Northern NY Agricultural Development Program
2014 Project Report

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

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

Background:
This project is based on two questions identified by NNY 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.

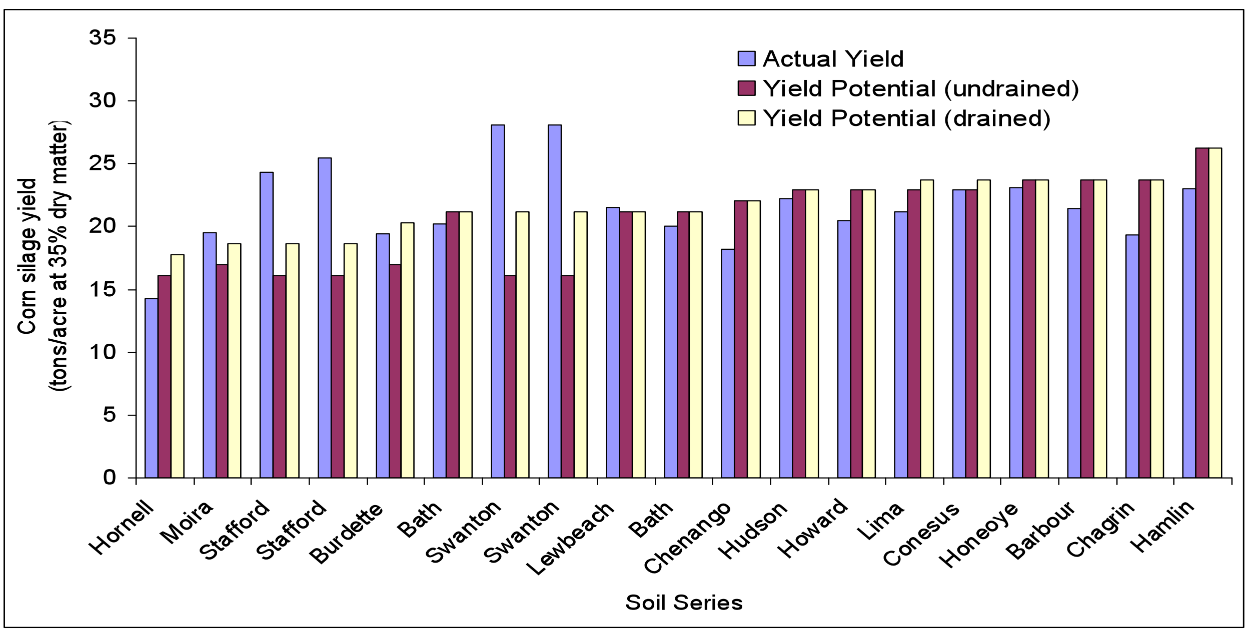

Figure 1: Actual corn silage yields (measured in on-farm trials) and yield potentials listed for the respective soils in the Cornell soil database show the need to re-evaluate yield potentials across the Northern New York region.

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 2nd 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 36 Northern New York Fields.

In the 2013 growing season, 22 fields selected to evaluate yield and CSNT-N and ISNT-N and an additional 14 in 2014 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 County).

With field selection, we targeted 2nd 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. In reality, for four fields in 2013 and three fields in 2014, the actual application of N equated the Cornell recommended N application based on the Cornell yield potential database. For all fields, yield data and CSNT samples were collected. Field history forms were completed so actual N applications 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 2014 for grain and corn silage (most recent data available) using the New York State annual agricultural statistics service data to determine trends in yields over time.

Results:

Part 1: Implement the Adaptive Management Protocol on 36 Northern New York Fields.
In 2014, 64% of the field sites were planted to brown midrib corn (BMR), compared to 18% of the fields in 2013. Of the 36 field sites for which we successfully obtained yields in the combined years, 14 fields (39%) yielded less than 90% of the Cornell yield potential for the soil type (sites 1–3, BMR corn, and 4–8 in 2013; sites 23–28 in 2014, all BMR corn), eleven fields (31%) were within 10% of the listed yield potential (sites 9–14 in 2013, one was BMR corn; sites 29–36 in 2014, three were BMR corn), while nine fields (25%) yielded more than 110% of the Cornell yield potential (sites 15–22 in 2013; site 36, BMR corn, in 2014). Actual yields compared to yield potential for each site are presented in Figure 2.

The average yield across 2013 and 2014 equaled 113 bu/acre versus an average listed yield potential of 117 bu/acre for the soil types in the study (Table 3). 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 3). It is clear that the BMR varieties averaged a lower yield than the conventional varieties, a difference that was only partially explained by the lower yield potential of the soils at some sites on which BMR corn was grown (Table 3).

Table 3: 2013 and 2014 average yield results by year, combined years, and by BMR and non-BMR corn fields as compared to the Cornell yield potential database. Average nitrogen (N) applications across fields are given as the ratio of manure plus fertilizer N applied to the Cornell nitrogen recommendation for the fields.

	Fields	Average Yield Potential across all fields	Average yield		Yield/Yield Potential	Total N applied/Cornell recommendation
	number	bu/acre	ton/acre	bu/acre	ratio (bu/bu)	ratio (lb/lb)
2013 All corn	22	119	20.9	124	1.04	2.0
2014 All corn	14	113	16.4	97	0.86	1.2
2013 and 2014	36	117	19.2	113	0.97	1.7
2013 Non BMR corn	17	122	22.3	131	1.08	1.7
2014 Non BMR corn	5	119	19.5	115	0.97	1.3
2013 and 2014	23	122	21.7	128	1.06	1.6
2013 BMR corn	4	105	14.9	88	0.83	3.4
2014 BMR corn	9	109	14.6	86	0.81	1.2
2013 and 2014	13	108	14.7	87	0.81	1.9

For five sites in 2013 and eight sites in 2014, the CSNT exceeded 2000 ppm, with two sites exceeding the 3000 ppm cutoff in 2013 and four sites exceeding it in 2014 even though N applications on those and all but two of the 2014 fields were at or no more than 10% above

Cornell recommendations. In comparison, N applications in 2013 were, on average, twice the Cornell recommendation as can be seen in Table 3.

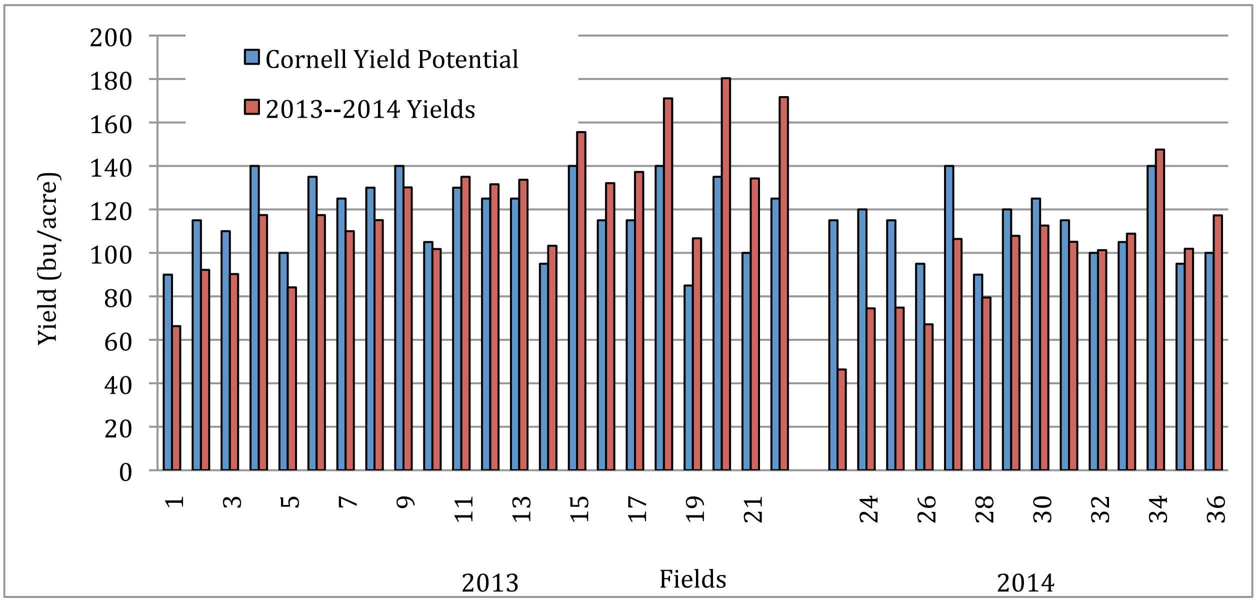

Figure 2: Actual corn silage yields (measured in on-farm trials) converted to bushels per acre and yield potentials for those fields harvested in 2013 and 2014 at sites that participated in the yield potential study. This database uses a conversion from silage to grain where 1 ton of silage at 35% dry matter equates to 5.9 bushels of grain at 15% moisture.

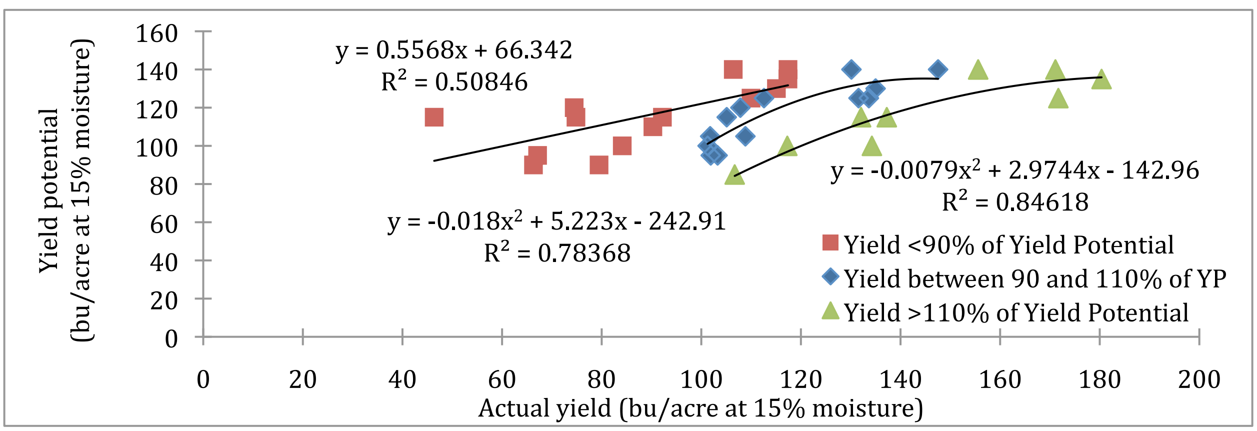

Figure 3: Actual corn yields (measured in on-farm trials) and yield potentials listed for the respective soils in the Cornell soil database. This database uses a conversion from silage to grain where 1 ton of silage at 35% dry matter equates to 5.9 bushels of grain at 15% moisture.

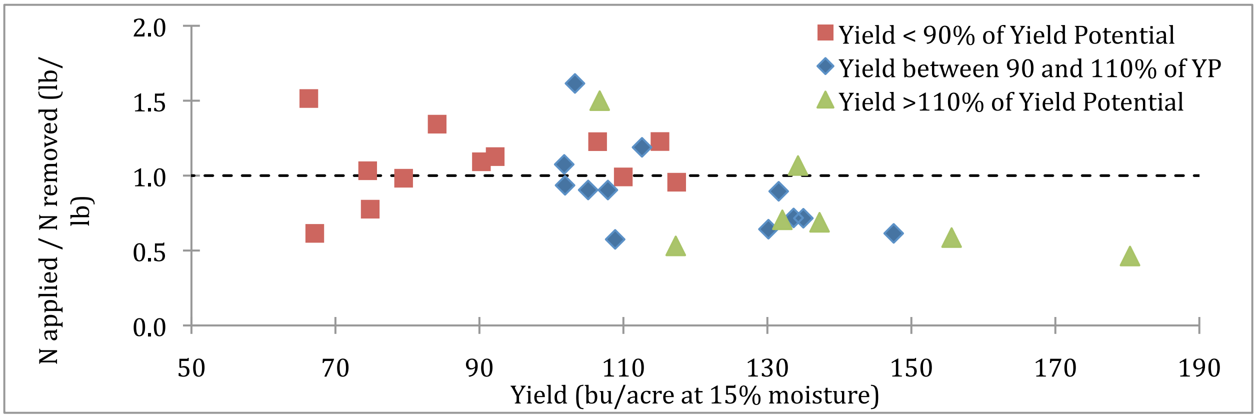

Figure 4: Ratio of nitrogen (N) applied (manure and fertilizer combined) to N removed with the actual harvest and the yield for each site. Two grain sites and a silage site missing data to calculate N-removal not included. This database uses a conversion from silage to grain where 1 ton of silage at 35% dry matter equates to 5.9 bushels of grain at 15% moisture.

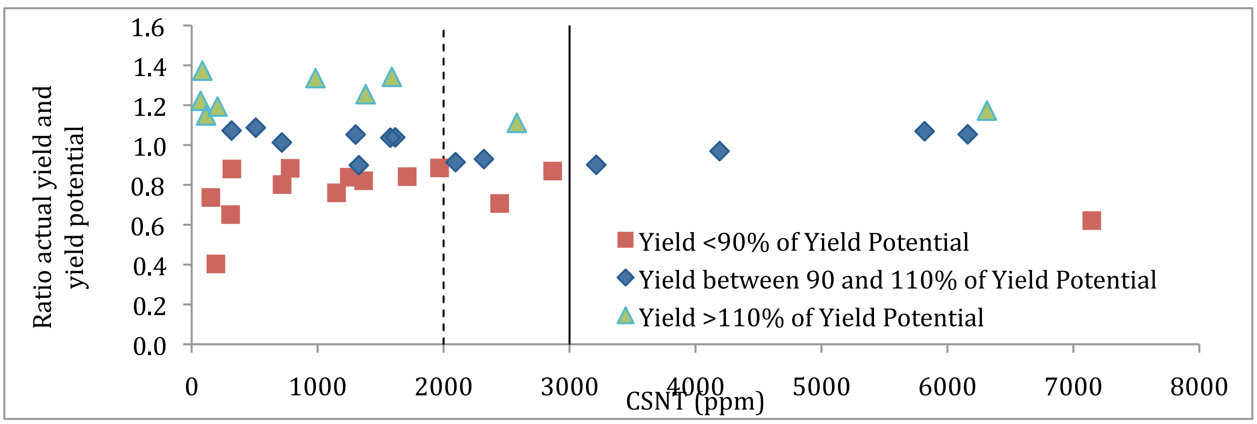

Figure 5: Ratio of actual yield to yield potential and the CSNT result for each site. Above 2000 ppm, nitrogen is considered to have been in excess of crop requirements that season. If CSNT results from a 2nd year or higher corn field exceed 3000 ppm for two years, manure applications, yield, and soil information should be evaluated to reduce N application rates and manage the CSNT below 3000 ppm. 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 6) 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.

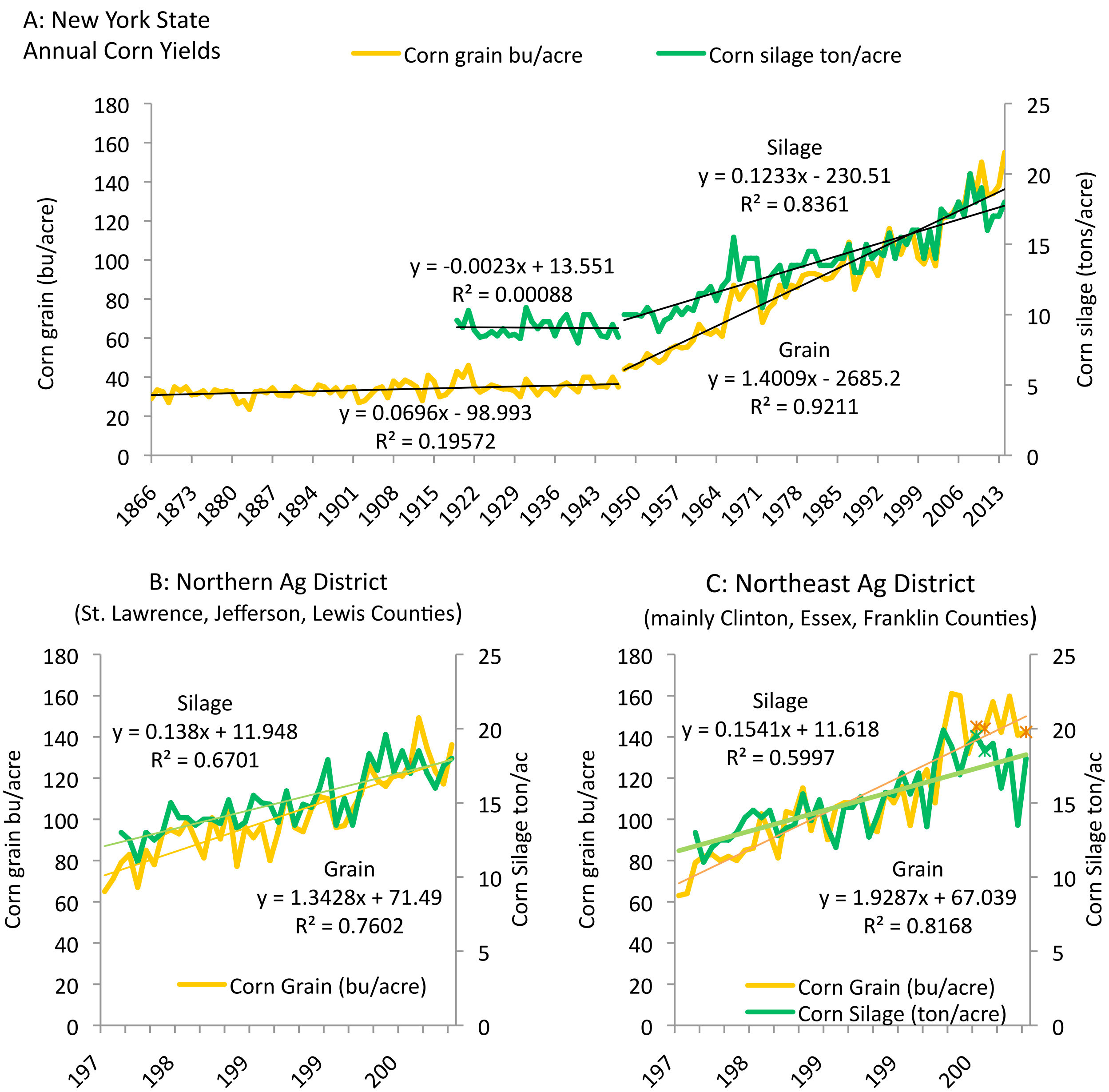

Figure 6: New York State (A) and Northern New York (B and C) average corn silage and grain yields over time show a steady increase since 1948 in both silage and grain yields but also large year to year variation. Yield data through 2014. Source: New York State Agricultural Statistics Service.

Conclusions/Outcomes/Impacts:

Both 2013 and 2014 had their weather related challenges (excessive rainfall in June 2013 and below average growing degree days in July and August 2014) for many areas in the state, including Northern New York. Clinton County sites were particularly affected both years.

On average, yields across the 36 fields equaled the yield potentials listed for the soil types.

Stalk nitrate values exceeded the 3000-ppm threshold in six of the 36 fields: two of those in the greater GDD but wet 2013 growing season, and four in the 2014 low GDD season.

The rainfall patterns and GDDs in 2013 and 2014 could have influenced yields, PSNT and CSNT values and a third year and data from additional sites (both in NNY and statewide) are needed to be able to draw conclusions.

Experiences in 2013 and 2014 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 of 2013 and to some degree in 2014, as well as reduced growing degree days in 2014; see Appendix A).

Collaborators with yield monitors faced challenges with their equipment and downloading of data in 2014, but more farms were able to weigh every load in 2014.

We aim to focus on further enhancing our protocols for measuring yield in year 3, building on feedback from our 2013-2014 collaborators. Future work will include assessment of yields across farms, through use of yield monitoring technology.

Outreach:

A website was established as part of the New York 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.
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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. Protocols for 2015 will be adjusted based on farmer and collaborator feedback.

Talks on yield potentials for corn in NY and use of technology (yield monitors and crop sensors) were given in Northern NY (2015 Crop Congress) as well as in Western NY (Corn Congress).

Next Steps:

In 2013 and 2014, we selected and sampled (yield, ISNT, PSNT, CSNT) 2nd 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. In 2015, we propose to gather data from all corn fields on a farm in a given year with yield monitoring technology so we can update the Cornell yield database quicker. We proposed to work with five farms to gather yield data and to compare those results to the current yield potential database. Yield data will be combined with field information (soil types, drainage, manure and N management, soil test data etc.) to also evaluate drivers for high yields.

Acknowledgments:

In addition to NNYADP funding, we received funding from NRCS in the form of a conservation innovation grant (CIG) that allowed 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.

For More Information:

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