Adaptive Nitrogen Management in Corn using the Adapt-N Tool

Results from 2011 Strip Trials
What Have We Learned?

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Harold van Es, Jeff Melkonian
Bob Schindelbeck, Art DeGaetano, Laura Joseph
A Quick Review of Adapt-N
Precise Estimation of Corn N Fertilizer Needs

**Large losses occur AFTER crop demand is satisfied**

There are Win-Win Opportunities!

**NITROUS OXIDE** (Greenhouse Gas)

Snyder et al., 2009, based on Bouwman et al., 2002

**NITRATE LEACHING** (Water Pollution)

van Es et al., 2002

**RETURN TO N** (Profit)

Sawyer, 2005, Iowa State

**0.05**

**0.10**

**0.15**

**0.20**
Many sources of variation in N availability → generalized recommendations less applicable for corn N needs

Sources of Variability:

- Soil type differences and organic matter contents
- Organic amendments (manure, compost, etc.)
- Crop rotations
- Soil and crop management
- **Temperature**
- **Precipitation**

Can affect your fertilizer needs by 100lb N or more from year to year!

.....interact in complex ways!
Crop N uptake...
**SOM mineralization occurs ahead of corn N uptake...**

Soil or plant N

Critical Time Period – N builds up in soil before corn uptake

corn N uptake

... in normal year

Amount of Sidedress N Fertilizer Needed...

soil mineral N, normal year

Spring

Summer

Fall
Need for supplemental N fertilizer depends on early season weather ...

Determine precise N needs after Critical Time Period
Predicting N Needs for Corn: Precision for Different Times of Application

Main Factors:
- snow cover/melt
- spring rains
- summer drought

Predictability:
- intervention
- nonintervention

Seasons:
- fall
- winter
- spring
- summer
- fall
Equipment is Critical: High-Clearance Provides Greater Sidedress Flexibility
Nitrogen Management with Computational Tools

• Move from generalized to site-specific recommendations
• Allows for adaptive, *real-time* management
  - Weather conditions
  - Local soils and crop management
• Universal process-based approach
  - Incorporates system complexity through relevant processes
• Low cost
• Allows for progressive refinement
Adapt-N Infrastructure

High-Resolution Climate Data (5x5 km)
- Available to all of eastern USA in 2012
- Enables Adaptive, Field-Specific N Management
Why high resolution weather data?

Precipitation is highly localized....

June Precipitation

2009

2010

2011
“Cloud” Computing Model

• No software exchange with users, nor installation
• Server-based, with universal access through Web
  – Anywhere with internet access
  – Many platforms and operating systems (incl. tablets and smart phones)
• Easy and rapid updates
  – Databases
  – Software
• Centralized processing and records
Simply Log In On Our Website at: adapt-n.cals.cornell.edu
Select Location

Modify Location

Set Up New Location

Please identify the region, the season and the location name. You may also identify the group name if you wish.

Northeast 2011 Select Group (optional) Location Name

Please identify the latitude and longitude. You can use the map to do this; if you wish to enter latitude and longitude without using the map, you can click on the clear Lat./Lon. button to remove any information provided by the map.

Latitude (e.g. 42.443) 42.556447050 Longitude (e.g. -76.502) -73.99192535 clear Lat./Lon.

Submit New Location Cancel
Adapt-N Interface:
entering Mineral N/Cultivar info

<table>
<thead>
<tr>
<th>Application</th>
<th>Name</th>
<th>lbs N/acre</th>
<th>Placement Depth</th>
<th>Date</th>
<th>Delete Button</th>
</tr>
</thead>
<tbody>
<tr>
<td>starter (fertilizer banded with seed)</td>
<td>ammonium nitrate</td>
<td>30</td>
<td>3.0</td>
<td>n/a</td>
<td>Delete</td>
</tr>
</tbody>
</table>

You may enter one starter and up to four preplant/sidedress applications.

### Crop Information

- **Field Corn**
- **Grains: medium/early maturity (85-105 d CRM)**

**Planting Date**: 04/30/2011

- **32,500 plants/acre**
- **Select Expected Optimum Yield**
  - **Grain Cultivars (bu/acre)**
    - **Select Expected Optimum Yield**
      - **Grain Cultivars (bu/acre)**
      - **Silage Cultivars (tons(65% moisture))/acre**
      - **Sweet Corn (processing) (tons/ac, unhusked)**
      - **Sweet Corn (fresh market) (ears/acre)**

Click the submit button to submit your information.
Adapt-N Interface: entering Soil/Tillage info

Soil Information

Please select a soil texture class (New York) or soil series (Iowa) that best describes the soil in the field.

- medium: (silt loams)

Please select the estimated rooting depth. 26-30 inches

Please select the approximate slope (%) of the field. less than 3%

Was there a soil test? There was a soil test in the last 3 years.

- If you know the sample depth, please enter it in inches. Otherwise, please enter 6 inches. (inches) 6

- soil organic matter: (%) 3

Tillage System Information

Please select the tillage system for this field.

- Conservation tillage

When you've entered all your information, please click the submit button. Submit
Adapt-N Interface: entering Manure/Sod/Soybean info

When done entering all field info, click ‘Submit’ to run the simulation.
Sidedress Nitrogen Recommendation: 100 lbs N/Acre (91 - 118 lbs N/Acre)

This recommendation is based on an "Expected Yield" entry that is assumed to be the economically optimum yield for this field. The recommended range reflects the uncertainty with post-application fertilizer losses for the remainder of the growing season due to unknown future weather events. This uncertainty decreases with the progression of the growing season.

1. Calculation of Sidedress N Rate

Sidedress N rate estimated by $AdaptN = \text{CropN}_{\text{Harvest}} - \text{CropN}_{\text{Current}} - \text{SoilN}_{\text{Current}} - \text{SoilN}_{\text{postsidedress}} - \text{SoybeanN}_{\text{Credit}} + \text{Loss}_{\text{postapplication}}$

| $\text{CropN}_{\text{Harvest}}$ | 164 (lbs N/acre) |
| $\text{CropN}_{\text{Current}}$ | 1 (lbs N/acre) |
| $\text{SoilN}_{\text{Current}}$ | 45 (lbs N/acre) |
| $\text{SoilN}_{\text{postsidedress}}$ | 31 (lbs N/acre) |
| $\text{SoybeanN}_{\text{Credit}}$ | 0 (lbs N/acre) |
| $\text{Loss}_{\text{postapplication}}$ | 16 (lbs N/acre) |

Root Zone Crop Available Water

Note that these estimates are for non-irrigated corn production.

- Current root zone crop available water: **4 inches**
- Crop available water at field capacity: **4 inches**

- Full Report and Graphs (pdf file)
- Sidedress N Definitions
Sidetread Nitrogen Recommendation: No sidetread N recommended at this time (0 - 0 lbs N/Acre)

This recommendation is based on an "Expected Yield" entry that is assumed to be the economically optimum yield for this field. The recommended range reflects the uncertainty with post-application fertilizer losses for the remainder of the growing season due to unknown future weather events. This uncertainty decreases with the progression of the growing season.

1. Calculation of Sidetread N Rate

Sidetread N rate estimated by AdaptN = CropNHarvest - CropNCurrent - SoilNCurrent - SoilNpostsidetread - SoybeanNCredit + Losspostapplication

<table>
<thead>
<tr>
<th></th>
<th>lbs N/acre</th>
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<tr>
<td>CropNHarvest</td>
<td>154</td>
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<tr>
<td>CropNCurrent</td>
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<tr>
<td>SoilNCurrent</td>
<td>149</td>
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<td>SoilNpostsidetread</td>
<td>70</td>
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<tr>
<td>SoybeanNCredit</td>
<td>0</td>
</tr>
<tr>
<td>Losspostapplication</td>
<td>0</td>
</tr>
</tbody>
</table>

2. Excess N

Adapt-N has estimated that the seasonal N supplied (all sources) will exceed total crop N demand (CropNHarvest) by at least 10 lbs N/acre.

Estimated Excess N: **55 lbs N/acres**

Root Zone Crop Available Water

*Note that these estimates are for non-irrigated corn production.*

| Current root zone crop available water: | 4 inches |
| Crop available water at field capacity | 4 inches |

Downloadable pdf

- Full Report and Graphs (pdf file)
- Sidetread N Definitions
Adapt-N Results
Example Report

A downloadable pdf file provides:
- All user inputs listed for easy record keeping.
- Recommendations from Results page on interface
- Graphs describing N dynamics and relevant weather, soil water and plant parameters
Adapt-N Graphs

Cumulative Nitrogen (N) Mineralization
(all organic N sources)

Cumulative Nitrogen Uptake by the Crop
Adapt-N Graphs

Cumulative Nitrogen Losses From the Root Zone

Cumulative Nitrogen Leaching Losses From the Root Zone
Adapt-N Graphs

Other graphs provided:
- Growing Season Daily Rainfall
- Cumulative Rainfall for Growing Season
- Post-Emergence Growing Degree Days
- Post Planting Day Leaf Number
- Growing Season Daily Average Temperature

PSNT value: divide by 4
Coming in 2012:
Email/text alert system for any fields you choose

Sidedress Notifications
To setup email and/or text message notification, please complete the Notification and Monitoring sections. You will only receive information about locations for which all Adapt-N input has been provided. Email addresses and cell phone numbers will be kept confidential.

Notification
Select email notification and/or text message notification by checking the appropriate boxes. Please insure that your email address and cell phone information is correct.

☐ Email:  
If your email address needs to be updated, please send email to lje5@cornell.edu

Email Address on record:  lje5@cornell.edu

☐ Text Notification:  
If your cell phone number needs to be updated, please send email to lje5@cornell.edu identifying your cell phone number and your cell phone carrier.

Cell Phone number on record: missing
Cell Phone Carrier: missing  Update Carrier

Monitoring
You will get daily simulation updates for all farm locations that are checked.

<table>
<thead>
<tr>
<th>Group Name</th>
<th>Locations in this Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>groupTwo</td>
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<td></td>
<td>□ field10</td>
</tr>
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<td>□ stuffff</td>
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</tbody>
</table>
Questions so far?

Adapt-N 2011 Case Studies and Strip Trial Results
A Case Study on the Use of Adapt-N

How variable are recommendations on one farm? Opportunities?

James LaGioia, Harold van Es,
Jeff Melkonian and Bianca Moebius-Clune
Crop and Soil Sciences

David Shearing
WNYCMA
• Large grain farm in western New York
• 87 corn fields, nearly 1200 acres
• 76% mapped as silt loam, 23% as silty clay loam, and 1% as gravelly soil
• Soil organic matter varied from 0.9% to 9.9%

• Urea applied preplant/starter, totals around 190 lbs/ac.
• 58% of corn ground was planted early - before May 1 - and 
  42% was planted late in the season - after June 1
• Yield goals 240 bu/ac (early plant) and 200 bu/ac (late plant)
• Adapt-N tool was run every 5 days from June 6, 2011 until crop
  was too high for sidedressing
Results - N recommendations by date
early (before May 1) and late (after June 1) planted corn

Negative recommendation = excess N

Each point on the graph represents an individual field

Negative values indicate excess N
Results

N recommendations as affected by soil organic matter content, soil type and planting period.

Each point on the graph represents an individual field.
Conclusions

• Main benefit in 2011: accounting for effect of early vs. late planted fields and variable soil OM
• Early-planted corn required additional N to make up for post-planting losses from wet May weather, which would otherwise result in yield losses from N deficiencies.
• Late-planted corn had considerable excess N, especially on soils with high organic matter. Fertilizer saving for the farm would have been $11,000.
NYFVI and NRCS-CIG projects

Strip Trial Collaborators

**New York**
- Keith Severson, Cayuga County
- Kevin Ganoe, Central NY
- Chuck Bornt, Capital Region
- Sandy Menasha, Long Island
- Eric Young, Miner Institute
- Anita Deming, Michael Davis, and Eric Bever, and Mike Contessa, Lake Champlain Region
- David Shearing, Nate Herendeen, Jason Post, and David DeGolyer, WNYCMA

**Iowa**

MGT Envirotec:
- Shannon Gomes, NE Iowa
- Frank Moore, NE Iowa
- Michael McNeil, NC Iowa
- Hal Tucker, W Iowa

Iowa Soybean Association
Strip Trials

- **NY: 30 strip trials, 18 with yield data**
  - Grain
    - Corn – Corn
    - Soybean/Clover – Corn
  - Silage
  - Sweet corn

- **IA: 25 trials, 19 with yield**
  - All Grain

- **N Management**
  - Fall/Spring manure
  - Spring fertilizer N
  - IA: Fall anhydrous ammonia
Strip Trials

- Two N management practices:
  - Conventional/Grower-N rate
  - Adapt-N recommended N rate (15-140 lb lower in NY, higher or lower in IA)
- Four replications / spatially balanced design*.

*van Es et al. 2007. Spatially-Balanced Complete Block designs for field experiments. Geoderma 140: 346–352; Some trials were more or less replicated with some varied layouts.
NY Trials

• Grain:
  – Measured yields equal to/greater than Adapt-N yield goal
  – Measured yields less than Adapt-N yield goal

• Silage
NY-Grain: Yield and N Application
Measured yields equal to/greater than Adapt-N yield goal

*corn following soybean
NY-Grain: Yield and N application
Measured yields less than Adapt-N yield goal

C - Clover cover crop modeled as sod rotation

**sidedress after silking for Adapt-N, all preplant for Grower-N

Without clover field
NY-Silage: Yield and N Application

**Graph 1:**
- **Yield at 65% moisture**
- **Grower_N:** 14.2 t/acre
- **Adapt-N:** 14.4 t/acre

**Graph 2:**
- **N Application**
- **Grower_N:** 130 lbs N/acre
- **Adapt-N:** 100 lbs N/acre
Estimated N leaching losses
NY Grain Trials (10/30/11)
Estimated N leaching losses
NY Silage Trials (10/30/11)

N Leaching (Adapt-N), lbs N per acre

- Grower_N 89 lbs N/acre
- Adapt-N 80 lbs N/acre
Did NY Growers using Adapt-N gain Profit?

Effect on Profit of Using Adapt-N Recommendation in 2011 in NY

- Gained Profit: $5 - 85/ac
- Lost Profit*: $5 - 100/ac
- Unsure**:

Profit from Adapt-N Use
- Average for all trials except after clover: ~ $27/ac
- Accounting for 2012 soy & model use improvements: ~ $35-40/ac

Profits calculated using: $4/bu corn grain ($6.50/bu minus $2.50/bu for drying/trucking)
$50/T silage
$0.60/lb N cost, $8/acre for sidedressing operation
Case Study: Central NY Farm

- Donald brothers: 1100 acres of corn. Organic matter ranges from about 1 to 5%.
- N application rates currently based on recommendations from A&L Great Lakes Laboratories, generated based on soil tests by management unit
- 2011: spent $107,000 on N fertilizer
- A&L GL Labs recommended **220 lbs/ac** at sidedress
- Adapt-N recommended **80 lbs/ac**
Donald brothers reported mid-season
Adapt-N strips appeared to be a lighter shade of green – they thought the Adapt-N rate was failing miserably.

End of season results:
Field avg yield of 171 bu/ac
  Grower-N yield: 174.1 bu/ac
  Adapt-N average yield was 173.6 bu/ac
  Both ranged from 169 to 179 between strips
  → No loss in yield despite the 140 lb application rate difference

Implications:
- Assuming trial field was representative farm, Donalds would have saved approximately $70,000 in fertilizer in 2011
- Estimated N leaching losses reduced from 142 to 32 lbs/ac, by about 77%
IA Trials – Very Preliminary Analysis

• Adapt-N Rate Higher than Grower N Rate
• Adapt-N Rate Lower than Grower N Rate
Iowa: Adapt-N Rate Lower than Grower N Rate

- Trial placed in wrong part of the field
- Sidedress rate was 10 lb below Adapt-N rec

![Graph showing comparison between Grower_N and Adapt-N rates.](image-url)

- 196 bu/acre for Grower_N
- 192 bu/acre for Adapt-N
- 140 lb/acre for Grower_N
- 99 lb/acre for Adapt-N
Iowa: Adapt-N Rate Higher than Grower N Rate

LY – Yields 20-35 bushels lower than expected
So – what did we learn from 2011 Strip Trials?

- Adapt-N generally accurately estimated lower N needs, and in some cases higher N needs.
- In a few cases Adapt-N slightly under-predicted N needs, often explained by model input factors.
- NY: Most NY grower profits increased, N savings and reduced environmental losses were often considerable.
- Adapt-N will need minor adjustments.
Adapt-N for 2012 and 2013

2012:
• Adapt-N interface and PNM model improvements based on 2011 NY and IA data and feedback
  – Post-application loss probabilities
  – N immobilization and soybean credit
• Sweet corn trials
• Cover crops, price ratio correction, inhibitors, irrigation?
• Daily summaries; text/email alerts
• High resolution climate data East of 100th Meridian
• Limited extension to other Corn Belt States: MN, WI, IL, IN

2013:
• Estimation of N₂O losses
• Possibly batch-uploads of field info
Using *Adapt-N* for Site-Specific Adaptive Management

![Map of Soil Organic Carbon Content](image)

- **Soil Organic Carbon (%)**
  - 0.75 - 1.25
  - 1.25 - 1.75
  - 1.75 - 2.25
  - 2.25 - 2.75
  - 2.75 - 3.5

- **Field 1**

![NRCS Soil Survey](image)

Organic Carbon Content (%) estimated with VIS-NIR Spectroscopy (Veris Technologies)
N Sidedress Recommendation (kg/ha)

wet spring

If you have a yield monitor:
Low Risk Trial on multiple fields

• Adapt-N Pdf
• Yield
• Soil data if available
• Sidedress dates and amounts
Adapt-N is a web-based computational tool that allows for dynamic-adaptive-real-time N management in corn production.

2011 strip trials in NY and IA indicate that Adapt-N performs well. It increases profits and reduces environmental impacts.

Adapt-N is being refined and geographically expanded, and new features are added.
Workshop

Cornell Adaptive Nitrogen Management and Soil Health Workshops
Cornell University, Ithaca, NY

March 19th, 2012. 8:30 am to 5:30 pm – 6 CCA Credits
Adaptive Nitrogen Management in Corn using the Adapt-N Tool

March 20th, 2012. 8:30 am to 12:30 pm – 3.5 CCA Credits
Soil Health Assessment and Management using the Cornell Soil Health Test

http://adapt-n.cals.cornell.edu/
Web Site:

http://adapt-n.cals.cornell.edu

or

Google “Adapt-N”
Thank You!

Questions?

bnm5@cornell.edu

Funding

- New York farm Viability Institute
- USDA-NRCS Conservation Innovation Grants program
- USDA-NIFA Special Grant on Computational Agriculture (Rep. Maurice Hinchey)
- Hatch – Smith Lever Funds
- Northern NY Agricultural Development Program