Nitrogen Fertilizer Rate in Corn: Factors to Consider

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Economic optimal N rates (EONR): How variable are they?
How variable is EONR across the U.S. Midwest over a 3-year period.

7 N rate studies in 2018
N fertilizer treatments created two N response curves

<table>
<thead>
<tr>
<th>Nitrogen Treatments</th>
<th>Single Nitrogen Application</th>
<th>Split Nitrogen Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>lbs.-N ac⁻¹</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>40+0</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>40+40</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>40+80</td>
</tr>
<tr>
<td></td>
<td>160</td>
<td>40+120</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>40+160</td>
</tr>
<tr>
<td></td>
<td>240</td>
<td>40+200</td>
</tr>
<tr>
<td></td>
<td>280</td>
<td>40+240</td>
</tr>
</tbody>
</table>

Grain Yield (bu. ac⁻¹)

Nitrogen Rate (lbs./acre)

Single EONR=157

Split EONR=141
EONR varied from 0-280 lbs./ac
There was a wide range of EONRs within states among years.

- North Dakota
- Nebraska
- Minnesota
- Iowa
What do I need to consider when deciding on my nitrogen fertilizer rate?
Nitrogen response data over 3-years at a total of 49 sites
Weather

Precipitation and temperature
Soil Sampling

Soil characterization

- Texture
- Bulk density
- Organic matter
- Carbon
- Total nitrogen
- pH
- CEC

Soil nitrate

- Pre-plant (PPNT), 0-90 cm
- V5 (PSNT), 0-60 cm
Mean annual temperature increases from 35 to 65°F
Precipitation increases from 14 to 52 in.
Soil textures varied across the 49 site-years.
What do soil measurements tell me about N fertilizer rate?
Soil Texture’s influence on EONR

Economic Optimal Nitrogen Rate (lbs.-N/ac)
Soil Organic Matter’s influence on EONR

Economic Optimal Nitrogen Rate (lbs. -N/ac)

- 0 - 2%
- 2 - 3.5%
- 3.5+ %

Site-years
Crop rotation’s influence on EONR

- **Site-years**
- **Crop rotation**
- **Economic Optimal Nitrogen Rate (lbs. - N/ac)**

- **Tiled**
- **Irrigated**
- **Corn**
- **Sunflower**
- **Soybean**
Tillage’s influence on EONR

- Economic Optimal Nitrogen Rate (lbs. N/ac)

- Site-years

- No-till
- Conventional tillage
- Tiled
- Irrigated

Sites:
- Belmont
- Amenia
- Durbin
- SCAL
- Lorenzo
- Crawford
- New Richland
- Plano
- Lewis
- Sand
- Wauzeka
- St Charles
- Mason City
- Ames
- Bradford
- Boone
- New Richmond
- Story
- Sand
- Mason City
- Urbana
- Sand
- Urbana
- Shumway
- Waseca
- Loess
- Becker
- Bay
- Urbana
- Troth
- Vanderland
- Brandes
- Lone Tree
- Brandes

Graph showing the influence of tillage on Economic Optimal Nitrogen Rate.
Decomposition of Organic Materials

- Organic-nitrogen
- Inorganic-nitrogen

Nitrogen Fertilizers

- Inorganic-nitrogen
  - $\text{NO}_3^-$
  - $\text{NH}_4^+$
Grain yield with NO nitrogen applied

19 – 100% of N required by corn crop
CO$_2$ evolution increases

Decomposition of soil organic matter by microorganisms

Available soil N decreases/immobilized

Available N increases through N Mineralization

Length of Times Varies by Residue

Nitrogen Availability

Time

Nitrogen Availability

CO$_2$

NO$_3$-

Available N increases through N Mineralization

Decomposition of soil organic matter by microorganisms

Available soil N decreases/immobilized

CO$_2$ evolution increases
Greater C:N increases time until net mineralization

- Cotton C:N 33:1
- Alfalfa C:N 13-25:1
- Corn C:N 57:1
- Wheat C:N 80:1

Net Immobilization

Net Mineralization
Greater C:N increases time until net mineralization

Net Immobilization

C:N Ratio

Time

Rye C:N
82:1 Straw
37:1 Anthesis
26:1 Veg.

Annual Ryegrass
C:N 21:1

Crimson Clover
C:N 21:1

Oilseed Radish
C:N 20:1

Hairy Vetch C:N- 11:1

Greater C:N increases time until net mineralization.
Soybean residue decomposes and mineralizes N faster than corn residue

(Adapted from Li et al., 2013)
More N is mineralized after soybean than corn

(Gentry et al., 2001)
Tillage and crop rotation influences N fertilizer needs
Tillage affects soil characteristics and erosion

- Labor and fuel costs
- Weed Control
- Compaction
- Soil temperature, moisture, and structure
- Residue Incorporation
- Nitrogen availability
Study designed to compare tillage, herbicide, and nitrogen treatments.

<table>
<thead>
<tr>
<th>Tillage type and timing</th>
<th>Herbicide Timing</th>
<th>Nitrogen Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall Conv</td>
<td>Fall</td>
<td>0 lbs. N/ac</td>
</tr>
<tr>
<td>Sp. Conv</td>
<td></td>
<td>50 lbs. N/ac</td>
</tr>
<tr>
<td>Fall Strip</td>
<td>Spring</td>
<td>100 lbs. N/ac</td>
</tr>
<tr>
<td>Sp. Strip</td>
<td>In-crop</td>
<td>200 lbs. N/ac</td>
</tr>
<tr>
<td>No-till</td>
<td>Control</td>
<td></td>
</tr>
</tbody>
</table>
Results
No additional nitrogen was needed when herbicides were used to control alfalfa.
Decomposition of Organic Materials

Can we estimate nitrogen mineralization to adjust N fertilizer guidelines?
What’s the best PMNan protocol to predict EONR?

- Soil sampling timing: Pre-plant and V5 (5 horizontal leaves)
- Nitrogen Rate: 0 and 180 kg ha$^{-1}$ (V5 sampling time)
- Incubation length: 7, 14, 28 days
Sampling timing and N fertilizer addition altered PMNan in some sites.

The bar chart shows the percent of sites in different statistical groups:

- **PP = V5**: 50 sites
- **PP > V5**: 23 sites
- **PP < V5**: 27 sites
- **0-N = 180-N**: 63 sites
- **0-N > 180-N**: 31 sites
- **0-N < 180-N**: 6 sites
Questions

• Q-1) Will changes in PMNan due to sampling timing, N rate, and incubation length improve predictability of EONR?

• Q-2) Can using PMNan values in conjunction with other soil-N tests improve corn response predictions?
Pre-plant N mineralization does not predict EONR well.

\[ y = -1.15x + 189.51 \]
\[ R^2 = 0.07 \]
V5 N mineralization \underline{\text{WITHOUT N}}
does not predict EONR well

\[ y = -0.05x + 149.98 \]
\[ R^2 = < 0.01 \]
V5 N mineralization **WITH N** does not predict EONR well

\[ y = -0.33x + 182.33 \]

\[ R^2 = 0.01 \]
Delayed sampling and increased incubation length do not improve predictability of EONR
Soil inorganic N + Mineralization
Q-2) Can using PMNan values in conjunction with other soil-N tests improve corn response predictions?

Predicting grain yield at 0-N, grain yield at EONR, and EONR with:

- **Soil nitrate** (PPNT and PSNT)
- Soil nitrate + **mineralizable N** (PMNan)
- Soil nitrate + PMNan + **initial NH$_4^+$**
PPNT is not well related to grain yield at 0-N.

\[ y = 0.48x + 4.84 \]
\[ R^2 = 0.18 \]
PSNT improves relationship with grain yield at 0-N.

\[ y = 0.41x + 4.24 \]

\[ R^2 = 0.39 \]

PPNT: \( R^2 = 0.18 \)
Including soil $\text{NO}_3^-$, PMNan, and $\text{NH}_4^+$ improves predictability of grain yield at 0-N.
Soil textures varied across the 49 site-years.
Mean annual temperature increases from 35 to 65°F
Texture or temperature categories improved predictability of grain yield at 0-N
Adding N lowers the ability to predict grain yield.

Grain Yield at EONR

- Soil-N
- Soil-N+PMNan
- Soil-N+PMNan+NH4

Soil N Sampling Timing

- PPNT
  - R-square: < 0.01
- PSNT
  - R-square: 0.22

- R-square for Soil-N+PMNan: 0.2
- R-square for Soil-N+PMNan+NH4: 0.44
Texture or temperature categories improved predictability of grain yield at EONR

Grain Yield at EONR

Texture or temperature categories improved predictability of grain yield at EONR.

Texture and Temperature Categories

- Coarse
- Medium
- Fine
- High
- Low

R-square

- 'PSNT+PP0N+NH4'
- 'PSNT+V50N+NH4'
- 'PSNT+V5160N+NH4'
PPNT and PSNT alone best predicts EONR
Texture or temperature categories improved predictability of EONR

Texture and Temperature Categories
- 'PSNT'
- 'PSNT+PP0N'
- 'PSNT+V50N+NH4'
- 'PSNT+V5180N+NH4'

R-square

Texture
- Coarse
- Medium
- Fine
- High
- Low

Temperature
Conclusions

No increase in the predictability of EONR by:
- Increasing incubation length
- Delaying soil sampling
- N fertilizer addition

Predictability of Grain yield and EONR increases:
- Delaying soil-N sampling from PPNT to PSNT
- Separating by soil texture and temperature
  - Including PMNan and initial NH$_4^+$
    - PMNan used varies by texture or temperature categories
What do I need to consider when deciding on my nitrogen fertilizer rate?

- Crop rotation
- Soil organic matter
- Soil texture
- Nitrogen carryover
- Tillage practices
- Cover crop use
- Temperature
- Precipitation
- Topography
Thank You!

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