Variable-Rate N Fertilization of Wheat and Corn in Virginia

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INC\ إ\\NCE\ rsing N Fertilizer Efficiency

- Match Timing of Fertilization with Crop Demand
  
  But... if it’s been a wet early summer...

  ... if it’s been a dry early summer...

- More Knowledge of Crop N Need
  
  – 1 lb N/bu of expected yield
TEMPORAL VARIABILITY
60 acre field in Caroline County

Wheat yields: 44 to 80 bu/acre

Corn yields: 85 to 178 bu/acre
ADDRESSING THIS VARIABILITY

• Temporal
  – Shoot from the hip
  – PSNT
  – Tissue tests
  – Chlorophyll meter
  – Precision Ag Technologies

• Spatial
  – Soil map
  – Yield/History map
In-Season Remote Sensing

- Satellite
- Aerial photography
- Ground-based Sensing
Questions…. Answers

• Do Optimum N rates Vary From One Year to the Next in the Same Field?
• Can We Measure and Address this Variability?
• Can N Rates be Adjusted based on Early-Mid Season Measurements?
• Can the Responsiveness to N be Predicted?
OPTICAL SENSORS

- Measures spectral reflectance in a 3/8" x 24" area
- Samples at a frequency of 60 times/sec
- Average reflectance measurements calculated every second
BACKGROUND

- ~60 sites across Virginia since 2000
- Irrigated and non-irrigated
- Conventional and no till
- Various rotations, hybrids, varieties, and soil types

- Wide range of preplant, starter, and in-season N rates (including VR)
- Collected spectral measurements and an assortment of plant physical and chemical characteristics at various growth stages
- Determine grain yield
VIRGINIA APPROACH

- Generated calibration models for wheat and corn grown in the Mid-Atlantic
VIRGINIA APPROACH

- Generated calibration models for wheat and corn grown in the Mid-Atlantic

\[ y = 6.7825e^{367.41x} \]
\[ R^2 = 0.9752 \]

\[ y = 8.5528e^{244.11x} \]
\[ R^2 = 0.95 \]
VIRGINIA APPROACH

- Generated calibration models for wheat and corn grown in the Mid-Atlantic
- Developed N fertilization algorithms for both crops
In-season N management

1st topdress based on estimated tiller #

2nd topdress based on Tissue N concentration

30 to 40 lb N/ac preplant
In-season N timing

1st topdress based on estimated tiller #

2nd topdress based on NDVI and DFP

Days From Planting

Zadoks stage, in parenthesis
Wheat N Rate Algorithm

Rate (kg/ha) vs. NDVI

N Rate, kg/ha
Constrained N Rate, kg/ha

We need a little
We need a lot!
We don’t need much
What’s Needed

• Reference Strips
  – Difference between:
    • High N reference (best possible with more than adequate N)
    • Low N reference (0 N applied)
  And
  • Area currently in sensor’s view.
**VIRGINIA APPROACH - Wheat**

<table>
<thead>
<tr>
<th>TARGET NDVI</th>
<th>LOW REFERENCE</th>
<th>HIGH REFERENCE</th>
<th>GS 25 N</th>
<th>DAP</th>
<th>MAX YIELD</th>
<th>MAX N</th>
<th>NUE</th>
<th>N RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.60</td>
<td>0.50</td>
<td>0.80</td>
<td>50</td>
<td>150</td>
<td>85</td>
<td>80</td>
<td>50</td>
<td>80</td>
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</tbody>
</table>

87.1361 N fertilizer required
23.5681 N required for additional grain
46.0133 Bushel/A expected yield increase due to fertilizer

**coefficients**

<table>
<thead>
<tr>
<th></th>
<th>Define these units</th>
<th>SI units?</th>
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<tbody>
<tr>
<td>ka</td>
<td>0.74076</td>
<td></td>
</tr>
<tr>
<td>kb</td>
<td>577.66</td>
<td></td>
</tr>
<tr>
<td>kc</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td>kd</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NUE</td>
<td>50%</td>
<td></td>
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<tr>
<td>CONVERSION</td>
<td>0.0149</td>
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</table>

![Rate (LB/ac) vs. NDVI](image_url)
### VIRGINIA APPROACH - Corn

<table>
<thead>
<tr>
<th>NDVI</th>
<th>Low_Ref</th>
<th>Hi_Ref</th>
<th>N_preplant</th>
<th>DFP</th>
<th>MAX YIELD</th>
<th>MAX N</th>
<th>N RATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.82</td>
<td>0.50</td>
<td>0.90</td>
<td>60</td>
<td>63</td>
<td>175</td>
<td>100</td>
<td>85</td>
</tr>
</tbody>
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<table>
<thead>
<tr>
<th></th>
<th>lbs/N</th>
<th>dap</th>
<th>bushels</th>
<th>max constr: gal/acre</th>
<th>kg/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>85.27</td>
<td>56.479</td>
<td>67.626</td>
<td>56</td>
<td>60%</td>
<td>0.0125</td>
</tr>
</tbody>
</table>

#### coefficients

- ka: 56.479
- kb: 67.626
- kc: 56
- kd:
- NUE: 60%
- Pn: 0.0125

#### Rate (gal/ac) vs. NDVI

- N Rate
- Constrained
Virginia Approach

- Generated calibration models for wheat and corn grown in the Mid-Atlantic.
- Developed N fertilization algorithms for both crops.
- Validated these rate equations for performance.
EXPERIMENTAL PROCEDURES

- Spra Coupe 220 w/ 60 ft boom and GreenSeeker RT200
- Raven 440 flow rate controller
- Diverse locs; RCBD; 3-8 reps
- Plot size: 60 by 250 to 500 ft
- In-season N:
  - 4-5 Fixed Rates
  - 1 Standard Rate
  - 1 Variable Rate
- Grain Yield
Average: Single N rate determined using Greenseeker® (VA algorithm)
Variable: Variable Nitrogen rate determined using Greenseeker® Virginia Algorithm
Standard: Nitrogen rate determined based on GS 30 tissue test (Standard Virginia recommendation system)
Greenseeker®: Variable N rates determined using default Greenseeker® wheat algorithm

0 – 75 N kg/ha: (numerical rates): Predetermined Nitrogen rates applied in lb/acres
As-applied N rate, tissue test (STD) vs. Greenseeker (GS) recommended rate

N rate, kg ha\(^{-1}\)
AVG of 16 site years

Grain Yield, bu/ac

GS 30 N Rate Applied, lb/ac

7% less N with GS
The Rx rate prediction map and real time map demonstrate the small trend in values — SW to NW values almost normal distributed; in the real time map those values ranged from 17 to 20 in the prediction map (interpolation) the recommended rate in that area still normal but decrease to 10 – 12 gal/acre.
The Rx rate prediction map and real time map demonstrate the small trend in values – SW to NW values almost normal distributed; in the real time map those values ranged from 17 to 20 in the prediction map (interpolation) the recommended rate in that area still normal but decrease to 10 – 12 gal/acre.
Corn Algorithm Performance

Grain Yield, bu/ac and Sidedress N, lb/ac

21% (21 lb/ac) less N with GS

STD, GS
Surface-applied Manure
72 lb N/ac

Injected Manure
61 lb N/ac

Augusta County RT 200 2008
Corn plot as applied rates

-1,000 - 4,900 (less than 4.9 mostly outliers)
5.001 - 16.100
16.101 - 21.900
21.901 - 47.200
47.201 - 989.900
Challenges

- Timing
  - Size of the corn
RX vs. Applied Rates

A20080624_kpcorn
RX RATE
- 11,000 - 12,340
- 12,341 - 16,060
- 16,061 - 18,869
- 18,861 - 20,760
- 20,761 - 22,999

Augusta County RT 200 2008
Corn plot recommended rates

A20080624_kpcorn
RATE
- -1.000 - 4.999 (less than 4.9 mostly outliers)
- 4.901 - 15.100
- 15.101 - 23.900
- 23.901 - 47.200
- 47.200 - 999.999

Augusta County RT 200 2008
Corn plot as applied rates

![Graph showing RX vs. Applied Rates](chart.png)
Challenges

- N rich strips
  - Timing
  - Same Field
  - Same Hybrid/Variety
  - Mark it!

- N “poor” strips

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<td>0.60</td>
<td>0.79</td>
</tr>
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</table>
Challenges

- Herbicide Applications
Challenges

- Skepticism
- How to tell if the system was “right”
- Risk
- Cost
  - EQIP cost share
  - Tax credits
Questions?