Nitrogen Rate Recommendation System for Iowa Corn Production

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Nitrogen Is Needed for Corn Production
Rate Management is a Challenge

- Corn has a high N demand
- Need N fertilization for profitable production
- Rate based on economic return to N
- Crops are grown in an open soil system
- Need to maintain soil N and C resource
Long-Term Yield Response to N Application

Seven N Rate by Crop Rotation Sites (109 Site-Years)
2000-2016 SC and CC Rotations

Corn Yield, bu/acre

Nitrogen Rate, lb N/acre

SC

CC

Sawyer and Barker, ISU 2016
Productive Soils Supply a Large Portion of Corn Nitrogen Requirements

- 40% with continuous corn
- 60% with corn following soybean

We worry about applied fertilizer N, but soil N supply/retention variation may be as much or more important – including forecasting corn N needs

Corn yield with the zero-N rate as a percentage of yield at the economic optimum N rate across multiple sites and years in Iowa
Corn Yield Trend For Iowa

149 bu/acre increase since 1940.
Why Are Nitrogen Rate Guidelines Similar Across Many Years and Corn Yield Gains?

<table>
<thead>
<tr>
<th>Reference (year)</th>
<th>Rotation</th>
<th>Low – High</th>
<th>Suggested N Rate Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM-905 (1979)</td>
<td>Soybean-Corn</td>
<td>100 – 150</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corn-Corn</td>
<td>150 – 200</td>
<td></td>
</tr>
<tr>
<td>CNRC (2017)</td>
<td>Soybean-Corn</td>
<td>126 – 152</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corn-Corn</td>
<td>175 – 203</td>
<td></td>
</tr>
</tbody>
</table>

PM-905 Crop Rotations, Effect on Yields and Response to Nitrogen, 1979
Corn Nitrogen Rate Calculator (CNRC), 2017
# Corn Era Comparison: 1960 vs. 2000

## What’s Changed?

<table>
<thead>
<tr>
<th>Era</th>
<th>1960</th>
<th>2000</th>
<th>For 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain Yield (bu/acre)</td>
<td>134b</td>
<td>224a</td>
<td>+67%</td>
</tr>
<tr>
<td>Total Plant N (lb/acre)</td>
<td>159b</td>
<td>190a</td>
<td>+19%</td>
</tr>
<tr>
<td>Grain N (lb/acre)</td>
<td>113b</td>
<td>138a</td>
<td>+22%</td>
</tr>
<tr>
<td>Grain N Harvest Index</td>
<td>0.71a</td>
<td>0.73a</td>
<td></td>
</tr>
<tr>
<td>Harvest Index (%)</td>
<td>49a</td>
<td>53a</td>
<td></td>
</tr>
<tr>
<td>Grain (bu/lb total plant N) (IE)</td>
<td>0.84b</td>
<td>1.18a</td>
<td>+40%</td>
</tr>
<tr>
<td>Grain N Concentration (%DM)</td>
<td>1.61a</td>
<td>1.23b</td>
<td>-24%</td>
</tr>
<tr>
<td>Grain N (lb N/bu) at 15%</td>
<td>0.77a</td>
<td>0.59b</td>
<td>-24%</td>
</tr>
</tbody>
</table>

*Inverse of Internal Efficiency (IE) gives the per bushel N factor times yield: 1.2 (1960) and 0.8 (2000).*

Woli et al.
Nitrogen Recommendation System

❖ Corn Yield Goal (Realistic Yield Potential)

➢ Yield Goal x N Rate Factor

• Ex. for SC: 220 bu/acre x 1.2 – 50 lb N/acre = 214 lb N/acre

• SC recommendation in Iowa: 140 lb N/acre

➢ Went away from this in Iowa in 1997

➢ Went away from this across much of corn belt in 2005-2006

• Iowa, Indiana, Illinois, Minnesota, Ohio, Michigan Wisconsin began using the Regional N Rate (MRTN) Guideline Approach

J.E. Sawyer, Iowa State Univ.
Why the **Maximum Return To Nitrogen** (MRTN) Approach was Developed

- Diverse N rate guideline systems across states in the Midwest USA
- Various agency programs
- Volatile N fertilizer and corn prices
- Lack of optimum N rate relationship with yield
Natural Gas Price

Daily Natural Gas Futures Price (NYMEX) - Henry Hub

Data Source: Energy Information Administration, DOE
Nitrogen:Corn Price Ratio

U.S. Ammonia N Price : Yearly Corn Grain Price

Year

Price Ratio, $/lb N:$/bu

0.00 0.02 0.04 0.06 0.08 0.10 0.12 0.14 0.16


J.E. Sawyer, Iowa State Univ.
Yield Level Does Not Relate to Optimum N Rate

\[ R^2 = 0.12 \]

\[ R^2 = 0.07 \]
Do High Corn Yields Need High N Rates?

Mean economic optimum N rate (EONR) in high corn yield environments (corn yield ≥ 220 bu/acre), across seven long-term N rate by rotation sites, 2000-2016.

<table>
<thead>
<tr>
<th>Rotation</th>
<th>No. Site-Years</th>
<th>Mean EONR</th>
<th>Mean yield at EONR (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC</td>
<td>40</td>
<td>150</td>
<td>233 (220-272)</td>
</tr>
<tr>
<td>CC</td>
<td>13</td>
<td>183</td>
<td>232 (220-250)</td>
</tr>
</tbody>
</table>

EONR at 0.10 Nitrogen: corn price ratio.

J.E. Sawyer and D.W. Barker.
MRTN 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://cnrc.agron.iastate.edu/

Ext. Public. PM 2015
Diminishing Return to Nitrogen Application
Economic Principle Behind the CNRC/MRTN

J.E. Sawyer, Iowa State Univ.
MRTN/CNRC - Database Driven Approach
Direct Use of “BIG DATA”

❖ Corn response data from many recent research-based N rate trials
  ➢ 1,968 trials ≈ 40,000 research plots
  ➢ > 90% less than 15 years Old
  ➢ Iowa: SC 271 trials and CC 136 trials

❖ Analytical/predictive method to determine economic response and most profitable N rates directly from research trials

Current Data → N Rate Guidelines
Steps in MRTN Computation

1. Collect N rate response trial data
2. Observe shape of N response
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](image)

- **Yield Plateau**
- **Equation**: \( \text{Yield} = 117.7 + 0.8219N - 0.00263N^2 \)
- Points: a, b, c
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 site 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
Maximum Net Return Determines MRTN Rate and Profitable Range

$0.40/lb N:$4.00/bu

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

MRTN

Iowa - SC

Flat Payoff

Most Profitable Range Within $1/acre MRTN

J.E. Sawyer, Iowa State Univ.
Effect of Corn Prices on Net Return and Nitrogen Cost (CNRC - SC)

J.E. Sawyer, Iowa State Univ.
# Nitrogen Rate Guidelines In Iowa

Maximum Return to Nitrogen (MRTN) rate guidelines for Iowa continuous corn and corn following soybean based on output of the Corn Nitrogen Rate Calculator (CNRC) and in publication CROP 3073.

<table>
<thead>
<tr>
<th>Price Ratio&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Corn Following Soybean Rate&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Range&lt;sup&gt;3&lt;/sup&gt;</th>
<th>Corn Following Corn Rate&lt;sup&gt;2&lt;/sup&gt;</th>
<th>Range&lt;sup&gt;3&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>$/lb N:$/bu</td>
<td>- - - - - - - - - - - - - - - - lb N/acre - - - - - - - - - -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main Iowa Region</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.05</td>
<td>159</td>
<td>142 - 178</td>
<td>210</td>
<td>194 - 229</td>
</tr>
<tr>
<td>0.10</td>
<td>140</td>
<td>126 - 153</td>
<td>188</td>
<td>174 - 204</td>
</tr>
<tr>
<td>0.15</td>
<td>124</td>
<td>112 - 137</td>
<td>171</td>
<td>156 - 185</td>
</tr>
<tr>
<td>0.20</td>
<td>113</td>
<td>102 - 124</td>
<td>154</td>
<td>142 - 167</td>
</tr>
<tr>
<td>Southeast Iowa (Soil Regions 17, 21, 22)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.05</td>
<td>179</td>
<td>160 - 201</td>
<td>239</td>
<td>217 - 240</td>
</tr>
<tr>
<td>0.10</td>
<td>153</td>
<td>138 - 168</td>
<td>201</td>
<td>185 - 220</td>
</tr>
<tr>
<td>0.15</td>
<td>136</td>
<td>126 - 148</td>
<td>182</td>
<td>175 - 195</td>
</tr>
<tr>
<td>0.20</td>
<td>127</td>
<td>115 - 137</td>
<td>178</td>
<td>164 - 186</td>
</tr>
</tbody>
</table>

<sup>1</sup> Price per lb N divided by the expected corn price. For example, N at $0.35/lb N and corn at $3.50/bu is a 0.10 price ratio. Corn held at $3.50/bu for all price ratios.
Yearly Yield Response to MRTN Rate

Central Iowa
Clarion loam; MRTN rate 140 lb N/acre.

Southeast Iowa
Kalona silty clay loam; MRTN rate 153 lb N/acre.
Spring Precipitation as a Tool for Decisions About Additional Nitrogen Application (Main Iowa)

Overall Correct: 76%

Ames-Lewis-Kanawha-Nashua-Sutherland (SC and CC)

Correct: 58%

Incorrect: 14%

Total at 15.5 Inches

Correct: 18%

Incorrect: 10%

MRTN minus EONR (lb N/acre)

April through June Precipitation Total (Inch)
Strengths of MRTN Approach

❖ Straightforward computation
❖ Based on N rate response trials
❖ 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”
❖ Easily add or remove N response trial data
❖ Can use a variety of N response trials
❖ Documents data used for guidelines
Adjusting Nitrogen Rate Decisions

❖ Rotation
❖ Fertilizer: Corn price ratio
❖ MRTN and most profitable range
   ➢ LOW ↔ MRTN ↔ HIGH
❖ Producer experience and attitude toward risk, capital allocation, water quality
❖ Local research, seasonal weather, soil and plant N tests
Regional Approach for Corn N Rate Guidelines

Concepts and Rationale for Regional Nitrogen Rate Guidelines for Corn PM 2015

Corn Nitrogen Rate Calculator
http://cnrc.agron.iastate.edu/

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 website 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 regional approach for determining corn N rate guidelines that is implemented in several Corn Belt states.

START HERE
Choose how you want to calculate N rates, using one set of prices or using multiple prices.

SINGLE PRICE  MULTIPLE PRICE

In association with these Universities

IOWA STATE UNIVERSITY
PURDUE UNIVERSITY
ILLINOIS UNIVERSITY
WISCONSIN UNIVERSITY

For questions about the Corn Nitrogen Rate Calculator website contact John Sawyer at jsawyer@iastate.edu

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http://cnrc.agron.iastate.edu/  J.E. Sawyer, Iowa State Univ.
Rates and Charts

State: Iowa  
Region: Main  
Number of sites: 222  
Rotation: Corn Following Soybean

Options

- Small
- Medium
- Large

DISPLAY CHARTS

- Return to N  
- % of Max Yield  
- EONR Frequency  
- EONR vs. Yield

HELP

Definitions  
Calculated values

Nitrogen Price ($/lb): 0.40  
Corn Price ($/bu): 4.00  
Price Ratio: 0.10

MRTN Rate (lb N/acre): 140  
Profitable N Rate Range (lb N/acre): 126 - 152

Net Return to N at MRTN Rate ($/acre): $210.87  
Percent of Maximum Yield at MRTN Rate: 99%

Anhydrous Ammonia (82% N) at MRTN Rate (lb product/acre): 170  
Anhydrous Ammonia (82% N) Cost at MRTN Rate ($/acre): $56.00

Graph showing the relationship between N Rate (lb N/acre) and Return to N ($/acre). The MRTN rate is marked at 140 lb N/acre.
ISU Agronomy Soil Fertility Web Site

http://www.agronext.iastate.edu/soilfertility/