NITROGEN MANAGEMENT EVALUATION TOOL

TUTORIAL WORKBOOK

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Nutrient Management Spear Program
Collaboration among the Cornell University Department of Animal Science, PRODAIRY and Cornell Cooperative Extension
http://nmsp.cals.cornell.edu

Teaching Goals

The exercises presented in this teaching guide are designed as a computer laboratory exercise. The purposes of this segment of the curriculum are two-fold:

(1) To reinforce nitrogen (N) management concepts presented in lecture by reading through extension fact sheets and answering question independently or through group discussions.
(2) Become familiar with the “look and feel” of the tool/software.

Completing this section of the curriculum after the lecture solidifies concepts presented in lecture by providing the same information in multiple learning formats. It also engages the use of professional reference tools (fact sheets and software), providing experiences and skills that are immediately applicable for crop and farm advisors or managers.

Materials used for this section of the curriculum are:

(1) Software - The Nitrogen Evaluation for Corn Tool
(2) Tutorial Workbook - The Nitrogen Evaluation for Corn Tool

The Tutorial for the Nitrogen Evaluation for Corn Tool takes the user through a step by step set of fact sheet references, questions, data entry and evaluation exercises. This Teaching Guide offers guidance on discussion points for each section.

The tutorial begins with downloading and opening the Nitrogen Evaluation for Corn Tool on each student’s desktop which requires an internet connection. If an in-class internet connection is unavailable, the calculator can be downloaded on a computer that does have internet access and transferred to class computers using a portable drive or disk.

It is recommended that no more than two people share a computer for optimal learning.

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Downloadable from: http://nmsp.cals.cornell.edu/projects/curriculum.html.

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Contents

Introduction

The Nitrogen Evaluation for Corn Tool automates calculation of nitrogen (N) guidelines using information about soil type, crop rotation, legume management in the rotation, drainage and manure and fertilizer applications.

In this calculator white cells (boxes) are open for data entry and yellow cells (boxes) are calculated values. The yellow cells present results based on data entered into white cells. Yellow cells are locked and cannot be manipulated.

Warning: Useable output requires realistic values as input variables. The quality of the output is dependent on the data used and is the responsibility of the person using the calculator.

Efficient use of N is an important economic and environmental goal for many farms. Nitrogen can be difficult to manage due to its multiple and very mobile forms. Fine-tuning N management requires developing site-specific knowledge through on-farm measurements. The Nitrogen Management Evaluation Tool is a Microsoft Excel spreadsheet that combines multiple tools for N management for improved understanding and evaluation of farm-specific, field-specific N conditions. The tool requires Microsoft Excel to be installed (Microsoft Office 2003® or 2007®).

The Nitrogen Evaluation for Corn Tool integrates four stand-alone tools:

- Cornell Corn N Guidelines
- Pre-Sidedress Nitrate Test (PSNT)
- Illinois Soil Nitrogen Test (ISNT)
- Corn Stalk Nitrate Test (CSNT)

Each individual tool can be used to develop skills for accurately assessing farm-specific conditions that impact N availability and evaluating and fine-tuning decisions. Use of these tools can lead to improved N use efficiency over time.

Quick Review of Nitrogen Basics

A review of N basics is suggested by reading the two fact sheets listed below and then answering questions 1-5. The fact sheets can be found in the Appendix of this tutorial workbook or downloaded from http://nmsp.cals.cornell.edu/guidelines/factsheets.html.

- *Agronomy Fact Sheet #2: Nitrogen Basics – The Nitrogen Cycle.*
- *Agronomy Fact Sheet #41: Soil Organic Matter.*

Question (1):

- A large proportion of the N in animal manure (feces + urine + bedding) is in the form of inorganic N. What makes this form of N so (1) valuable, and (2) difficult to manage?

Answer (1):

Question (2):

- When a large quantity of corn stalks are plowed in to the soil or manure with lots of straw bedding is applied to a field (hint: both materials have a high carbon (C) to N ratio) what happens for a number of weeks to the plant available N in the soil?

Answer (2):

Question (3):

- List long-term physical, chemical and biological benefits that result when materials with a high C:N ratio is added to the soil.

Answer (3):

Question (4):

- It is early summer and soils have been moist, warm and well-aerated for a number of weeks. What two microbial-driven processes have been taking place that will provide corn plant available N?

Answer (4):

Question (5):

- After a spring and early summer of conditions as described above in question (4) an area that you work in received four inches of rain over two days! You receive a call from a farm manager wondering about N availability for corn in soils that (1) are well-drained and gravelly, (2) for soils that are high in organic matter but have a poorly drained sub-layer and have been saturated for the past two days, and (3) for soils that are deep with a long history of high organic matter levels built up and maintained through manure applications and cover crop incorporation. Each field received 30 pounds of starter N. How to do you respond?

Answer (5):

- Soils that are well-drained and gravelly.

- Soils that have high organic matter levels but also have a poorly-drained sub-layer and the soils above have been saturated for 48 hours.

- Soils are deep with a long history of high organic matter levels built up and maintained through manure applications and cover crop incorporation.

Farm Contact Information

Proper labeling of field information as it is collected is important for tracking and linking farm management information with analysis results. This spreadsheet provides a place for Farm Name and Address, and the crop year to which the crop information and soil and plant analysis are applicable (Figure 1).

Nitrogen Management Evaluation Tool
Cornell University Department of Animal Science

12/8/2010

The Illinois Soil Nitrogen Test (ISNT) and late-season stalk nitrate test were calibrated for corn grown under New York growing conditions. Recent assessment has shown these tests to be effective in identifying fields with the potential for N fertilizer savings. In our "Whole Farm ISNT Project" our intent is to assess the field and farm data from several dairy and crop farms to (1) identify ISNT-N distribution over the farm: and (2) assess the potential for changes in manure and/or fertilizer N management. In this project we will analyze soils for ISNT-N and general soil fertility and then combine those data with field histories and stalk nitrate for corn fields. The field information required includes field size, crop rotation, and fertilizer and manure records. This survey sheet is the field information collection form.

Farm Name:
Farm Address:
City: State: Zip:
Crop Year: 2011

Questions? **Contact:** Quirine Ketterings qmk2@cornell.edu, 607-255-3061

Figure 1: Contact, identification and crop year information needed to link analysis results with farm management practices.

Action 1: Fill in the following information for this section:

Farm Name:	Robert Biddle
Farm Address:	1798 Rural Route 320, Iliad NY 12345
Crop Year:	2011

Field and Crop Characteristics

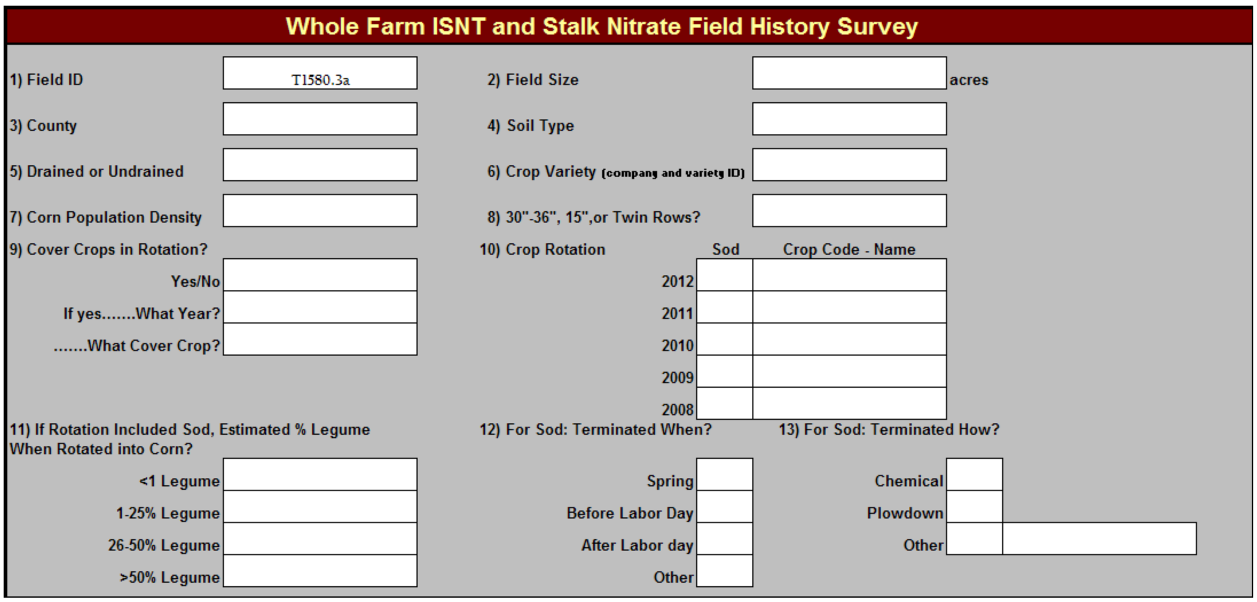
Field characteristics such as soil type, drainage, rotation and sod legume content are needed to estimate the amount of N required to reach the optimal yield for the corn crop.

Read the following three agronomy fact sheets included in the appendix of this tutorial workbook before continuing on with this section.

- *Agronomy Fact Sheet #35: N Guidelines for Corn.*

- *Agronomy Fact Sheet #21: Nitrogen Needs of 1st Year Corn.*
- *Agronomy Fact Sheet #30: Soybean N Credits.*

In addition to the data needed for estimating corn N needs, crop characteristics such as population density, row spacing, and sod termination date and method help with accurate interpretation of sampling results. When these data are combined with Field ID and field size, producers and advisors can work together to develop field specific guidelines (Figure 2).



Whole Farm ISNT and Stalk Nitrate Field History Survey

1) Field ID: T1580.3a
2) Field Size: ____ acres
3) County
4) Soil Type
5) Drained or Undrained
6) Crop Variety (company and variety ID)
7) Corn Population Density
8) 30"-36", 15",or Twin Rows?
9) Cover Crops in Rotation?
Yes/No
If yes.......What Year?
.......What Cover Crop?
10) Crop Rotation — Sod — Crop Code - Name
2012
2011
2010
2009
2008
11) If Rotation Included Sod, Estimated % Legume When Rotated into Corn?
<1 Legume
1-25% Legume
26-50% Legume
>50% Legume
12) For Sod: Terminated When?
Spring
Before Labor Day
After Labor day
Other
13) For Sod: Terminated How?
Chemical
Plowdown
Other

Figure 2: Field and crop information needed for estimating N needs, evaluating analysis results and developing site-specific recommendations.

Action 2: Fill in the following information for this section:

Field ID:	T1580.3a
Field size:	6.6
County:	Cortland
Soil type:	Palmyra
Drainage:	Drained
Crop variety:	Frontier-FM670, BMR
Planting date:	May 25th
Corn population:	31,000
Row spacing:	30”
Cover crops	None
Crop rotation	AGT,AGT,COS,COS,COS
Sod	Put an ‘x’ next to each the AGT crops to signify a sod
Percent legume:	30%
Sod termination-timing	Spring
Sod termination-method	chemical

Current and Past Manure Application Section

Manure provides N in primarily two forms: inorganic (often listed as ammonium or ammonia) N and organic N. After manure is applied these two forms become available to crops following different mechanisms. Read through the following agronomy fact sheet prior to continuing further in this user manual:

- *Agronomy Fact Sheet #4: Nitrogen Credits from Manure.*

Manure application information is collected for the current growing season and the past two growing seasons (Figure 3). This information allows estimation of the manure N credits for the current corn crop.

14) Current and Past Manure Applications	2011 Growing Season				2010 Growing Season		2009 Growing Season	
	Application #1		Application #2		Sum of Applictions		Sum of Applications	
Animal Type								
Rate								
Gallons/acre or Ton/acre?								
Month								
15) Application Method								
Injected								
Incorporated in 1 day								
Incorporated in 2 days								
Incorporated in 3 days								
Incorporated in 4-5 days								
Incorporated after 5 days								
Not Incorporated								
16) Incorporation Equip.								
17) Manure Analysis	2011		2011		2010		2009	
Density		lbs/gal		lbs/gal		lbs/gal		lbs/gal
% Solids		% as is		% as is		% as is		% as is
Inorgani-N		% as is		% as is		% as is		% as is
Organic-N		% as is		% as is		% as is		% as is
P_2O_5		% as is		% as is		% as is		% as is
K_2O		% as is		% as is		% as is		% as is

Figure 3: Manure application information needed to estimate N credits for corn crops in New York State.

Manure application information is requested per growing season. A growing season is the time between the harvest of the last crop and the end of the growth of the next crop (i.e. September or October of 2010 to September or October of 2011 for the 2011 growing season) (Figure 4).

Growing Season	2010 Growing Season												2011 Growing Season											
Month	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S
Calendar Year	2009			2010												2011								

Figure 4: Growing seasons begin after final crops are removed the preceding year, usually by October 1st.

The manure applied in the current growing season can be a source of inorganic N depending on timing and application methods. The calculator uses the manure analysis, manure rate, timing and application method to calculate the amount of inorganic N to be credited. Manure applied in the current and past two growing seasons supplies the current crop with N from mineralization of the organic N in the manure. Nitrogen credits from the organic fraction depend on the species of animal that the manure came from, the solids content of the manure and the manure application rate.

Action 3: Fill in the following information for this section:

	Current Growing Season	Last Growing Season	Two Seasons Ago
Animal Type	Cattle	Cattle	Cattle
Rate	8,000	10,000	8,000
Gallons or Tons?	Gal	Gal	Gal
Month	April	April	Oct
Application Method	Surface	Inc. 1 day	Surface
Incorporation Equipment		Aeration tool	
Manure Analysis			
Density	8.4	8.4	8.4
% Solids	6	6	6
Inorganic N	0.206	0.206	0.206
Organic N	0.093	0.093	0.093
P_2O_5	0.094	0.094	0.094
K_2O	0.298	0.298	0.298

Fertilizer Additions

Information on pre-plant, starter, and sidedress fertilizer treatments are important for determining where additional fertilizer may be needed or where fertilizer savings can be made.

Read through the following agronomy fact sheet included in the appendix of this user manual:

- *Agronomy Fact Sheet #44: Nitrogen Fertilizers for Field Crops*.

The data needed in the calculator are the fertilizer analysis (N:P_2O_5:K_2O), rate (in lbs/acre or gallons/acre), the density (for liquid fertilizers), and method of application (Figure 4).

18) Fertilizers for Crops in: 2011	Fertilizer #1	Units	Fertilizer #2	Units	Fertilizer #3	Units
Nitrogen (N)		%		%		%
Phosphorus (P_2O_5)		%		%		%
Potassium (K_2O)		%		%		%
Application Rate						
If Liquid, Density?		lbs/gal		lbs/gal		lbs/gal
Application Method						

(preplant/broadcast, preplant/broadcast & incorporate, starter/banded, starter/popup, sidedress/broadcast, topdress, sidedress/incorporate)

Figure 4: Fertilizer analysis, rates and application methods are needed to identify potential areas where additions or reductions in fertilizer could be made.

Action 4: Fill in the following information for this section:

	Fertilizer #1	Fertilizer #2	Fertilizer #3
Application Date:	May 25		
Nitrogen (N)	20		
Phosphorus (P_2O_5)	10		
Potassium (K_2O)	0		
Application Rate	150 lbs/acre		
Liquid Density			
Application Method	Starter/banded		

Crop Conditions

Conditions in the field during crop development can impact nutrient dynamics during the growing season. Therefore it is important to keep notes and field observations to help interpretation and evaluation of soil and tissue testing results (Figure 5). Additional field information to track for N availability includes rainfall events and temperature.

19) Did Any of the Following Conditions Occur this Year (#1 = most impact, #6 = least impact):
- weed pressure - insect damage - hail damage - severe compaction - lodging - other

						Define "other"
#1		#2		#3		
#4		#5		#6		

20) Crop Yield?

Amount	Units	If Bales, Bale Weight?	% Moisture
	wet ton/acre		

21) Additional Field Information of Relevance?

Figure 5: The ISNT/CSNT calculator provides a place to record observation of field conditions during the growing season to aide in evaluation later on.

Action 5: Fill in the 'Addition Field Information of Relevance' with the following data:

- 5/28 - planted
- 6/20 - 3 inches of rain (24 hrs), 68 degrees
- 6/24 - 1 inch of rain, 72 degrees
- 6/28 - 0.8 inches of rain, 75 degrees

Soil Test Results

The calculator provides a place to record soil analysis results that relate directly to N availability (ISNT and PSNT) as well as other soil nutrient levels that could interact with plant uptake of nitrogen (Figure 6). Recording all soil analysis results allows the most comprehensive interpretation of N availability during the growing season.

22) Most Recent Soil Test Data

Lab Name	Date	Sample ID	Extraction Method	pH
P (lbs/acre) (Morgan Extraction or Converted)	K (lbs/acre) (Morgan Extraction or Converted)	Mg (lbs/acre)	Ca (lbs/acre)	Ex. Acidity (ME/100g)
Al (lbs/acre)	Fe (lbs/acre)	Mn (lbs/acre)	Zn (lbs/acre)	OM (%)
Buffer pH	CNAL LOI (%)*	CNAL - ISNT-N (ppm)*	ISNT-N Critical Value (ppm)	PSNT (ppm)
pH $CaCl_2$	pH (0-1 inch; notill)	Soluble Salts (mmho)	B (lbs/acre)	CEC (NH_4OAc)

Figure 6: Nutrient analysis results are recorded and when combined with additional field conditions listed in previous sections allows a comprehensive evaluation of nitrogen availability during the growing season.

Action 6: Fill in the following information for this section:

Lab Name	Cornell -CNAL	Mn (lbs/ac)	
Date	9/2/2010	Zn (lbs/ac)	
Sample ID		OM (%)	5.28
Extraction Method	Morgan	Buffer pH	
pH	7.4	CNAL - LOI (%)	2.5

P (lbs/ac)	25	CNAL - ISNT-N (ppm)	230
K (lbs/ac)	180	PSNT (ppm)	28
Mg (lbs/ac)	890	pH $CaCl_2$	
Ca (lbs/ac)	5862	pH (0-1 inch: no till)	
Ex. Acidity (ME/100g)		Soluble salts (mmho)	
Al (lbs/ac)		B (lbs/ac)	
Fe (lbs/ac)		CEC (NH_4OAc)	

Nitrogen Balance

Keeping track of the N balance prior to and during the growing season can help estimate the quantity of fertilizer or manure needed at planting and sidedress time.

This spreadsheet is a tool that can help calculate corn N need based on the information entered. This tool can also help to interpret the results of different tools for fine-tuning N management for improved efficiency on the farm.

The information entered so far for the field shows that it is has a well-drained Palmyra soil in its second year of corn silage. The legume is generally 26-50% legume when plowed up and no cover crops are planted. The field has at least had 8,000 gallons of manure applied two years ago, 10,000 gallons last year and 8,000 gallons applied this year and the field received 30 lbs of N as a starter fertilizer. According to the information entered in the spreadsheet on soil type, drainage, crop rotation, percent legume in the previous sod and manure and fertilizer additions the N balance for this field shows a 26 lbs/acre deficient remaining (Figure 7).

(1) Corn N Balance		
Yield Potential for Corn (bushels/acre)		168
		(lbs/acre)
Soil N Credit		70
Sod N Credit		30
N uptake efficiency		75%
Past Manure N Credit		12
Preliminary N Need		**78**
Preplant N (lbs/acre)	*0*	
Starter N (lbs/acre)	*30*	
Sidedress N (lbs/acre)	*0*	
Fertilizer N Credit		30
Organic-N (lbs/acre)	*22*	
Inorganic-N (lbs/acre)	*0*	
Current Manure N Credit		22
Corn Nitrogen Balance		-26

Figure 7: Corn N balance is calculated based on information entered in the calculator.

The preliminary N need is calculated for the crop using the Cornell Nitrogen Guidelines for Corn equation (*Agronomy Fact Sheet #35: N Guidelines for Corn).*

N needs (lbs/acre) = [(Yield potential*1.2-SoilN-SodN)/(N uptake efficiency of the soil/100)]

Past manure credits are subtracted to give the ‘Preliminary N Need’ at the beginning of the cropping season.

Filling in the equation using the information entered in the spreadsheet would provide:

[(168-70-30)/0.75]-12 = 78 lbs N/acre

Since the beginning of the growing season field has already received manure and starter fertilizer. These N credits are subtracted from the current year needs:

(22+30) – 78 = -26 lbs of N/acre

The crop is still short about 26 lbs of N per acre.

Question (6):

- Change the crop rotation so that the 2010 year is an alfalfa/grass year and check the sidebox indicating it is a sod. We are now developing recommendations for first year corn. How much N is recommended and why?

Answer (6):

Go back and change the 2010 crop to corn silage and remove the sod check.

Action 7: Go to the fertilizer section of the worksheet and add in a second fertilizer as a sidedress fertilizer according to the data below:

	Fertilizer #1	Fertilizer #2	Fertilizer #3
Nitrogen (N)	20	46	
Phosphorus (P_2O_5)	10	0	
Potassium (K_2O)	0	0	
Application Rate	150 lbs/acre	75	
Liquid Density			
Application Method	Starter	Sidedress/topdress	

Question (7):

- How did the new fertilizer change the N delivered to the crop and what is the resulting Corn Nitrogen Balance.

Answer (7):

Go back and remove the second fertilizer application.

Question (8):

- Go to the manure section and change the current year manure incorporation time to 'Not incorporated', 'incorporated after 5 days', 'incorporated within 4-5 days', then '3 days', then '2 days', then '1 day' and finally 'injected'. Fill in the table below with the resulting values.

Answer (8):

	Organic N Credit	Inorganic N Credit	Corn Nitrogen Balance
• Injected			
• Incorporated within 1 day			
• Incorporated within 2 days			
• Incorporated within 3 days			
• Incorporated within 4-5 days			
• Incorporated after 5 days			
• Not incorporated			

Question (9):

a. Why does the application method impact the inorganic N and not the organic N contribution?
b. How many pounds of inorganic nitrogen per acre can be saved when this manure is incorporated within 1 day?

Answer (9):

a.

b.

Question (10):

- At the current application rate of 8000 gallons of manure per acre, how many days after application does the manure need to be incorporated to meet the N needs of the crop without adding a sidedress fertilizer?

Answer (10):

Action 8: Set manure incorporation to within 1 day.
Question (11):

- What is the minimum application rate (round to the nearest 500 gallons) the farm could use and still meet the N needs of the crop?

Answer (11):

Put the manure application back to 8000 gallons with incorporation within 4-5 days.

Pre-Sidedress Nitrate Test

The Pre-Sidedress Nitrate Test (PSNT) is an in-season soil nitrate test that can be used to estimate where additional fertilizer may not be needed. This test is taken at corn sidedressing time just before the period of major N demand by corn. It should be used on fields with a history of manure and/or sod incorporation and cannot be used on fields that received N beyond 30 lbs N/acre in the starter band. The PSNT is designed to (1) estimate the soil's N supplying potential from organic N sources, and (2) decide if that is enough N to meet crop needs.

Read through both of the following two page documents, which can be found in the appendix.

- *Agronomy Fact Sheet #3: Pre-sidedress Nitrate Test.*
- *Pre-Sidedress Nitrate Test (PSNT) Refresher.*

Our example data show that Field T1580.3a had a PSNT value of 28 ppm (this value was entered in the soil test results section above and in the evaluation table is marked with an 'x' and highlighted in yellow) (Figure 8).

(2) Pre-Sidedress Nitrate Test (PSNT) Evaluation

Field Name : T1580.3a

	Nitrate-N (ppm)	N Guidelines
X	≥25	No additional N needed.
	21-24	If you expect a yield response, consider sidedressing 25-50 lbs N/acre.
	<21	Apply sidedress N according to the Cornell N guidelines for corn.

Figure 8: The PSNT results are highlighted in the PSNT evaluation table and marked with an 'X'.

Question (12)

- Based on what you have read and the PSNT results on our example field and the manure management on this field what would you recommend? Should the farmer sidedress N?

Answer (12)

.

Illinois Soil Nitrogen Test

The Illinois Soil Nitrogen Test (ISNT) estimates the amount of readily mineralizable soil organic N and when coupled with the organic matter levels in the soil (loss-on-ignition (LOI)) the ISNT-N value can be used to determine if a field is likely or unlikely to respond to additional N (i.e. if the soil has sufficient mineralizable N to not need external supplies in the form of fertilizer N). Read through the following agronomy fact sheet before continuing further in this user manual:

- *Agronomy Fact Sheet #36: Illinois Soil Nitrogen Test.*

Our example field, T1580.3a, shows 2.5% LOI and an ISNT-N value of 375 ppm (Figure 9). The soil sample used to generate these results was taken last fall.

(3) Illinois Soil Nitrogen Test (ISNT) Evaluation

Field Name	T1580.3a
LOI (%)	2.5
ISNT-N (ppm)	375
Critical ISNT-N (ppm)	216
ISNT:Critical ISNT ratio	1.73
Interpretation	Optimum - Soil N supply is enough
Convertor Tool:	%OM to % LOI
CNAL OM (%)	
CNAL LOI (%)	

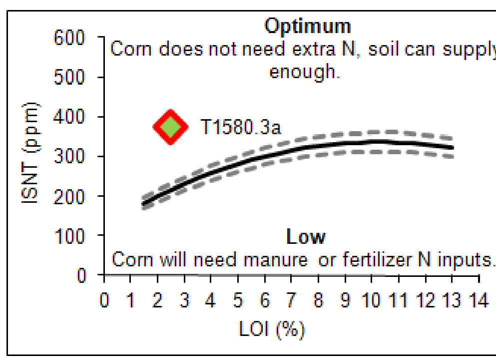


Figure 9: ISNT x LOI results show that field T1580.3a is considerably above the critical value line for a soil with an LOI content of 2.5%.

Question (13):

- According to the ISNT for this field, is additional fertilizer N needed next year?

Answer (13):

Question (14):

- Refer back to the Corn N Balance evaluation table. A number of factors were considered to estimate the Preliminary N Need for a field. Which of these numbers may have been underestimated according to the ISNT results? Why?

Answer (14):

-

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Question (15):

- Why might a farm still want to apply manure to a field even when the ISNT analysis shows that additional N is not needed?

Answer (15):

Question (16):

- Go up to the soil analysis data entry section and change the ISNT value to 250 ppm. Would your recommendation to the farm manager change?

Answer (16)

Change the soil ISNT value back to 375 ppm.

Corn Stalk Nitrate Test

The CSNT is useful as an end-of-season test because it helps identify opportunities for reducing or increasing fertilizer inputs and/or re-allocate manure over time for the greatest benefits of the manure.

Read the following agronomy fact sheet before proceeding further in this user manual:

- *Agronomy Fact Sheet #31: Late Season Stalk Nitrate Test.*

Action 9: List the case study field CSNT as 1500 ppm. You should get results that look like Figure 10.

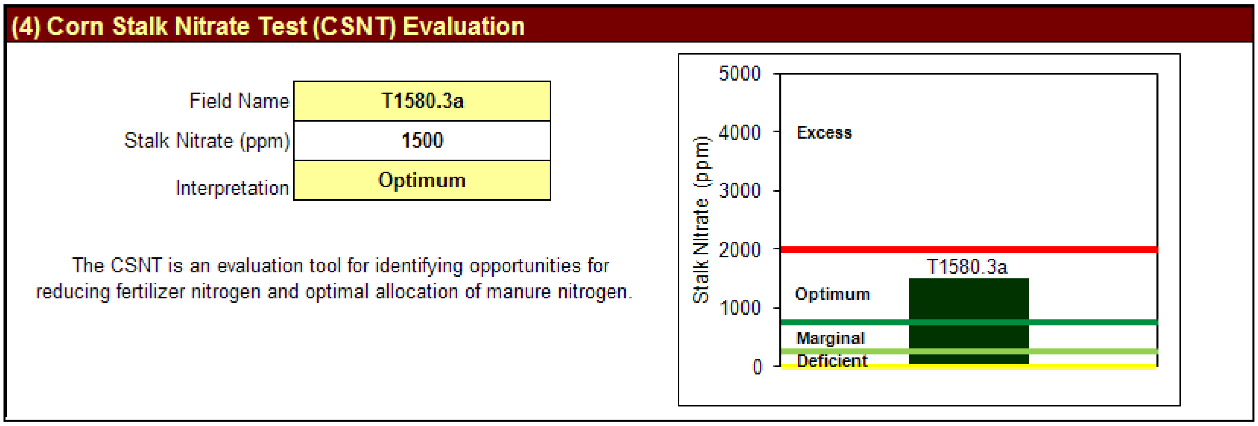


Figure 10: Corn Stalk Nitrate results are graphically displayed in the N evaluation tool.

Question (17):

- Based on the information provided during the previous exercises (the crop N balance, the PSNT, the ISNT) how would you interpret this result?

Answer (17):

Question (18):

- Based on the information provided during the previous exercises (the crop N balance, the PSNT, the ISNT) what would you recommend to the farm manager?

Answer (18):

Summary Questions

Question (19):

- Based on the above N delivery to a corn crop through manure and fertilizer, give a reason why lowering the manure application rate would be advantageous for the farm and environment.

Answer (19):

Question (20):

- Based on the above nitrogen delivery to a corn crop through manure and fertilizer, give a reason why lowering the manure application rate would be disadvantageous for the farm and environment. Explain.

Answer (20):

Question (21):

- If the PSNT results indicated more nitrogen *might* be needed. How might the ISNT results for a field help fine-tune your interpretation of the PSNT results?

Answer (21):

-

Question (22):

- Given the results of both the PSNT and the ISNT in the class example, what would your recommendation be to the farm production manager?

Answer (22):

Question (23):

- Corn is six inches tall and the weather has been wet and cold for two weeks. Growing degree days for corn are barely accumulating and the corn is barely growing. Warmer temperatures are in the forecast but the rain is due to continue for another week, about every other day a new storm rolling through with predictions of an inch or more of rain. A farmer calls for you to come look at some fields that he wants to sidedress. You arrive at the fields and notice the topography is very gently rolling, the corn in the headlands and depressions (which account for over half the field acreage) are a few inches shorter than the higher ground, and it is showing signs of N deficiency. The field has an ISNT test result that shows the soil testing considerably above the critical value for the LOI level of the field. Should the field be sidedressed?

Answer (23):

Question (24):

- As farms work to reduce their carbon footprint through manure digestion and energy generation, the manure tends to be less viscous (more liquid, less solids) and the nutrients are more reactive in the environment (immediately available to plants and microbes and potential for environmental loss). Knowing what you have learned about nutrient dynamics in the field what are some management changes that could be made to help keep nutrients on the field where they are needed?

Answer (24):

Appendices

- 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

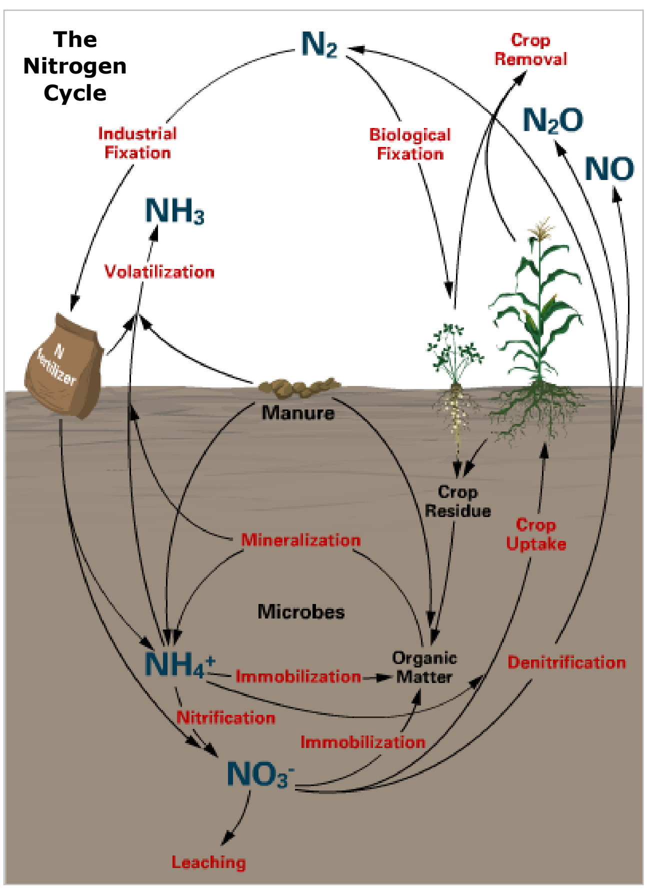
Nitrogen Basics – The Nitrogen Cycle

Nitrogen, Crops and the Environment

Nitrogen (N) is essential for the development of field crops. When N is deficient, root systems and plant growth are stunted, older leaves turn yellow and the crop is low in crude protein. Too much N can delay maturity and cause excessive vegetative growth at the expense of grain yield. Nitrogen fertilizer is expensive and losses can be detrimental to the environment. Efficient use of N by meeting crop needs while avoiding excessive applications of N is an important goal. This fact sheet provides a brief overview of the important components of the N cycle to aid in reaching that goal.

Nitrogen Cycle

The N cycle illustrates how N from manure, fertilizers and plants moves through the soil to crops, water and the air. Understanding the N cycle will help you make the best use of manure and fertilizers to meet crop needs while safeguarding the environment. In general, the N cycle processes of *fixation*, *mineralization* and *nitrification* increase plant available N. *Denitrification*, *volatilization*, *immobilization*, and *leaching* result in permanent or temporary N losses from the root zone. Read on for specifics about each of the N cycle processes.



Fixation refers to the conversion of atmospheric N to a plant available form. This occurs either through an industrial process, as in the production of commercial fertilizers, or a biological process, as with legumes such as alfalfa and clover. Nitrogen fixation requires energy, enzymes and minerals, so if a plant available form of N is present, the crop will use it instead of fixing it from the air.

N_2	→	NH_3	→	$R\text{-}NH_2$
nitrogen gas		*ammonia*		*organic N*

- When legumes are tilled into the soil, the N stored in their roots is released and made available to the next crop or lost to the environment, depending on management.
- In mixed legume-grass stands, the grass can utilize N fixed by the legumes. If the stand has 25% or more legume, no additional N is needed.

Mineralization is the process by which microbes decompose organic N from manure, organic matter and crop residues to ammonium. Because it is a biological process, rates of mineralization vary with soil temperature, moisture and the amount of oxygen in the soil (aeration).

$R\text{-}NH_2$	→	NH_3	→	NH_4^+
organic N		*ammonia*		*ammonium*

- Mineralization readily occurs in warm (68-95°F), well-aerated and moist soils.
- In New York State, approximately 60—80 lbs of N per acre is mineralized on average from soil organic matter each year.

Nitrification is the process by which microorganisms convert ammonium to nitrate to obtain energy. Nitrate is the most plant available form of N, but is also highly susceptible to leaching losses.

NH_4^+	→	NO_2^-	→	NO_3^-
ammonium		*nitrite*		*nitrate*

- Nitrification is most rapid when soil is warm (67-86°F), moist and well-aerated, but is virtually halted below 41°F and above 122°F.

Denitrification occurs when N is lost through the conversion of nitrate to gaseous forms of N, such as nitric oxide, nitrous oxide and dinitrogen gas. This occurs when the soil is saturated and the bacteria use nitrate as an oxygen source.

NO_3^-	→	NO_2^-	→	NO	→	N_2O	→	N_2
nitrate		*nitrite*		*nitric oxide*		*nitrous oxide*		*dinitrogen gas*

- De-nitrification is common in poorly drained soils.

Volatilization is the loss of N through the conversion of ammonium to ammonia gas, which is released to the atmosphere. The volatilization losses increase at higher soil pH and conditions that favor evaporation (e.g. hot and windy).

$H_2N\text{-}C(=O)\text{-}NH_2$	→	NH_4^+	→	NH_3
Urea		*ammonium*		*ammonia*

- Volatilization losses are higher for manures and urea fertilizers that are surface applied and not incorporated (by tillage or by rain) into the soil.
- Manure contains N in two primary forms: ammonium and organic N. If manure is incorporated within one day, 65% of the ammonium N is retained; when incorporated after 5 days the ammonium N will have been lost through volatilization. Organic N in manure is not lost through volatilization, but it takes time to mineralize and become plant available.

Immobilization is the reverse of mineralization. All living things require N; therefore microorganisms in the soil compete with crops for N. Immobilization refers to the process in which nitrate and ammonium are taken up by soil organisms and therefore become unavailable to crops.

NH_4^+ *and/or* NO_3^-	→	$R\text{-}NH_2$
ammonium *nitrate*		*organic N*

- Incorporation of materials with a high carbon to nitrogen ratio (e.g. sawdust, straw, etc.), will increase biological activity and cause a greater demand for N, and thus result in N immobilization
- Immobilization only temporarily locks up N. When the microorganisms die, the organic N contained in their cells is converted by *mineralization* and *nitrification* to plant available nitrate.

Leaching is a pathway of N loss of a high concern to water quality. Soil particles do not retain nitrate very well because both are negatively charged. As a result, nitrate easily moves with water in the soil. The rate of leaching depends on soil drainage, rainfall, amount of nitrate present in the soil, and crop uptake.

- The EPA has set the maximum contaminant level for drinking water at 10 ppm N as nitrate.
- Well-drained soils, unexpected low crop yield, high N inputs (especially outside of the growing season) and high rainfall are all conditions that increase the potential for nitrate leaching.

Crop Uptake is the prime goal of N management on farms. The greatest efficiency occurs when adequate N is applied at a time when the crop is actively taking it up. Efficient N use also depends on a number of other factors including temperature, soil moisture, pest pressure, and soil compaction.

- In the moist Northeast climate, nitrate remaining in the soil after the growing season will be lost to leaching or denitrification between crop harvest and the next planting season.
- Efficient N use during the growing season and the use of cover crops can minimize such losses.

Summary The ultimate goal of N management is to maximize N efficiency by increasing crop uptake and minimizing N losses to the environment. Crop N needs can be met through existing N sources (e.g. from soil organic matter, past sods and previously applied manure) and supplementary applications of N through manure and fertilizers. To make the most of existing N sources and purchased fertilizers, consider the N cycle facts, below:

- N released from killed sods, via mineralization and nitrification, can supply enough N for most, if not all, of the N needs of the following corn crop.
- The timing and method of manure and fertilizer applications determine the availability of nitrogen to the crop, but also the potential for loss. Spring applications with immediate incorporation will conserve ammonium from volatilization losses.
- Fall cover crops act as a "nutrient savings account" by taking up residual N from the growing season or fall manure applications and, thereby, reducing leaching losses. The nutrients in the cover crop become available for the next crop (by mineralization) after the sod is rotated.

For more information about N management in field crops (N guidelines, N calculators, etc.), see the "Nutrient Guidelines" section of the Nutrient Management Spear Program web site, below, or contact your local Cornell Cooperative Extension field crop educator.

For more information

Cornell University Cooperative Extension

Nutrient Management Spear Program
http://nmsp.css.cornell.edu

Authors
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2005

Soil Organic Matter

Soil organic matter is the fraction of the soil that consists of plant or animal tissue in various stages of breakdown (decomposition). Most of our productive agricultural soils have between 3 and 6% organic matter.

Soil organic matter contributes to soil productivity in many different ways. In this fact sheet, we describe the various components of organic matter and the different roles organic matter plays in soil productivity. We also discuss field management practices that will help preserve or increase soil organic matter levels over time.

What is Soil Organic Matter?

Organic matter is made up of different components that can be grouped into three major types:

1. Plant residues and living microbial biomass.
2. Active soil organic matter also referred to as detritus.
3. Stable soil organic matter, often referred to as humus.

The living microbial biomass includes the microorganisms responsible for decomposition (breakdown) of both plant residues and active soil organic matter or detritus. Humus is the stable fraction of the soil organic matter that is formed from decomposed plant and animal tissue. It is the final product of decomposition.

The first two types of organic matter contribute to soil fertility because the breakdown of these fractions results in the release of plant nutrients such as nitrogen, phosphorus, potassium, etc.

The humus fraction has less influence on soil fertility because it is the final product of decomposition (hence the term "stable organic matter"). However, it is still important for soil fertility management because it contributes to soil structure, soil tilth, and cation exchange capacity (CEC, see Agronomy Fact Sheet #22). This is also the fraction that darkens the soil's color.

Benefits of Stable Soil Organic Matter

There are numerous benefits to having a relatively high stable organic matter level in an agricultural soil. These benefits can be grouped into three categories:

Physical Benefits

- Enhances aggregate stability, improving water infiltration and soil aeration, reducing runoff.
- Improves water holding capacity.
- Reduces the stickiness of clay soils making them easier to till.
- Reduces surface crusting, facilitating seedbed preparation.

Chemical Benefits

- Increases the soil's CEC or its ability to hold onto and supply over time essential nutrients such as calcium, magnesium and potassium.
- Improves the ability of a soil to resist pH change; this is also known as buffering capacity (see Agronomy Fact Sheet #5).
- Accelerates decomposition of soil minerals over time, making the nutrients in the minerals available for plant uptake.

Biological Benefits

- Provides food for the living organisms in the soil.
- Enhances soil microbial biodiversity and activity which can help in the suppression of diseases and pests.
- Enhances pore space through the actions of soil microorganisms. This helps to increase infiltration and reduce runoff.

Organic Materials

Over time, the application and incorporation of organic materials can result in an increase in stable soil organic matter levels. Sources of organic materials include:

- Crop residues.
- Animal manure.

- Compost (Figure 1).
- Cover crops (green manure)
- Perennial grasses and legumes.

The quickest increases are obtained with sources that are high in carbon such as compost or semi-solid manure.

Figure 1: Compost application can increase soil organic matter levels over time.

Organic Matter Management

Farm practices that help to maintain or increase soil organic matter levels:

- Use of conservation tillage practices (for example zone tillage or no-till). Tillage exposes the organic matter to air and will result in the lowering of stable organic matter due to increased mineralization rates and erosion losses.
- Rotation of annual row crops with perennial grass or legume sods will reduce erosion and build up organic matter as a result of the decomposition of the rootmass.
- Establishment of legume cover crops will enhance organic matter accumulation by providing the nitrogen (N) needed for decomposition of freshly added organic materials, especially those with a high C to N ratio (corn stover, cereal straw, heavily bedded manure, etc.).
- Avoiding soil compaction which increases waterlogging, and maintaining proper pH to enhance microbial activity and decomposition of freshly added materials.

Actual buildup of stable organic matter will, in addition to the amount and source of organic material added, and tillage and rotation practices, also depend on**:**

- Soil temperature.
- Precipitation and soil moisture holding capacity.
- Soil type and drainage class.
- Existing microbial community.
- Soil fertility status and soil pH.

Monitoring Soil Organic Matter

To get an idea of the effect of farm management practices on soil organic matter buildup or decrease, soil samples should be taken over time. Consistency in sampling time is important to build records for fields over time (see Agronomy Fact Sheet #1). Although other tests are available, most laboratories will do a loss-on-ignition (LOI) test to estimate the organic matter content of the soil. At Cornell University, soil is exposed to 105°C (221°F) for 1.5 hours to remove soil moisture and then to 500°C (932°F) for 2 hours to determine LOI. Not all laboratories us the same method so for accurate records over time, it is important to consistently use the same laboratory service.

In Summary

With careful management the preservation and accumulation of soil organic matter can help to improve soil productivity resulting in greater farm profitability.

Additional Resources

- Cornell University Agronomy Fact Sheet series: nmsp.css.cornell.edu/publications/factsheets.asp.

Disclaimer

This fact sheet reflects the current (and past) authors' best effort to interpret a complex body of scientific research, and to translate this into practical management options. Following the guidance provided in this fact sheet does not assure compliance with any applicable law, rule, regulation or standard, or the achievement of particular discharge levels from agricultural land.

For more information

Cornell University Cooperative Extension

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http://nmsp.css.cornell.edu

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2008

N Guidelines for Corn

With increasing fertilizer prices and concerns about nutrient losses to the environment, it is especially important to account for all nutrient sources when determining the optimum nitrogen (N) application rate for corn.

Recommendations for phosphorus (P), potassium (K) and other nutrients are derived from soil tests. However, in the humid climate of the Northeastern US, it is difficult to base N guidelines on soil nitrate because soil nitrate levels change rapidly depending on rainfall and temperature. Instead, Cornell N guidelines for corn consider soil specific yield potentials (YP in bushels/acre), annual N contribution from the soil organic matter (SoilN in lbs N/acre), N release from a decomposing sod (SodN in lbs N/acre), and soil specific fertilizer N uptake efficiency (Neff as a percentage):

Recommended N = (YP*1.2-SoilN-SodN)/(Neff/100)

In this fact sheet we describe each of these inputs, identify where you can find the necessary information, and show some example calculations.

Yield Potential (YP)

Yield potential is defined as the expected yield over 3-4 of 5 years under good management. Corn yield potentials have been derived for all agricultural soils in New York and are updated as new research is conducted. Yield potentials are drainage dependent, reflecting different yields under drained and undrained conditions for soils that are, by nature, poorly drained. A few examples for New York soils are given in Table 1.

Table 1: Examples of corn yield potentials (YP) for New York soils.

Soil type	Corn yield potential	
	Undrained	Drained
	bushels per acre	bushels per acre
Howard	135	135
Hamlin	155	155
Volusia	95	105
Rhinebeck	105	120

Yield potentials can be looked up in Appendix 1 of the Nitrogen Guidelines for Field Crops in New York (see additional resources). They are given in bushels/acre (85%DM). To convert to the equivalent yield as silage (35% DM), divide grain yield by 5.9 bu/ton. Use a local soil survey to determine the soil type.

Soil Nitrogen (SoilN)

Soil N availability through mineralization of soil organic matter is a function of soil type and artificial drainage class. Look-up tables exist that show estimates of SoilN under undrained (UD) and under excellent artificial drainage conditions (see Appendix 1 of the Nitrogen Guidelines for Field Crops in New York).

Table 2: Examples of soil N contributions for New York soils.

Soil type	Soil N supply (SoilN)	
	Undrained	Drained
	lbs per acre	lbs per acre
Howard	70	70
Hamlin	80	80
Volusia	60	70
Rhinebeck	65	75

Sod Nitrogen (SodN)

Sods provide a substantial amount of N for three years following plow down. When the sod is killed, the organic N will become available through mineralization. The amount of N available is a function of the sod density and quality, the percent of legume, and time since the sod crop was plowed or killed. The amount of N available from different sods can be estimated using Table 3.

Table 3: Sod N release rates.

	Available N			
Legume in sod (%)	Total N pool	Yr 1*	Yr 2	Yr 3
	lbs per acre			
0	150	83	18	8
1-25	200	110	24	10
26-50	250	138	30	13
50 or more	300	165	36	15

* First year following plow down.

For more information on accounting for sod N contributions see fact sheet #21 (Nitrogen needs for first year corn).

Soil N Uptake Efficiency (Neff)

The percentage of applied fertilizer that can become part of the plant is called the uptake efficiency. Plants are not able to take up 100% of the inorganic N supplied to the soil. Sidedress applications of fertilizer and inorganic N from manure can be high (if applied at the right amount) but usually efficiencies for NY soils range from 50 to 75%. Nitrogen uptake efficiency data can be found in Nitrogen Guidelines for Field Crops in New York (see additional resources below).

Table 4: Examples of soil N uptake efficiencies.

Soil type	N uptake efficiency (Neff)	
	Undrained	Drained
	%	%
Howard	75	75
Hamlin	75	75
Volusia	60	65
Rhinebeck	60	65

Other Factors

- The N requirement for corn in a no-till system is increased 10 lbs/acre due to slower soil warming in the spring.
- The N requirement of corn grown on muck soils is 95 lbs per acre.

Example Calculations

Using the information presented above, N recommendations can be calculated for a second year corn crop in an undrained, Hamlin soil in continuous corn:

*[(155*1.2) – 80 – 0] / (75/100) =*
141 lbs N per acre

Another example is the N recommendation for a third year corn following a 50% alfalfa sod on a drained Volusia soil:

*[(120*1.2) – 70 – 13] / (65/100)*
94 lbs N per acre

Both fields require additional fertilization with either manure or chemical fertilizers or a combination. When calculated N needs are zero (or negative) and no manure has been applied, a starter fertilizer is recommended at a rate of 10-30 lbs per acre (fact sheet #21).

Manure N Credits

After calculating the N recommendation for a field, N supplies from manure applications in the three previous years must be accounted for and subtracted from the N recommendations. More information on how to account for manure N credits can be found in fact sheet #4 (Nitrogen credits from manure).

Software and Calculators

Tools have been developed to estimate N contributions without having to go through the calculations. An on-line calculator can be used that also incorporates residual manure N and current year manure N (refer to additional resources below for web address). The results can be used to identify additional fertilizers that may need to be purchased or N surpluses on a field.

Cropware, a comprehensive nutrient management software, can provide automatic calculations of N, P and K recommendations for numerous crops. The software can be downloaded, free of charge, from the website listed below.

Additional Resources

- Nutrient Management Spear Program Agronomy Fact Sheet Series: http://nmsp.css.cornell.edu
- Nutrient Guidelines for Field Crops in New York: http://nmsp.css.cornell.edu/nutrient_guidelines/
- Cropware: A tool for nutrient management planning: http://msp.css.cornell.edu/software/cropware.asp
- NYS Corn Nitrogen Calculator: http://nmsp.css.cornell.edu/nutrient_guidelines/

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"Soybean N Credits"

Introduction

Soybean acreage has more than doubled in New York State over the last 10 years. In response to high fertilizer prices, growers with soybean-corn rotations are asking about possible nitrogen (N) fertilizer savings for corn after soybean. We reviewed the scientific literature on soybean N fertilizer replacement values and potential causes of differences in N needs for corn after soybean as compared to corn after corn. In this agronomy fact sheet, our findings are summarized and Cornell guidelines are listed.

Figure 1: The optimum N rate for corn after soybean is often lower than for corn after corn. The difference is called the N fertilizer replacement value of soybean for corn.

Terminology

The term "soybean N credit" has been applied to the estimated N savings when corn follows soybean as compared to continuous corn. This term is confusing as N savings for corn after legumes are not necessarily due to N release of the previous crop alone. Two types of rotation effects are identified in the literature:

- *N rotation effects*
  - o Effects that can be compensated for with an application of fertilizer N.
- *Non-N rotation effects*
  - o Effects for which an application of fertilizer N is unable to compensate such as:
    - Soybean interruption of pest cycles.
    - Enhanced corn root functioning in the year after soybean (possibly due to soybean root exudates or changes in mycorrhizal fungi communities).
    - Changes in physical soil properties and moisture availability as a result of the year of soybean production.

To avoid confusion, we will use the more general term "N fertilizer replacement value" (NFRV) when talking about differences in optimum N rates for corn after soybean as compared to corn after corn, and use the term "soybean N credits" for direct references to N release from soybean residue.

Findings

- Nitrogen fixation by soybean is often *not* a major factor in the overall N fertilizer replacement effect of soybean on corn in a soybean-corn rotation.
- Soybean residue decomposes more rapidly than corn residue. This leads to more rapid immobilization and also N mineralization resulting in an earlier N release peak than would be seen for corn after corn.
- Non-N rotation effects can and usually have a positive impact on yield beyond what an

extra N addition to corn after corn can achieve.

- Several management factors can impact the N fertilizer replacement value of soybean for corn in a rotation, but additional research is needed in the following areas before adjustments can be recommended:
  - Soil type and properties:
    - Some studies show higher N savings on medium textured soils with low organic matter (OM) than on sandy or heavy clay soils with higher OM.
  - Tillage systems:
    - Some studies show higher N savings in tilled than in reduced-till systems.
- There is no consistent link between previous year soybean yield and nitrogen fertilizer replacement value.
- The beneficial effects of soybean in the rotation last one year only.

N Guidelines for Corn after Soybean
Based on this literature summary and limited research in New York State, we conclude that for corn grown after soybeans in New York State, the optimum economic N rate can be lowered by 20-30 lbs N/acre as compared to corn after corn.

Table 1: Adjustment in Land Grant University recommended rate of nitrogen for corn after soybean versus corn after corn.

Location	N replacement value (lbs N/acre)
Northeast	
Connecticut	No soybean production
Maine	0
Massachusetts	0
New Hampshire	30
New Jersey	15
New York	20-30
Vermont	30
Mid-Atlantic	
Delaware	0.5 lb N/bu soybean yield
Maryland	15-40
Pennsylvania	1 lb N/bu soybean yield
Virginia	0.5 lb N/bu soybean yield*
West Virginia	0.5 lb N/bu soybean yield*
Canada	
Ontario	27

*If yields are unknown, a N fertilizer replacement value of 20 lbs/acre is recommended.

This adjustment should be applied for one year only and is very much in line with recommendations from other land grant universities in the Northeast and Mid Atlantic States and Ontario, Canada (Table 1). To derive N guidelines for corn after soybean, determine N guidelines for corn without soybean or grass/alfalfa sod history (see nmsp.css.cornell.edu/nutrient_guidelines/) and subtract 20-30 lbs N/acre from the recommended N rate for corn after corn.

Cornell University

Nitrogen Fertilizer Replacement Value of Soybean for Corn

"Soybean N credits"

The optimum economic N rate for corn after soybean can be lowered by 20-30 lbs N/acre. This adjustment should be applied only for the first year of corn following soybean.

Additional Resources:

- Cornell Guide for Integrated Field Crop Management: http://www.fieldcrops.org.
- Cornell Nutrient Guidelines for Field Crops: http://nmsp.css.cornell.edu/nutrient guidelines.
- Cornell University Agronomy Fact Sheets #2 (Nitrogen Basics – The Nitrogen Cycle), #3 (Pre-sidedress Nitrate Test), #4 (Nitrogen Credits from Manure), and #21 (Nitrogen needs for first year corn). http://nmsp.css.cornell.edu/publications/factsheets.asp.

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2007

Cornell University Cooperative Extension

Agronomy Fact Sheet Series | Fact Sheet 4

Nitrogen Credits from Manure

Nitrogen Sources

There are often four main sources of nitrogen (N) on farms: (1) soil organic matter; (2) organic residues (animal and green manure, compost, plowed under sods); (3) N fixed by legumes; and (4) inorganic fertilizer N. To calculate the amount of fertilizer N required for optimum economic yield, adjustments need to be made for fixed N and any N released from the organic sources. This fact sheets provides an overview of nitrogen credits from manure.

Nitrogen in Manure

There are primarily two forms of N in manure: inorganic (ammonium) N and organic N (Figure 1). The ammonium N is initially present in urine as urea in dairy or beef manure, and may account for about 50% of the total N. Urea in manure is no different from urea in commercial fertilizer. It converts rapidly to ammonium when conditions allow.

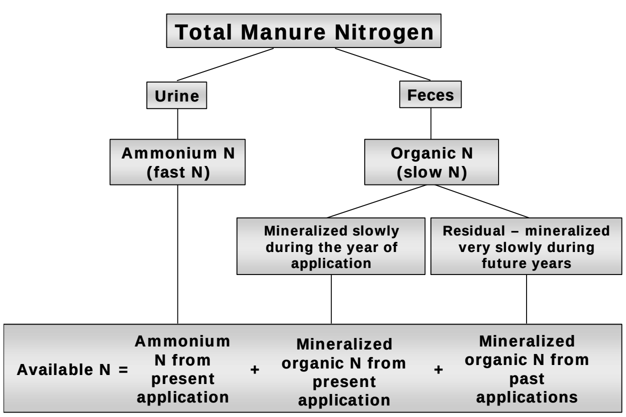

Figure 1: Manure N consists of ammonium and organic N (modified from Klausner, 1997).

Ammonium N in Manure

In principle, the ammonium from urea in manure is available for plant growth. However, part or all of it may be lost because ammonium is rapidly converted to ammonia gas. When manure is spread on the surface of the soil (especially high pH soils), ammonia enters the air or "volatilizes". Whenever manure is exposed to air on the barn floor, in the feedlot, in storage, or after spreading, N loss occurs. Testing is essential to determine how much inorganic N could potentially be conserved. Samples should be taken while loading the spreader or while spreading in the field for a good estimate of the nutrient value of the manure. Table 1 shows the estimated amount of ammonium N available for plant use for different application methods and timing. The table shows the benefits of manure incorporation shortly after spreading in the spring. For example, if manure contains 14 lbs inorganic N per 1000 gallons, incorporation of 6000 gallons within 1 day can save 55 lbs of fertilizer N!

Table 1: Estimated ammonia-N losses as affected by manure application method.

Manure Application Method	% remaining
Injected during growing season	100
Incorporated within 1 day	65
Incorporated within 2 days	53
Incorporated within 3 days	41
Incorporated within 4 days	29
Incorporated within 5 days	17
No conservation or injected in fall	0

Figure 2: Surface application of manure without incorporation will result in the loss of inorganic N from the manure.

Organic N in the Manure

The feces contain organic N that is more stable and slowly released. The organic N breaks down over time, some the first year after application, some in the following years. Repeated application to the same field results in an accumulation of a slow release manure N source.

A decay or mineralization series is commonly used to estimate the rate of N availability from stable organic N over the years following application. A decay series of 35, 12, and 5% in years 1, 2, and 3 is used to estimate the rate of decomposition of organic N in liquid (<18% dry matter) dairy manures in New York (Table 2). This sequence of numbers means that 35% of the organic N is mineralized and potentially taken up by the growing crop during the year the manure was applied, 12% of the initial organic N application is mineralized and taken up during the second year, and 5% is mineralized and taken up in the third year. There is evidence that manure containing large amounts of bedding may mineralize at a slower rate than fresh manure so the estimated availability of N during the year applied is reduced from 35% to 25% when the dry matter content of manure exceeds 18%. Nitrogen fertilizer recommendations from Cornell University need to be adjusted for the release of N from previous years' applications.

Table 2: Decay series for stable organic N in manure by animal type. A "Next Year" release rate of 12% indicates that an estimated 12% of the organic N applied in the manure is expected to be utilized by the crop a year after application.

		Release rate for organic N in manure (%)		
Source	Dry matter (%)	Present Year	Next Year	In Two Years
Cows	<18	35	12	5
Cows	≥18	25	12	5
Poultry	<18	55	12	5
Poultry	≥18	55	12	5
Swine	<18	35	12	5
Swine	≥18	25	12	5
Horses	<18	30	12	5
Horses	≥18	25	12	5
Sheep	<18	35	12	5
Sheep	≥18	25	12	5

Practical Applications

- Base manure application rates on field histories (rotation and manure), soil characteristics and environmental conditions.
- Minimize fall and/or winter manure application on good grass and/or legume sods that will be rotated the next spring.
- Conserve ammonia. Losses can either be reduced by immediately incorporating after spreading in the spring or directly injecting manure as a sidedress application to growing crops.
- Manure may be applied in the fall where there is a growing crop. Fall manure can be applied on perennial crops or winter hardy cover crops. Fall applications should not exceed 50-75 lbs/acre of available N. Manure application on hayland stands is acceptable to satisfy agronomic requirements when legumes represent less than 50% of the stand. If more than 50% of the stand is legume, manure applications should not exceed 150 lbs of available N/acre.

Additional Resources

- To download a spreadsheet to calculate "Crop Available Nutrients from Manure": nmsp.css.cornell.edu/nutrient_guidelines
- Cornell Guide for Integrated Field Crop Management: www.fieldcrops.org
- Cornell University Agronomy Fact Sheet #1: Nitrogen Basics – The Nitrogen Cycle: nmsp.css.cornell.edu/publications/factsheets.asp
- Cornell Nutrient Guidelines for Field Crops: nmsp.css.cornell.edu/nutrient_guidelines
- "Recommended Methods of Manure Analysis":cecommerce.uwex.edu/pdfs/A3769.pdf

For more information

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Nutrient Management Spear Program
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2005

Nitrogen Fertilizers for Field Crops

Introduction

With the increased cost of nitrogen (N) fertilizer and concerns about the adverse environmental impacts of N losses, there is great interest in fine-tuning N fertilizer management. The goal is to match application source, rate, timing and method to supplement on-farm sources of N (e.g., manure, soil organic N, sod, legume cover crops) to meet crop needs and achieve optimum levels of N use efficiency. Optimum N fertilizer management requires an understanding of the different N fertilizers. In this fact sheet we will discuss the basic properties of major N fertilizer sources.

Urea

Urea is a highly soluble, dry material. Its N becomes plant-available when converted to ammonium (NH_4^+) and then nitrate (NO_3^-). Urea can be used as a starter, broadcast or topdress application and can be used in fertilizer mixes (dry or liquid). Advantages of urea are its high N content (45 to 46%), relatively low cost per lb of N, and rapid conversion to plant-available N. If urea is surface applied and not incorporated (either by rain or tillage), N losses to the air (as ammonia) can approach 40% of the applied N. In addition, a rapid pH increase after application caused by hydrolysis of urea can result in ammonia release that can damage seedlings if the urea is applied too close to the seed. If urea is used as a band-applied starter, the planter should be carefully checked to ensure placement is not closer than 2 inches beside and below the seed, and be calibrated to apply no more than 60 lbs urea per acre (30 lbs of actual N from urea). Conversion of ammonium to nitrate results in the formation of hydrogen ions (H^+), so, like most N fertilizers, repeated urea applications will cause a reduction in soil pH over time.

Urea Ammonium Nitrate

Urea ammonium nitrate (UAN) is a soluble, readily available N source with 28-32% N prepared by mixing of ammonium nitrate and urea. It is primarily used as a non-pressurized liquid fertilizer and is for many the preferred source of N for sidedressing of row crops. UAN can be broadcast or placed in the starter band. If broadcast, UAN should be incorporated into the soil as the urea portion is subject to volatilization. However, because of its lower % of N in urea and ammonium form, volatilization losses per pound of N from UAN will be lower than for urea. Banding with drop nozzles has been found to minimize volatilization losses. The benefits of this product are its uniformity, ease of storage, handling and application. Like urea, UAN will lower the pH because of conversion of ammonium to nitrate and subsequent release of H^+.

Figure 1: Urea ammonium nitrate in liquid form is a commonly used fertilizer to sidedress corn.

Ammonium Sulfate

Ammonium sulfate is a soluble, readily available source of N and sulfur (S). Dry forms contain 21% N and 24% S, while liquid forms have an analysis of 8-0-0-9. Ammonium sulfate can either be broadcast or applied in the starter band. In high P and K fertility situations, many NY producers use ammonium sulfate alone in the starter band. Ammonium sulfate is well-suited as a topdress application as it has a lower N volatilization risk than surface-applied urea. Also, where S is needed, ammonium sulfate is a good source of S.

The drawbacks to using ammonium sulfate include a relatively high salt index and greater acidification potential per unit N applied than other ammonium-containing N sources, higher cost per lb of N, and relative low N content, requiring more frequent refilling of hoppers.

Anhydrous Ammonia

Anhydrous ammonia has the highest percentage of N of all fertilizers (82% N) and tends to be the cheapest N source (cost per unit N). It is a high-pressure liquid that can be deep-banded before, at or after seeding provided that there is no direct seed contact. Anhydrous ammonia must be injected 6 to 8 inches deep into moist and friable soil to limit ammonia loss (liquid ammonia converts to gas when no longer under pressure). It must be stored under high pressure, which requires specially designed, well-maintained equipment and facilities should be well-protected for safety reasons. During application, personal protective equipment (gloves and goggles) should be used.

Ammonium Nitrate

Ammonium nitrate is an odorless salt with 33 to 34% N. It can be surface-applied or incorporated into the soil. It contains both ammonium and nitrate resulting in reduced volatilization risk as compared to urea, and the nitrate provides a directly available N source. Since it contains ammonium, this fertilizer also lowers the pH of the soil.

Potassium Nitrate

Potassium nitrate, also known as saltpeter or nitric acid, is considered a specialty fertilizer. It is a colorless transparent crystal or white powder with 14% N and 46% potassium (K). Potassium nitrate does not lower the soil pH.

Mono-Ammonium Phosphate

Mono-ammonium phosphate (MAP) contains readily available sources of N (11%), P (52%) and S (1.5%). MAP is a dry granular material that is applied alone or often blended with other materials such as potash. It can be broadcast, band-applied or placed in the seed furrow. MAP can lower the soil pH but is an excellent starter fertilizer.

Di-Ammonium Phosphate

Di-ammonium phosphate (DAP) is dry fertilizer that contains readily available sources of N (18%) and P (46%). Formation of free ammonia produced after mixing of DAP with soil can cause seedling injury as described for urea. To prevent such injury using DAP, it is recommended to limit band-applications to (1) 65 lbs per acre of DAP, or (2) 30 pounds of urea N plus N from DAP.

Chilean Nitrate

Chilean nitrate can be used in conventional and organic cropping systems (permitted for use by USDA/NOP in 2003). It contains 16% of a readily plant-available form of nitrate-N and sodium. It is available in a dry, flowable prill form.

Enhanced-Efficiency Nitrogen Sources

Enhanced efficiency N sources are designed to reduce losses of N due to leaching, denitrification and/or volatilization. For more information on these enhanced-efficiency fertilizers see Agronomy Fact Sheet #45.

Concluding Remarks

Applying the right source of N fertilizer at the right rate, time, and place is critical to proper N management. For the best results, apply N only when needed, calibrate application equipment to ensure proper placement, and adjust source, rate and timing to meet N needs and avoid seed or seedling injury.

Additional Resources

- Nutrient Management Spear Program Agronomy Fact Sheet Series. http://nmsp.css.cornell.edu.

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For more information

Cornell University Cooperative Extension

Nutrient Management Spear Program
http://nmsp.css.cornell.edu

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Pre-sidedress Nitrate Test

The Pre-sidedress Nitrate Test (PSNT) is an in-season soil nitrate test that can be used to determine if additional fertilizer nitrogen (N) is needed for corn. This test should be conducted on soil samples taken just prior to sidedressing (just before the period of major N demand by corn). The test can be done for fields with a history of manure and/or sod incorporation. The PSNT is designed to: (1) estimate the soil's nitrate supplying potential, and (2) decide if that is enough N to meet crop needs.

When to use:

- In corn fields, 2nd year or more after a sod and/or where the manure rate is uncertain.
- If not enough manure was applied to meet the expected N needs of the crop.

Where not to use the PSNT:

- The test is useless for corn fields that received pre-plant or early post-plant broadcast fertilizer N applications (other than <40 lbs starter N/acre in the band). Any "leftover" nitrate from broadcast fertilizer that is measured by the PSNT could overestimate the true nitrate supplying potential.
- First year corn after a grass sod with adequate starter N (20-30 lbs N/acre) is not likely to need additional N. Only a few soils in New York State (i.e. those with the highest yield potentials: Hamlin, Genesee, Hartland, Ross) would show a yield response to a moderate sidedress N rate after a grass sod.
- First year corn after a grass/alfalfa stand rotated to corn is unlikely to respond to sidedress N because sufficient amounts of N will be available from the plowed-down sod. It is a waste of time and money to sidedress N in these situations so it is also not necessary to take a PSNT.

How to take samples?

For accurate results, 2nd or higher year corn fields should be sampled for PSNT according to the following procedure:

- Limit sample to areas of 15 acres or less and take a separate sample for areas with different corn stands (different population densities, stage of development, and/or color), crop histories, fertility management, significant changes in slope, etc.
- Sample between corn rows to a depth of 12 inches (stay away from the starter band).
- Sample when the corn is 6-12 inches tall.
- Do not sample too close to a rain event that could have resulted in nitrate leaching (wait for 2-3 days after significant rainfall).
- For more information on soil sampling see Agronomy Fact Sheet #1.

Figure 1: PSNT samples need to be taken over 12 inch depth when the corn is 6-12 inches tall to provide an accurate prediction of nitrate availability from organic N.

Samples should be dried immediately (spread the sample thinly and dry in the sun or under a fan) to stop N mineralization and sent to the laboratory. Most laboratories that conduct PSNT analyses will guarantee a 24-hour turnaround time.

If you use a Cardy Nitrate Meter:

- Use fresh reagents and frequently re-calibrate with the standard solutions supplied with the meter.
- At the beginning of the season, test a few soil samples and send duplicates to a reliable laboratory to check on performance of the meter. This could prevent surprises at PSNT time.

- For a user manual of Cardy nitrate meter: www.specmeters.com/pdf/2300%20CARDY%20NO3%20Meter.pdf. Make sure to read the manual prior to use of the meter.

Interpreting PSNT results:

The PSNT guidelines for those fields with ≥25 ppm or 21–24 ppm are straightforward:

Table 1: Interpretations of the presidedress nitrate test.

PSNT ppm nitrate-N	Likeliness of an economic response to extra N	N guideline
≥ 25	Low	No additional N needed
21 – 24	About 10%	If you expect a yield response, consider sidedressing 25-50 lbs N/acre
<21	High	Apply sidedress N according to the Cornell N guidelines for corn*

*The N guidelines for corn as well as the NYS Corn N Calculator can be downloaded from the NMSP website: http://nmsp.cals.cornell.edu/guidelines/nutrientguide.html.

For fields with <21 ppm:

- If you took a PSNT on a field that you expected to need sidedress N (for example a field that received less manure than needed to meet N needs), add the extra N.
- If you took a PSNT on a field that you expected to not require sidedress N (for example where manure applications should have supplied sufficient N), make sure the field actually received the planned manure application and that the field history is correct. Check N needs with the NYS Corn N Calculator. If the calculator shows that no additional N is needed, despite the PSNT being <21 ppm, organic-N mineralization rates early in the season were likely lower than average. No additional N is needed because the field is expected to supply sufficient N from organic sources once mineralization conditions improve (warm and moist soils). If the calculator shows that additional N is needed, consider adding the extra N fertilizer.

The PSNT is particularly useful when it is unclear whether enough manure was actually applied. Over the course of a few years, carefully compare PSNT results with fertilizer and manure inputs *and* crop performance to develop the skills and local experience to best use this test.

If you decide to sidedress but want to check if the additional N is (was) needed:

- Leave untreated check strips in the field.
- At harvest time evaluate the strips visually: if the leaves are green to the bottom of the plant, it is likely that too much N was applied. Many users will be very uneasy with this, but yield is not suppressed when about 3 leaves or so from the ground up are yellow at harvest time. See the 2005 Cornell Guide for Integrated Field Crop Management ("Nitrogen Status of the Corn Crop" on page 56) for more discussion.
- Check the yield: harvest and weigh at least two rows of 17.5 feet (1/1000th of an acre with 30 inch rows) in each treatment and determine dry matter to correct for moisture differences.
- Conduct a corn stalk nitrate test (CNST) at harvest time. This test is an end-of-season "report card" for N management. For more information, see Agronomy Fact Sheet 31.

Additional resources:

- New York State Corn Nitrogen Calculator: http://nmsp.cals.cornell.edu/guidelines/nutrientguide.html.
- Cornell Guide for Integrated Field Crop Management: http://ww.fieldcrops.org.
- Cornell Agronomy Fact Sheet #2: Nitrogen Basics – The N Cycle; and #31: Corn Stalk Nitrate Test. http://nmsp.cals.cornell.edu/guidelines/factsheets.asp.
- Cornell Nutrient Guidelines for Field Crops: http://nmsp.cals.cornell.edu/guidelines/nutrientguide.html.

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2012 (Revised)

Updated June 4, 2008.

Pre Sidedress Nitrogen Test (PSNT) Refresher

With the PSNT season upon us, here are a few things to keep in mind about the test. The PSNT can be used to test if sidedress N fertilizer is needed on fields with a history of manure and/or sods. It attempts to 1) gauge the pool of potentially mineralizable organic N in the soil and 2) link that pool with a likelihood of a yield response from additional N fertilizer at sidedressing time.

Where to use…

- Corn fields, 2 years or more after a sod where the manure rate is uncertain.
- Where calculations indicate not enough manure was applied to meet the expected N needs of the crop.
- Cases where N mineralization rates are expected to be higher than average.

When not to use…

- Corn fields that had pre-plant / early post-plant broadcast fertilizer N applications (other than <30 lbs starter N/acre in the band). Any nitrate from broadcast fertilizer that's picked up by the PSNT could overestimate the true N mineralization potential;
- First year corn regardless of legume percentage in the sod or timing of sod kill (spring or fall after soil temperatures at 4 inch depth is approach 45^{o}F). Our New York field trials show no yield response from sidedress N (see project results and farmer stories on N savings for corn at http://nmsp.css.cornell.edu/projects/Nitrogenforcorn.asp), so skip those fields for PSNT and N sidedressing.

How to sample…

- When corn is 6-12 inches tall.
- Between rows (i.e. not in the starter band).
- Not too close to a rain event that could have resulted in nitrate leaching (wait for 2-3 days after significant rainfall).
- Sample down to 12 inches.
- Dry sample immediately and send to the lab.

If using a Cardymeter…

- Use fresh reagent.
- Frequently re-calibrate with the Cardymeter's standard solutions.
- Calibrate by sending a duplicate sample to a lab periodically during the PSNT season.
- See also: http://nmsp.css.cornell.edu/publications/factsheets/factsheet3.pdf.

PSNT results…

PSNT (ppm of nitrate-N)	**Probability of an economic yield response from additional N**	**N Guideline**
≥ 25	Low	No additional N needed
21 – 24	About 10%	If you expect a yield response based on experience with the field, consider sidedressing 25-50 lbs N/acre
<21	High	Apply sidedress N according to the Cornell N Guidelines for corn*

* The N Guidelines for corn as well as the NYS Corn N Calculator can be downloaded from the Nutrient Management Spear Program (http://nmsp.css.cornell.edu/nutrient_guidelines).

Updated June 4, 2008.

The PSNT guidelines for those fields in the ≥25 ppm and the 21–24 ppm ranges are straightforward. For fields with <21 ppm (assuming a good sample was taken), the N guideline for the PSNT falls into one of two camps:

1) If you took a PSNT on a field that you expected to require some sidedress N (i.e. the pre-season N recommendation called for additional N), then make sure the original N management plan for the field is still relevant and, if so, put that plan for sidedress N into action.
2) If you took a PSNT on a field that you expected to not require sidedress N (e.g. it received enough manure), make sure the field actually received the planned manure application, that the field history is correct, and then run it through the NYS Corn N Calculator. If the revised guideline still doesn't call for additional N, despite being <21 ppm, organic-N mineralization rates and/or N losses were likely significantly different than average.

The PSNT is particularly useful when there is uncertainty as to whether enough manure was actually applied to meet expected corn N requirements. PSNT users and anyone else attempting to adjust N applications to corn, should, over the course of a few years, carefully compare test results with fertilizer and manure inputs AND crop performance to develop the skills and local experience to best use this test. Consider the following for this year to begin to build your experience bank.

If you decide to sidedress:

- Leave untreated check strips on fields:
  - that received enough manure to satisfy N needs based on NYS Corn N Guidelines, yet have PSNT results<21 ppm;
  - second year corn fields that received some manure;
  - first year corn fields following a good grass or grass/legume sod (if in the habit of sidedressing these based on PSNT).
- At harvest, visit the strips to judge if the extra N was needed.
- Evaluate visually: If the leaves are green to the bottom of the plant, it is likely that TOO MUCH N was applied. As plants mature, the lower leaves become useless and so a plant will recycle N from there for other uses. Many users will be very uneasy with this, but yield is not suppressed when about 3 leaves or so from the ground up are YELLOW at harvest time. See the 2007 Cornell Guide ("Nitrogen Status of the Corn Crop" on page 51-53) for more discussion on this.
- Check the yield: harvest and weigh at least two rows over a 17.5 foot length (1/1000th of an acre with 30 inch rows) of representative areas in each treatment and run dry matter to correct for moisture differences.

Please contact Quirine Ketterings (qmk2@cornell.edu or 607-255-3061) or Karl Czymmek (kjc12@cornell.edu or 607-255-4890) with any questions, discussions, or interest in on-going N for corn research.

Illinois Soil Nitrogen Test (ISNT)

Accounting for in-field sources of nitrogen
Plants take up nitrogen (N) from different sources; plant residues, roots, past manure applications, soil organic matter and fertilizer N all contribute to the total amount of N used by a crop. The Cornell N equation calculates an N guideline for corn by taking into account the amount of N needed by the corn crop (based on soil and drainage specific corn yield potentials), and N available from sources already on the farm, including biomass from previous crops (sod N or soybean N credits), N from past manure applications, and N expected to be mineralized from soil organic matter (SOM) that growing season (soil N supply). Once in-field sources are accounted for the final N application value is adjusted (upward) to reflect fertilizer uptake inefficiencies (N fertilizer uptake efficiency under good management ranges from 50-75%). See Agronomy Factsheet #35 (N Guidelines for Corn) for more details.

Variability of soil N supply
A major factor in the Cornell N equation is soil N supply, yet soil N supply is very difficult to predict accurately. The soil N-supply values used for the Cornell N equation for corn are estimates (book values) developed for more than 600 New York soil types. Book values are based on studies of N uptake by continuous corn grown without additional N. For New York soils, soil N supply can range from 50 to 140 lbs N/acre, with 60-70 lbs N/acre typical for many common agricultural soils.

There are many challenges to develop a soil test that can more accurately predict the soil N-supply for a specific field in a timely manner. Soil organic matter levels have been used to gauge soil N availability; however, this method is not accurate. Typically, to determine SOM as reported on a soil fertility report, a soil sample is burned at a very high temperature. This method is called loss-on-ignition (LOI). The difference in mass before and after burning is converted into a percent SOM (%SOM). This LOI value on its own, although useful for other purposes, is not a good predictor of soil N supply as it does not distinguish between SOM with readily available N and SOM that does not supply N, and proportions vary across fields and farms. Until recently, the best option to estimate if there was sufficient plant available N from organic sources (manure, sod, soil) was the pre-sidedress nitrate test (PSNT) but the PSNT presents some practical sampling challenges, results can be misleading in both dry and wet springs, and often N management decisions need to be made earlier in the season.

Illinois Soil Nitrogen Test (ISNT)
Field research in New York the past 8 years has shown a new soil N test, the Illinois Soil Nitrogen Test (ISNT), to be the best option for determining soil N supply potential for New York corn growers. The ISNT is a laboratory test that estimates the amount of readily mineralizable soil organic N. The test has been 83% accurate in our trials predicting if soil-N supply alone could provide adequate N for a corn crop in New York.

Interpreting the results
To interpret ISNT-N values, we have to know both the ISNT-N value and the LOI value (Figure 1). Three results are possible: (1) above the curve (the black line in Figure 1) and outside the upper marginal grey zone; (2) below the curve and outside the lower marginal grey zone; or (3) close to the curve in the marginal (grey) zone.

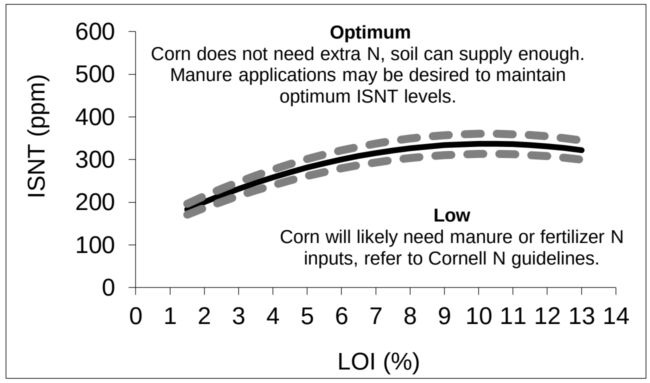

Figure 1: ISNTxLOI critical value curve for predicting if corn will respond to extra N.

(1) ***Optimum****: Above the ISNTxLOI curve*

The soil can supply enough N for optimum corn yield and no additional N is needed (small amount of starter N only). These soils will supply enough N throughout the growing season to support optimum corn growth and can quickly mobilize N into a plant available form as soils warm up in June and corn begins to grow rapidly.

(2) ***Low****: Below the ISNTxLOI curve*

The soil alone does not have enough N supply potential to meet crop N needs. These fields will likely show a response to additional N either from fertilizer or manure and the Cornell N equation for corn can be used to estimate how much N will be needed (Agronomy Fact Sheet #35).

(3) ***Marginal****: In the grey zone*

Soils falling within the gray dotted lines in Figure 1 are considered marginally adequate in soil N supply. These fields might have enough soil N but additional monitoring is needed. These are good fields for fertilizer test strips.

Soil sampling for ISNT

Soil samples for the ISNT can be taken any time during the year, except within 5 weeks after manure spreading or sod/cover crop turnover, with the same sampling and handling methods as used for regular soil samples (0-8 inches, see Agronomy Fact Sheet #1). Since sampling procedures are identical, the same sample can be used for regular fertility assessment as well as for ISNT analyses.

Results from the ISNT analysis will reflect soil organic N mineralization potential for the next 2-3 years. The sample is best taken in the fall after harvest of 1^{st} year corn before manure application to guide decisions for 2^{nd} year corn or higher. First year corn after grass/legume sod does not need N beyond 20-30 lbs N/acre in the starter (Agronomy Fact Sheet #21). Thus, we do not need to evaluate the ISNT and LOI levels of 1^{st} year corn fields.

Sample submission

Soil samples can be submitted to:

Quirine Ketterings
Nutrient Management Spear Program
Dept. of Animal Science, 323 Morrison Hall,
Cornell University, Ithaca NY 14853

See http://nmsp.cals.cornell.edu to download a sample submission form.

Alternatively, samples can be submitted to other laboratories that offer ISNT analysis but for accurate interpretation of the ISNT data for New York growing conditions (i.e. to use Figure 1), make sure the laboratory that you submit samples to has implemented a 2-hour and 500°C method for determining LOI. Burning at lower temperatures can result in lower LOI estimates possibly resulting in incorrect interpretations of the ISNT results. The %OM using the 2-hour and 500°C method can be converted to %LOI using the following formulas:

$$\%LOI = (\%OM + 0.23) / 0.7$$
$$\%OM = (\%LOI * 0.7) - 0.23$$

Conclusion

The ISNT can accurately predict soil N-supply capacity for corn in New York, sampling for the ISNT fits nicely into a regular soil sampling protocol (0-8 inch depth samples), and the results can be applied for the following 2-3 years of corn. The ISNT has proven to be a useful tool for fine-tuning N applications and reducing purchased N inputs costs, especially when used together with the corn stalk nitrate test.

Additional Resources

- Nutrient Management Spear Program Agronomy Fact Sheet Series: nmsp.cals.cornell.edu/index.html
- Nutrient Guidelines for Field Crops in New York: nmsp.cals.cornell.edu/guidelines/nutrientguide.html
- New York State Corn Nitrogen Calculator: nmsp.cals.cornell.edu/software/calculators.html

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Corn Stalk Nitrate Test (CSNT)

Recent increases in nitrogen (N) fertilizer costs have caused producers to strive for better use of the N already on the farm (manure, sods, cover crops, etc.) to meet N requirements of silage corn. However, at the end of the growing season, unless drastic yield losses are observed, it is often difficult to determine if the corn crop had enough N for optimum yield that growing season. An end-of-season stalk nitrate test for evaluation of the N supply during the growing season is useful as a management tool as it helps identify if adjustments in N management are needed in future years. In 1996 researchers at Iowa State University developed a new tissue test: the Corn Stalk Nitrate Test (CSNT). In their studies, this plant test could evaluate management practices used in any corn field in any year.

Since it was first developed, the CSNT has gained use in several parts of the US and over the past three years we have tested its performance under New York growing conditions. In this fact sheet we summarize our research findings and give interpretations for New York soils and growing conditions.

Sampling procedure

Timing

For corn silage, samples could be collected starting one week prior to harvest until four days after harvest.

Method

The portion of the stalk used for the test is important as the test is calibrated for the nitrates that accumulate in this part of the stalk. First measure up 6 inches from the soil surface and cut the plant. Then measure 8 inches up from this first cut, and make a 2nd cut. These cuts result in an 8-inch sample taken from between 6 and 14 inches above the ground (see Figure 1). Make sure not to touch the soil with the corn stalk segment; contamination with soil will impact test results. Split each stalk into four parts by cutting it lengthwise using a clean kitchen knife. Discard 3 of the 4 quarters. This will quicken the drying process without compromising on the number of plants sampled. In a uniform field (≤15 acres in size), fifteen 8-inch segments should be randomly cut and combined to make one sample to be submitted for analysis. Areas differing in management or soil type should be sampled separately. Similarly, fields that are more than 15 acres large should be subdivided into smaller sampling units.

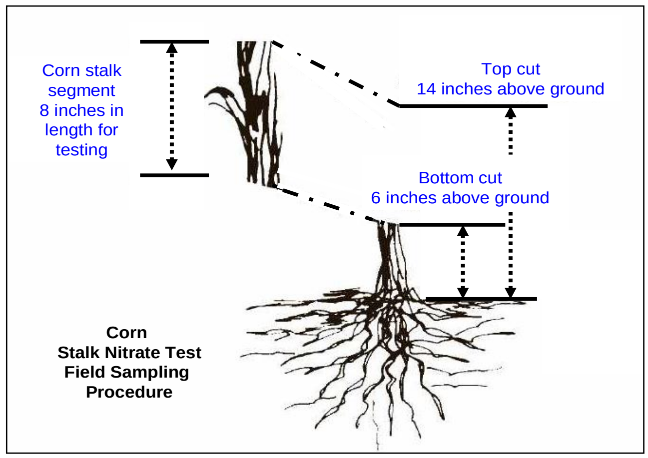

Figure 1: Sample an 8-inch segment of the corn stalk between 6 and 14 inches above the ground.

Sample submission

Samples should be submitted as soon after collection as possible. Samples should be placed in a paper bag (not plastic). This allows for some drying to occur and minimizes growth of mold. Samples should not be stored for more than 1 day before shipment to the laboratory. See http://nmsp.cals.cornell.edu to download a sample submission form. Samples can be submitted for CSNT analyses to:

Quirine Ketterings
Nutrient Management Spear Program
Dept. of Animal Science, 323 Morrison Hall,
Cornell University, Ithaca NY 14853

Interpretation of test results

Research conducted in New York supports the following interpretations:

- Low = less than 250 ppm N
- Marginal = 250 to 750 ppm N
- Optimal = 750 to 2000 ppm N
- Excess = greater than 2000 ppm N

Low – Marginal – Optimal - Excess

Low (deficient)
Plants had difficulty accessing enough nitrogen in these fields. Nitrogen access was hindered by inadequate supply, root restrictions, lack of moisture, or nutrient deficiency interactions. At harvest time, leaves are dead to or above the ear leaf and/or the entire plant has a light to very light green color.

Marginal
In some years, yields could have been increased with some additional N. In those years, plants look like described as above. In other years, the N supply was sufficient. Since it is difficult to predict what kind of growing conditions a season will bring, farmers are advised to target CSNTs in the optimal range.

Optimal (sufficient)
Nitrogen availability was within the range needed for optimum economic production of corn. In this range, three of the five lower leaves will be dead by harvest time while the top leaves remain medium to dark green.

Excess
If the sample has more than 2000 ppm N, the corn had access to more N than it needed for optimum yield. Most likely, fewer than three leaves from the bottom will have died; the top leaves remain medium to dark green. If manure and/or N fertilizer was applied, the application(s) supplied more N than the crop needed that growing season.

Multiple Year Assessment
This test is not meant as a one time measurement; it is most effective when used for multiple years on the same field (or fields with similar histories) to determine how the fields respond to the way N is being managed. However, if fields test 3000 ppm or higher in CSNT, there will be opportunities to cut N application rates without impacting yield after just one year of results. Crop history, manure history, other N inputs, soil type, and growing conditions all impact CSNT results and crop management records that include these pieces of information can be used to evaluate CSNT results and determine where changes can be made.

Summary
The CSNT reflects N availability during the growing season. The greatest benefit of this test is that it allows evaluation and fine-tuning of N management for each specific field. It does, however, require multiple years of testing to gain experience with on-farm interpretation. Corn stalk nitrate test results >2000 ppm indicate excessive levels of available N during the growing season. If such high CSNTs occur multiple years in a row, consider lowering fertilizer and/or manure application rates.

Additional Resources:
- New York State Corn Nitrogen Calculator: nmsp.cals.cornell.edu/software/calculators.html
- Cornell Guide for Integrated Field Crop Management: www.fieldcrops.org.
- Cornell University Agronomy Fact Sheet #2: Nitrogen Basics – The Nitrogen Cycle. nmsp.cals.cornell.edu/guidelines/factsheets.html.
- Cornell Nutrient Guidelines for Field Crops: nmsp.cals.cornell.edu/guidelines/nutrientguide.html

Disclaimer:
This fact sheet reflects the current (and past) authors' best effort to interpret a complex body of scientific research, and to translate this into practical management options. Following the guidance provided in this fact sheet does not assure compliance with any applicable law, rule, regulation or standard, or the achievement of particular discharge levels from agricultural land.

For more information

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http://nmsp.cals.cornell.edu

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