Northern NY Agricultural Development Program
2021 Project Report

Expanding Adaptive Nutrient Management Options for N and P Management of Corn

Project Leader:

• Quirine M. Ketterings, Ph.D., Cornell Nutrient Management Spear Program (NMSP), 323 Morrison Hall, Department of Animal Science, Cornell University.

Collaborators:

- Crop Consultants and Nutrient Management Planners: Mike Contessa and Eric Beaver, Champlain Valley Agronomics, Peru, NY
- Cornell Cooperative Extension: NNY Regional Field Crops Specialists Kitty O'Neil, Ph.D., Mike Hunter
- Cornell University Campus: PRO-DAIRY Senior Extension Associate Karl Czymmek and NMSP Research Aide II Jonny Berlingeri
- Northern New York dairy producers (4).

Background:

Nitrogen (N) management is challenging given the dynamic nature of N; tendency for loss through leaching, volatilization and denitrification; and many additional environmental and management factors that impact plant growth and soil and plant interactions. To be accurate, N fertility guidelines need to consider the yield potential for a field as well as soil N supply, crop rotation credits (sod, soybean, cover crops), uptake efficiencies, past manure credits, and current year available N applications.

Over the past four years, we built, in collaboration with cash grain and dairy farmers and their crop consultants, a statewide dataset with more than 230,000 acres of corn grain and silage yield data to date, including almost 50,000 acres of yield data from northern New York. This database was used to set new soil yield potentials for corn grain and for corn silage for all soil types of agricultural importance in the state.

The yield data gathered over the years emphasized (1) the need for more farm-specific and field-specific yield assessments as yields per soil type across farms greatly varied (see example in Figure 1a) and large differences in yield for the same soil type on the same farm occurred (see example in Figure 1b); and (2) the need for evaluation tools to assess when and if changes should be made over time to reduce over-application while also increasing N rates where the extra N benefits yield and crop quality.

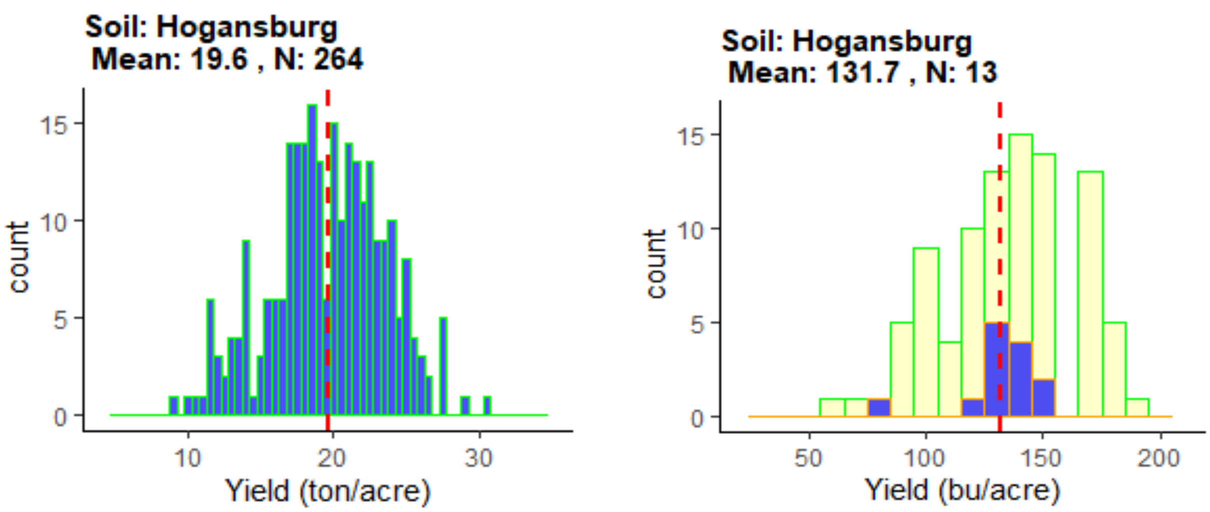

Figure 1: Yield distributions for silage yield for a soil type across farms (1a) and for grain yields for the same soil type across fields on one single farm (1b).

Since the introduction of regulations for Concentrated Animal Feeding Operations (CAFOs) in New York in 1999, CAFOs have had two state-approved approaches to derive N guidelines for corn: (1) soil type-specific corn yield potentials (documented in the Cornell University soil database) and the corn N equation (Agronomy Factsheet 35); or (2) actual corn yield measured over a 3-year period under current N guidelines and the corn N equation (drought years excluded; N management as in approach 1).

In 2013, Adaptive Management was introduced to give farms more options. The expanded policy said higher rates could be applied to fields than would have been recommended based on options 1 or 2, and without prior yield records, as long as the farm measured yield going forward and managed corn stalk nitrate test (CSNT) results below 3000 ppm over time. In 2018, in consultation with farmers, consultants, and state agencies, additional evaluation options were introduced that included implementation of a control strip and targeted CSNT sampling. Yield potential was clarified as well (Box 1).

Box 1: Adjusted Yield Potential

"Farms with at least three years of corn yield data can use actual farm yields for individual fields, for the predominant soil type within that field, or by yield potential for the soil type (if sufficient information is available) for the specific farm. With only 3 years of yield data, the lowest yielding year can be dropped from the average while yield tracking continues. With 4 years of data, the lowest yielding year can be dropped from the average to obtain a 3-year average while tracking continues. With 5 years of data, up to 2 low years can be dropped to determine the 3-year average. Once 5 years of data are obtained, maintain a rolling average (most recent 5 years) with the option to drop the two lowest yielding years from the average."

http://nmsp.cals.cornell.edu/publications/files/

In 2018, the stakeholders on the NMSP external advisory committee discussed the need for and benefits of using field balances for corn as well, but such an option could not be introduced then as there was insufficient information to determine what type of N balance was needed (how to handle manure contributions) and we could not set benchmarks.

Given the growing number of farms with yield monitor data, we can now also explore the development of (1) field-specific yield potentials, combining yield data of multiple years, and (2) field and within-field N (and P) balances. Ranking of fields then allows for identification of fields where changes in fertilizer and manure management may lead to better nutrient use efficiency, benefiting both farm economics and the environment.

With this NNYADP project, we worked with four northern New York farms to set farm-specific yield potentials according to Box 1, and to derive field balances.

Methods:

We worked with four northern NY farms with at least four years of yield data to derive multi-year yield reports that list per field the average yield and yield potentials, adjusted by the number of years of data, following the state-approved protocol for setting yield potentials (Box 1). In addition, we determined crop N and P removal and used field management information (soil type, rotations, manure history, fertilizer use, cover crops, etc.) to determine field N and P balances for corn silage fields for the four farms, for two growing seasons.

Field balances and within-field balances were derived for N and P. Phosphorus balances were derived as total P applied minus P harvested. Nitrogen supply comprised soil N (soil type-specific book values), rotation N, past manure N, and current year N (fertilizer and/or manure). Total N balances included all current year manure N while available N balances considered only plant-available N from manure. Earlier work, conducted in collaboration with Dairy Forage Systems Specialist Joe Lawrence of the Cornell PRO-DAIRY Program, showed that yield explained 81% of the variability in N uptake across hybrids. Nitrogen uptake intensity (NUI; N uptake per unit of yield) averaged 8.6 ± 0.6 lbs N per ton of silage for short-season hybrids (≤ 95 days-to-maturity) vs. 8.2 ± 0.6 lbs N per ton for longer-season hybrids. These averages were used to determine crop N uptake and removal with harvest of corn silage.

Results:

Yield Potentials

Drought and excessively wet years impact yield levels. The multi-year reports for the four farms showed the benefits of generating longer-term yield records: corn silage yield potentials averaged 0.5-1.0 tons/acre higher when the lowest-yielding year was excluded from the calculation of average year (for fields with 3 or 4 years of data), and 1.0-1.5 tons/acre higher when the two lowest years were excluded (for fields with 4 or 5 years of data). Similarly, for grain, the differences were 5-10 bu/acre when the lowest year was excluded and 10-15 bu/acre when the lowest two years were excluded. Yield potentials per field varied greatly among fields in a farm, emphasizing once more the importance of collecting farm and field-specific yield records instead of relying on book values.

Farm Cropland Balances at the Whole-Farm Level

Whole-farm average field total N balances ranged from 124 lbs N/acre to 224 lbs N/acre, averaging 145 lbs N/acre with a standard deviation of 63 lbs N/acre. The whole-farm P balance across farms ranged from 25 lbs P/acre to 137 lbs P/acre with a mean of 53 lbs P/acre and standard deviation of 45 lbs P/acre. Available N balances ranged from 38 lbs N/acre to 95 lbs N/acre with a mean of 48 lbs N/acre and standard deviation of 45 lbs N/acre.

The results clearly illustrate the need to derive both total N and available N balances for fields that receive manure. Results also show that for N balances inclusion of just fertilizer and manure N (i.e., without recognition of N pools already in the soil such as soil N and rotation N) is insufficient and can lead to overapplication of N sources. Year-to-year differences were large on some farms and small on others (Table 1). In general, differences from farm to farm were larger than differences from year to year on the same farm. Higher balances were not associated with higher yield; the highest balances occurred on the farm with the lowest overall crop yields (Table 1).

Table 1: Area weighted, whole-farm, mean and standard deviation of nitrogen and phosphorus supply and uptake and nitrogen and phosphorus balances for four dairy farms.

Farm ID	Year ID	N Uptake	N Supply Available	N Supply Total	N Balance Available	N Balance Total	P Uptake	P Supply Total	P Balance Total
		lbs/acre	lbs/acre	lbs/acre	lbs/acre	lbs/acre	lbs/acre	lbs/acre	lbs/acre
A	1	117 ± 29	199 ± 29	298 ± 70	82 ± 45	181 ± 74	23 ± 5	101 ± 51	78 ± 53
A	2	97 ± 27	192 ± 40	272 ± 44	95 ± 43	189 ± 51	18 ± 5	155 ± 47	137 ± 49
B	1	158 ± 46	195 ± 31	292 ± 59	38 ± 57	145 ± 68	32 ± 9	61 ± 24	29 ± 25
B	2	151 ± 46	206 ± 28	377 ± 77	55 ± 53	224 ± 47	29 ± 8	99 ± 37	70 ± 31
C	1	201 ± 27	217 ± 18	325 ± 50	17 ± 29	125 ± 65	40 ± 5	91 ± 30	51 ± 32
C	2	198 ± 23	222 ± 15	344 ± 46	18 ± 26	124 ± 59	38 ± 4	82 ± 18	44 ± 19
D	1	176 ± 30	212 ± 18	319 ± 50	34 ± 33	140 ± 54	35 ± 6	61 ± 21	25 ± 20
D	2	166 ± 42	215 ± 15	307 ± 46	49 ± 72	141 ± 83	32 ± 8	58 ± 30	26 ± 36
A-D	1	163 ± 33	206 ± 24	309 ± 57	42 ± 41	148 ± 65	33 ± 9	79 ± 40	43 ± 43
A-D	2	153 ± 34	209 ± 24	325 ± 54	54 ± 48	170 ± 60	32 ± 9	86 ± 83	65 ± 44
A-D	1&2	158 ± 34	207 ± 24	317 ± 55	48 ± 45	159 ± 63	33 ± 9	82 ± 43	53 ± 45

Farm Field Balances

Individual field balances ranged from -7 lbs N/acre to +404 lbs N/acre for total N, averaging 160 lbs N/acre, while available N balances ranged from -59 lbs N/acre to +233 lbs N/acre, with a mean of 55 lbs N/acre. These findings show that some fields could possibly have benefited from additional N, while others received up to 3-4 times more N than the crop was able to take up that year. Typically, fields with the highest N balances were low yielding, as shown in the example in Figure 2. Ranking fields based on balances typically results in identification of a handful of fields where reductions in N allocation can be made, and others where additional N could be considered.

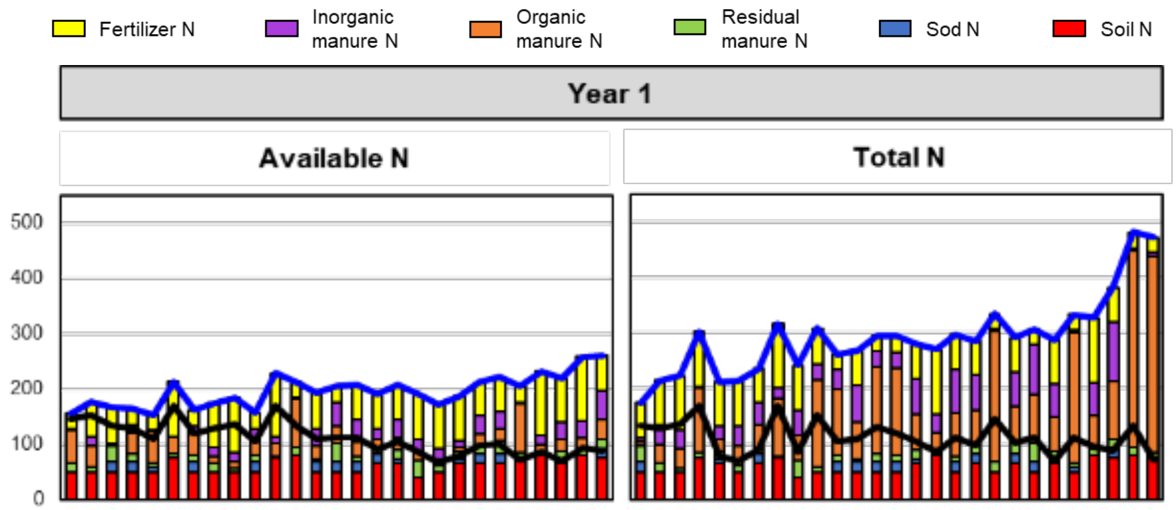

Figure 2: Comparison of crop N uptake (black lines; reflecting yield) and N supply (blue line) for all corn fields of one single farm. Fields are ranked from low balance (left) to highest balance (right).

Within-Field Balances

Within-field balances showed significant differences in balances for most fields, on all four farms. This is shown for N in Figure 3. This variability should be considered when setting feasible field N and P balances, but it also shows that within-field or zone-based, variable rate N management can lead to further improvements in N management for farms.

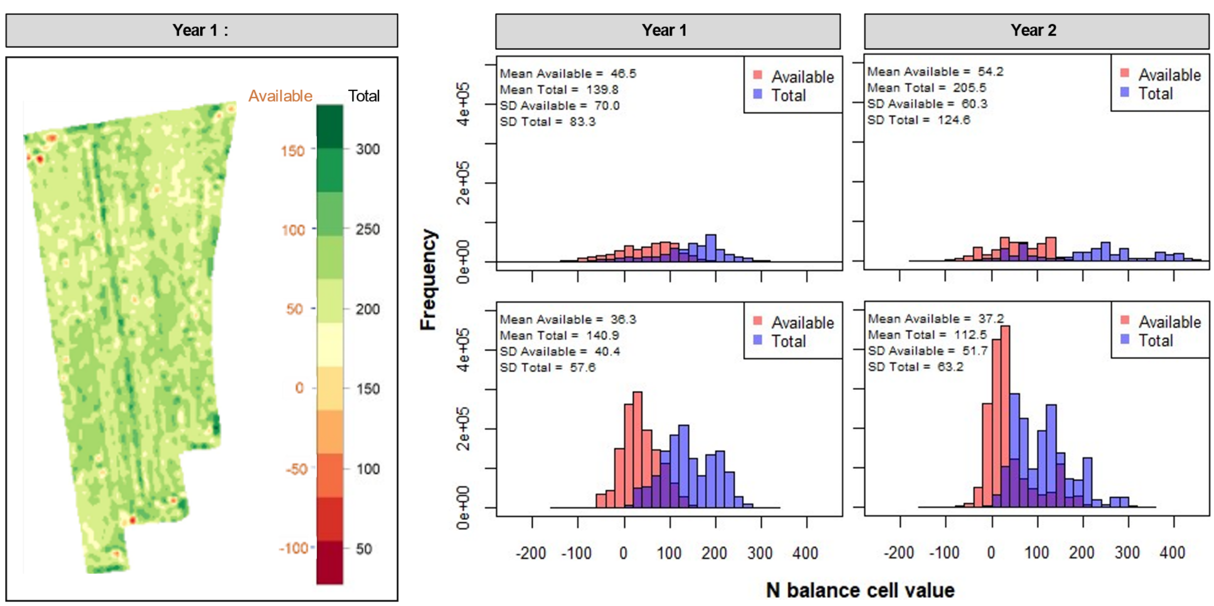

Figure 3: Within-field nitrogen balance represented as a map for a single field and as histograms for all within-field areas on one farm.

Conclusions/Outcomes/Impacts:

Based on the work with these four farms in northern New York, we conclude that:

(1) variability in corn silage N and P balances at field and within-field scales and across year is large, emphasizing the need for field and within-field (where feasible) evaluation tools and management options, and

(2) feasible limits for N balances, as part of the adaptive management approach, should include both total and available N.

Outreach:

Each of the participating farms received their annual and multi-year reports, listing yield potentials for each field with a minimum of three years of data. Field balance reports were summarized across farms and findings were shared at farm meetings and extension talks. Findings were published in a peer-reviewed journal article. The concepts of field balances were presented in two articles for the Manager, Progressive Dairy, and field balance slides were included in numerous talks on use of yield data and evaluation of field management this winter.

Extension Articles:

- Czymmek, K.J., J. Berlingeri, and Q.M. Ketterings. Soil organic matter as nitrogen source. The Manager. Progressive Dairy. pp 10-11.
- Berlingeri, J., K.J. Czymmek, and Q.M. Ketterings (2021). In pursuit of improved nitrogen management for corn silage: tracking field nitrogen balances. The Manager. Progressive Dairy. pp 11-12.

Journal Article:

- Berlingeri, J. J.R. Lawrence, S. Sunoj, K.J. Czymmek, and Q.M. Ketterings (2021). Nitrogen and phosphorus balances vary at the whole-farm, field, and within-field scales. Frontiers in Sustainability. https://doi.org/10.3389/frsus.2021.747883

Next Steps:

We continue this work with northern New York dairy farms, their staff and advisors to process yield data for 2021, generate updated multi-year yield reports, and generate field and within-field balances. Multi-year data help with identification of opportunities for improvement over time.

We are actively looking for funding and participating farms to determine field balances for farms in other regions in the state as well, with the aim to create a statewide dataset. Such a dataset can then be used to evaluate drivers for balances, to set feasible limits, and to facilitate on-farm evaluation of yield limitations and within-field, zone-based, management.

Acknowledgments:

We thank the northern New York farmers participating in the project for sharing data and providing valuable feedback on findings and scenarios to evaluate.

For More Information:

- Quirine M. Ketterings, Ph.D., Cornell Nutrient Management Spear Program (NMSP), Department of Animal Science, Cornell University, qmk2@cornell.edu, 607-255-3061, http://nmsp.cals.cornell.edu.

Photos:

Photo 1: The NMSP team met with Champlain Valley Agronomics (Mike Contessa, left) and Miner Institute (Laura Klaiber, right) collaborators to discuss, among other topics, field and within-field management of nutrients. Photo: Allen Wilder.