NNY Agricultural Development Program
2006-2007 Project Report

Precise Nitrogen Management for Corn Production

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Background:

Deep placement of nitrogen (N) fertilizer for corn production. Successful new soil tillage management practices for corn production include the use of 'strips' or 'zones' that involve deep localized soil loosening with minimal surface disturbance. These methods maintain crop residue cover, conserve soil, and increase soil health and crop yields. With these, farmers may also apply N fertilizer through deep placement (10-12") when they perform the strip/zone tillage prior to planting. A three year replicated on-farm study in western NY has demonstrated that both the zone tillage and the deep N placement boost corn yields and improve soil health, and the combination of the practices resulted in average profit increases of $57 per acre. In this study, UAN was applied at planting (deep N placement) and contained a urease inhibitor to slow the conversion of urea to ammonium for up to two weeks (to reduce ammonia volatilization from broadcast N containing urea) It also contained a nitrification inhibitor to slow the conversion of ammonium to nitrate for up to 6 – 8 weeks, roughly corresponding to the beginning of the rapid growth and N uptake period for corn. The nitrification inhibitor was intended to protect the deep applied N from leaching, retaining more N in the root zone for the corn crop. Both the deep N placement and nitrification inhibitor also may reduce denitrification losses on fine-textured soils as suggested in a Minnesota study. There have not been any controlled trials that evaluated the N dynamics associated with deep vs. shallow N placement on different soil types, nor determined the potential for reduced N rates with increased soil health.

Precision N application. Nitrogen management for both silage and grain corn production continues to be a challenge for economic, agronomic and environmental reasons. Nitrogen fertilizer prices have recently risen 50% or more as the cost of fossil fuels have increased. Year-to-year variability in weather can affect the timing of application and amount of fertilizer to add that will meet the crop's N needs without over-fertilizing. Off-farm N losses to the environment from crop (particularly corn) production are receiving increased attention with possible legal implications. Improving crop N use efficiency is, therefore, important for maintaining or improving farm incomes from corn production, and can also reduce N losses to the environment. From past research, we have quantified the effects of various fertilizer N and manure management practices on N losses associated with corn production (see Appendix 1). This research, and other research at Cornell and elsewhere has shown a year-to-year variation in optimum N rates for corn of up to 80 lbs/acre that is due, in part, to variability in soil N as affected by early season weather. This range in optimum N rates represents an opportunity for more efficient use of N fertilizer. Based on this research, we have developed and calibrated a computer model-based approach (using the Precision Nitrogen Management Model, PNM) that accounts for the impact of early season weather on soil N to provide more precise recommendations for N management in corn. Dairy farmers are especially interested in such predictions, as fields are often manured based on estimated N availability, but may still require costly additional sidedressing in wet years. Given the high nitrogen fertilizer prices and the increased regulatory pressure to reduce agricultural N losses to surface waters and groundwater, there is a need for improved N management for corn production in northern New York. This project seeks to encourage NNY farmers and extension staff to adopt PNM-generated recommendations, allowing for more precise N management.

Methods:

Deep placement of N fertilizer for corn production. This study was conducted on sandy loam and clay loam plots at the Willsboro Farm. For each soil texture class, there were subplots representing long-term continuous corn and corn after grass under plow till and no till. Nitrogen (nitan) was applied on no-till plots through deep placement (10-12") associated with deep tillage using a two row ripper with attached tubes behind the ripper shanks for deep N placement (Photo 1a,b) and (ii) conventional sidedress. On plowed plots, N (nitan) was applied as (i) broadcast/incorporated at planting using the same two row ripper but with N applied on the surface and immediately incorporated (Photo 2), and (ii) conventional sidedress. Deep N placement (no till) and broadcast/incorporated N at planting (plow till) contained a nitrification/urease inhibitor (Agrotain Plus®)[1] at the recommended rate. The same total N (125 lbs N/acre) was applied in all treatments. The crop was planted on 5/10/07 (Seedway E224RR, 85 d RM at 42,000 seeds/acre) and sidedress subplots received N on 6/19/07. We tracked N in the soil, crop and in subsurface drainage water from the subplots. Soil samples were collected for soil health measurements prior to planting and samples for soil N (0-6", 6-12") were collected periodically from planting to sidedress. Subplots at both the sandy loam and clay loam plots had sub-surface drainage with wells where the drainage water (from below the root zone) was collected after periods of high rainfall to determine N leached out of the root zone. The subplots on both the sandy loam and clay loam plots were harvested on 8/29/07 to get crop harvest information including silage yield (65% moisture and dry weight) and crop N uptake.

Precision N application. We established different sidedress N treatments on plots at a long-term zone till and plow till tillage experiment at the Willsboro research farm. Soil samples were collected for soil health measurements prior to planting and samples for soil N (0-6", 6-12") were collected periodically from planting to sidedress. All plots were planted on 5/9/07 (Seedway E224RR, 85 d RM at 42,000 seeds/acre) and received 15 lbs N/acre starter. Different levels of sidedress N (nitan) (0, 45, 75, 105, 135 and 165 lbs N/acre) were applied on 6/19/07 as subplots in each of the tillage plots. The 105 lbs

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[1] Agrotain International LLC

N/acre treatment corresponded most closely to the PNM-model adjusted sidedress recommendation for this date, location and soil type (Appendix 2, Climate Region 7 N). The subplots on both the zone till and plow till plots were harvested on 8/29/07 to get crop harvest information including silage yield (65% moisture and dry weight) and crop N uptake.

Results:

Deep placement of N fertilizer for corn production. The application of the deep tillage/deep N placement (Photo 3) and surface broadcast treatments (Photo 4) using the two row deep ripper was successful.

Sandy loam plots. There were no significant differences in final harvest population or in silage yield among the main treatments or related to previous cropping history (continuous corn, corn after grass). (The no till/sidedress subplots suffered significant animal damage and we were unable to obtain reliable data from this treatment. Additional measures will be taken in 2008 to prevent this from occurring again.) Average harvest populations ranged from approximately 35,000 to 37,000 plants/acre. Average silage yield (65% moisture) of the plow till/sidedress treatment (19 tons/acre) was a slightly lower than the other two treatments (no till/deep tillage and N placement (20.2 tons/acre) and plow till/surface broadcast N (21 tons/acre)) (Appendix 3, Fig. 1). May and June 2007 rainfall at the Willsboro research farm was below average (Appendix 3, Fig. 2). There was very little drainage into the tile lines under the subplots in 2007. We have not analyzed the collected drainage samples for N content yet, but given the very small flows, N losses through leaching out the root zone were minimal. Since leaching is the main pathway for N loss sandy loam soils, this indicates that, for a dry early season like 2007, N availability to the crop was similar regardless of the N management practice (deep N placement, broadcast/incorporation at planting, sidedress),. Reduced early season soil N losses combined with 125 lbs N/acre fertilizer applications resulted in relatively high soil N levels following harvest (50 and 70 lbs N/acre in the top 12").

Clay loam plots. There were no significant differences in final harvest population among the treatments. (As with the sandy loam plots, the no till/sidedress subplots suffered significant animal damage and we were unable to obtain reliable data from this treatment. Additional measures will be taken in 2008 to prevent this from occurring again.) Average harvest populations ranged from approximately 33,000 to 35,000 plants/acre. Silage yields (65% moisture) were slightly lower in the plow till/sidedress (18.2 tons/acre) and plow till/surface broadcast N (17.8 tons/acre) treatments compared to the no till/deep tillage and N (20.1 tons/acre) (Appendix 3, Fig. 3) indicating a possible advantage of deep tillage/deep N placement in the clay loam soils. (Results from the upcoming 2008 growing season should allow us to test this further.) As with the sandy loam subplots, there was very little drainage into the tile lines under the clay loam subplots indicating little N leaching losses out of the root zone. Previous research has shown that denitrification N losses are more significant than N leaching losses on heavier textured soils. However, we expect that denitrification losses were low because of the relatively dry conditions (N losses by denitrification are favored by high soil moisture and temperature). Again, as with the sandy loam subplots, reduced early season N losses combined with the 125 lb N/acre applications resulted in relatively high soil N levels (50 to 100 lbs N/acre in the top 12") following harvest.

Precision N application. Soil N in the top 12" from late May to sidedress is shown for the zone till and plow till plots (Appendix 3, Fig. 4). Soil N (from mineralization of native organic matter) increased from approximately 50 lbs/acre in late May to approximately 160 lbs N/acre (zone till) and 125 lbs N/acre (plow till) in early June. The large accumulation in soil N under both tillage practices indicates the capacity of the soil to supply N when soil N losses are low due to lower than average rainfall. (The higher soil N accumulation in the zone till plots was correlated with higher soil organic matter (4.8%) in the top 6" of the soil under that tillage practice compared with plow till plots (3.9%).)

Both the zone till and plow till plots showed an N response to the different sidedress N rates. In both tillage plots, silage yields (65% moisture) increased to a maximum as sidedress N increased from 0 to 105 lbs N/acre (the PNM model recommended rate for this location) (Appendix 3, Fig. 5a (zone till subplots), b (plow till subplots)). Silage yield did not increase with sidedress N rates above 105 lbs N/acre on both the zone till and plow till plots. There was a significant yield response to the tillage practice also. Yields in the zone till subplots were 3.5 to 5 tons/acre (65% moisture) higher compared to the plow till plots at all sidedress N rates (Appendix 3, Fig. 5a, b).

Conclusions/Outcomes/Impacts:

Deep placement of N fertilizer for corn production. In 2007, there was no significant yield advantage on either the clay loam or sandy loam plots related to deep tillage and N placement in the no till subplots. (As previously mentioned, we did not have the data to compare the no till deep tillage and N placement with no till sidedress N.) Rainfall totals for May and June 2007 were low compared to the averages for these months so that soil N leaching losses were low (little drainage occurred in either the clay loam or sandy loam subplots) and it is likely that N losses due to denitrification were also low (although this was not measured directly). We believe this resulted in no advantage (reduced denitrification losses on heavier textured soils) or disadvantage (greater leaching losses on coarser textured soils) of the deep tillage/deep N placement compared to the other treatments. We will continue this testing in 2008 including an additional focus on the possible impact of the nitrification inhibitor on N losses.

One suggested management practice from this study is that a cover crop should be considered in years where there was a dry early season and significant residual soil N after harvest. We measured up to 100 lbs N/acre in some of the subplots after harvesting and past research has shown that soil N levels the following spring are generally low as a result of N losses over the fall/winter/early spring period when there is no crop cover and crop water uptake. Another suggested management guideline is to adjust N application rates for early season weather using tools like the PNM model (see below).

Precision N application. Based on our results at the Willsboro research farm in 2007 and other testing, we recommend that growers use the PNM model for more precise N management in corn production. The PNM model-recommended sidedress N rate of 105 lbs/acre was the optimum sidedress rate for both the zone till and plow till plots. There was also a clear yield advantage related to zone tillage. This should be considered as a management option where recommended (see the 2007 Cornell Guide for Integrated Field Crop Management).

Outreach:

Deep placement of N fertilizer for corn production. Results of the 2007 research will be presented at meetings in Canton (1/30/08), Plattsburgh (2/7/08) and Malone (2/8/08) in conjunction with presentations on the Soil Health NNYADP 2007 project (van Es et al.). Anita Deming (CCE Executive Director, Essex Co.) and John Idowu (Dept. of Crop and Soil Sciences, Cornell) are the contact people for these meetings.

Precision N application. The PNM model for field or farm level N application recommendations for corn will be offered in 2008 via the web. The url for accessing the interface will be made available later this winter. Training for CCE staff on the use of the interface will be held at a combined Soil Health/ PNM model workshop at Cornell University on Tuesday, March 18, 2008 ("Cornell Soils Workshop: Soil Health & Dynamic Nitrogen Modeling"). Bob Schindelbeck and Larissa Smith (Dept. of Crop and Soil Sciences, Cornell) are the contact people for the workshop.

We will also continue offering PNM model-generated sidedress N recommendations by climate region for 2008. These will be provided twice a week from late May to early July, 2008. As in the past, the recommendations will be sent out as part of an email extension bulletin to CCE staff, including those in NNY.

Next steps:

We have received NNYADP funding to continue both projects ("Deep placement of N fertilizer for corn production" and "Precision N application") at the Willsboro research farm in 2008. This will allow us to more thoroughly test deep N placement and the PNM model as N management tools for NNY, particularly since early season precipitation in 2007 was below average. Results from the 2008 field season will be presented at workshops in NNY in the winter of 2008-2009.

Acknowledgements:

We would like to acknowledge the NNY Agricultural Development Program for their generous support in 2007. We would also like to acknowledge Mr. John Altobelli (grower) and Chuck Bornt (CCE, Team Leader, Capital District Regional Vegetable Program) for their assistance with the deep ripper/deep N applicator.

Reports:

Handouts on our 2007 NNYADP-funded research were provided at the 2007 CCE Agricultural and Food Systems Inservice, 11/15/07, at the Ramada Inn in Ithaca. The handouts were from an oral presentation by J. Melkonian as part of the Field Crops Soil Management Update.

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Soil N and yield plots.

Figure 1. Mean subplot silage yields in the sandy loam plot at the Willsboro research farm in 2007. NT_DeepN = no till deep tillage and N (125 lbs N/acre) placement at planting; PT_BroadcastN = plow till, N (125 lbs N/acre) broadcast and incorporated at planting; PT_SidedressN = plot till sidedress N (15 lbs N/acre) applied as starter and 110 lbs N/acre applied as sidedress on 6/19/07). (Error bars: ± s.e.)

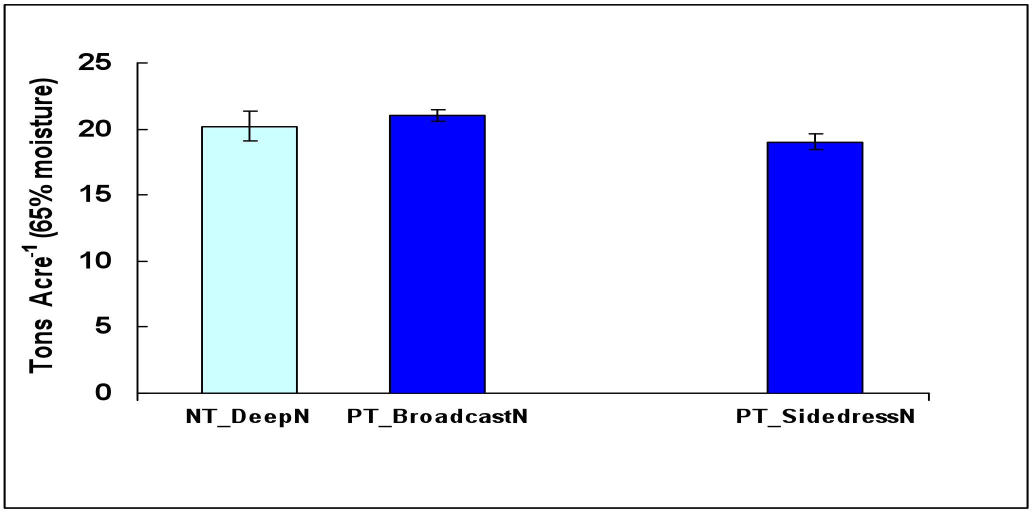


Figure 2. Long term vs. 2007 May and June rainfall totals (inches) for the Willsboro research farm.

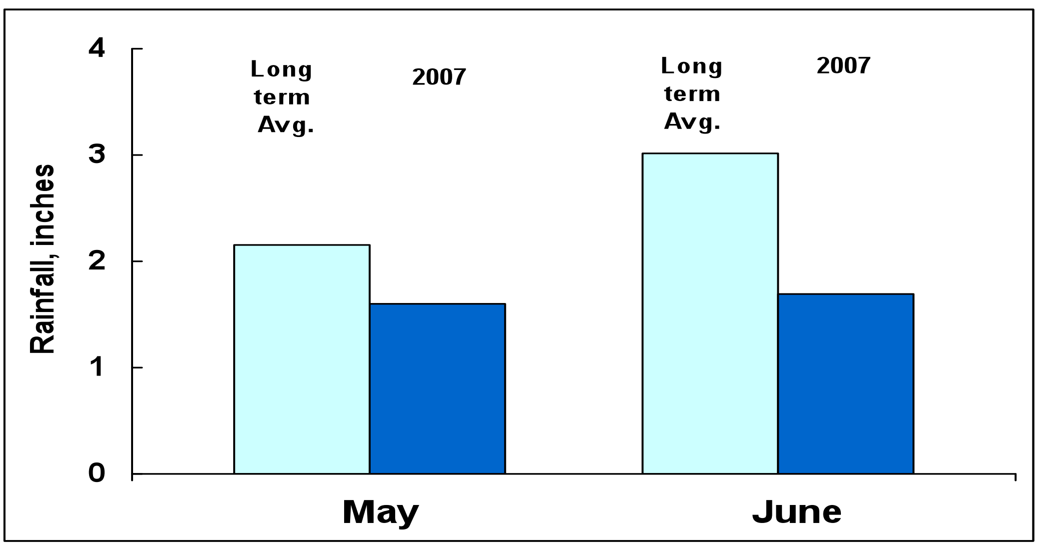


Figure 3. Mean subplot silage yields in the clay loam plot at the Willsboro research farm in 2007. NT_DeepN = no till deep tillage and N (125 lbs N/acre) placement at planting; PT_BroadcastN = plow till, N (125 lbs N/acre) broadcast and incorporated at planting; PT_SidedressN = plot till sidedress N (15 lbs N/acre) applied as starter and 110 lbs N/acre applied as sidedress on 6/19/07). (Error bars: ± s.e.)

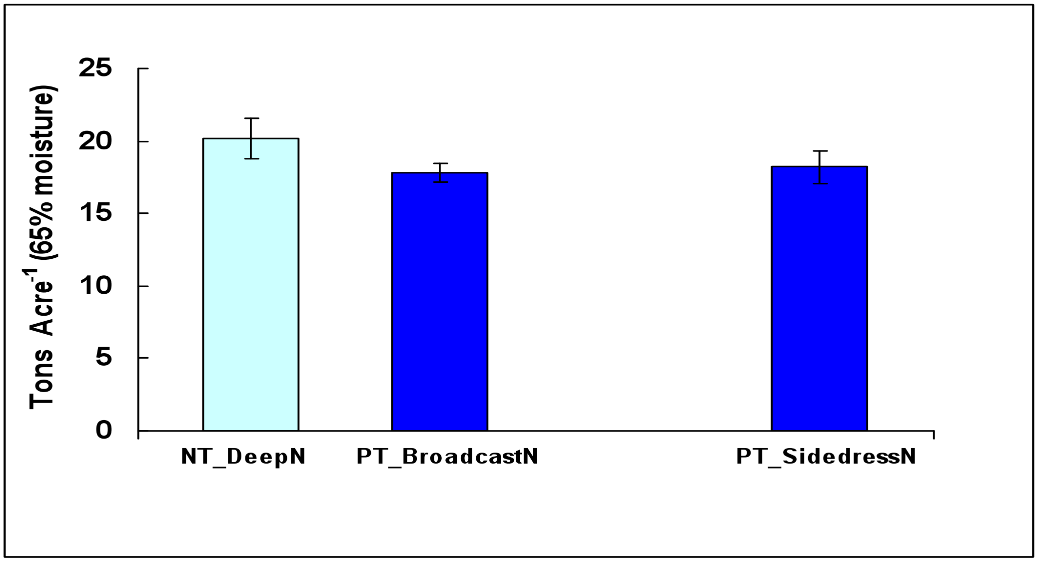


Figure 4. Soil N (nitrate-N and ammonium-N) in the top 12" of the root zone in the zone till and plow till plots at the Willsboro research farm in spring, 2007.

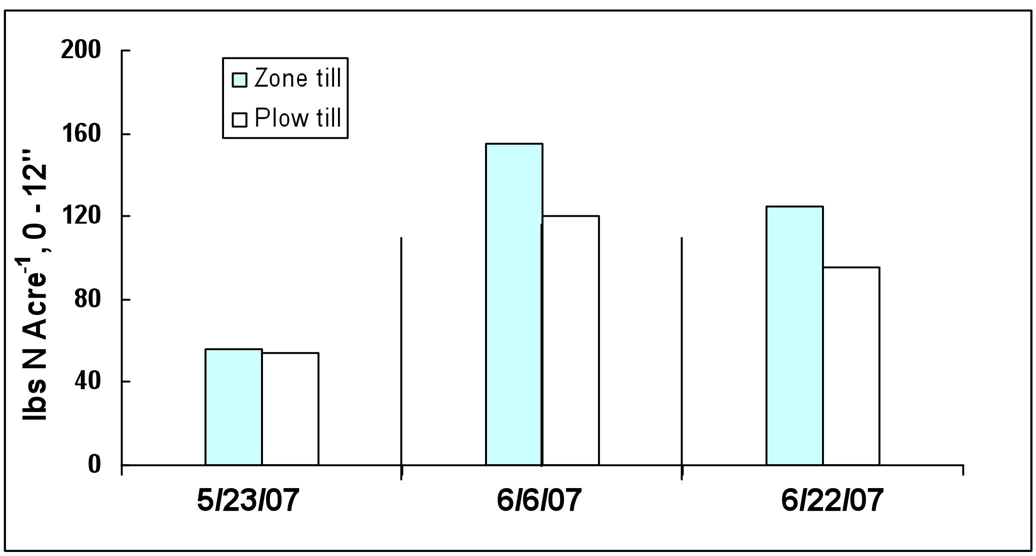
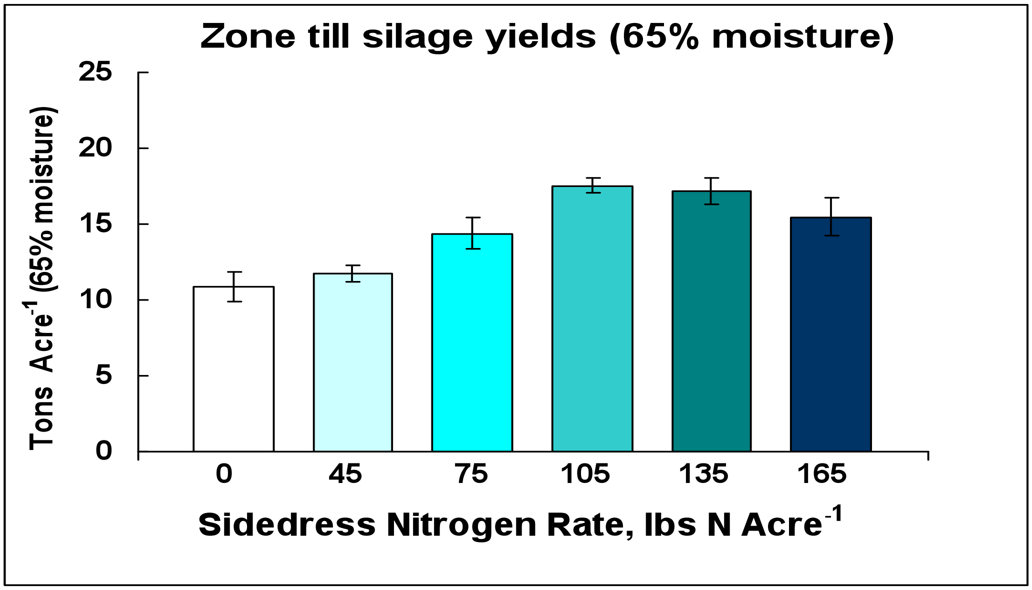


Figure 5 a,b. Mean sidedress N subplot silage yields in the zone till plots (a) and plow till plots (b) at the Willsboro research farm in 2007. (Error bars: ± s.e.)

(a)



(b)