Precision Nitrogen Management of Corn

Adaptive N management:
Fine-tuning Nitrogen Management for Corn
Field by field, year by year

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Cornell University Nutrient Management Spear Program
http://nmsp.cals.cornell.edu
Nitrogen

Nitrogen availability limits the productivity of most ecosystems in the US.
Nitrogen

**Deficiency:**

- Little new growth.
- Yellowing (chlorosis) of older leaves.
- Earlier fall leaf drop.
- Low protein content.

**Excess:**

- Very dark green leaves.
- Excessive vegetative growth.
- Lodging and delayed maturity.
- High nitrate content of some crops.
Nitrogen can be lost from dairy farms to:

- The atmosphere.
- Groundwater and surface waters.
Conversion processes:

1. N fixation
2. Mineralization
3. Nitrification
4. Denitrification
5. Ammonia volatilization
6. Immobilization

+ Nitrate leaching

From Penn State Agronomy Facts 12
Nitrogen Guidelines for Corn – the Basics

- Take into account all nitrogen sources
  - Soil N supply (soil organic matter)
  - Sod and other rotation credits
  - Past and current manure applications
- Use fertilizer only to supplement
- Fine-tune over time and field by field using N management tools:
  - Illinois Soil Nitrogen Test (ISNT)
  - Pre-sidedress Nitrate Test (PSNT)
  - Corn Stalk Nitrate Test (CSNT)
Corn N Recommendations (NY)

How to find out how much N is needed?

- Yield potential
  - soil type and drainage

- Soil N supply
  - soil type and drainage

- N fertilizer uptake efficiency
  - soil type and drainage

- N credits from sods
  - % legume/grass in the sod

- N credits from manure
  - manure source & application method
Corn N Recommendations

\[ \text{N req.} = \frac{(\text{yield potential} \times 1.2) - \text{soil N} - \text{sod N}}{\left(\frac{\text{fertilizer efficiency}}{100}\right)} \]

in bushels/acre

in lbs N/acre

in lbs N/acre

in %

Cornell Nitrogen Recommendations
To get yield potentials:

✓ Use the Cornell database to obtain yield potentials.

✓ Use higher yield potentials only when you have 3 years worth of proof of higher yields.
### Corn Yield Potential

Expected yield 3 to 4 years out of 5 under good management:

<table>
<thead>
<tr>
<th>Variety</th>
<th>Undrained bu/acre</th>
<th>Drained bu/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hamlin</td>
<td>155</td>
<td>155</td>
</tr>
<tr>
<td>Bath</td>
<td>125</td>
<td>125</td>
</tr>
<tr>
<td>Volusia</td>
<td>95</td>
<td>105</td>
</tr>
<tr>
<td>Fremont</td>
<td>100</td>
<td>110</td>
</tr>
<tr>
<td>Howard</td>
<td>135</td>
<td>135</td>
</tr>
</tbody>
</table>

1 tons of silage (35% dry matter) equals about 5.9 bushels of grain (85% DM)
Corn N Recommendations

\[ \text{N req.} = \frac{(\text{yield potential} \times 1.2) - \text{soil N} - \text{sod N}}{(\text{fertilizer efficiency}/100)} \]

in bushels/acre

in lbs N/acre

in lbs N/acre

in %

Cornell Nitrogen Recommendations
### N from Soil Organic Matter

Soil N: soils database

<table>
<thead>
<tr>
<th>Location</th>
<th>Undrained</th>
<th>Drained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honeoye</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Palmyra</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Volusia</td>
<td>60</td>
<td>70</td>
</tr>
<tr>
<td>Wayland</td>
<td>60</td>
<td>75</td>
</tr>
<tr>
<td>Howard</td>
<td>70</td>
<td>70</td>
</tr>
</tbody>
</table>
Corn N Recommendations

\[ \text{N req.} = \frac{(\text{yield potential} \times 1.2) - \text{soil N} - \text{sod N}}{\text{(fertilizer efficiency/100)}} \]

in bushels/acre \quad \text{in lbs N/acre}

in lbs N/acre \quad \text{in %}

Cornell Nitrogen Recommendations
## Nitrogen from Sods

<table>
<thead>
<tr>
<th>Legume (%)</th>
<th>N (lbs/acre)</th>
<th>Year 1 (lbs/acre)</th>
<th>Year 2 (lbs/acre)</th>
<th>Year 3 (lbs/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>150</td>
<td>83</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>1-25</td>
<td>200</td>
<td>110</td>
<td>24</td>
<td>10</td>
</tr>
<tr>
<td>25-50</td>
<td>250</td>
<td>138</td>
<td>30</td>
<td>13</td>
</tr>
<tr>
<td>50+</td>
<td>300</td>
<td>165</td>
<td>36</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(55%)</td>
<td>(12%)</td>
<td>(5%)</td>
</tr>
</tbody>
</table>
Corn N Recommendations

\[
\text{N req.} = \frac{(\text{yield potential} \times 1.2) - \text{soil N} - \text{sod N}}{(\text{fertilizer efficiency}/100)} \text{ in lbs N/acre}
\]

in bushels/acre

in lbs N/acre

in bushels/acre

in lbs N/acre

in %

Cornell Nitrogen Recommendations
Fertilizer N Uptake Efficiency

- Reflects the observation that <100% of the applied inorganic N will be taken up by the corn (losses to the environment will occur).

- N uptake efficiency depends on:
  - Soil type
  - Artificial drainage (drained/undrained)
# Fertilizer N Uptake Efficiency

<table>
<thead>
<tr>
<th>Soil type</th>
<th>N efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>undrained</td>
</tr>
<tr>
<td>Angola</td>
<td>60</td>
</tr>
<tr>
<td>Bath</td>
<td>75</td>
</tr>
<tr>
<td>Niagara</td>
<td>60</td>
</tr>
<tr>
<td>Honeoye</td>
<td>75</td>
</tr>
<tr>
<td>Swanton</td>
<td>60</td>
</tr>
<tr>
<td>Volusia</td>
<td>60</td>
</tr>
<tr>
<td>Howard</td>
<td>75</td>
</tr>
</tbody>
</table>

Examples
Most of what is left after harvest is lost in Northeast climates!!

![Graph showing nitrate N levels over time and different nitrogen applications.]
N Recommendations for Corn

Sample calculation
N Recommendations for Corn

Question:
- Corn will be planted on an Angola soil. How much inorganic N should we add at side-dressing time?

Given:
- The soil is artificially drained.
- This is the third year that corn is planted.
- A 15% legume containing sod was plowed down prior to the first corn year.
- 100 lbs of 17-20-0 starter was applied.
N Recommendations for Corn

Answer:

What is the corn yield potential of a drained Angola soil?  
110 bu/a

How much N will a drained Angola soil supply?  
80 lbs/a

How much N will a 15% legume sod supply in the 3rd year?  
10 lbs/a

What is the N uptake efficiency for a drained Angola soil?  
65 %

What is the total N requirement?

\[
N_{\text{req.}} = \frac{(\text{yp} \times 1.2) - \text{soil N} - \text{sod N}}{(\text{fertilizer efficiency}/100)} = \frac{(110 \times 1.2) - 80 - 10}{(65/100)} = 65 \text{ lbs N/a}
\]
N Recommendations for Corn

How much N was added with the starter?  17 lbs/acre

100 lbs of 17-20-0 gives .....lbs N/acre total.

Note: Target starter N to 10-30 lbs, up to 50 lbs
     Actual N + K₂O should not exceed 80-100 lbs/acre
     Limit actual N from urea in starter to <30 lbs/acre

How much N still needs to be applied?  ~48 lbs/acre

Check results with Pre Sidedress Nitrogen Test (PSNT).
Corn N Recommendations

Can I meet N needs with manure?
How much should I apply?
N Credits From Manure

Total Manure Nitrogen

Urine

- Unstable Organic N (Fast N)
  - Urea - mineralized
  - Ammonium N
  - Inorganic N

Available N = Ammonium N from present application

Feces

- Stable Organic N. (Slow N)
  - Mineralized slowly during the year of application
  - Mineralized organic N from present application
  - Mineralized organic N from past applications

- Residual - mineralized very slowly in future years

Organic N

Available N = Ammonium N from present application + Mineralized organic N from present application + Mineralized organic N from past applications
An example of a manure analysis:

<table>
<thead>
<tr>
<th></th>
<th>%</th>
<th>lbs/ton</th>
<th>lbs/1000 gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Nitrogen (N)</td>
<td>0.41</td>
<td>8</td>
<td>34</td>
</tr>
<tr>
<td>Ammonium Nitrogen</td>
<td>0.19</td>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>Organic Nitrogen</td>
<td>0.22</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>0.08</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Phosphate Equivalent (P₂O₅)</td>
<td>0.18</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Potassium (K)</td>
<td>0.26</td>
<td>5</td>
<td>22</td>
</tr>
<tr>
<td>Potash Equivalent (K₂O)</td>
<td>0.32</td>
<td>6</td>
<td>27</td>
</tr>
</tbody>
</table>
Ammonium N in Manure

- If incorporated in the fall, assume 100% loss.
- If applied as sidedress injection for row crops, assume 100% fertilizer equivalent.
- For spring application:

<table>
<thead>
<tr>
<th>days after spreading</th>
<th>% available</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>53</td>
<td>53</td>
</tr>
<tr>
<td>41</td>
<td>41</td>
</tr>
<tr>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>&gt;5 d after spreading</td>
<td>0 % available</td>
</tr>
</tbody>
</table>
## Organic N in Manure

<table>
<thead>
<tr>
<th>Manure Type</th>
<th>Current year</th>
<th>Last year</th>
<th>2 years ago</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow manure &lt;18% DM</td>
<td>0.35</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>Cow manure ≥18% DM</td>
<td>0.25</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>Poultry manure &lt;18% DM</td>
<td>0.55</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>Poultry manure ≥18% DM</td>
<td>0.55</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>Swine manure &lt;18% DM</td>
<td>0.35</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>Swine manure ≥18% DM</td>
<td>0.25</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>Horse manure &lt;18% DM</td>
<td>0.30</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>Horse manure ≥18% DM</td>
<td>0.25</td>
<td>0.12</td>
<td>0.05</td>
</tr>
</tbody>
</table>
Question:

- How much manure do we need to apply to meet corn N requirements given the following scenario?
  - N requirement: 50 lbs N/acre.
  - Manure is applied in this year only (i.e. no past manure applications).
  - *Manure was surface applied, no incorporation.*
  - Manure contains 5 lbs organic N and 4 lbs ammonium N per ton.
  - Dry matter content of the manure is 8%.
Manure is surface spread without incorporation so all ammonium N is lost as ammonia.

Per ton of manure, there are 5 lbs of organic N.

In the first year 35% of the organic N will be available for manure with less than 18% dry matter.

Thus, per ton of manure there is $0.35 \times 5 = 1.75$ lbs N.

To obtain 50 lbs of N, we need to apply $50 / 1.75 = 29$ tons/acre of this manure.
N Recommendations for Corn

Additional question:

- How much $P_2O_5$ and $K_2O$ are supplied with the 29 tons of manure?

Given: 5 lbs of $P_2O_5$ per ton of manure.
6 lbs of $K_2O$ per ton of manure.

Answer:

\[
5 \times 29 = 145 \text{ lbs } P_2O_5 \text{ /acre}!!!
\]

\[
6 \times 29 = 174 \text{ lbs of } K_2O/\text{acre}
\]
N Recommendations for Corn

Another scenario:

- How much manure do we need to apply to meet corn N requirements given the following scenario?

  - N requirement: 50 lbs N/acre.
  - Manure is surface applied in the spring and incorporated within one day.
  - Manure contains 5 lbs organic N and 4 lbs ammonium N per ton.
  - Dry matter content of the manure is 8%.
  - Manure is applied in this year only.
N Recommendations for Corn

- Manure is incorporated within one day in the spring so 65% of the ammonium N is conserved and available is \(0.65 \times 4 = 2.6 \text{ lbs/ton}\).
- Per ton of manure, there are 5 lbs of organic N.
- In the first year 35% of the organic N will be available for manure with less than 18% dry matter.
- Thus, per ton of manure there is \(0.35 \times 5 = 1.75 \text{ lbs N from the organic fraction}\).
- Total N supply by the manure is \(2.6 + 1.75 = 4.35 \text{ lbs/ton}\).
- To obtain 50 lbs of N, we need to apply \(50 / 4.35 = 11 \text{ tons/acre}\).
N Recommendations for Corn

Additional question:

- How much $\text{P}_2\text{O}_5$ and $\text{K}_2\text{O}$ are supplied with the 11 tons of manure?

Given: 5 lbs of $\text{P}_2\text{O}_5$ per ton of manure.

6 lbs of $\text{K}_2\text{O}$ per ton of manure.

Answer:

- $5 \times 11 = \textbf{55}$ lbs $\text{P}_2\text{O}_5$/acre
  (compare to 145 lbs when $\text{NH}_4^+$ is not conserved!!)

- $6 \times 11 = \textbf{66}$ lbs of $\text{K}_2\text{O}$/acre
  (compare to 174 lbs when $\text{NH}_4^+$ is not conserved!!)
N Recommendations for Corn

Another scenario:

- How much manure do we need to apply to meet corn N requirements given the following scenario?
  - N requirement: 50 lbs N/acre.
  - Manure is injected in the spring.
  - Manure contains 5 lbs organic N and 4 lbs ammonia N per ton.
  - Dry matter content of the manure is 8%.
  - 32 tons of the same manure were applied in each of the two previous years.
From the organic N in the 32 tons of manure applied two years earlier, 5% will be mineralized this year: 32*5*0.05=8 lbs of N.

From the organic N in the 32 tons of manure applied last year, 12% will be mineralized this year: 32*5*0.12=19 lbs N.

Total requirement for this year is: 50-8-19=23 lbs N/acre.

Manure is injected in the spring so 65% of the ammonia N is conserved and available is 0.65 * 4 = 2.6 lbs/ton.

Per ton of manure, there are 5 lbs of organic N.

In the first year 35% of the organic N will be available: 0.35 * 5 = 1.75 lbs N per ton of manure.

Total N supply by the manure is 2.6 + 1.75 = 4.35 lbs/ton.

To obtain 23 lbs of N, we need to apply 23 / 4.35 = 5 tons/acre.
Tools for N Management

- Presidedress nitrate test (PSNT)
- Illinois soil N test (ISNT) and LOI
- Stalk nitrate test
Pre-Sidedress NO$_3^-$ Test (PSNT)

Measures the amount of nitrate. Predicts if there is enough N from organic sources for optimum yield without further fertilizer addition.

12 inch cores taken when the corn is 6-12 inches tall
Pre-Sidedress NO$_3^-$ Test (PSNT)

![Graph showing relationship between soil test nitrate N and relative yield.]

- **Relative yield, %**
  - (13%)
  - (7%)

- **Soil test nitrate N, ppm**
  - 0
  - 10
  - 20
  - 30
  - 40
  - 50
  - 60
  - 70
  - 80

- **Input of organic N**
  - ○ low
  - ● high

**Relationship between pre-sidedress N soil test and relative yield. 1986-95.**

- 25 ppm
## Pre-Sidedress NO$_3^-$ Test (PSNT)

### PSNT interpretations:

<table>
<thead>
<tr>
<th>PSNT (ppm)</th>
<th>Economic response to N?</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;21</td>
<td>highly likely</td>
<td>add N as recommended</td>
</tr>
<tr>
<td>21-24</td>
<td>10% chance</td>
<td>consider 25-50 lbs N</td>
</tr>
<tr>
<td>≥25</td>
<td>unlikely</td>
<td>do not add extra N</td>
</tr>
</tbody>
</table>
Illinois Soil N Test (ISNT)
\[ y = 126.36 + 4.0944x - 0.0199x^2 \]
\[ r^2 = 0.9851; \quad n = 33 \]

**Organic matter (g kg\(^{-1}\))**

**ISNT-N (mg kg\(^{-1}\))**

- **NONRESPONSIVE**
  - DOES NOT NEED EXTRA N
  - Critical Values
    - Loss on Ignition (%): 0 [0], 2 [1.2], 4 [2.6], 6 [4.0], 8 [5.4], 10 [6.8], 12 [8.2]
    - [% Organic Matter from Cornell]
  - NEEDS EXTRA N

- **RESPONSIVE**
Late Season Stalk Nitrate Test

Low:
= less than 250 ppm N

Optimal:
= 250 to 2000 ppm N

Excess:
= more than 2000 ppm N
Nitrogen Guidelines

- Pre-Sidedress Nitrogen Test (PSNT) Refresher
- Agronomy Fact Sheet #2: Nitrogen Basics
- Agronomy Fact Sheet #3: Pre-Sidedress Nitrate Test
- Agronomy Fact Sheet #4: Nitrogen Credits from Manure
- Agronomy Fact Sheet #21: Nitrogen Needs of 1st Year Corn
- Agronomy Fact Sheet #22: Cation Exchange Capacity (CEC)
- Agronomy Fact Sheet #30: Soybean N Credits
- Agronomy Fact Sheet #31: Late Season Stalk Nitrate Test
- Agronomy Fact Sheet #35: N Guidelines for Corn
- Agronomy Fact Sheet #36: Illinois Soil Nitrogen Test
- Agronomy Fact Sheet #39: Nitrogen Fixation
- Agronomy Fact Sheet #41: Soil Organic Matter
- Agronomy Fact Sheet #44: Nitrogen Fertilizers for Field Crops
- Agronomy Fact Sheet #45: Enhanced-Efficiency Nitrogen Sources
The vision of the Cornell University's Nutrient Management Spear Program is to assess current knowledge, identify research and educational needs, conduct applied, field and laboratory-based research, facilitate technology and knowledge transfer, and aid in the on-farm implementation of strategies for field crop nutrient management, including timely application of organic and inorganic nutrient sources to improve profitability and competitiveness of New York State farms while protecting the environment. For more information see our latest (2/15/2011) Program Report.

News

- 12/17/10: New Student Intern Impact Story: Joseph Foster.
- 12/03/10: New value of manure calculator and tutorials added to the: Nutrient Management Curriculum.
- 11/17/10: New whole farm mass nutrient balance software: MNB_1.0.
- 10/2/10: New Story: Manure Expo Highlights (Manure Manager Magazine).
- 9/21/10: Webcast: Novel Approaches to Manure Application in No-Till (Livestock and Poultry Environmental Learning Center).
- 5/16/10: New York Corn Systems Cover Crop Survey: For Farmers with Experience with Cover Crops or For Farmers without Experience with Cover Crops (Print, Complete and Mail).

Featured Links

- Cornell Nutrient Guidelines for Field Crops
- Agronomy Factsheets
- Impact Statements
- Nutrient Management Tutorials
- Nitrogen Management on Dairy Farms

Events

2011 Northeast Region CCA Conference
November 29-December 1, 2011. Register by November 5 for an early registration discount.

http://nmsp.cals.cornell.edu