VARIABLE RATE NITROGEN MANAGEMENT

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WHY USE VARIABLE RATE N?

• Adjust N rates to = crop N need throughout each field

• Benefits:
  ▪ Avoids applying too much or too little N
  ▪ Increase profits
  ▪ Reduce environmental risk
ENVIRONMENTAL ISSUES

• Nitrate leaching
  ▪ Nitrate in ground water
  ▪ Nitrate in tile drain outflow
• Nitrate contributions to Gulf of Mexico hypoxia
NEEDS FOR USING A VARIABLE RATE N APPROACH

• Predict economic optimum N rate on a site specific (sub-field) basis
• Apply N at variable rates within fields to meet predicted crop N needs
PREDICTING OPTIMUM N RATES

• Nitrogen availability is affected by many factors
• Numerous attempts to develop diagnostic criteria to predict optimum N rates
DETERMINING FERTILIZER N RATES

• Yield goal
• Soil-specific recommendations
• Delta yield approach
Mass Balance Approach to Nitrogen Recommendations

Crop N use = Sum of avail. N x Effic.

N Sources:

- Soil N mineralization
- Legume and manure N
- Residual profile nitrate
- Fertilizer N
TYPICAL YIELD GOAL APPROACH TO N RECOMMENDATIONS

N recommendation = target yield x 1.2 – N credits
Concerns with yield goal-based nitrogen recommendations

• Selection of unrealistic yield goals
  – Unprofitable N rates
  – Environmentally undesirable N rates
• Uncertainty on how yield goals should be determined
• Poor relationship between optimum N rates and recommendations
Year to year differences in corn yield in the same field

Corn yield in 1999

Corn yield in 2000

Bushels per acre
Relationship between optimum N rate and yield – Wis.

![Graph showing the relationship between Economic optimum N rate (lb/acre) and Grain yield (bu/a) for different Soil yield potentials. The graph distinguishes between Medium and High yield potential levels.](image-url)
Relationship between corn yield and optimum N rate, Pennsylvania.
Optimum N rate for corn

- Soil-specific characteristic
- Not affected by annual variations in yield
- Year-specific adjustments for soil nitrate and organic N inputs needed
DELTA YIELD APPROACH TO N RECOMMENDATIONS

• Measures yield increase from added N
• Delta yield = Yield at opt. N rate – Yield with no N
DELTA YIELD APPROACH TO N RECOMMENDATIONS

- Requires information on size of N response in each production unit
- Year to year or within field variation is likely
DEVELOPING VARIABLE RATE N MANAGEMENT

- What measurements will be used to identify within-field variation in N supply or availability?
- What N recommendation or base N rate will be used?
STRATEGIES TO GUIDE VARIABLE RATE N APPLICATIONS

• Before the growing season (proactive)
• During the growing season (reactive)

Doerge (2001)
Before the growing season (proactive) approach

- Divide fields into sub-units
- Apply diagnostic tools
- Develop N rate prescription map for the field
  - e.g. grid sampling, soil nitrate tests, field map showing variable N rate to apply
PPNT BASED N RATE AT THE TREINEN FIELD, 1997

Wolkowski, 1998
Before the growing season (proactive) strategies

- Soil nitrate testing
- Remote sensing of crop and soil properties
- Site-specific data from yield monitors
- Soil electrical conductivity maps
During the growing season (reactive) strategies

- Monitor crop N status in the field
- Apply N at variable rates to meet crop needs
During the growing season (reactive) strategies

• Plant or canopy reflectance
• Chlorophyll measurements
• On-the-go or remotely sensed crop canopy imagery
• In-field reference strip may be needed
Reference Strips for Chlorophyll Meter

- N MANAGED FIELD
- ADEQUATELY FERTILIZED STRIP
- N MANAGED FIELD
Field trials with variable rate N, Wisconsin (Wolkowski, 1998-99)

- THREE LOCATIONS
- GEO-REFERENCED 1 ACRE PREPLANT N TEST
- DEVELOP N RECOMMENDATION
- APPLY FIELD LENGTH STRIPS OF UNIFORM FULL RATE OR VARIABLE - 28%
- OTHER: PSNT, ELEVATION, PSA
- HARVEST STRIPS WITH YIELD MONITOR EQUIPPED COMBINE
## Preplant soil nitrate tests and N recommendations, 1997-1998

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<td>SCHEUER</td>
<td>120</td>
<td>63</td>
<td>57</td>
<td>107</td>
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<tr>
<td>STEIGER</td>
<td>110</td>
<td>122</td>
<td>104</td>
<td>49</td>
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<td>TREINEN</td>
<td>99</td>
<td>81</td>
<td>111</td>
<td>128</td>
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*STEIGER N REC. INCLUDES 40 lb/a SOYBEAN CREDIT*
PPNT BASED N RATE AT THE SCHEUEER FIELD, 1997
PPNT BASED N RATE AT THE TREINENEN FIELD, 1997
EFFECT OF UNIFORM AND VARIABLE N ON CORN YIELD, 1997

GRAIN YIELD (bu/a)

SCHEUER STEIGER TREINEN

ON
UNIFORM
VARIABLE

50 70 90 110 130 150 170 190

SCHUEER STEIGER TREINEN

ON
UNIFORM
VARIABLE

ON
UNIFORM
VARIABLE
## Partial Budget for Variable N Management

<table>
<thead>
<tr>
<th></th>
<th>Scheuer UNF</th>
<th>Scheuer VRT</th>
<th>Steiger UNF</th>
<th>Steiger VRT</th>
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<td>Gross Return</td>
<td>393</td>
<td>388</td>
<td>458</td>
<td>445</td>
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<td>N Mgt. Cost</td>
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<td>36</td>
<td>42</td>
<td>47</td>
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<td>Return Above</td>
<td>361</td>
<td>352</td>
<td>416</td>
<td>398</td>
<td>293</td>
<td>289</td>
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----- $/a -----
EFFECT OF N MANAGEMENT ON POST HARVEST SOIL NITRATE

SCHEUER, 1997
## Partial Budget for Variable N Management, 1998

<table>
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<th>Factor</th>
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<th>Scheuer VAR</th>
<th>Steiger UNF VAR</th>
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<tr>
<td>Return</td>
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<td>335</td>
<td>513</td>
<td>508</td>
<td>448</td>
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<tr>
<td>Cost</td>
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<td>48</td>
<td>33</td>
<td>34</td>
<td>42</td>
<td>53</td>
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<tr>
<td>Net</td>
<td>246</td>
<td>287</td>
<td>480</td>
<td>474</td>
<td>406</td>
<td>385</td>
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Assumes $2.50/bu; $0.24/lb N
Within-field variation of optimum N rates

- Substantial variation: <30 to >200 lb N/acre (Malzer, Minn.)
- Very little variation on medium-textured soils (Bundy, Wis.)
- Spatial patterns of optimum N rates within the same field can vary from year to year.
Variable Rate N Management Studies

Field Locations:
Dane Co. - Sun Prairie
Grant Co. - Bloomington
Wood Co. - Marshfield

Design: Four N rate trials in each field (0 to 210 lb N/acre, 30 lb N/acre increments)
Typical distribution of small plot experiments in variable rate N study fields.
## Optimum N rates at four locations in corn fields

<table>
<thead>
<tr>
<th>Location</th>
<th>Dane</th>
<th>Grant</th>
<th>Wood</th>
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<tbody>
<tr>
<td>1</td>
<td>127</td>
<td>130</td>
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<tr>
<td>2</td>
<td>127</td>
<td>130</td>
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<tr>
<td>3</td>
<td>127</td>
<td>109</td>
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<tr>
<td>4</td>
<td>127</td>
<td>130</td>
<td>0</td>
</tr>
</tbody>
</table>

Prev. crop: Corn, Corn, Alf.-corn
Recent Work to Develop Variable Rate N Management

• Hendrickson & Han (2000)
  – Used infrared aerial photos
  – Three N rates applied
  – Prepared N stress field maps
  – Variable rate N applied just before silking
Recent Work to Develop Variable Rate N Management

• Hendrickson & Han (2000)

Results:
— Yields at 7 sites were equivalent to N applied at emergence
— One site with wet spring had higher yields with the variable rate
Work to Develop Variable Rate N Management (Scharf & Lory, 2000)

- On-the-go sensing of crop N status
- Radiometer- green:near infrared reflectance
- Compare readings with well-fertilized strip
- Predict optimum sidedress N rates
Obstacles/Challenges for variable rate N management

- Reliable method to identify within-field variation in crop N supply
- Absence of yield, profitability, or environmental benefits in comparisons
- Small differential between potential profit increases and costs of variable rate management
Future Developments for Variable Rate N

- New diagnostic tests for N
  - e.g. Illinois N test
  - Simple, inexpensive
  - Identifies optimum N rate and in-field variation
THE ILLINOIS NITROGEN SOIL TEST (Mulvaney, et al.)

- Rate of mineralization appears to be related to amino-sugar N
- Illinois soil test detects amino sugar N
- Test is simple, inexpensive, and convenient
- Nitrate is not included
Future Developments for Variable Rate N

• Remote of in-field sensing of plant N status
  – Interpretation of photos
  – Reflectance measurements in field
  – Incorporation of climatic & crop data