Northern NY Agricultural Development Program

2023 Final Report

On-Farm Evaluation of the Value of Manure

Project Leader:
Quirine M. Ketterings, Cornell Nutrient Management Spear Program (NMSP), 323 Morrison Hall, Department of Animal Sciences, Cornell University, Ithaca, NY

Collaborators:
- Crop Consultants and Nutrient Management Planners: Mike Contessa and Eric Beaver, Champlain Valley Ag, Peru, NY
- Miner Institute: Allen Wilder and Laura Klaiber, Chazy, NY
- Cornell Campus: NMSP: Juan Carlos Ramos, Manuel Marcaida, Carlos Irias, Ithaca, NY; PRO-DAIRY: Kirsten Workman
- Northern New York dairy farms

Background:
Manure contains all seventeen nutrients a plant needs making it a tremendously valuable nutrient source for crop production. In addition, manure application to fields can build soil organic matter, enhance nutrient cycling, and, in general, improve soil health and climate resilience.

It has been recognized for a long time that manure contains both inorganic and organic nitrogen (N) and not all of the N in manure is plant-available at the moment of application. Organic N is released into plant-available forms over the span of multiple years, while inorganic N can be lost when manure is surface applied at a time when the crop grown cannot benefit from its N supply. To take this into account, a manure N crediting system has been in place in NY that credits N from manure based on manure content as well as the timing and method of application.

The original manure crediting system was derived using manure sources that were common at that time, including raw liquid dairy manure and semi-composted solids. With advances in nutrition, overall farm management, and emergence of new manure treatment systems, manure that is land-applied on dairy farms currently may be very different from the manure sources that were tested to develop the crediting system. In addition, the manure crediting system currently in

place does not explicitly recognize that manure addition may increase yield beyond what can be obtained with fertilizer.

To test both the yield-enhancing properties and N supply from different manure sources, farmers in NY, including northern NY, are participating in the "value of manure project". This includes on-farm N rate trials as well as sampling for manure nutrient content and variability across farms (different manure sources).

Materials and Methods:
This project included two main components: (1) N rate field studies, and (2) manure nutrient composition variability survey. Each will be described shortly.

Field N Rate Trials:
In 2023, we implemented three N rate trials in Northern NY (NNY) with Northern New York Agricultural Development Program (NNYADP) funding (and six other trials in other parts of NY, funded by New York Farm Viability Institute). Unfortunately, the required sidedress application could not be done for one of the northern NY locations but all other locations were successfully implemented and harvested. The results of these sites were added to three identical N rate studies conducted in 2022, and earlier ones conducted in 2016 and 2017. Each trial had a split-plot design with manure (with or without) as the main treatment strips, and sidedress N rate as the subplot treatments (Figure 1). The length and width of the strips varied depending on each farm's equipment.

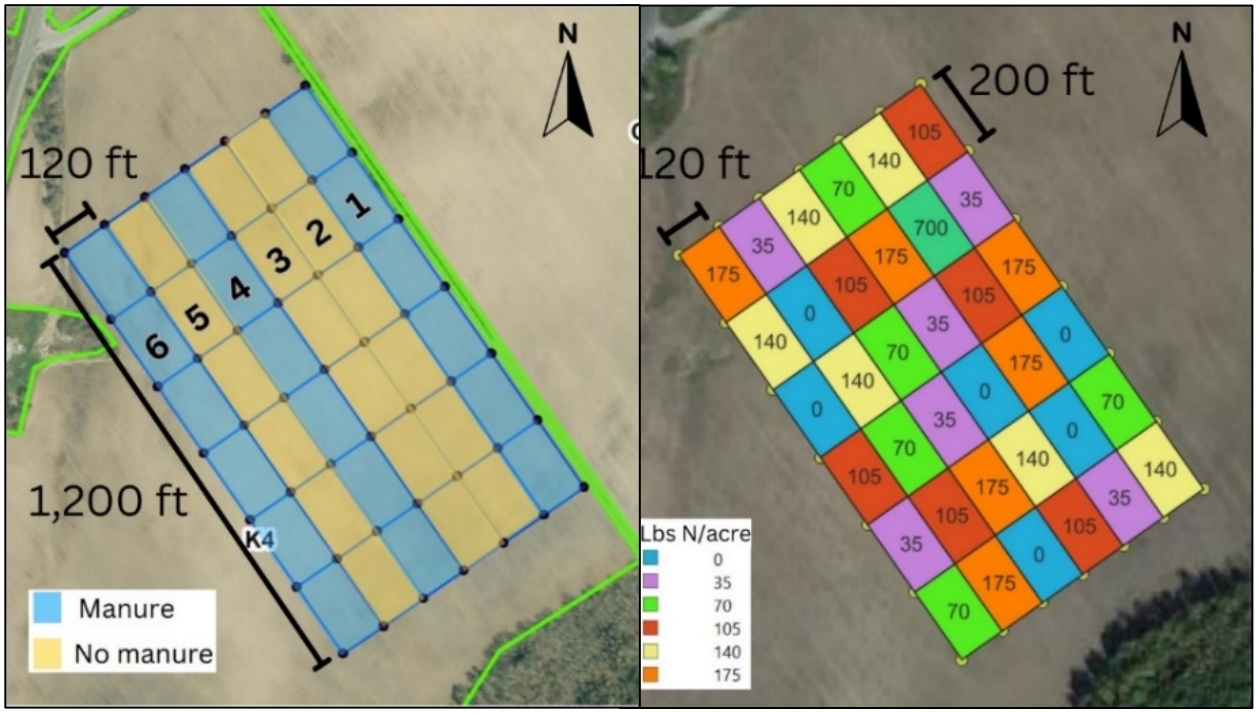

Figure 1: Field N rate trials plot design implemented on a northern NY farm in 2023. Each trial had three strips that received manure versus three no-manure strips (left picture). Manure was applied before planting. At sidedress time, each strip was subdivided into six subplots with sidedress N rates ranging from 0 to 175 lbs N/acre (right).

For the northern NY farms in 2023, 10,370 gallons/acre of dairy liquid manure were injected in April 2023 for farm A, while, for farm B, 30 tons/acre of solid dairy manure were broadcasted and incorporated 6 days after application. Both trials were planted to corn silage. At sidedress time, each strip was subdivided into six subplots that received sidedress N fertilizer rates ranging from 0 to 175 lbs N/acre at farm A, and 0 to 200 lbs N/acre at farm B.

In addition to manure samples, we collected soil samples just before sidedressing that were analyzed for the Pre-Sidedress Nitrate Test (PSNT; 0-12 inch depth) and Morgan extractable nutrients (0-8 inch depth). Forage quality and corn stalk nitrate test (CSNT) samples were taken at harvest. Both trials were harvested using a yield monitor. The same approach was taken at the other six NY sites, although manure and fertilizer rates differed to adjust to expected crop N needs. The most economical rate of N (MERN) was calculated to identify the N rate that would give the maximum economic return for both manured and non-manured scenarios. A fertilizer price of $0.73 and a silage value of $55/ton (at 35% DM) were used for this calculation.

Manure Nutrient Composition Variability Survey:

To start documenting the range in manure products that could be land-applied in NY, we sampled the manure nutrient composition of sixteen manure sources of five northern NY farms in February 2023. For each source (e.g., storage unit, barn, solid pile, etc.) we collected three 500 ml containers that were sent to analytical laboratories and analyzed for solids content, inorganic N, organic N, phosphorus and potassium content.

Results:

Field N Rate Trials:

The most economic rate of N (MERN) for farm A was 109 lbs N/acre when no manure was applied versus 0 lbs N/acre where manure had been applied, suggesting manure provided at least 109 lbs of crop available N per acre (Figure 2). When no sidedress N was applied (zero-N fertilizer subplots), the average yield in the manured plots was 4.2 ton/acre (at 35% DM) higher than when no manure was applied. Similarly, the yield at the MERN was 24.3 tons/acre when manure had been applied versus 22.9 tons/acre without manure. The predicted return at the MERN (not including cost of application) was $1,137/acre when manure was applied versus $986/acre without manure use, assuming a fertilizer price of $0.73/lb of N, and a $55 per ton silage value (at 35% DM). These results (Figure 2) reflect both the yield and fertilizer benefits of manure.

For farm B, when no sidedress N was applied (zero-N fertilizer subplots), the average yield in the manured plots was 4.6 ton/acre (at 35% DM) higher than when no manure was applied. Similarly, the yield at the MERN was 17.1 tons/acre when manure had been applied versus 12.5 tons/acre without manure. However, the MERN was 56 lbs N/acre when no manure was applied versus 113 lbs N/acre where manure had been applied, reflecting the drastic yield increase and suggesting manure supplied at least 57 lbs N/acre (Figure 2). The predicted return at the MERN (not including cost of application) was $658/acre when manure was applied versus $449/acre without manure use, assuming a fertilizer price of $0.73/lb of N, and a corn silage value of $55 per ton of silage (at 35% DM). These results (Figure 2) also reflect both the yield and fertilizer benefits of manure.

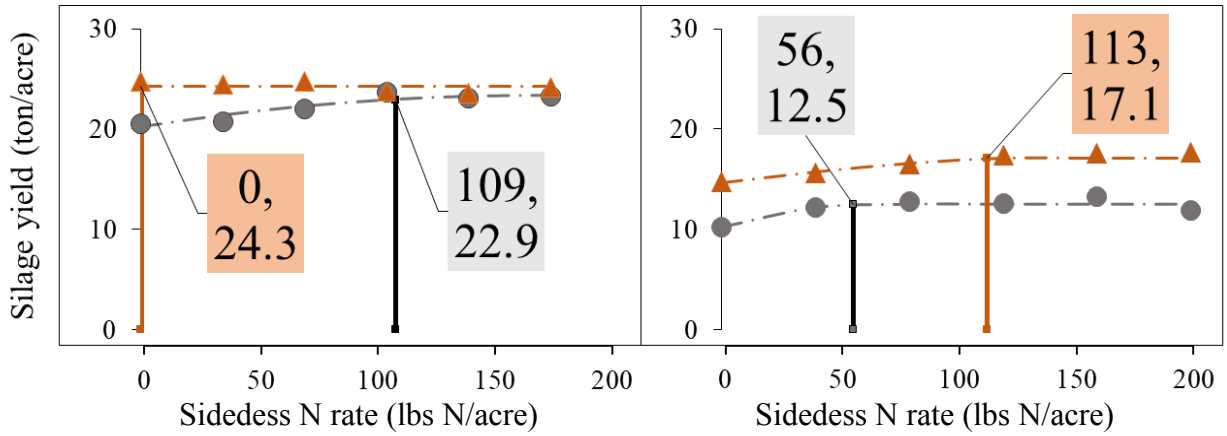

Figure 2. Effect of manure and nitrogen (N) sidedress rates on corn silage yields at farm A (left, liquid manure) and B (right, solid manure). Text boxes show the most economical rate of N (MERN) and yield at the MERN for manure (brown) and no manure plots (grey).

Both sites showed optimal to high levels for soil fertility and pH, suggesting sufficient fertility to support the crop without the need for additional P, K, Mg, etc. (Table 1). For farm A, manure application increased soil nitrate and potassium. The PSNT results increased with manure application and suggested no need for sidedress N in manure plots and a chance of yield response to sidedress in the no manure plots. For farm B, manure application increased soil test K as well while PSNT results were not impacted by the addition of the solid manure. The PSNT results for farm B also suggested a need for sidedress N for both the with and without manure plots, consistent with the observed crop response to N applied.

Table 1. Soil fertility status (0-8 inches) at PSNT sampling time in farms A and B. The predominant soil types at both farms were in soil management group 4.

Farm	Treatment	pH	NO_3+NO_2-N	PSNT	P	K	Mg
			--------- ppm ---------		-------- lbs/acre --------		
A Liquid	Manure	6.5	68a	76a	16	405a	631
	No Manure	6.5	26b	21b	12	252b	553
	P-value	0.42	0.01	0.02	0.20	0.05	0.25
B solid	Manure	6.2	17	15	14	138 a	569
	No Manure	6.1	56	20	10	97 b	564
	P-value	0.82	0.43	0.47	0.17	0.04	0.94

For farm A, manure increased forage K, Ca, Mg, and Cu content but did not impact any of the other forage quality parameters measured. Crude protein, P, K, and Cu contents were lower in the lower N sidedress subplots than in the higher rate subplots. The CSNT values were high for all the subplots that received manure (Table 2), and for plots that had not received manure and received 105 lbs/acre of sidedress N or more, which was consistent with the MERNs. For farm

B, manure increased forage soluble protein, neutral detergent fiber (NDF), and manganese concentrations but did not impact any of the other forage quality parameters measured. Crude protein and soluble protein contents were lower when less N was sidedressed. The CSNT values were optimum or higher in the plot that received 200 lbs N/acre plus manure (Table 2), and all the values were low for plots that did not receive manure.

Table 2. Corn Stalk Nitrate-N Test (CSNT-N) at farms A and B. The CSNT-N values are classified as deficient if <250 ppm, marginal if between 250 and 750 ppm, optimum if between 750 and 2000 ppm, and excess if higher than 2000 ppm. Samples analyzed in the NMSP Laboratory, Cornell University.

Farm		---------- Corn Stalk Nitrate-N (ppm) ----------					
A	Sidedress N rate (lbs/acre)	0	35	70	105	140	175
	Manure	9,011	8,217	8,818	9,291	11,067	9,887
	No manure	89	123	140	2,989	2,791	4,917
B	Sidedress N rate (lbs/acre)	0	40	80	120	160	200
	Manure	63	68	78	99	614	1,304
	No manure	44	38	40	37	139	102

At the six other locations - in western NY, central NY, and eastern NY, three sites showed both the N value of the manure (offsetting between 13 to 58 lbs N/acre) and the yield-enhancing properties of manure (yield increases between 2 and 6%) while the other sites showed no response to manure or N sidedress applications reflecting high N supply from past credits (past manure application, cover crops, and/or sods).

Manure Nutrient Composition Variability:

Manure nutrient composition was very different, impacted by the different manure management systems in the sampled farms (Table 3). Total N content was mainly driven by organic N.

Table 3. Variability in nutrient content of 16 manure sources sampled in 5 northern NY farms.

Component	Median	Minimum	Maximum	Standard deviation
Dry matter (%)	11	3	39	8
Total nitrogen (lbs/1000gal)	29	13	53	10
Ammonia-N (lbs/1000gal)	16	3	28	6
Organic-N (lbs/1000gal)	11	2	51	9
Phosphorus as P_2O_5 (lbs/1000gal)	11	6	17	3
Potassium as K_2O (lbs/1000gal)	23	7	54	11

Among the sixteen manure sources sampled from five northern NY farms, changes in total N were driven mainly by changes in organic N, with inorganic N playing a smaller role in the variability (Figure 3). Dry matter was also strongly correlated with organic N, and poorly correlated to inorganic N. Manure sources with higher dry matter contents are expected to present higher organic N contents, while inorganic N is less likely to vary with dry matter changes. In addition, the P_2O_5 content was positively correlated with S content of the manure while the K_2O content was positively correlated with inorganic N content.

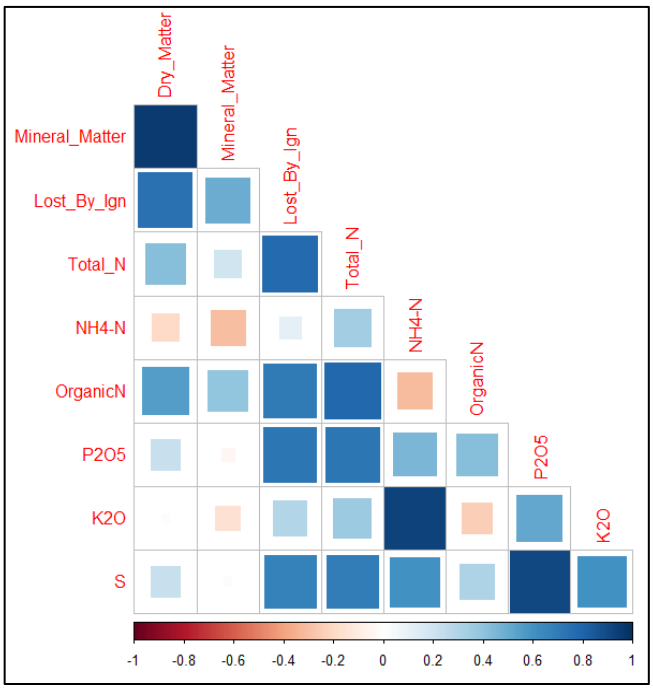

Figure 3. Manure nutrient correlation coefficients of 16 manure sources sampled in 5 northern NY farms. Bigger and darker blue or red squares represent stronger positive or negative correlations, respectively.

Conclusion: The northern NY N rate studies showed both a yield and an N benefit of manure. The data from these trials are added to the larger state-wide database that currently contains the results of sixteen on-farm trials.

Outreach:

Extension article: The Manager: Quantifying the value of manure – Taking uncertainty out of an inherently variable nutrient source. November 2023.

Software Tools: Value of manure calculator and phone app: https://valueofmanure-nmsp.glideapp.io/.

Protocols: http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/Value_of_Manure.html.

Extension Talks:

- Ketterings, Q.M. (2024). Connecting the Dots: Dairy Sustainability, Value of Manure, Yield Stability Zones. NNYADP Research Update Meetings in Chazy, NY. March 13, and in Lowville, NY, March 20, 2024)
- Workman, K., J.C Ramos, Q.M. Ketterings, and J. Oliver (2023). Manure nutrients interactive booth. New York State Fair. Syracuse, NY. August-September 2023.
- Workman, K., Dairy Support Services, J.C. Ramos, A. Augarten (2023). Manure Constituent Sensing: Panel Discussion. 2023 Northeast Region Agribusiness and CCA Training. Syracuse, NY. November 28, 2023.
- Irias, C., J.C. Ramos, and Q.M. Ketterings (2023). Nutrient Management Update. Agriculture, Food & Environmental Systems In-service. Ithaca, NY. November 7, 2023.

Winter/spring 2024: Presentations to farmers, including at 2 NNYADP Research Update Meetings. Active programming is ongoing to build an on-farm research partnership (field trials, manure sampling) around the topic of value of manure. For an invitation to participate: http://nmsp.cals.cornell.edu/NYOnFarmResearchPartnership/Value_of_Manure.html.

Next Steps:
As additional datapoints (trials) are needed for the development of a revised and refined manure crediting system., additional on-farm research trials with NNYADP support will be conducted in 2024 involving more farms in northern NY.

In 2023, we developed a web-based value of manure calculator to quickly allow for calculation of nutrient supply with manure based on our current nitrogen crediting system. This calculator can be accessed online at this link: https://valueofmanure-nmsp.glideapp.io. We propose, for 2024, to evaluate and where needed update a more comprehensive value of manure calculator http://nmsp.cals.cornell.edu/software/ManureValueCalculatorv3.xls), working with two farms participating in the on-farm trials. See https://nnyagdev.org, Research: Field Crops tab for background on the development of this project (Year 1: 2022) and the manure calculator.

Acknowledgments: We thank the farms participating in the project for their help and support hosting the trials, and for providing valuable feedback on the findings.

Photos:



Above left: Mike Contessa (CVA) marks manure strips using a GPS during manure application in a Value of Manure plot in NNY (04/12/2023). Photo credit: Juan Carlos Ramos Tanchez.

Above center: Value of manure trial in Northern NY at sidedressing time. Darker green was observed in the manure strips (06/28/2023). Photo credit: Juan Carlos Ramos Tanchez.

Above right: Corn growing on a solid manure strip in Farm B in Northern NY (6/14/23). Photo credit: Juan Carlos Ramos Tanchez.

Above: Erick Amaya (NMSP visiting scholar from Honduras) collects CSNT samples in value of manure study in Northern New York. Photo credit: Juan Carlos Ramos Tanchez.