Northern NY Agricultural Development Program
2006-2007 Project Report

Best Management Practices for the Use of Dairy Manure

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Background:

Environmental regulations, high fertilizer prices, improved manure handling and storage technologies, and steadily increasing animal densities on farms force us to re-examine manure management. Maintaining a high quality, high yielding crop has always been a priority for farmers. We must now work to sustain those yields while minimizing the potential for nutrient loss while providing farmers with management options that allow manure nutrients to be most efficiently used.

The greatest concern in applying manure is typically the fate of phosphorus (P) and nitrogen (N). These elements are macronutrients that are needed in large quantities so producers want to ensure these nutrients are readily available for crop uptake. But, both N and P could be potential pollutants if lost from the farm fields and transported to surface and/or groundwater. It is critical to understand the potential environmental loss pathways of these nutrients as minimizing loss through one pathway may lead to increasing losses through others. For instance, surface application of manure without incorporation may reduce N leaching but increase P accumulation and/or P runoff. Incorporation of manure may reduce P runoff but if amounts are not adjusted, it may lead to increase N leaching.

An additional question often asked is "How quickly do we build soil test levels with application of fertilizer or manure?" or in other words "How much P is needed to increase soil test P levels with one unit?" Recent developments in the poultry industry advocate the use of chemical Al-based amendments to lower P availability and conserve N but it is unknown how (cost) effective these amendments are for dairy manure.

Our project had three major research components: (1) assessment of the amount of P fertilizer vs manure, with or without chemical treatment, needed to raise soil test P levels with one unit; (2) runoff versus leaching losses in tile drained systems; and (3) development of outreach materials on soil fertility and nutrient management.

Phosphorus Runoff and Tile Drainage Project

Methods:
This year was the second year of rainfall simulations conducted on manured plots. Our primary objective for this study is to quantify losses of P and N in tile lines and surface runoff while evaluating the effects of manure application on orchardgrass yield, quality and nutrient uptake. We established 12 large (60' x 500') orchardgrass plots designed to collect runoff and drainage water on the Willsboro Research Farm. Baseline measurements for these plots collected in previous years include general fertility of topsoil, depth profiles, orchardgrass yield and quality, analysis of leachate samples collected from the lysimeter plot manhole sites and rainfall runoff simulations. In 2006 we conducted rainfall simulations in plots 2, 7 and 8. Yield measurements continued on the 12 large plots in 2007. Natural flow rates were measured following rainfall events of over 0.5 inches as well as at other times. The leachate was analyzed for N and P. The dates of these events are summarized in Table 1. Plots with similar flow characteristics were chosen based on flow rate measurements taken in spring 2006 and the flow histories of the plots. To increase our chances of getting runoff, sections of the plots with the greatest slopes (ranging from 3-9%) were chosen. The chosen plots, numbered 4, 5 and 6, also had higher levels of natural flow. As in 2006, three plots were chosen to receive each of three treatments for rainfall simulation runoff and leaching measurements. A control treatment received only inorganic fertilizer. The other two treatments involved the application of manure at a rate of 5000 gallons per acre (providing 25 lbs/acre P) in addition to the inorganic fertilizer. For one treatment, an Aerway soil aerator was run over the plot prior to manure application. Manure was applied to undisturbed ground for the final treatment. Manure was applied only within the area of the runoff frames. Manure treatments were applied after each cut. Rainfall simulations were performed from 3 to 5 days following the application.

The protocol followed for the rain simulation was modified from the protocol developed by the National Phosphorus Project. The equipment used and rainfall rates followed the protocol. Due to our manure treatment we did not saturate the soil the day prior to the rainfall simulation and rained on each treatment only once. We also decided to standardize the amount of time rain was applied to each plot, instead of raining until 30 minutes after runoff commences. The simulation after the first cutting followed an extremely dry spring, so the rainfall duration was increased to 2.5 hours at a rate of 125 ml/s. However, even at this rate there was no runoff or drainage from any of the treatment plots. After the second cutting a rainfall period of 1.5 hours was used. This was adequate to generate drainage in two of the three plots but runoff did not occur in any of the plots. During the simulation, all flow from the tile drain in the plot was weighed and retained to determine flow rate and total volume recovered. Samples were taken at 5 minute intervals for analysis. A bulk sample collected over the entire event was also obtained. Filtered samples were submitted to the Cornell Nutrient Analysis Laboratory for nitrate nitrogen and elemental (P) analyses. Prior to rainfall simulations, 8" soil samples were taken within the plot. Sample holes were plugged to prevent preferential flow. At the second cutting a hand harvest was performed within the runoff frames. Hand samples were also taken outside the frames for comparison with the machine harvest yields.

Research Results:

Yields: First and second cut yields of the larger plots (no manure applied) are shown in Table 2. The average 2007 yield was 2.57 tons of dry matter per acre, much less than previous years, primarily due to dry weather. Yields and forage quality were very similar between plots, identifying uniformity of the plots. Yields from all treatments of the second cut hand harvests within the frames (Table 3) were higher than those obtained by machine harvest within the whole plots. This is likely due to the treatment areas receiving rain from the simulator. To verify this, an extra set of hand harvest was conducted from outside the plots. These yields were similar to the machine harvest yields.

Leaching data – natural flow: There were few rainfall events sufficiently large to generate flow in the tile drains. When there was flow, the concentrations of phosphorus in the leachate were very low, as shown in Table 4. The highest concentration of 0.042 mg/L occurred in the spring. Nitrate nitrogen concentrations were also low (Table 5) with a high of 0.144 mg/L following a 1.6 inch rainfall in July.

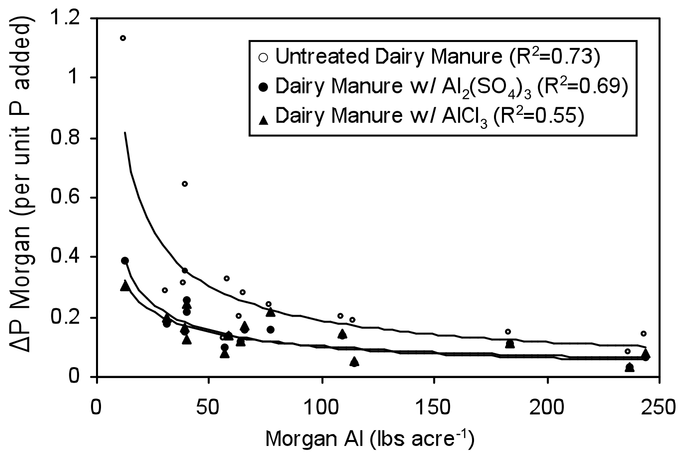
Runoff data: We applied significant amounts of simulated rainfall but were unable to generate runoff this year. This indicates that runoff is unlikely to be a problem in dry years independent of fertilizer/manure application method.

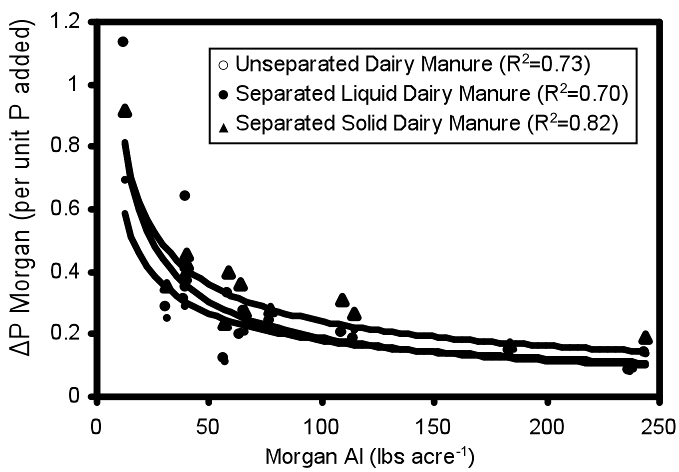
Leaching data: The amount of rainfall required to initiate flow from the tile lines was highly variable, as were the time to flow initiation and flow duration (Table 6). Tile flow was initiated between 47 and 109 minutes after water was applied to the plots. This is similar to conditions in the fall of 2006, where in some plots tile flow took as long as 103 minutes to begin. The duration of drainage was also variable, ranging from 50 to 109 minutes. The average volume of tile water collected was the same for inorganic and the Aerway treatment (2%). For the plots to which the manure was applied on the surface without Aerway disturbance, a larger portion of the amount of rainfall applied was recovered in the tile drain (4% in plot 5 and 17% in plot 4). If significant, such a difference would suggest Aerway disturbance might reduce preferential flow but additional work is needed as results were highly variable and we were unable to generate flow in one of the three replications in the experiment, reducing statistical rigor.

Average concentrations of P and nitrates were similar to concentrations at peak flow. Plot 4 had some baseline flow which had to be accounted for in flow rate and nutrient concentration calculations. Plot 5 was not impacted by baseline flow. Phosphorus loss through the tile line was low overall (Table 7).

Comparing the three treatments in plot 5, nitrate concentrations in the leachate were higher in the manured plots than in the inorganic fertilizer plot (Table 7). Average and peak N concentrations varied from 9 to 12 ppm in the surface applied manure without Aerway. Initial comparisons suggest N losses to be lower in Aerway treated plots (excluding plot 4 where source water contained more N than tile water) than in plots where manure is surface applied, suggesting Aerway treatment can reduce N loss in tile. However, the dataset is too variable to draw such conclusions and 2006 data do not show the same trend. Additional larger-scale field work is needed.

Soil P Accumulation Project





We previously (2006 project) found that Morgan extractable Al was the best predictor of a soil's P sorption capacity, and that soils with high Morgan extractable Al levels need more P to achieve the same Morgan soil test P increase as a soil with lower Al levels. In 2007, we conducted incubation studies using fifteen different NNY soils to further assess the effect of Al on P sorption capacity. The soil types used for the study were Malone from Clinton County; Amenia, Churchville, Deerfield, and Kingsbury from Essex County; Collamer, Kingsbury, Rhinebeck, and Vergennes from Jefferson County; and Adams, Croghan, Grenville, Kalurah, Pyrities, and Swanton from St. Lawrence County. We also compared the effects of addition of different manure fractions (unseparated, separated liquid, and separated solid) on soil test P increases, and the effects of two manure additives: aluminum sulfate (alum, $Al_2(SO_4)_3$) and aluminum chloride ($AlCl_3$). The alum was added at the rate of 21 gal/1000 gal for unseparated dairy manure and 19 gal/1000 gal for separated liquid dairy manure; the $AlCl_3$ was added at 14.5 gal/1000 gal for both unseparated and separated liquid dairy manure. The two graphs above illustrate our results. This work confirms that high Al soils need more P to achieve the same soil test P increase as low Al soils. It also shows that (1) untreated manure is more effective at increasing soil test P levels than manure treated with alum or $AlCl_3$; and (2) there are no large differences in the effectiveness of unseparated, separated liquid, and separated solid dairy manure in raising soil test P levels with the same addition of total P. We will further evaluate the data set as our treatments included a comparison of manure P versus fertilizer P as well. In addition, we will investigate P and N dynamics upon chemical treatment in a greenhouse experiment with similar manure treatments and sorghum sudangrass as test crop.

Conclusions/Outcomes/Impacts:

One year of runoff and two years of leaching data show very low levels of P movement over the surface and through the profile of the plots, including those treated with manure. There is initial evidence that aeration of grass prior to manure application reduced P runoff in wet years (not in 2007) without increasing N and P loss in tile lines. Nitrate leaching to the tile line appears to be an area of greater concern than P leaching in our work in Willsboro. Results so far suggest aeration prior to manure application does not enhance N or P leaching to tile drains and might be a good alternative to surface application of manure. However larger-scale plots are needed to further investigate the impact of Aerway incorporation on grass production and N and P dynamics.

The P incubation study has shown to date that soils high in Morgan Al (greater than 50 lbs/acre) need more P to increase soil test P levels than low Al soils, Al-treatment of manure reduces soil test P increase (i.e. the Al binds and makes P unavailable for plant uptake), and there does not seem to be a difference between raw manure, separated solids and liquids in the amount of P needed to raise soil test P with one unit.

Outreach:

In 2007, we generated six additional agronomy fact sheets, published a peer-reviewed journal article, and completed the 2002-2006 soil test summary reports for the 6 NNY counties. For a complete listing, see "reports". New project results will be discussed in upcoming winter meetings.

Next steps:

Based on the results of the P incubation study, we initiated a greenhouse pot experiment with sorghum sudangrass as test crop and untreated manure, manure treated with alum, manure treated with $AlCl_3$ as the three main treatments using a sandy low N and low P soil from St Lawrence County. This experiment included a series of pots to which P was added so an N response could be studies (conservation of N with the chemical treatments) and a series to which N was added to study the impact of chemical treatment on P availability. This project is ongoing (1st cutting was harvested, 2nd cutting is growing).

For the field season of 2008, we proposed to focus on quantification of N dynamics and P accumulation upon Aerway incorporation of manure versus surface application and/or injection. Work in other parts of New York has show Aerway incorporation can result in N conservation equal to chisel incorporation but additional field trials are needed to test this under NNY conditions.

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Reports and/or articles.

Agronomy Fact Sheets:

- # 18: Manure Spreader Calibrations (1/19/2007)
  - Shawn Bossard, Kristen Bossard, Joe Lawrence, Quirine Ketterings
- # 24: Teff as Emergency Forage (3/22/2007)
  - Mike Hunter, Peter Barney, Tom Kilcer, Jerry Cherney, Joe Lawrence, and Quirine Ketterings
- # 25: Mass Nutrient Balance Software (6/7/2007)
  - Sara Moss, Caroline Rasmussen, Q. Ketterings, Joe Lawrence, Peter Barney
- # 26: Brown Midrib Sorghum Sudangrass Nitrogen Management (6/30/2007)

  - Quirine Ketterings, Tom Kilcer, Jerry Cherney, Peter Barney, Greg Godwin, Patty Ristow

27: How Quickly Will Soil Test P Levels Increase? (7/10/2007)
  - Ryan Haden, Quirine Ketterings, Jason Kahabka, and Karl Czymmek

28: Phosphorus Removal by Field Crops (7/21/2007)
  - Quirine Ketterings, and Karl Czymmek

<u>Journal Article:</u>

- Haden, V.R., Q.M. Ketterings, and J.E. Kahabka (2007). Factors affecting the change in soil test P levels following manure and fertilizer application. SSSAJ 71: 1225-1232.

<u>Soil test summaries:</u>

- Essex County Soil Sample Survey (2002-2006) (released August 24, 2007).
  - Rao, R., A., Deming, Q.M. Ketterings, and H. Krol (2007). Essex County Soil Test Summary (2002-2006). CSS Ext. Bull. E07-6. 33 pages.
- Jefferson County Soil Sample Survey (2002-2006) (released August 23, 2007).
  - Rao, R., M. Hunter, Q.M. Ketterings, and H. Krol (2007). Jefferson County Soil Test Summary (2002-2006). CSS Ext. Bull. E07-5. 36 pages.
- Clinton County Soil Sample Survey (2002-2006) (released August 23, 2007).
  - Rao, R., A. Ivy, Q.M. Ketterings, and H. Krol (2007). Clinton County Soil Test Summary (2002-2006). CSS Extension Bull. E07-4. 33 pages.
- Franklin County Soil Sample Survey (2002-2006) (released July 30, 2007).
  - Rao, R., C. Tillinghast, Q.M. Ketterings, and H. Krol (2007). Franklin County Soil Test Summary (2002-2006). CSS Ext. Bull. E07-3. 32 pages.
- St. Lawrence County Soil Sample Survey (2002-2006) (released July 12, 2007).
  - Rao, R., P. Barney, Q.M. Ketterings, and H. Krol (2007). St. Lawrence County Soil Test Summary (2002-2006). CSS Ext. Bull. E07-2. 35 pages
- Lewis County Soil Sample Survey (2002-2006) (released July 10, 2007).
  - Rao, R., J. Lawrence, S. Place, Q.M. Ketterings, and H. Krol (2007). Lewis County Soil Test Summary (2002-2006). CSS Ext. Bull. E07-1. 34 pages.

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Table 1. 2007 field operation spanned from late April until late October.

Date		Field Activity
4/26/2007		Sampled natural flow
4/30/2007		Top dress (75 lbs N/acre)
6/12/2007		1st hay cutting
5/8/2007		Sampled natural flow
5/17/2007		Sampled natural flow
6/15/2007		Install frames
6/16/2007		Apply manure at 5000 gal/acre
6/18/2007		Rain simulation/no runoff or drainage
6/19/2007		Rain simulation/no runoff or drainage
6/20/2007		Sampled natural flow
6/25/2007		Top dress (75 lbs N/acre)
7/12/2007		Sampled natural flow
7/24/2007		Hand harvest subplots
7/25/2007		2nd hay cutting
7/30/2007		Apply manure at 5000 gal/acre
8/1/2007		Rain simulation/no runoff
8/2/2007		Rain simulation/no runoff
8/3/2007		Rain simulation/no runoff
10/30/2007		Sampled natural flow

Table 2. 2007 Orchardgrass yield and quality for the 12 plots. Yield data are expressed in tons of dry matter.

	Yield			Quality			
Plot	(Tons of Dry Matter)			Crude Protein % Dry Matter		Neutral Detergent Fiber % Dry Matter	
	1st Cut	2nd Cut	Total	1st Cut	2nd Cut	1st Cut	2nd Cut
1	1.70	0.55	2.25	13.6	20.0	64.6	60.0
2	2.31	0.68	2.99	12.8	19.3	69.1	61.6
3	1.80	0.57	2.37	11.4	18.4	66.0	58.2
4	2.04	0.61	2.65	12.1	21.0	67.2	58.9
5	2.22	0.66	2.88	11.2	19.8	69.6	57.2
6	2.02	0.62	2.63	12.5	20.4	68.7	60.1
7	1.95	0.70	2.64	11.1	19.5	67.7	57.9
8	1.63	0.61	2.25	10.9	19.8	64.8	55.7
9	1.84	0.78	2.62	10.4	20.2	68.2	59.0
10	1.95	0.75	2.70	11.2	17.2	66.4	58.0
11	1.76	0.70	2.46	10.8	18.4	66.8	60.6
12	1.74	0.71	2.46	10.0	17.1	68.3	61.2
Mean	1.91	0.66	2.57	11.5	19.3	67.3	59.0

Table 3. 2007 orchardgrass yield and quality hand harvested within and adjacent to the rainfall simulator frames. Yield data are expressed in tons of dry matter.

Treatment	Plot	Yield	Quality	
			CP	NDF
		TDM	% DM	% DM
Inorganic	4	0.86	23.4	59.3
	5	0.76	20.8	56.9
	6	0.69	21.6	54.9
	Mean	0.77	21.9	57.0
Aerway	4	0.69	21.8	56.4
	5	0.64	23.4	53.2
	6	0.82	24.4	52.3
	Mean	0.72	23.2	54.0
Surface	4	0.73	22.8	60.7
	5	0.88	23.2	55.9
	6	0.84	24.2	52.4
	Mean	0.82	23.4	56.3
Outside	4	0.70	23.6	51.1
	5	0.71	19.6	55.9
	6	0.47	24.4	49.0
	Mean	0.62	22.5	52.0