidedress N Rates for No-till Corn

<table>
<thead>
<tr>
<th>Soil Series</th>
<th>Starter Band* N Rate (lbs/ac)</th>
<th>Side-dress N Rate (lbs/ac)</th>
<th>Yield (bu/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pamunkey</td>
<td>66</td>
<td>0</td>
<td>89</td>
</tr>
<tr>
<td>Slagle sil</td>
<td>70</td>
<td>93</td>
<td>168</td>
</tr>
<tr>
<td>Pamunkey fsl</td>
<td>70</td>
<td>80</td>
<td>154</td>
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<tr>
<td>Slagle sl</td>
<td>49</td>
<td>125</td>
<td>128</td>
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<tr>
<td>Turbeville sl</td>
<td>27</td>
<td>107</td>
<td>111</td>
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<tr>
<td>Cullen l</td>
<td>44</td>
<td>58</td>
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<tr>
<td>Eubanks sil</td>
<td>70</td>
<td>0</td>
<td>122</td>
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<tr>
<td>Ross l</td>
<td>70</td>
<td>93</td>
<td>105</td>
</tr>
<tr>
<td>Pamunkey sil</td>
<td>70</td>
<td>93</td>
<td>148</td>
</tr>
</tbody>
</table>

*Starter band placed 2x2. N rates were 10, 30, 50, 70 lbs N/acre.
Field id: 
Sample id: Pioneer 1197

<table>
<thead>
<tr>
<th></th>
<th>Nitrogen</th>
<th>Sulfur</th>
<th>Phosphorus</th>
<th>Potassium</th>
<th>Magnesium</th>
<th>Calcium</th>
<th>Sodium</th>
<th>Boron ppm</th>
<th>Zinc ppm</th>
<th>Manganese ppm</th>
<th>Iron ppm</th>
<th>Copper ppm</th>
<th>Aluminum ppm</th>
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<tbody>
<tr>
<td>Analysis</td>
<td></td>
<td>3.37</td>
<td>0.21</td>
<td>0.35</td>
<td>1.88</td>
<td>0.19</td>
<td>0.55</td>
<td>0.01</td>
<td>9</td>
<td>29</td>
<td>75</td>
<td>125</td>
<td>17</td>
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<tr>
<td>Normal Range</td>
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<td>4.00</td>
<td>0.15</td>
<td>0.25</td>
<td>1.81</td>
<td>0.15</td>
<td>0.25</td>
<td>0.01</td>
<td>5</td>
<td>20</td>
<td>15</td>
<td>30</td>
<td>5</td>
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Crop: Corn
Growth Stage: Silking (R1)

<table>
<thead>
<tr>
<th></th>
<th>N/S</th>
<th>N/K</th>
<th>P/S</th>
<th>P/Zn</th>
<th>K/Mg</th>
<th>K/Mn</th>
<th>Ca/B</th>
<th>Fe/Mn</th>
<th>Ca/K</th>
<th>Ca/Mg</th>
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<tbody>
<tr>
<td>Actual Ratio</td>
<td>16.0</td>
<td>1.8</td>
<td>1.7</td>
<td>120.7</td>
<td>9.9</td>
<td>250.7</td>
<td>611.1</td>
<td>1.7</td>
<td>0.3</td>
<td>2.9</td>
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<tr>
<td>Expected Ratio</td>
<td>9.2</td>
<td>1.4</td>
<td>1.0</td>
<td>83.3</td>
<td>6.4</td>
<td>289.8</td>
<td>338.8</td>
<td>1.7</td>
<td>0.2</td>
<td>1.4</td>
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<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Very High</th>
<th>High</th>
<th>Sufficient</th>
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<th>Deficient</th>
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</table>

Comments: 02002) Nutrient levels are adequate at this time.

Analysis prepared by: Waypoint Analytical Virginia, Inc.
Nitrogen Management In Winter Wheat Production
Historic Wheat Yields

\[ y = 0.9968x - 1935.6 \]

\[ R^2 = 0.7305 \]

\[ y = 0.3992x - 755.35 \]

\[ R^2 = 0.6157 \]
Split Apply N According to Growth Stage

60% N Uptake After GS 30
GS 25 N Rate
Directly Related to Tiller Numbers

![Graph showing the relationship between GS 25 N recommendation and tiller density](image)
Growth Stage 30
Just prior to jointing
GS 30 N Application
Directly Related to Tissue N Content

total spring N not to exceed 120 lb N/acre
To move any of these pictures:
Put cursor on picture and right click
Cut or copy
Paste on the slide of your choice

To make them larger:
Put cursor on picture and right click
Use the cursor to grab a corner circle and drag to the size you need

And of course you can call me if you need help.
Theresa
Questions ?