Response Trial Database to Corn N Rate Recommendations – the MRTN Approach

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Why the **Maximum Return To Nitrogen (MRTN)** was Developed

- Diverse N rate guideline systems across states in the Midwest USA
- Cross-state programs
- Volatile N fertilizer and corn prices
- Lack of optimum N rate relationship with yield
  - Yield-based N rates greater than economic optimum with high yields and too low rates on lower OM, less productive “southern area” soils
Why the Maximum Return To Nitrogen (MRTN) was Developed

- A well defined Extension and Outreach need for the database
  - An attempt to better understand corn response to N application rate
  - An attempt to develop a consistent (regional) approach to N rate recommendations
  - An end-user method for making N rate decisions for producers and crop advisers
Why the Maximum Return To Nitrogen (MRTN) was Developed

- Corn yield had increased across time but optimal N rates had not changed
  - Analysis of long-term N rate studies from, 1979 to 2004 in WI and IA by ten-year periods found no clear indication of a change in needed N rates
Why the **Maximum Return To Nitrogen (MRTN)** was Developed

- Published research by Dr. Larry Bundy, Univ. of Wisconsin, indicated N rate recommendations and N rate refinement should be based on data from multiple N rate response trials and use of soil specific characteristics – not yield goals.
Lack of Relationship Between Yield Level and Economic Optimum N Rate
MRTN/CNRC Development Timeline

- Discussions in 2004
- Initial N response trial database completion in 2005
- Web based Corn N Rate Calculator (CNRC) in 2005
- Regional extension publication in 2006

Corn Nitrogen Rate Calculator

http://extension.agron.iastate.edu/soilfertility/nrate.aspx
Original Participants in MRTN Approach Development

<table>
<thead>
<tr>
<th>Regional Effort - Participating States and University Personnel:</th>
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<tbody>
<tr>
<td>John Sawyer, Iowa State University</td>
</tr>
<tr>
<td>Emerson Nafziger, University of Illinois</td>
</tr>
<tr>
<td>Gyles Randall, University of Minnesota</td>
</tr>
<tr>
<td>George Rehm, University of Minnesota</td>
</tr>
<tr>
<td>Larry Bundy, University of Wisconsin</td>
</tr>
<tr>
<td>Brad Joern, Purdue, University</td>
</tr>
<tr>
<td>Robert Hoeft, University of Illinois</td>
</tr>
<tr>
<td>Carrie Laboski, University of Wisconsin</td>
</tr>
<tr>
<td>Robert Mullen, The Ohio State University</td>
</tr>
<tr>
<td>Mike Duffy, Iowa State University</td>
</tr>
<tr>
<td>William Edwards, Iowa State University</td>
</tr>
<tr>
<td>Randy Killorn, Iowa State University</td>
</tr>
<tr>
<td>Sylvie Brouder, Purdue University</td>
</tr>
</tbody>
</table>
Online CNRC tool for corn N rate guidelines

- Seven states in the Midwest USA Cornbelt
  - MN, WI, IA, IL, IN, OH, MI

Implementation of the Maximum Return To Nitrogen (MRTN) approach
MRTN/CNRC - Database Driven Approach
Direct Use of “BIG DATA”

- Corn response data from many recent research-based N rate trials
  - 1,500 trials ≈ 36,000 research plots
  - 100% <25 yrs. old and >90% <15 yrs. old
- Analytical/predictive method to determine economic response and most profitable N rates directly from research trials

Current Data → N Rate Guidelines
Nitrogen Response Trial Components of the CNRC Database

- Maximum N rate applied
- Grain yield with zero N applied
- Regression model and parameters
- Maximum response rate
- Grain yield at maximum N
- Economic optimum N rate
- Grain yield at economic optimum N rate
Nitrogen Response Trial Requirements

- 3 to 4 replications
- 5 to 7 N rates – spring and sidedress applied
- Non-irrigated (*irrigated added later*)
- Corn following soybean
- Corn following corn
- Nitrogen response regression model for each trial fit to corn grain yield
  - Responsibility for each state
Metadata Found Useful for Differentiating N Rate Recommendations

- State
- Within-state geographic region
- Crop rotation
- Soil potential
- Irrigation
Steps in MRTN Computation

- 1. Collect N response trial site data
- 2. Observe shape of N response data
- 3. Fit regression equation to each trial data
- 4. Compile database of site response equations for CC and SC
Steps in MRTN Computation

- Corn N rate response trial example

![Graph showing Corn Yield vs Nitrogen Rate]

Yield = 117.7 + 0.8219N - 0.00263N^2

- Yield Plateau

J.E. Sawyer, Iowa State Univ.
Steps in MRTN Computation

- Iowa corn following soybean CNRC response database (228 trials)
Steps in MRTN/CNRC Computation

5. Calculate by 1-lb N rate increments: gross yield return, fertilizer cost, net return to N (RTN) using the regression equations

6. For user specified dataset (CC, SC, state, or substate), N and corn prices -- average across the RTN for selected response trials

7. The N rate with largest average RTN is the MRTN rate, with the most profitable range being the N rates within $1.00/acre of the maximum RTN
Net Return Determines MRTN Rate and Most Profitable Range

$0.40/lb N: $4.00/bu

J.E. Sawyer, Iowa State Univ.
Effect of Prices on MRTN and Most Profitable N Rate Range

Iowa - SC

MRTN

Flat Payoff

Most Profitable Range Within $1/acre MRTN

J.E. Sawyer, Iowa State Univ.
Corn Nitrogen Rate Calculator

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

This web site provides a process to calculate economic return to N application with different nitrogen and corn prices and to find profitable N rates directly from recent N rate research data. The method used follows a newly developed regional approach for determining corn N rate guidelines that is being implemented in several Corn Belt states.

Regional Corn N Rate Publication

Choose state
- Iowa
- Illinois - North
- Illinois - Central
- Illinois - South
- Indiana - West & Northwest
- Indiana - East & Central
- Indiana - Remainder
- Michigan
- Minnesota
- Ohio
- Wisconsin - HYP Soils
- Wisconsin - MYP Soils
- Wisconsin - Irr. Sands
- Wisconsin - Non-Irr. Sands

Choose rotation pattern(s)
- Corn following soybean
- Corn following corn

Include non-responsive sites

Set up to 4 corn and nitrogen prices
- Anhydrous Ammonia (82% N)
- Nitrogen price
- Corn price

Calculate
Reset

Illinois Map
Indiana Map
How to Use
More Info
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: 61
Rotation: Corn Following Soybean
Non-Responsive Sites Not Included

<table>
<thead>
<tr>
<th>N Price ($/lb N):</th>
<th>$0.30</th>
<th>$0.50</th>
<th>$0.75</th>
<th>$0.90</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn Price ($/bu):</td>
<td>$5.00</td>
<td>$5.00</td>
<td>$5.00</td>
<td>$5.00</td>
</tr>
<tr>
<td>Price Ratio:</td>
<td>0.06</td>
<td>0.10</td>
<td>0.15</td>
<td>0.18</td>
</tr>
</tbody>
</table>

MRTN Rate (lb N/acre):

<table>
<thead>
<tr>
<th></th>
<th>121</th>
<th>108</th>
<th>100</th>
<th>95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profitable N Rate Range (lb N/acre):</td>
<td>110 - 135</td>
<td>100 - 120</td>
<td>91 - 107</td>
<td>86 - 103</td>
</tr>
<tr>
<td>Net Return to N at MRTN Rate ($/acre):</td>
<td>$224.04</td>
<td>$200.98</td>
<td>$175.09</td>
<td>$160.54</td>
</tr>
<tr>
<td>Percent of Maximum Yield at MRTN Rate:</td>
<td>99%</td>
<td>99%</td>
<td>98%</td>
<td>96%</td>
</tr>
</tbody>
</table>

Anhydrous Ammonia (82% N) at MRTN Rate (lb product/acre): 140 132 122 116
Anhydrous Ammonia (82% N) Cost at MRTN Rate ($/acre): $36.30 $54.00 $75.00 $85.50
Strengths of MRTN Approach

- Straightforward computation
- Based on N rate response trials
  - Can use a variety of N trials & not just one set of rates
  - Documents data used for guidelines
  - Incorporates N response temporal and spatial variability
  - Can include environmental costs in rate determination
- CNRC output provides details of response database
Strengths of MRTN Approach

- Easy to add new response trials
  - Keeps rate guidelines current with production practices and climatic conditions

![Iowa MRTN Rate Over Time](chart)

J.E. Sawyer, Iowa State Univ.
Strengths of MRTN Approach

- Based on economic profitability
  - Not derived from yield level, but actual yield response which pays for the N applied
- Directly provides CC and SC rate guidelines
  - No reliance on inconsistent “soybean credit”
- Can be used for any rate-dependent input
  - If response trial data exists and is adequate
- Provides for dynamic online Corn N Rate Calculator and mobile app (WI and IL)
Strengths of MRTN Approach

❖ Adaptability of the approach
  ➢ Started with seven states and basically one rate guideline per state
  ➢ Has evolved over time with several discrete sub-state rate guidelines
    • Illinois North, Central, South geographic regions
    • Indiana NW & WC; N,EC, & C; rest of state regions/soils
    • Wisconsin soil yield potential
    • Iowa potential Southeast Iowa geographic region
    • Others?

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Strengths of MRTN Approach

- Provides opportunity for user input and N rate adjustment
  - Rotation
  - Fertilizer and corn price
  - Profitable N rate range
    - LOW ↔ MRTN ↔ HIGH
      - Farmer experience and attitude toward risk
      - Capitol allocation
      - Water and air quality
      - Local research information
      - Seasonal expectation
MRTN Rate and Nitrate-N Loss in Tile Drainage

Iowa Tile-Flow Nitrate-N Concentration -- Iowa SC Return to N

- Tile Flow Nitrate-N
- Net Return

Nitrate-N, mg/L

Nitrogen Application Rate, lb N/acre

MRTN: 137  YG: 176

$0.40/lb N; $4.00/bu

J.E. Sawyer, Iowa State Univ.  Lawlor et al., 2008.
How Well Does the MRTN Approach Work?

Potential from using exact site-specific N rate compared to MRTN rate

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Using MRTN Rate Across Sites</th>
<th>Using Site EONR’s</th>
<th>Added Net Profit from Using Site EONR’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC</td>
<td>137</td>
<td>122</td>
<td>$13.08</td>
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<tr>
<td>CC</td>
<td>189</td>
<td>168</td>
<td>$16.92</td>
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</tbody>
</table>

Corn at $4.00/bu and N fertilizer at $0.40/lb N.  
\( n = 228 \) SC N rate trial sites.  
\( n = 129 \) CC N rate trial sites.
How Well Does the MRTN Approach Work?

- Comparison of site EONR to MRTN across N rates, Iowa soybean-corn CNRC database

$\text{Net Loss for Sites with EONR's <N Rate}$
$\text{Net Loss for Sites with EONR's >N Rate}$

$0.40/\text{lb N}; \$4.00/\text{bu}$
How Well Does the MRTN Approach Work?

- Example comparison of site EONR to MRTN and Adapt-N “modelling”, soybean-corn sites in Iowa

### Graphs

- **Corn Following Soybean**
  - MRTN minus Site EONR, lb N/acre
  - Adapt-N minus Site EONR, lb N/acre

### Tables

<table>
<thead>
<tr>
<th>Year</th>
<th>N Rate Diff. (lb N/acre)</th>
<th>Net Return Diff. ($/acre)</th>
<th>No. Sites</th>
</tr>
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<tbody>
<tr>
<td>2011</td>
<td>-15</td>
<td>-30</td>
<td>13</td>
</tr>
<tr>
<td>2012</td>
<td>21</td>
<td>-9</td>
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</tr>
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<td>2013</td>
<td>-27</td>
<td>-27</td>
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<tr>
<td>All</td>
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<td>-22</td>
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</tr>
<tr>
<td>2011</td>
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<tr>
<td>All</td>
<td>-71</td>
<td>-102</td>
<td>43</td>
</tr>
</tbody>
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Future Enhancements of CNRC/MRTN

- Update data (a large commitment)
- Fill in data gaps
  - Geographic, soil productivity, cross-state
  - Watershed or regional N rate projects
  - More robust metadata for database subgroupings within and across states
- Explore additional CNRC output
  - Enhance understanding of N rate decisions