# Northern NY Agricultural Development Program
# 2013 Project Report

## Evaluation of Yield Potentials of Corn Grain and Silage in NNY to Improve Crop Production, Nutrient Recycling and Environmental Protection


**Project Leader:**

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**Collaborators:**

- St Lawrence County: Peter Barney and Dale Morse
- Lewis County: Joe Lawrence and Terry McClelland
- Jefferson County: Mike Hunter and Chris Watkins
- Clinton, Essex and Franklin Counties: Eric Beaver and Mike Contessa
- Campus collaborators: Karl Czymmek, Animal Science; PRODAIRY); Sheryl Swink, Greg Godwin, NMSP.


**Cooperating Producers:**

- Clinton County: Adirondack Farm, B.C.S. Farm, Hidden View Farm, Leduc's Green Acres, Miner Institute's (Heart's Delight Farm)
- Franklin County: Trainer Farm
- Jefferson County: Porterdale Farms, Robbins Family Grain
- Lewis County: HanCor Holsteins
- St. Lawrence County: Greenwood Dairy Farm, Maple View Dairy, McKnight's River Breeze Farm.

**Background:**

This project is based on two questions identified by Northern New York farmers and researchers alike:

(1) With gains in corn genetics and overall crop production, should the corn yield potentials that currently drive Cornell guidelines for nitrogen (N) fertilizer and manure use be re-evaluated? and

(2) Does higher productivity mean more N needs to be supplied through manure and/or fertilizer, requiring a change in the Cornell recommendation system, or are new varieties simply better able to make use of existing N?

Cornell guidelines for N management of corn use the yield potential (YP) in bu/acre of grain multiplied by 1.2 to determine total N needed, with various N credits such as soil organic matter and sod contributions subtracted out. For fields where corn is harvested as silage, yields can be converted to grain yield estimates assuming that 1 ton silage [35% dry matter (DM)] = 5.9 bushels of shelled corn (85% DM), so if a field yielded an average of 24 tons/acre, its estimated grain yield is 142 bu/acre (24*5.9). Manure and fertilizer N is not 100% available, so the result (total N needed minus credits) is divided by an N uptake efficiency value. For example, if total N needed is 100 lbs, and the N uptake efficiency is 65%, 100/0.65 = 155 lbs of N should be supplied. If manure was applied in the past two years, manure N credits are taken into account as well.

The concept of using yield potential to determine N rates is based on the idea of fertilizing for the better crop years. In this way a theoretical average yield of the best 4 out of 5 crop years can be used to set a target N rate as a place to start.

Each of the nearly 600 different soil types in New York has an estimated YP (see Table 1 for a subset). For soils that are very poorly, poorly, or somewhat poorly drained, the assigned yield potentials increase if artificial drainage is installed. High performing soils (high YP) tend to have a greater capacity to supply soil N and to make use of fertilizer N or manure N than low YP soils (Table 2).

As a result, a higher yield does not necessarily mean that more external N is needed to produce such a yield. Lower yielding soils are often impacted by factors other than N supply (i.e., drainage, root restrictive soil layers, etc.) and tend to need the highest N applications.

Table 1: Corn yield potentials from the Cornell soils database for a subset of New York soils*.

| Soil Type | Drainage | SMG | Corn Yield Potential UDr | Corn Yield Potential Dr |
|---|---|---|---|---|
| | | | bu/acre | bu/acre |
| Kingsbury | S | 1 | 95 | 110 |
| Vergennes | M | 1 | 115 | 120 |
| Honeoye | W | 2 | 140 | 140 |
| Hamlin | W | 2 | 155 | 155 |
| Canandaigua | P | 3 | 90 | 110 |
| Tioga | W | 3 | 140 | 140 |
| Swanton | P | 4 | 95 | 125 |
| Madrid | W | 4 | 135 | 135 |
| Adams | W | 5 | 95 | 95 |
| Muck | V | 6 | NA | 150 |

*SMG = soil management group. Drainage: V = very poorly drained, P = poorly drained, S = somewhat poorly drained, M = moderately well drained, W = well drained. UDr = undrained, Dr = artificially drained. For the complete Cornell University soil database see: http://nmsp.cals.cornell.edu/publications/tables/soils_database.pdf. To convert silage yields into grain estimates, assume that 1 ton silage (35% dry matter (DM) equals approximately 5.9 bushels of shelled corn (85% DM).

Table 2: The N uptake efficiencies, soil N supply, and YP for a subset of New York soils.

| Soil Type | N uptake efficiency UDr | N uptake efficiency Dr | Soil N supply UDr | Soil N supply Dr | Corn Yield Potential UDr | Corn Yield Potential Dr |
|---|---|---|---|---|---|---|
| | % | | % | lbs N/acre | bu/acre | |
| Kingsbury | 60 | 65 | 65 | 75 | 95 | 110 |
| Vergennes | 70 | 70 | 75 | 75 | 115 | 120 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Honeoye | 75 | 75 | 75 | 75 | 140 | 140 |
| Hamlin | 75 | 75 | 80 | 80 | 155 | 155 |

Research on New York farms in the past decade has shown that although for many sites the corn yield potentials recorded in the Cornell soil database are in line with actual yields obtained, there are notable exceptions. For example, Figure 1 shows the yield data of N response trials (max yield obtained) for 19 on-farm trials, indicating actual yields exceed the yield potentials listed for four fields, all of which were in Northern New York (Stafford and Swanton soils).

Yield potentials drive the N guidelines for corn. Although the higher yields in Figure 1 for the Stafford and Swanton soils were obtained without the need for additional N, these findings do illustrate greater crop nutrient removal at these locations. A region-wide assessment of corn yields is needed to re-evaluate yield potentials for Northern NY soils and the link between the current N guidelines and yield potentials.

In past years, two approaches based on yield potential data were permissible for deriving N guidelines for corn on regulated farms:

(1) Corn yield potential for the soil type as documented in the Cornell soil database in conjunction with recommendations based on the corn N equation (Agronomy Factsheet 35); and

(2) Actual corn yield measured over a 3-year period under current N guidelines (drought years excluded; N management as in approach 1).

It is realized that using YP as the basis for an N guideline is only a starting point; variations in management, soils, and many other factors will impact actual N needs. In addition, there is variability in the conversion from silage to grain yield among varieties, fields, growing seasons, and field management conditions. Also, higher yielding fields do not necessarily need more external N to obtain such yields. An adaptive N management approach that allows for changes over time is needed.

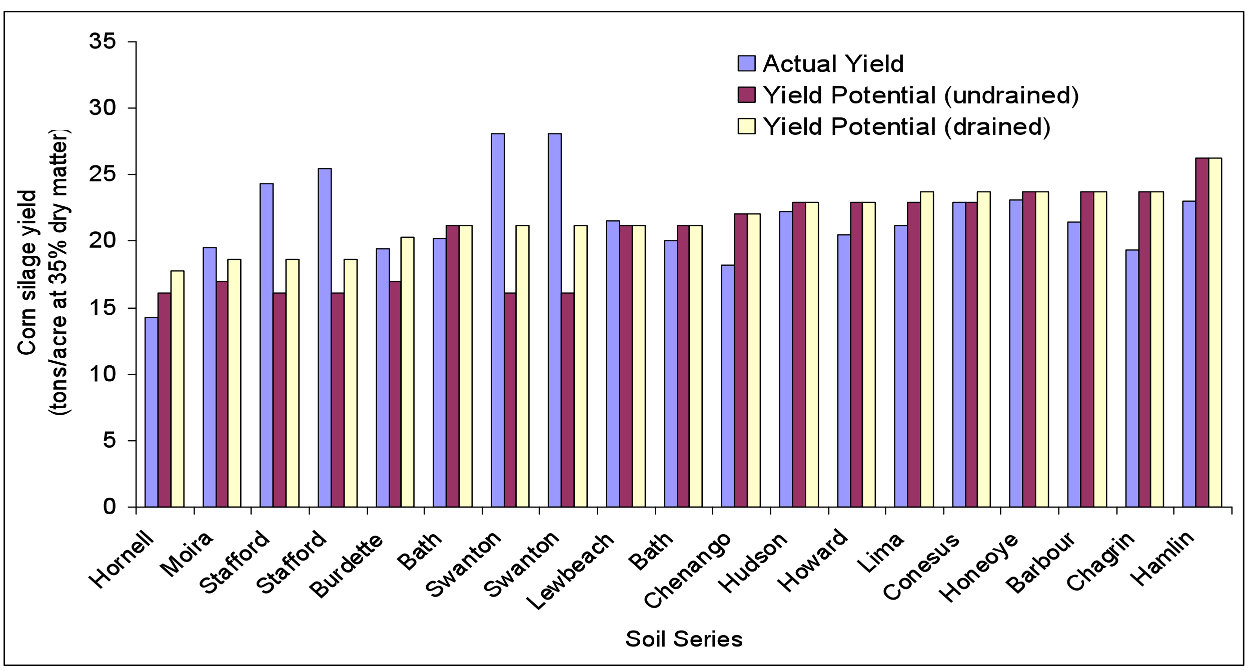


Figure 1: Actual corn silage yields (measured in on-farm trials) and yield potentials listed for the respective soils in the Cornell soil database show the need to re-evaluate yield potentials across the Northern New York region.

In consultation with agency partners involved in nutrient management planning in New York, two new adaptive management techniques were added recently that support additional fertility from manure and/or fertilizer for specific fields. The new guidance states that application of N fertilizer and/or manure *for a specific corn field* shall be based on approaches 1 or 2 above *or* one of the following two new adaptive management approaches:

(3) Findings of two years of on-farm replicated trials with a minimum of four replications and five N rates including a zero-N control treatment; or

(4) Yield measurements and the results of the corn stalk nitrate test (CSNT) and other tests such as the Illinois Soil Nitrogen Test (ISNT).

Approaches 3 and 4 are adaptive management approaches that allow producers to exceed current Cornell University N guidelines for corn (based on approach 1 and documented in Agronomy Factsheet 35).

All four approaches are approved for use within the USDA-NRCS 590 Standard. Details for each of the approaches can be found in Agronomy Factsheets 35 (Nitrogen guidelines for corn), 71 (Measuring corn silage yield), 68 (On-farm research), and 78 (Adaptive management of N for corn). Approach 4 states in more detail:

> *"If CSNT results from a 2^nd^ or higher year corn field exceed 3,000 ppm for two years, manure application information, yield data, and soil information should be evaluated to actively reduce N application rates to attempt to manage the CSNT below 3,000 ppm. An Illinois Soil Nitrogen Test (ISNT) sample is recommended to better assess soil organic N supply in these situations. Continue to use the CSNT each year until management changes reduce values below 3000 ppm. In a scenario where CSNT results exceed 3,000 ppm for one year, but not the other, measure the CSNT a third year to further evaluate current management. To account for sod N credits in a sod to corn rotation, the corn N equation should be used to determine manure and fertilizer rates for first year corn after sod."*

Experience to date has shown that accurate yield records are *the* major bottleneck on many farms for diagnosing causes of high nutrient balances, identifying solutions, designing rotations that feed the cows in a sustainable way, and confidently managing nutrients on a field by field basis.

Because home-grown forage and grain production impact all aspects of the farm (economics, nutrient use, environmental footprint, risk management, cost of production), without accurate yield records, it is nearly impossible to systematically measure progress at the field level, much less identify where the largest nutrient use efficiency gains can be made.

Thus, accurate yield records are needed, not just to evaluate the Cornell yield potential database and associated manure and fertilizer guidelines for corn, but also to help farms to more quickly achieve nutrient reductions across the entire farm operation.

## Methods:

*Part 1: Implement the Adaptive Management Protocol on 22 Northern New York Fields.*

In the 2013 growing season, 22 fields selected to evaluate yield and CSNT-N and ISNT-N were successfully harvested. The goal was to determine and document corn silage (or grain) yields for a variety of soil types and field histories, focusing on fields from all 6 NNY counties, selecting two fields per farm (four fields on one farm; no fields were identified for Essex Co.).

The fields that were selected were 2$^{nd}$ year or higher corn fields for which the yield potential was expected to exceed what is currently recorded in the Cornell yield database (http://nmsp.cals.cornell.edu/publications/tables/soils_database.pdf) by 20-25% or more.

Assuming the higher yield potential, a higher than currently recommended (based on Cornell yield potentials) manure or fertilizer application rate was to be applied although for four locations, the actual application of N equated the Cornell recommended N application based on the Cornell yield potential database. For these fields, yield data and CSNT samples were collected. Field history forms were completed so actual N recommendations and nutrient balances could be estimated. Soil samples were taken mid-season (PSNT time) to complete the dataset.

*Part 2: Evaluate State Recorded Yield Data.*
We summarized state annual corn silage and grain yields from 1919 through 2011 using the New York State annual agricultural statistics service data to determine trends in yields over time and the ratio of grain over silage yield. This database can also be used to analyze the grain to silage ratio.

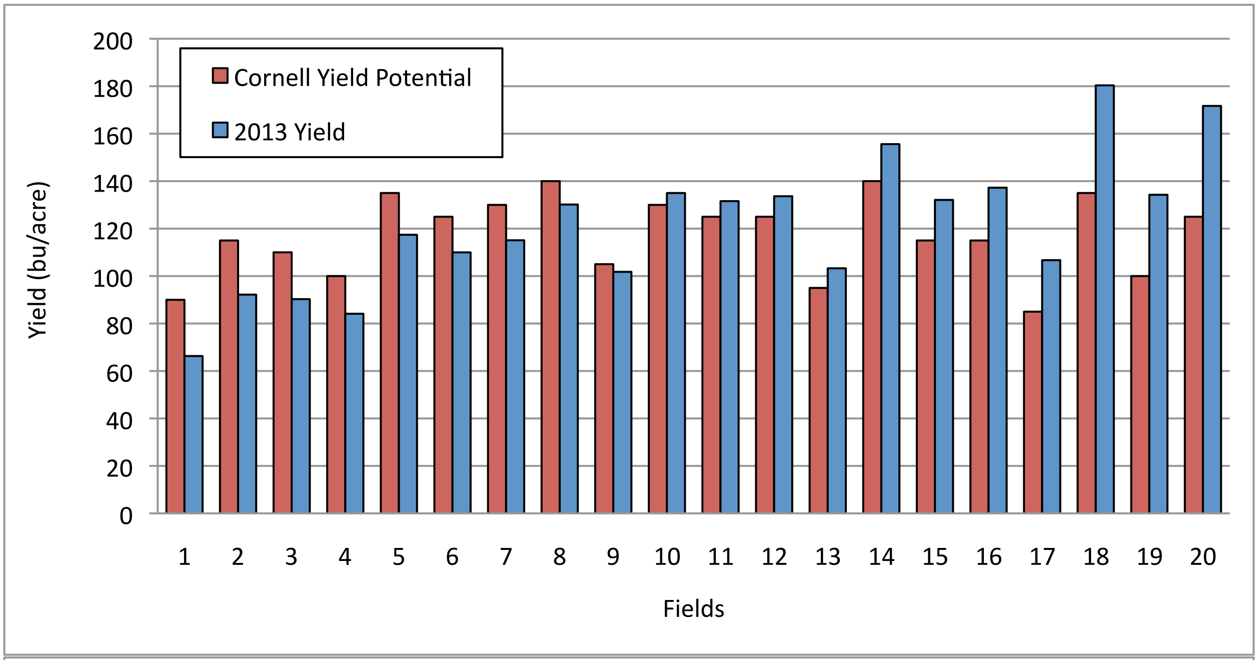
## Results:

*Part 1: Implement the Adaptive Management Protocol on 22 Northern New York Fields.*
Of the 22 field sites for which we successfully obtained yields,

- eight fields yielded less than 90% of the Cornell yield potential for the soil type (sites 1 through 8),
- eight fields yielded more than 110% of the Cornell yield potential (sites 15-22),
- while another six (sites 9-14) were less than 10% higher or lower than the listed yield potential.

On average, actual yield across all sites equaled the listed yield potential for the sites. Within each of the three relative yield groups, there was a high correlation between actual yield and yield potential but the slopes were different (Figure 2).

For five sites, the CSNT exceeded 2000 ppm, with two sites exceeding the 3000 ppm cutoff. For corn silage fields with an ISNT classified as optimal, CSNT results increased from optimal to excess with increase in ISNT level, suggesting that for such soils, no additional fertilizer N is needed. There was one grain site for which the ISNT was classified as optimal, yields were high, but CSNTs were classified as low. It is uncertain how much the late sampling of this field impacted the CSNT levels or whether the larger yield reduced overall N levels of the crop. Additional work is needed.



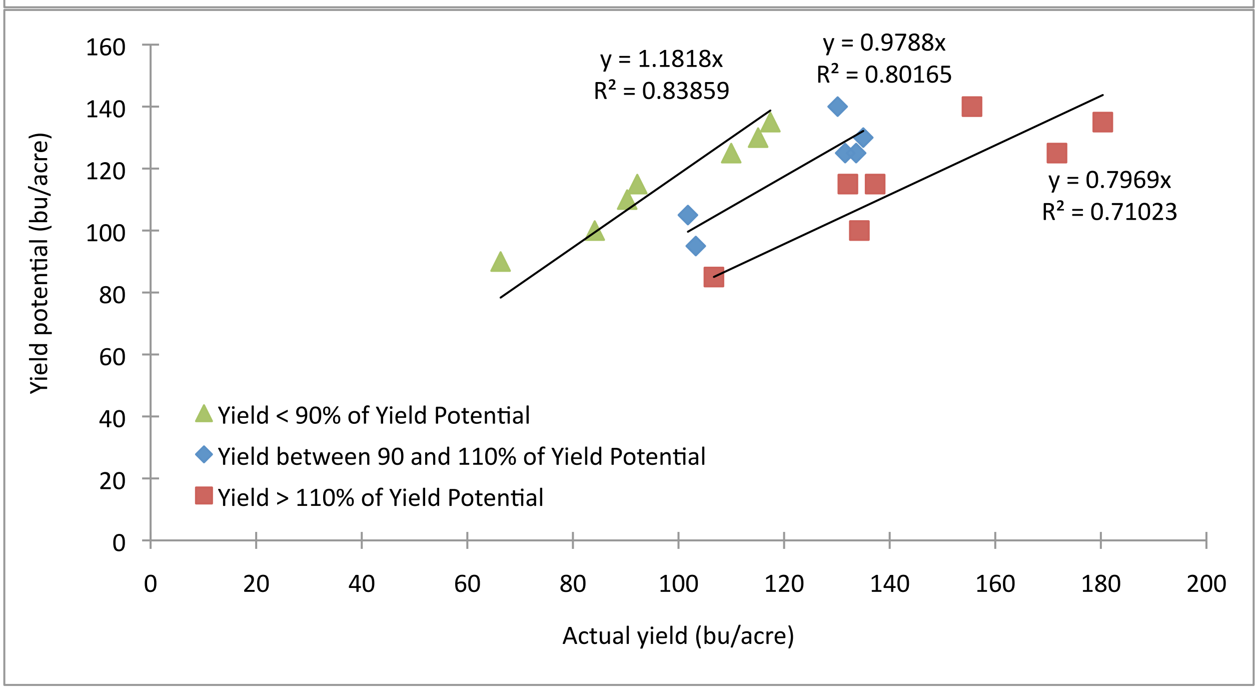




Figure 2: Actual corn silage yields (measured in on-farm trials) and yield potentials listed for the respective soils in the Cornell soil database. This database uses a conversion from silage to grain where 1 ton of silage at 35% dry matter equates to 5.9 bushels of grain at 15% moisture.

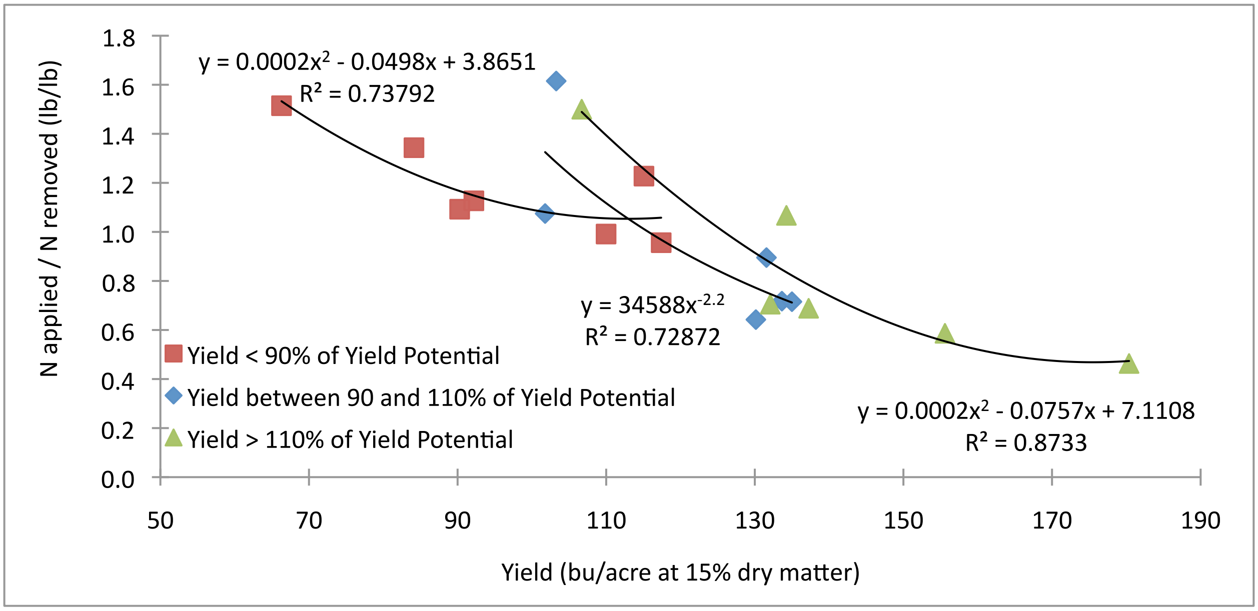



Figure 3: Ratio of nitrogen (N) applied (manure and fertilizer combined) to N removed with the actual harvest and the yield for each site. Two grain sites and a silage site missing data to calculate N-removal not included. This database uses a conversion from silage to grain where 1 ton of silage at 35% dry matter equates to 5.9 bushels of grain at 15% moisture.

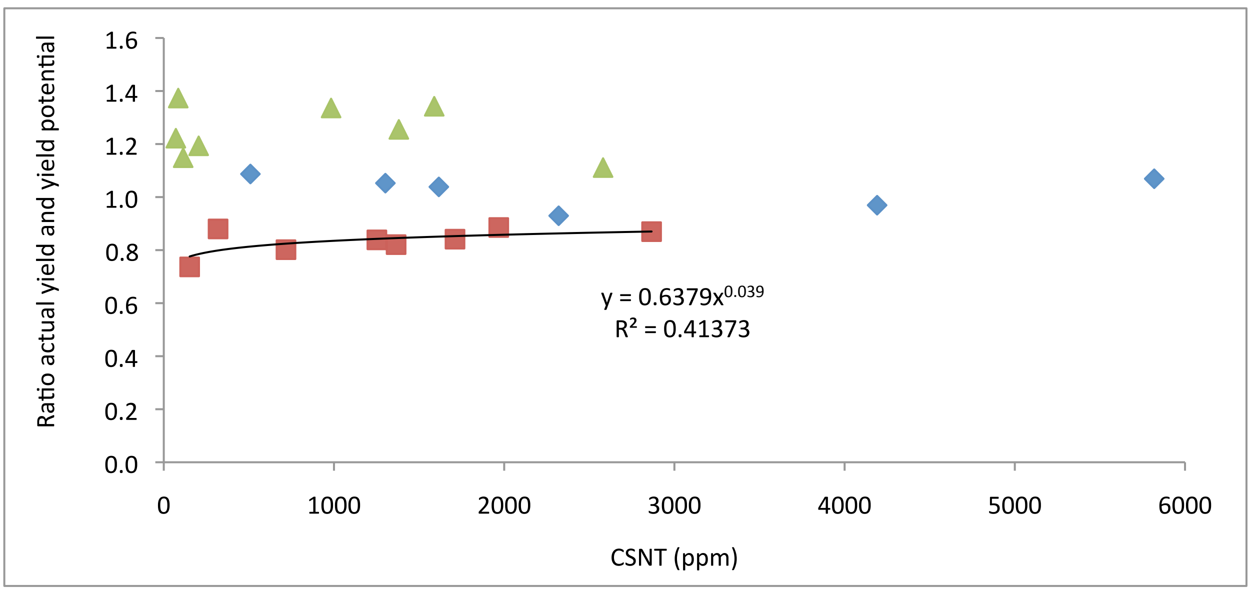



Figure 4: Ratio of actual yield to yield potential and the CSNT result for each site. This database uses a conversion from silage to grain where 1 ton of silage at 35% dry matter equates to 5.9 bushels of grain at 15% moisture.

*Part 2: Evaluate state recorded yield data.*

Corn silage and grain yields have increased over the past 40 years (Figure 5a) with a slightly greater increase per year for corn grain than for corn silage, possibly reflecting the efforts in plant breeding for grain in the past decades. The increase shown in Figure 5 compares to the statewide increases over the same period (Figure 5a).

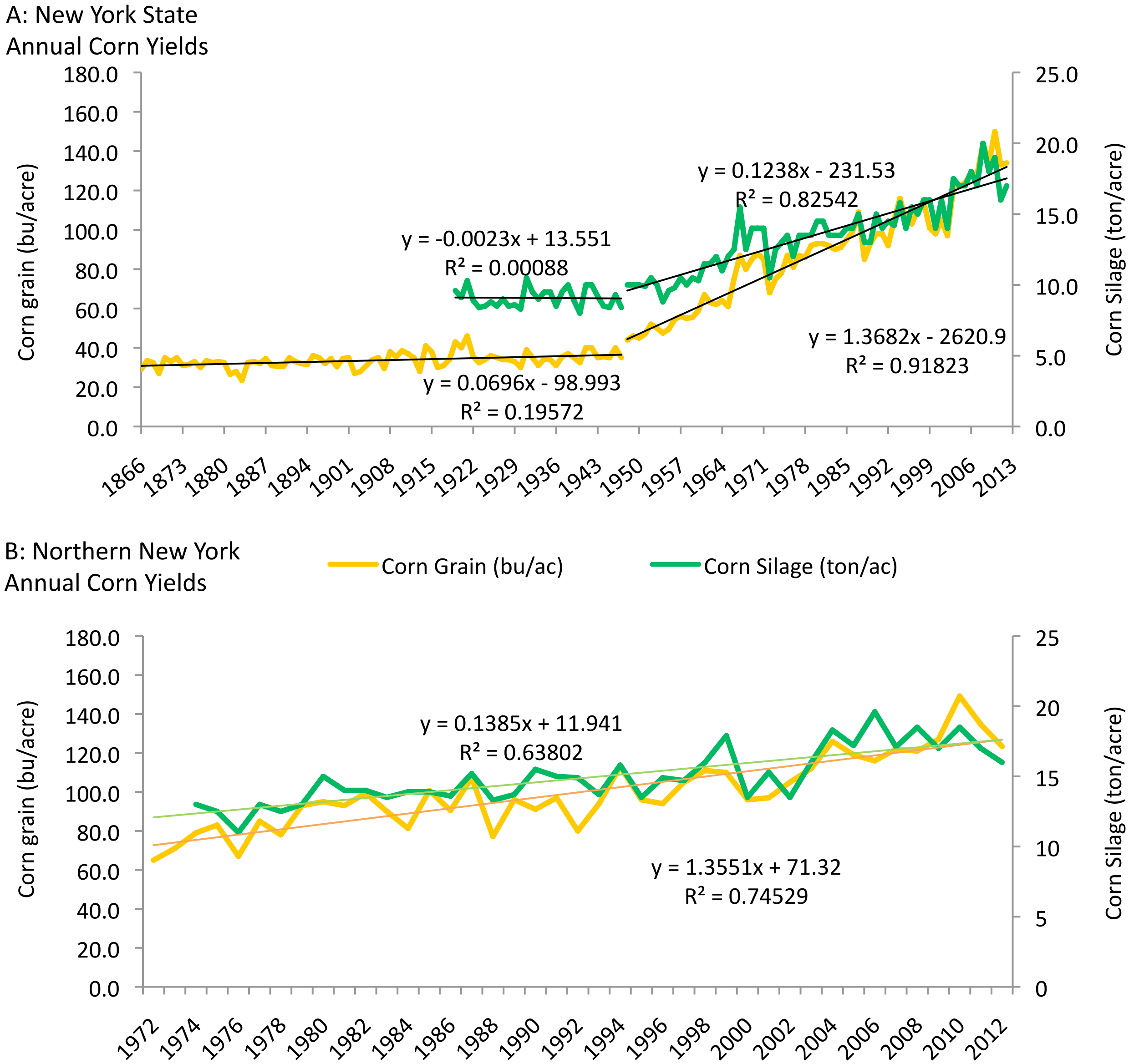



Figure 5: New York State (A) and Northern New York (B) average corn silage and grain yields over time show a steady increase since 1948 in both silage and grain yields but also large year to year variation. Yield data source: New York State Agricultural Statistics Service.

The slightly greater increase in corn grain yield as compared to corn silage yield resulted in an increase in the ratio of grain to silage from an average of 6.3 bu/ton in 1974–1978 (5.9 bu/ton or less prior to 1968) to an average of 7.5 in 2008–2012 (ratio = 0.0251x + 6.1985, $R^2 = 0.2147$ over the 1974–2012 time period). Currently, for fields where corn is harvested as silage, the recommendation system converts silage yields to grain yield estimates assuming that 1 ton silage (35% dry matter (DM)) = 5.9 bushels of shelled corn (85% DM), so if a field yielded an average of 24 tons/acre, its estimated grain yield is 142 bu/acre (24*5.9). Based on the data presented in Figure 3B, this ratio in the past five years averaged 7.5, suggesting that a field average yield of 24 tons/acre corresponds with an estimated grain yield of 180 bu/acre. Although the yield trends are clear and grain to silage ratios have increased over time (greater harvest index), the real question remains: do the higher yields require the addition of more additional manure and/or fertilizer N and does it matter what the soil type is?

## Conclusions/Outcomes/Impacts:

The year 2013 had it weather related challenges (excessive rainfall in June) for many areas in the state, including Northern New York. On average, yields across the 23 fields equaled the yield potentials listed for the soil types. Stalk nitrate values exceeded the 3000 ppm threshold in only two of the 22 fields. The rainfall patterns in 2013 could have influenced yields, PSNT and CSNT values and a second year is needed to be able to draw conclusions. Experiences in 2013 show that the biggest challenges with the adaptive management approach is in retrieving farm records and yield records and dealing with extreme weather conditions (excess rain in June this year; see Appendix A). We aim to focus on further enhancing our protocols for measuring yield in year 2, building on feedback from our 2013 collaborators.

## Outreach:

A website was established, as part of the NY On-Farm Research Partnership: http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/YieldDatabase.html. The protocols for field selection and sampling were added to the project website. Two factsheets on the new adaptive management approaches to N management for corn were released in October of 2013, following extensive discussions with certified nutrient management planners, NRCS, NYSDAM, and NYSDEC:

- Agronomy Factsheets #77: Nitrogen for Corn; Management Options.
- Agronomy Factsheets #78: Adaptive Management of Nitrogen for Corn.

These factsheets were shared at various extension meetings and made available through the factsheet website (http://nmsp.cals.cornell.edu/guidelines/factsheets.html). Adjustments in factsheets will be made as needed based on the findings of the project.

This is a 2-year project due to the need to reflect different growing seasons to create yield records and reliable CSNT values. Results will be shared with the participating farms and the NNY research group (collaborators listed above). Protocols for 2014 will be adjusted based on farmer and collaborator feedback. A meeting will be held in February/March of this year to discuss the project, experiences to date, and revise protocols.

## Next steps:

In 2013, we selected and sampled (yield, ISNT, PSNT, CSNT) 2$^{nd}$ year or higher corn fields for which the yield potential was expected to exceed what is currently recorded in the Cornell yield database (http://nmsp.cals.cornell.edu/publications/tables/soils_database.pdf) by 20-25% or more. We propose to continue this in 2014 for a 2-year record for each of the fields. Field history forms will be completed so actual N recommendations and nutrient balances can be estimated. Soil samples will be taken mid-season (PSNT time) and yield and CSNT data will be taken at harvest time to complete the dataset.

## Acknowledgments:
We acknowledge funding from NRCS in the form of a conservation innovation grant (CIG) that allows us to evaluate the accuracy and precision of yield monitoring equipment for corn silage on one of the participating farms in this project.

## Reports and/or articles in which results of this project have been published:
Project website (includes protocols)
1. http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/YieldDatabase.html.

## Person(s) to contact for more information:
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## Photos:
(Photos are encouraged where possible for press stories and fact sheets that might be developed from this report and previous work.) Submit photos in electronic format as attachments to this report. Photos should be at a resolution of 300 dpi in jpeg format. Include photographer's credit and suggestions for a caption, including the identity, affiliation and county.

Photo 1: Manure application at a corn silage site in the NNYADP yield potential study (Photo credit: Nutrient Management Spear Program).


Photo 1: Soil sampling and stand counts mid-season in the NNYADP yield potential study (Photo credit: Nutrient Management Spear Program).

Photo 3: Harvest of a corn silage site in the NNYADP yield potential study (Photo credit: Nutrient Management Spear Program).

Appendix: 2013 Precipitation and temperature data for 2013 yield potential project locations. The closest station with data for sites 7-9 in northern Clinton County is the site in Peru.

| Month | | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site 1 Lewis Co. (Sta. 304912, LOWVILLE) | | | | | | | | | | | | | |
| Precip. | 2013 | 2.77 | 2.65 | 2.02 | 3.17 | 2.28 | 5.19 | 5.18 | 2.20 | 2.80 | 2.46 | 7.01 | 4.60 |
| | 30-yr | 3.17 | 2.46 | 2.78 | 3.19 | 3.47 | 3.43 | 3.38 | 3.88 | 3.87 | 4.26 | 3.85 | 3.77 |
| Temp. | 2013 | 19.7 | 18.7 | 27.0 | 40.8 | 56.4 | 62.4 | 69.7 | 64.3 | 55.9 | 48.3 | 31.4 | 21.3 |
| | 30-yr | 17.4 | 19.1 | 28.7 | 42.5 | 54.0 | 63.2 | 67.4 | 66.0 | 57.9 | 46.5 | 35.9 | 23.6 |
| Sites 2 and 3 Jefferson Co. (Sta. 309005, WATERTOWN INTL AP) | | | | | | | | | | | | | |
| Precip. | 2013 | 2.20 | 2.11 | 0.99 | 3.70 | 1.64 | 6.04 | 3.06 | 2.10 | 2.81 | 4.57 | 3.15 | 2.42 |
| | 30-yr | 2.71 | 2.17 | 2.39 | 2.99 | 3.08 | 2.77 | 2.70 | 3.05 | 3.69 | 3.67 | 3.71 | 3.34 |
| Temp. | 2013 | 25.8 | 21.6 | 32.3 | 43.8 | 58.1 | 63.8 | 71.6 | 67.1 | 58.7 | 51.4 | 35.2 | 24.0 |
| | 30-yr | 20.0 | 21.2 | 31.0 | 43.9 | 54.9 | 63.7 | 68.8 | 67.4 | 59.7 | 48.6 | 38.3 | 26.4 |
| Sites 4 and 6 St. Lawrence Co. (Sta. 301185, CANTON 4 SE) | | | | | | | | | | | | | |
| Precip. | 2013 | 1.58 | 2.20 | 0.27 | 2.50 | 3.69 | 7.43 | 3.11 | 2.31 | NA | 2.65 | 3.84 | 3.17 |
| | 30-yr | 2.13 | 1.80 | 2.23 | 2.98 | 3.14 | 3.41 | 3.82 | 3.60 | 4.29 | 4.14 | 3.16 | 2.66 |
| Temp. | 2013 | 21.0 | 19.1 | 30.0 | 44.6 | 57.6 | 63.6 | 69.7 | 66.6 | 57.0 | 51.0 | 32.6 | 19.3 |
| | 30-yr | 16.6 | 18.5 | 28.8 | 43.2 | 55.0 | 64.4 | 68.7 | 67.1 | 58.9 | 47.3 | 36.5 | 23.7 |
| Site 5 St. Lawrence Co. (Sta. 305134, MASSENA INTL AP) | | | | | | | | | | | | | |
| Precip. | 2013 | 1.44 | 0.87 | 0.48 | 1.78 | 3.81 | 7.61 | 3.59 | 3.61 | 5.44 | 2.66 | 2.66 | 1.64 |
| | 30-yr | 2.15 | 1.67 | 2.10 | 2.92 | 3.18 | 3.52 | 3.53 | 3.40 | 3.55 | 3.27 | 2.87 | 2.49 |
| Temp. | 2013 | 18.9 | 19.0 | 29.9 | 42.8 | 57.7 | 63.4 | 70.4 | 66.6 | 57.6 | 49.3 | 32.4 | 17.7 |
| | 30-yr | 15.8 | 18.2 | 29.0 | 44.0 | 55.9 | 65.0 | 69.7 | 67.5 | 59.2 | 47.3 | 36.2 | 22.7 |
| Site 10 Franklin Co. (Sta. 304996, MALONE) | | | | | | | | | | | | | |
| Precip. | 2013 | 1.61 | 1.77 | 0.84 | 2.33 | 5.18 | 8.66 | 3.74 | 2.72 | 6.03 | 1.97 | 3.90 | 3.66 |
| | 30-yr | 2.23 | 1.85 | 2.26 | 3.03 | 3.29 | 3.98 | 4.16 | 4.40 | 4.01 | 4.04 | 3.14 | 2.77 |
| Temp. | 2013 | 18.5 | 17.3 | 27.4 | 40.8 | 57.2 | 62.0 | 68.6 | 64.6 | 56.6 | 48.8 | 31.1 | 17.2 |
| | 30-yr | 15.2 | 17.1 | 26.8 | 41.4 | 53.8 | 63.1 | 67.5 | 65.6 | 57.8 | 46.0 | 35.0 | 22.0 |
| Sites 7-12 Clinton Co. (Sta. 306538, PERU 2 WSW) | | | | | | | | | | | | | |
| Precip. | 2013 | 0.86 | 1.11 | 1.03 | 1.63 | 6.38 | 10.14 | 3.71 | 1.66 | 2.91 | 2.06 | 2.36 | NA |
| | 30-yr | 1.38 | 1.28 | 1.78 | 2.59 | 2.82 | 3.55 | 3.52 | 3.60 | 2.82 | 3.22 | 2.54 | 2.22 |
| Temp. | 2013 | 19.5 | 22.0 | 32.0 | 44.8 | 58.5 | 65.2 | 71.4 | 67.4 | 60.0 | 50.2 | 34.0 | 21.6 |
| | 30-yr | 19.2 | 22.4 | 31.6 | 44.9 | 56.6 | 66.0 | 70.3 | 68.5 | 60.5 | 48.3 | 37.5 | 25.9 |

The 30 year average is for years 1983-2012. NA means no data available.