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Statewide and Whole Farm Phosphorus Balances
Tools to Help with Long-Term Nutrient Planning on Dairy and Livestock Farms

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To date, nutrient management regulations in NY and most other states in the US have addressed the Clean Water Act through implementation of the NRCS 590 standard for nutrient management. The NRCS 590 standard focuses on reducing risk to water quality by managing applications of fertilizer and manure; this is accomplished through development of plans that include the use of the P runoff index, the N leaching index, and land grant university crop nutrient guidelines. However, current nutrient management practices may not sufficiently address importation and subsequent loading of nutrients onto farms and watersheds as shown, among others, by a steadily increasing number of acres testing high or very high in P in NY (see What's Cropping Up? 2004, 14(5): 3-6) and other states.

When the amount of P entering a field exceeds the P removed with harvest, this imbalance could lead to: (1) increase in soil reserves (potentially increasing the risk for future environmental losses), and (2) direct nutrient lost to the environment. A P balance can be derived for an individual field, a farm, a county, a watershed, a region, a state or even an entire country. An analysis of the nutrient flows onto and off the farm is essential to quantify current nutrient imbalances and identify farm practices that could be more efficient, thereby, increasing farm profitability and decreasing nutrient losses to the environment. As such, an imbalance may be an indicator of challenges and opportunities, current and future. The state- and county-wide balances have the potential to improve water quality protection by supporting activities that address the local differences between available nutrient supplies and potential nutrient use by crops. Such analyses are also the basis for measuring progress as farms make changes in management of soil, crop, fertilizer, feeds, and manure for watershed protection and long-term sustainability of our dairy industry.

Materials and Methods

To gain a better understanding of current balances, two studies were initiated: (1) state-wide and county-based assessment of P balances; and (2) individual farm mass nutrient balances for New York State dairy and livestock farms.

Statewide and county-based phosphorus balances for New York State

State-wide and county balances were derived as the difference between total amount of P in manure and fertilizer minus the amount of P in crop removal using the 2002 Census of Agriculture and NYS Agricultural Statistics Service data and following the same procedures used by the Mid-Atlantic Regional Water Program (http://mawaterquality.psu.edu/).

Nutrient accounting for New York dairy and livestock farms

The whole farm mass balance assessments included quantification of imports through feed and fertilizer purchases, nitrogen fixation from legumes, animals purchased, bedding as well as exports in the form of milk, animals, crops sold, and manure transported off the farm using a mass nutrient balance software tool (see http://nmsp.css.cornell.edu/projects/massbalance.asp). To date, 38 farms participated in this study. The information was collected from exiting farm sources such as farm financial, crop recordkeeping and animal nutrition records. Acres of

legumes, percent legume in the stand, yield, and crude protein content were used to estimate the amount of N fixed by the legumes if any.

Initial Results

Statewide and county-based phosphorus balances for New York State

The total P balance for New York State amounted to +28 million lbs of P (+17 lbs of P_2O_5 per harvested acre of cropland) in 2002. This net surplus per acre is lower than what was reported for the Mid Atlantic States (28 lbs P_2O_5 per acre for WV, 29 lbs for PA, 35 for MA, 39 for DE and 55 P_2O_5 per acre for VA; see http://mawaterquality.psu.edu/) but nevertheless, this is a substantial annual per acre surplus. It needs to be recognized that not all manure and fertilizer P is equally applied to every crop acre explaining why 47% of the soil samples test below the agronomic optimum for P in New York (see What's Cropping Up? 2004, 14(5): 3-6).

Nutrient accounting for New York dairy and livestock farms

Farms participating in the mass nutrient balance pilot study ranged in size from 37 to just over 1300 mature cows. Case study tillable crop and pasture acres ranged from 140 to 2700 acres. Of the 38 farms in the study to date, 34 farms are dairy farms, 2 farms are beef cow-calf and 2 farms had both beef and dairy enterprises. Preliminary evaluation of farm mass nutrient balances showed that, on average, phosphorus imports (feed, fertilizer, animals and bedding) exceeded sales/exports(milk, meat, animals, crops, manure) by 50% ([imports-exports]/imports) resulting in an average of 26 lbs of P_2O_5 "remaining" per acre cropland (Table 1).

Table 1. Selected farm characteristics and farm phosphorus balance factors, mean, median, minimum and maximum for 38 NY dairy and beef farms (2003 and 2004 data)[a].

	Mean	Median	Minimum	Maximum
Selected farm characteristics				
Animal density	0.72	0.73	0.15	1.42
Legume crop[b]	30%	30%	0%	75%
Purchased feed %[c]	30%	31%	1%	65%
Selected farm P balance factors				
P remaining (imports – exports)				
P remaining tons	4.08	1.66	-0.34	17.24
P remaining lbs/acre	11	10	-2	30
P remaining %	51%	58	-53%	81%
P imported as purchased feeds				
P feed import tons	5.09	2.22	0.02	26.45
P feed import lbs/acre	13	11	0	37
P imported as purchased fertilizer				
P fertilizer import tons	2.04	1.03	0.00	20.96
P fertilizer import lbs/acre	5	6	0	16
P exported as milk sales				
P milk sales tons	2.24	0.92	0.00	13.05
P milk sales lbs/acre	6	6	0	15
P exported as crop sales				
P crop sales tons	0.42	0	0.00	7.74
P crop sales lbs/acre	1	0	0	8

[a] Dataset is comprised of 32 farms with 2004 data and 6 farms with 2003 data; 34 farms primary farm enterprise is dairy, 2 farms primary farm enterprise is beef and 2 farms had both beef and dairy enterprises.
[b] % of tillable crop and pasture acres
[c] Mean, median, minimum and maximum values for "Purchased feed %" include 32 case study farms.

These results raise questions related to causes of such imbalances and opportunities to address these. Questions such as "what management decisions contribute most to these imbalances", "how do we increase nutrient use efficiency of nutrients already on the farm", "what happens if we expand in acres or number of cows, improve milk production per cow, improve yield per acre, change crop rotations, reduce storage losses?" etc. Our current work is focussing on trying to better understand these pools and flows (and farm economics) to find ways to reduce nutrient excesses and increase farm profitability.

In Summary

Typically more nutrients come onto dairy and livestock farms as purchased feedstuffs and fertilizer than leave the farm as animal products and crops. Losses could be significantly reduced if fewer nutrients could be imported onto the farm in the first place. The key solution lies in finding ways to increase nutrient use efficiency on farms and, thereby, decrease nutrient imports and reduce loadings to watersheds. Knowing a farm's mass nutrient balance is one step towards improving our understanding of nutrient movement onto, within, and away from the farm. For our mass nutrient balance project, a greater number of farms needs to be included with multiple years per farm so we can quantify the impact of best management practices on overall balances.

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