NITROGEN AND PHOSPHORUS EXCRETION BY UK DAIRY COWS

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ABSTRACT

Nitrogen (N) and phosphorus (P) excretion by dairy cows was quantified using a simple, whole-farm, nutrient balance: N/P excreted = N/P inputs (feeds, fertilisers, livestock) minus N/P outputs (milk, manure exports, livestock). Data were collected from 86 dairy farms throughout England for the year 2002. On average, 143 kg N and 8 kg P were excreted by each cow per year (0.391 kg N and 0.023 kg P /cow/day). N excretion was more strongly correlated with fertiliser N inputs than with feed N inputs whereas the reverse was true of P excretion. Reduction in fertiliser P inputs is unlikely to have any observable effect on P excretion by dairy cattle in the short term, whereas adjustment of dietary P is a much more effective way of reducing excretal P output. Fertiliser N inputs, however, appear likely to be very important as part of a strategy to reduce cattle N excretion and may be more effective than reductions in protein feed intake.

INTRODUCTION

Reliable quantitative data on nitrogen (N) and phosphorus (P) excretion by housed livestock are essential for research studies and many policy issues in the UK, including national inventories of pollutants (e.g. ammonia), codes of good agricultural practice and stocking rates in controlled areas, e.g. Nitrate Vulnerable Zones (NVZs). Dairy cows are particularly important because of their high numbers (c. 2.7m milking cows and >10m cattle in total) and their substantial excretal production which represents a high proportion of the total from housed livestock. Current 'standard values' for excretal output are associated with considerable uncertainty, being variously derived from analyses of stored manures, relationships between diet and excretion and/or limited measurements from animals fed experimental diets. Moreover, recent studies involving quantitative estimation of dung and urine excretion from groups of cattle on commercial dairy farms have suggested that the current UK standards may overestimate annual excretal N output by c. 25%.

MATERIALS AND METHODS

Data from 86 commercial dairy farms (40 'mixed' farms with both arable and livestock enterprises, and 46 supporting a dairy enterprise only) located throughout the main grass-growing areas of England were collected from farm records for the year 2002. Data for the whole year, relating to imports onto the farm as fertilisers and feeds and exports as milk (net milk sales after domestic use), livestock and manure, were collected using a pro-forma designed for the purpose. Also, details of cow numbers (lactating and non-lactating), milk production and composition, and a detailed breakdown of the cows' diet (home produced and purchased feeds) were gathered. On 'mixed' farms, the proportion of fertilisers used for the dairy enterprise was esti-

mated after deduction of likely N and P use on crops outside the dairy enterprise. The latter was based on typical rates of N and P application on each crop (Goodlass *et al*., 2003). For P-based fertilisers, it was evident that purchases were often not made on an annual basis, with surplus P likely to be carried over from one year to the next. Average P fertiliser use, according to the annual statistics were therefore taken as a more reliable way of accounting for fertiliser P inputs in this study. The nutrient content of manure exported to land used for growing non dairy-related crops was also calculated as an output from the dairy unit.

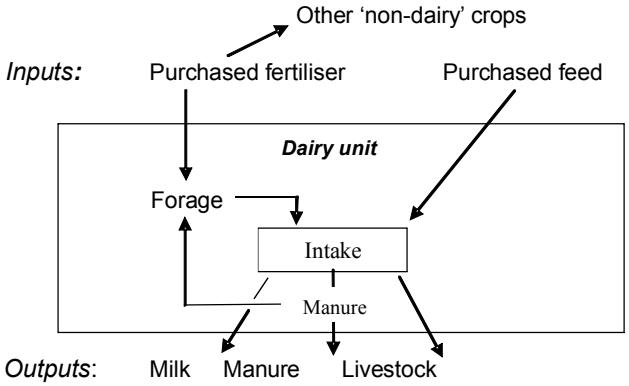

Figure 1. *Nitrogen and phosphorus flow chart for dairy farms*

A database was assembled and farm gate budgets for N and P were constructed according to the nutrient flow chart shown in Figure 1 and apparent N and P outputs in excreta were estimated using the simple relationship (Maynard and Loosli, 1969):

Excretal N/P = N/P Inputs *minus* N/P Outputs
Feed, fertiliser *Milk, manure, livestock*

RESULTS AND DISCUSSION

Herd and dietary information with the average for all farms and the overall range from lowest to highest are shown in Table 1.

Table 1. *Characteristics of dairy herd management on 86 study farms*

	Average	Range
Animals	126 cows (107 milking cows)	47 – 383 cows
Milk yield	7185 litres/cow	4,341 – 11,987 litres/cow
Stocking rate	1.5 cows/ha	0.8 – 2.7 cows/ha
Feeds:		
Farm produced	294 t grass silage DM (27.8 % DM) 168 t maize silage DM (29.8 % DM) 222 t grazed grass DM (18 % DM)	54 – 892 t grass silage DM 15 – 435 t maize silage DM 26 – 751 t grazed grass DM
Purchased	243 t DM (concentrates 1319 kg DM per cow + 809 kg DM per cow other supplements)	45 - 850 t DM; 80 - 3566 kg DM/cow from concentrates; 11 - 4324 kg DM/cow other supplements

N and P budgets (Table 2)

Inputs and outputs. Average purchased N inputs comprised fertiliser (67%) and feed (33%) with outputs of milk (70%), livestock (3%) and manure (26%). Corresponding P inputs and outputs were fertiliser (36%), feed (64%), milk (68%), livestock (4%) and manure (28%). Fertiliser N inputs averaged 136 kg/cow/year and ranged from 0 kg on an organic, dairy-only farm to 275 kg/cow/year. All the herds depended to some extent on purchased feed N and P with an average of 62 kg N/cow and 13 kg P/cow being fed. Total inputs (fertilisers plus feeds) averaged 198 kg N/cow/year and 21 kg P/cow/year. Average annual purchased P inputs totalled 2,740 kg/farm (21 kg/cow) and comprised 8 kg/cow/year of fertiliser P and 13 kg/cow/year of feed P. Total outputs as a proportion of total inputs were 28% for N and 59% for P.

Table 2. *Annual average N and P inputs, outputs and apparent N and P contents of excreta (inputs minus outputs), on a 'per farm' and 'per cow' basis.*

		per farm (kg)	range	per cow (kg)	range
Nitrogen					
Inputs:					
Fertiliser		16,427	0-53,770	136	0-275
Feed		8,198	1,199-36,922	62	11-141
	Total	24,497	6,751-77,812	198	69-320
Outputs:					
Milk		4,858	1,482-16,537	37	22-64
Net livestock		233	-199-1,005	2	-1.7-6.5
Manure export		1,811	0-16,145	16	0-122
	Total	6,901	1,634-25,364	55	27-152
Surplus		17,642	1,789-64,869	143	13-268
Phosphorus					
Inputs:					
Fertiliser		977	252-2,330	8	4-13
Feed		1,763	166-8,036	13	2-31
	Total	2,740	642-10,250	21	6-39
Outputs:					
Milk		1,044	314-3,698	8	5-14
Net livestock		68	-65-294	0.6	-0.6-1.8
Manure export		444	0-4054	4	0-30
	Total	1,556	358-8,046	12	6-36
Surplus		1,184	-2,535-7,377	8	-25-28

Apparent N and P output in excreta

On average, 143 kg N and 8 kg P were estimated to be excreted by each cow per year (0.391 kg N and 0.023 kg P /cow/day). Relationships between N and P inputs and N and P excreted for all the farms suggest that N excretion was influenced more by the amount of fertiliser N rather than feed N (Equation 1), whereas the reverse was true of P excretion (Equation 2).

$$N_{excreta} = -2430 + 0.9N_{fert} + 0.6N_{feed} \quad (R^2 = 0.91) \quad \text{(Equation 1)}$$

$$P_{excreta} = -348 + 0.2P_{fert} + 0.8P_{feed} \quad (R^2 = 0.62) \quad \text{(Equation 2)}$$

Most of the farms lying below the fitted regression line between N and P excretion and N and P inputs (Figures 2a-2d), are grass + arable farms, with a greater proportion of those farms bordering on inefficiency (occurring above the line) being grass only or grass + maize farms. Thus, it appeared that, when expressed on a per cow basis, for a given level of N and P input (feed and fertiliser), there was likely to be a higher N and P excretion on all grass or grass-maize

systems than on mixed livestock/arable farms. This apparent reduced N and P excretion in the 'mixed' farms can probably be attributed to the export of manure from the dairy enterprise and, therefore, reduced N and P loading on crops (from purchased fertiliser and manure) compared with 'dairy only' farms.

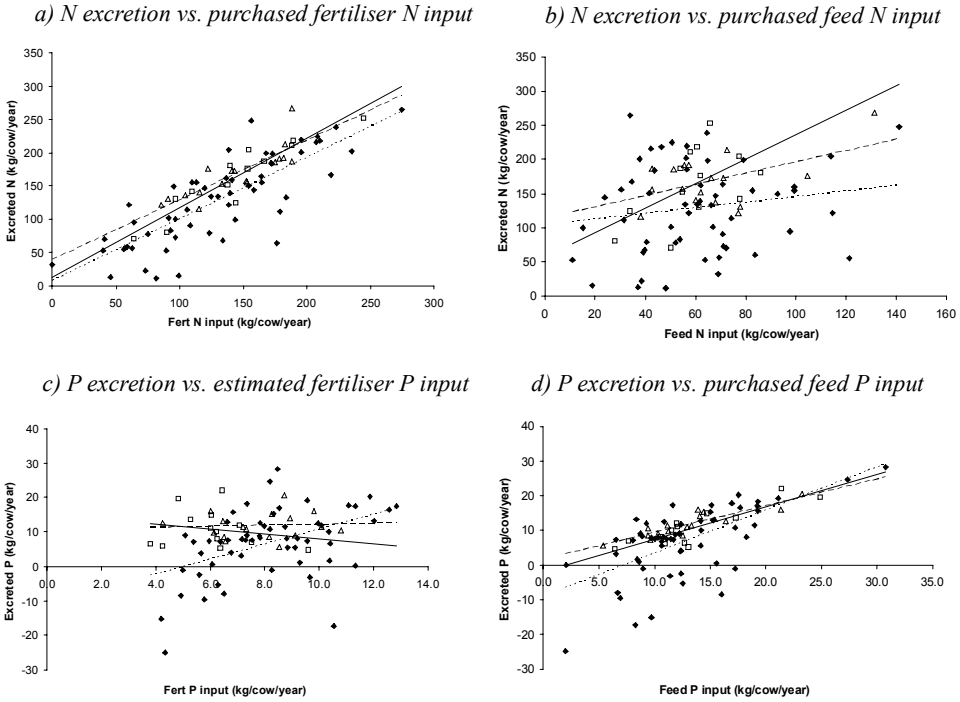

Figure 2. *Relationships between N and P excretion and purchased fertiliser and feed N inputs and estimated fertiliser and purchased feed P inputs on an individual cow basis each year for grass + arable farms (◆ ·····), grass + maize farms (△ - - - - -) and grass only farms (□ ——).*

These observations agree with our general understanding about P supply to the crop, from soils relatively high in P status, being insensitive to short term applications of fertiliser P. Thus, reduction in fertiliser P inputs is unlikely to have any observable effect on P excretion by dairy cattle in the short term, whereas adjustment of dietary P is likely to be a much more effective way of reducing excretal P output. Fertiliser N inputs, however, appear likely to be very important as part of a strategy to reduce cattle N excretion and may be more effective than reductions in protein feed intake. As part of a sustainable strategy for reducing N and P excretion by dairy cattle, it is clear that the N and P content of animal manures must be correctly accounted for when calculating crop fertiliser requirements.

REFERENCES

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