How much fertilizer N should you apply?

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Agricultural N Cycle

Ozone Depletion and Reduced Air Quality

Greenhouse Gas Emission

N2

Atmospheric N2

Reduced Air Quality

N Fertilization

Volatilization

Crop Removal

Manure

Crop Residues

NH3

Manure

N2

NOx

Groundwater and Surface Water Contamination

Nitrate Reduction

Dissimilatory Reduction

Nitrification

NH4+

Adsorption to Soil Particles

Mineralization

Immobilization

Organic Matter

Surface Water and Groundwater Contamination

Runoff and Erosion

Nitrate Reduction

Leaching

K.A. Congreves J.W. Gernon

N Cycle

Mineral N

NO$3^-$ - NH$_4^+$

Soil Organic Matter N
cRecently Dead
cDead

Living

Crop

Other

Cover crops

Crop Residue

Manure

How much corn yield can your soil provide?

What is the N credit of legume cover crops?

How do you optimize your farm to minimize N loss and maximize crop uptake?

113, 156, 174 bu/ac

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Why Red Clover (legume) cover crop?

Impact of cover crops on soil nitrate levels.

Red Clover mineralization matches crop uptake

Serran, 2006 Thesis
Thilakarathna et al. 2015. Agron. J. 107:1595
Similar to Vyn et al. Agron. J. 92: 915–924

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What is the N credit of legume cover crops?

Timing of legume cover crop mineralization key to N credit to corn crop

Mineral N

NO$_3^-$  NH$_4^+$

Losses
N Credit vs. Most Economic Rate of N

N rate applied

Corn yield

0                             100                                200

Maximum Economic Yield (MEY)

Does it pay to apply more N to get a few more kilograms?

Maximum Yield

Most Economical Rate of N

Depends on price of corn and fertilizer

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Most Economical Rate of N (MERN) of Legume Cover Crop

- **N rate applied**: 0, 100, 200
- **Corn yield**: Maximum Economic Yield
- **Yield Boost due to cover crop**
- **MERN**: difference in N applied = 60

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Red clover effects on N credit, yield and profit of conventional-till corn

<table>
<thead>
<tr>
<th>Tillage system</th>
<th>Corn Price $ bu⁻¹</th>
<th>N Cost $ / ac</th>
<th>Cover crop</th>
<th>MERN² Kg N ha⁻¹</th>
<th>MEY³ Mg ha⁻¹</th>
<th>Gross return ⁴ $ ha⁻¹</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional tillage</td>
<td>3.81</td>
<td>0.68</td>
<td>No red clover</td>
<td>107</td>
<td>129</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.54</td>
<td>0.68</td>
<td>Red clover</td>
<td>129</td>
<td>74</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Difference</td>
<td>73</td>
<td>55</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rotational effect (%)</td>
<td>**</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No-till corn</td>
<td>3.81</td>
<td>0.45</td>
<td>No red clover</td>
<td>143</td>
<td>129</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**N credit** for No-till corn

73 lb N/ac

4.5 -7% increase in yield

Increase profit of $28 to $48/ ac

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## Integrating Cover Crops for Nitrogen Management in Corn Systems on Northeastern U.S. Dairy Farms

Sheryl N. Swink, Sjoerd W. Duiker, Karen F. Kjoenings,* Douglas B. Beegle, and William J. Cox

N fertilization values (NFRVs) of legume winter cover crops for corn in rotations following the traditional method.

<table>
<thead>
<tr>
<th>State</th>
<th>Cover Crop</th>
<th>Season After</th>
<th>Timing</th>
<th>NFRV (lb N/acre)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON</td>
<td>Crimson clover</td>
<td>CT</td>
<td>Spring, into winter wheat</td>
<td>~78</td>
<td>Samson et al. (1991)‡</td>
</tr>
<tr>
<td>ON</td>
<td>Red clover</td>
<td>CT</td>
<td>Spring, into winter wheat</td>
<td>~78</td>
<td>Samson et al. (1991)‡</td>
</tr>
<tr>
<td>PA</td>
<td>Red clover spring seeded</td>
<td>yr1</td>
<td>CT</td>
<td>155</td>
<td>Dou and Fox (1994)§</td>
</tr>
<tr>
<td>PA</td>
<td>Red clover spring seeded</td>
<td>yr2</td>
<td>CT</td>
<td>27</td>
<td>Dou and Fox (1994)§</td>
</tr>
<tr>
<td>PA</td>
<td>Red clover spring seeded</td>
<td>yr1</td>
<td>NT</td>
<td>144</td>
<td>Dou and Fox (1994)§</td>
</tr>
<tr>
<td>PA</td>
<td>Red clover spring seeded</td>
<td>yr2</td>
<td>NT</td>
<td>42</td>
<td>Dou and Fox (1994)§</td>
</tr>
<tr>
<td>WI</td>
<td>Red clover</td>
<td>CT</td>
<td>Mid-late Apr. with oat</td>
<td>95–115</td>
<td>Stute and Posner (1995b)</td>
</tr>
</tbody>
</table>

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What is the N credit of legume cover crops?

Timing of legume cover crop mineralization key to N credit to corn crop

How do you optimize your farm to minimize N loss and maximize crop uptake?
Cycle depends on:

- Soil
  - Health
  - %OM
  - Texture
  - Temperature
  - Moisture
  - pH
  - Compaction
- Production Practices
  - Crop rotation
  - Tillage system
  - Cover crop
  - Manure
  - Fertilizer
- Weather
  - Temperature
  - Precipitation

How do you optimize your farm to minimize N loss and maximize crop uptake?

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**Ridgetown** Est. 1995
- clay loam, Orthic Humic Gleysol
- No till (NT) vs. CT (fall plow + spring cultiv.)
- Rotation: continuous corn (C-C), contin. soybean (S-S), S-C, S-winter wheat (S-W), and C-S-W
- 4 N fertilizer rates to corn and wheat
- 2008 increased N rates, sowed red clover into W, + changed to zone-till
Wheat: Don’t need more Fert N w red clover

Higher soybean yield with wheat

Gaudin et al. 2015

Fig. 4. Soybean yields response to rotation and tillage. LS means (2010–2013)
17% (till) to 21% (zone-till) increase in MERN with wheat ALONE and more with red clover
2015- August

from Dr. D.C. Hooker
Long-term trial - Ridgetown

Cornell soil health test score

- Continuous corn
- Soybean-corn
- Continuous soybean
- Soybean-wheat
- bluegrass fence row
- Conventional
- NoTill

Cornell Soil Health Testing for 2016

How do average crop yields relate to soil organic C & total N?

Average corn yields (Mg ha\textsuperscript{-1})

- **SOC (%)**
  - \( y = 1.9x + 5.7 \)
  - \( r = 0.32 \)
  - \( P = 0.0748 \)

- **TN (%)**
  - \( y = 1.93x + 5.7 \)
  - \( r = 0.32 \)
  - \( P = 0.0801 \)

Yield variability

- Average soil organic C in the top 20 cm (5 cm increments)
  - \( y = -0.04x + 4.0 \)
  - \( R^2 = 0.19 \)
  - \( r = -0.42 \)
  - \( P = 0.0242^* \)

- Average soil total N in the top 20 cm (5 cm increments)
  - \( P = 0.1388^{ns} \)

Congreves et al. 2015. unpublished

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Red Clover, Wheat Protects against extreme weather years

Winter wheat alone
- Better corn and soybeans yields in extreme years (cool-wet, hot-dry)

Red clover undersown into wheat
- Increased corn yield resilience by 7% and soybean 22%

At Elora

Increasing Crop Diversity Mitigates Weather Variations and Improves Yield Stability

Amélie C. M. Gaudin¹, Tor N. Tolhurst², Alan P. Ker², Ken Janovicek¹, Cristina Tortora³, Ralph C. Martin¹, William Deen¹
References


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How do you optimize your farm to minimize N loss and maximize crop uptake?

*Improve soil health + %OM
*Plant wheat with red clover

What is the N credit of legume cover crops?

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