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NUTRIENT STATUS IN RELATION TO MANAGEMENT AND PRODUCTIVITY ON ORGANIC DAIRY FARMS

Final Research Report E2007-12

INTRODUCTION

Dairy production systems face unique nutrient management challenges. Most dairy farms run large nutrient (NPK) surpluses as a result of high nutrient imports (mostly as feed) relative to farm nutrient exports (mostly as milk). For example, studies in the north-eastern US found that on conventional dairy farms with livestock stocking rates of 2.0 animal units per hectare, phosphorus was accumulating at an average rate of 36.7 kg P per hectare per year (Anderson and Magdoff, 2000). In contrast, on organic and pasture-based dairy farms with 1.2 animal units per hectare, the phosphorus surplus was considerably smaller (10.4 kg P per hectare per year). Data from Europe suggests that some organic dairy farms may develop phosphorus deficiencies. Loes and Ogaard (2001) assessed long term phosphorus trends (6 to 12 years) on five organic dairy farms in Norway. They observed a trend in decreasing topsoil phosphorus concentrations for all farms with negative farm P balances (imports-exports) over the same period.

Soil sampling on an organic dairy farm (K. Maitland)

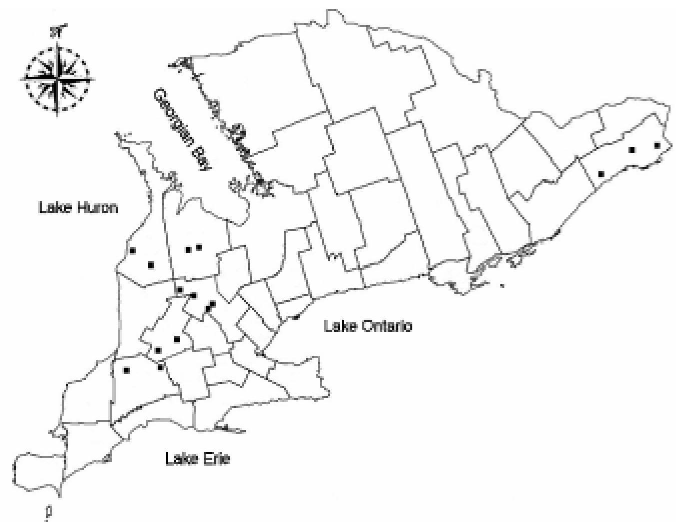

Figure 1. Location of Ontario organic dairy farms participating in this study

In Ontario, the number of organic dairy farms and the demand for organic dairy products has increased dramatically over the past decade. As production grows, there is a need to look more closely at the nutrient efficiency of these dairy management systems. The University of Guelph and the Organic Agriculture Centre of Canada (OACC) at the Nova Scotia Agricultural College have collaborated to characterize the nutrient status of Ontario organic dairy farms in order to more closely link livestock and crop management with soil and farm fertility status.

OBJECTIVES

- Describe farm management parameters on fifteen organic dairy farms
- Characterize current soil fertility and investigate historical trends in soil fertility
- Model whole farm nutrient (NPK) budgets to determine if organic dairy farms are sustainable with respect to the balance of nutrient imports and exports.

Table 1. Characteristics of Ontario organic dairy farms participating in the research

	Farm Size (ha)	Cows[z]	Stocking Rate (LU ha^{-1})	Milk Production (kg cow^{-1} yr^{-1})[z]	Crop production in 2003 (% of farm)				
					Forage	Small grains	Corn	Soy	Cash Crop
Mean	110	52	1.00	6526	65	24	6	4	5
Maximum	235	99	1.48	8162	100	42	23	21	28
Minimum	45	22	0.49	5053	29	0	0	0	0

[z] **Including lactating and dry cows**

WHAT WAS DONE

In fall 2003 and spring 2004, a farmer survey was conducted to characterize farm management (farm size, crops, organic certification timeline, animal husbandry characteristics and feeding regime). We collected data from 15 organic dairy farms (33% of the provincial total) in 9 different counties in Southern and Eastern Ontario. A partial summary is presented in Table 1. Most of the farms selected had been certified organic for at least 10 years and were relatively stable with respect to land-base and herd size.

Farm-gate nutrient budgets were conducted for all farms over two years. The nutrient contents of all managed inputs and outputs were characterized either from direct analysis, from farm records, or estimated from book values where no sample was available. The nutrient composition of imported mineral supplements was obtained directly from the manufacturer. Milk and meat exports were quantified and book values used for nutrient content. Legume N_2 fixation and atmospheric N deposition were estimated. The soil survey consisted of taking one composite topsoil sample (0-15 cm) from fields on each farm (average 80% of fields sampled). The soil was analyzed using provincial standard soil testing methods, and the study-weighted average is reported.

Table 2. Farm gate nutrient budget data for Ontario organic dairy farms, 2003-04

	Nutrient Surplus (kg ha^{-1} yr^{-1})			Soil Fertility (mg kg^{-1})	
	N	P	K	P	K
Mean	75	1.0	11.2	12.2	108
Maximum	103	7.6	57.1	28.1	160
Minimum	18	-2.5	-13.7	5.3	68

WHAT WE FOUND

Soil phosphorus (0.5M $NaHCO_3$) levels were low to medium (Table 2). Seven of the farms averaged in the low to very-low range (<10 mg P kg^{-1}), six farms were in the medium range (10-20 mg P kg^{-1}) and two farms were in the high range (>20 mg P kg^{-1}). However, the Ontario soil test P method may not be appropriate on organic farms where soil organisms may play a larger role in nutrient cycling. The average soil K (ammonium acetate) levels were medium (108 mg K kg^{-1}). Most farms (11) fell in the medium range while four were in the high range (>120 mg K kg^{-1}). The average soil organic matter (SOM) content was 4.84% (range 3.87 – 5.87), and soil pH was 7.42 (range 6.23 – 7.90).

Farm nutrient budgets were determined by considering the NPK levels in imports (feed and supplements) and exports (milk, animals and crops) from each farm. As shown in Table 2, there were net surpluses of N on all farms (mean 75 kg N ha^{-1} yr^{-1}). Legume N_2 fixation accounted for the majority of N inputs. Most farms had K surpluses, with the mean surplus lower than levels observed on most confinement-based farms. For P, nine farms had small surpluses and six had deficits, with a mean surplus of 1.0 kg N ha^{-1} yr^{-1}.

Farms were separated into three groups based on self-sufficiency with respect to percentage of feed produced on the farm. In terms of P imports from feed and mineral supplements, the farms could be classified as follows:

Group A - importing 0 to 2 kg P ha^{-1} yr^{-1};
Group B - importing 2 to 5 kg ha^{-1} yr^{-1}; and
Group C - importing >5 kg P ha^{-1} yr^{-1}.

As shown in Table 3, Group A farms were the most self-sufficient and used little off-farm feed or mineral supplements, relying instead on pasture and crop production. However, these farms were net P exporters, which could deplete soil P levels over the long term. They tended to have lower stocking rates and productivity per hectare. Use of a mineral supplement could help bring P levels back into balance. Group B imported a moderate amount of feed and supplements – almost twice as much as Group A. They had a relatively balanced system, with small nutrient surpluses for N, P and K. Group C used the greatest amount of off-farm inputs for feed and mineral supplementation. Although their milk production and stocking rates were highest, these farms had large nutrient surpluses. High surpluses can increase the risk of nutrient losses to the wider environment, which could impact rural air and water quality.

Other researchers looking at nutrient budgets on organic or sustainable dairy farms have produced interesting research results comparable to this study, summarized in Table 4.

- A large European study (Watson et al. 2002) found nutrient surpluses for organic and biodynamic dairy farms that were similar to the values observed in this trial. The researchers concluded that P and K levels on these farms were lower than desirable.

Table 3. Average farm management parameters and nutrient status for groups based on degree of feed self-sufficiency

	A	*B*	*C*
Number of farms	4	8	3
Feed imports	low	medium	high
Stocking rate (LU ha^{-1})	0.87	0.99	1.21
Milk produced (L ha^{-1} yr^{-1})	2208	2752	3111
Nutrient surplus	-----(kg ha^{-1} yr^{-1})----		
Nitrogen	53.3	77.6	98.5
Phosphorus	-1.5	0.4	6.0
Potassium	1.4	6.5	36.7

- A pasture-based farm transitioning to organic in Nova Scotia used no imported fertilizers for 16 years (Lynch et al. 2003). Nutrient surpluses for N and K were similar to our results, but higher surplus P was as a result of mineral P supplementation in the livestock diet, and imported poultry manure.

- In a research station trial in Wales, two paired organic milk production systems were assessed by Weller and Bowling (2004): the first used little or no purchased feed, and the second purchased concentrate feeds. Similar to Group C in this study, the purchased feed system had high nutrient surpluses. The self-sufficient system was deficient in P and K, even more so than low-input Group A farms from our trial (Table 3).

Table 4. Studies reporting farm nutrient budgets on organic dairy farms

	This study	Other studies			
Location	Ontario	Europe [z]	Nova Scotia[y]	Wales: Purchased feed[x]	Wales: Self-sufficient[x]
No. farms in study	15	47	1	1	1
Area (ha)	110	76.6	132	43.5	51
Stocking rate (LU ha^{-1})	1.00	0.88	0.76	1.65	1.27
Nutrient Surplus	---------------------------- (kg ha^{-1} yr^{-1})------------------------				
Nitrogen	75.3	92.3	75.6	151.2	99.2
Phosphorus	1.0	2.4	9.0	0.1	-4.5
Potassium	11.2	8.8	8.2	7.8	-2.5

[z]Watson et al. 2002
[y]Lynch et al. 2003
[x]Weller and Bowling 2004

Conclusions

Organic dairy farms in Ontario are productive and efficient at nutrient cycling - exporting a substantial proportion of nutrient inputs as farm products while avoiding excessive soil nutrient loading. In contrast to many large intensive dairy operations, these farms have lower nutrient surpluses and are less likely to be a source of nutrient losses to the wider environment. However, care must be taken to maintain K levels and maintain or increase P levels to promote healthy legume growth and associated N_2 fixation. Further research is required to ascertain whether standard soil tests are appropriate measures of soil nutrient availability in organic dairy systems.

Soil and farm nutrient analysis indicate that self-reliant farms use low amounts of imported feed and mineral supplements (about 27% of all farms in the study) and are net exporters of P. Without a more flexible approach toward the use of imports, these farms will have a challenge to remain sustainable over the long term.

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Credits

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The Bottom Line...

Farm nutrient budgets demonstrated that most Ontario organic dairy farms had N and K surpluses, but the average P surplus was only 1 kg P $ha^{-1}yr^{-1}$. Over 30% of farms were net P exporters; these producers imported little or no feed or nutrient supplements. While soil N and K levels on all farms were found to be adequate, approximately half of the farms tested low to very low in available soil P. Over the long term, combining an integrated approach to farm nutrient management with, where economically feasible, a more flexible approach to imported feed and concentrates will be critical for the continued sustainability and productivity of organic dairying.

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