HOW EVENLY ARE N AND P LOADS FROM ANIMAL EXCRETA DISTRIBUTED ACROSS THE FARM LANDSCAPE?

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Abstract

Nitrogen (N) and phosphorus (P) are key nutrients which drive production in grazing dairy farms. However, if not used efficiently, N and P deficiency can limit production while excesses can degrade water and air quality. Pasture and fertiliser management generally assume that nutrient loads are relatively uniform across a farm landscape. However, there is evidence that cows spend different times in different areas on the farm and uneven nutrient load distribution is poorly understood. The purpose of this paper is to outline key components of N and P flows and transformations within grazing-based dairy operations, and present data on N and P use efficiency and varying nutrient distribution from dairy cows at a grazing scale. We recommend that a greater understanding of animal movements and expected patterns of within-farm nutrient distribution is required to improve N and P management decisions on dairy farms.

Keywords: nutrient loading, animal movement, distribution pattern.

The ongoing trend for increased intensification is occurring in grazing-based, as well as confinement-based dairy farms, worldwide. Grazing-based dairy farms are increasingly reliant on imported feed and fertiliser, with consequent greater N and P flows, transformations and losses, and a decreasing dependence on N inputs from N_2 fixation by pasture legumes. Across a range of grazing-based dairy systems in various geographic locations, whole-farm level N and P exports in products are commonly 20 to 35% of total farm inputs (Gourley et al., 2012a).

While it is important to understand how much N and P is imported and subsequently removed in product on dairy farms, the ability to quantify within-farm flows and transformations, as well as the spatial and temporal distribution of N and P, is essential to identify opportunities for improved management.

While flow pathways of N and P on to and out of a dairy farm are generally easy to calculate from readily available data at the farm scale, within-farm N and P cycling processes are more difficult to quantify and may be different between contrasting systems (Rotz et al., 2005). The relationships between N and P intakes and that in milk and manure, have received considerable attention in confinement dairy systems (Powell et al., 2010), but relatively little information is available within grazing systems. This is likely due to the difficulty in accurately determining pasture N and P intakes from preferential grazing and species selectivity by the grazing animal and also variations in pasture quality and mineral contents due to climatic and seasonal conditions (Gourley et al., 2012a).

Dairy herds generally transform 11 to 50% of feed N and P into milk with the remainder excreted in urine and dung (Table 1). By contrast between 20 and 40% of fertiliser and manure N applied to soil may be utilised by pasture and crops (Powell et. al., 2010), with generally lower percentages for P.

Table 1. Feed N and P use efficiency and daily loads excreted by lactating cows from 43 dairy farms over 5 visits (Aarons, unpublished).

	Utilisation of nutrients (%)		Amount excreted (g/cow/day)	
	Nitrogen	**Phosphorus**	**Nitrogen**	**Phosphorus**
Mean	20.8	25	432	61
Minimum	10.5	10.7	199	20
Maximum	35.1	48.5	792	132

As stocking rates increases, the average nutrient loads from dairy cow excreta increase, often above agronomic requirements (Table 2). Consequently, dairy systems, irrespective of whether they are grazing or confinement based, are recognized as significant contributors of excess N and P to the environment (Steinfeld et al., 2006).

Table 2. The range and average nutrient loading rates from animal excreta for different cow stocking rates.

	Daily excretion (g/cow/day)	Stocking rate (cows/ha)	Annual excretion load (kg/ha)	Mean[*] (kg/ha)
Nitrogen	199 - 792	1 - 4	73 - 1156	523
Phosphorus	60 - 130	1 - 4	22 - 190	139

[*]Mean based on the average daily nutrient excretion and stocking rate of 2 cows/ha.

Pasture and fertiliser management generally assume that the nutrient loads are relatively uniform. However, cows spend different times in different areas within the farm (Aarons et al. 2012). A key feature of grazing-based dairy systems is that the majority of excreted manure is directly deposited onto pasture soils by grazing animals. Pastures are generally grazed on a rotational basis, determined by pasture growth rate and forage yields on offer. However, the animal density of various areas also results from convenient management practises such the frequent use of paddocks located close to the dairy shed, or those routinely used for feeding conserved forages or purchased feed, particularly when pasture growth rates are restricted by soil moisture or temperature. Consequently, N and P loads from animal excreta are often heterogeneously distributed across the farm landscape and in specific areas (Figure 1) may be well in excess of agronomic requirements (Gourley et al., 2012a).

Collection of excreta in grazing-based dairy systems typically occurs from the dairy shed where cows are milked and from adjacent concreted yards where the animals are held before or after milking. Effluent storage systems generally consist of open ponds or storage tanks, from which effluent is directly irrigated onto pastures. While in lower input grazing systems, this collected excreta is usually a relatively small proportion of total excreta N and P by the dairy herd, larger herds with a high reliance on purchased feed, can have up to 40% or more of excreta requiring land application (Gourley et al., 2012b).

The linking of farm-gate balances with internal N and P cycling processes provides opportunities for targeted improvements in N and P capture and recycling by farmers, and reducing losses of N and P from grazed dairy systems. In particular, this should include: (i) quantifying key nutrient inputs, outputs and stores (i.e. feed, manure) and nutrient balances and efficiencies at a simple (farm-gate) level, (ii) quantifying grazing animal N and P intakes and feed N and P use efficiencies, at least within each season, (iii) quantifying N and P distribution and loading rates at a paddock management scale, including inputs and outputs such as fertiliser applications, forage removal, and importantly grazing animal excreted N and P, and (iv) quantifying the amount and proportion of excreta N and P deposited in unproductive areas which go uncollected, as well as the amount and proportion of excreta N and P collected and redistributed.
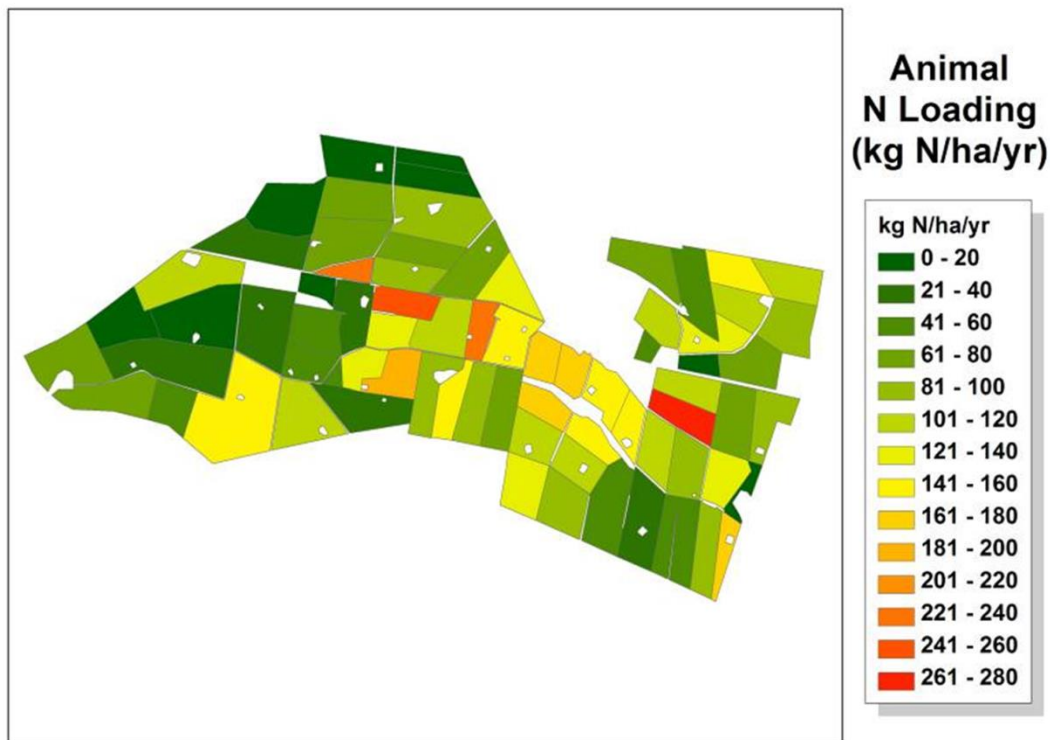

Figure 1. An example of paddock scale nitrogen loading rates from dairy cow excreta for a Victorian farm.

Conclusions

A key driver of within-farm nutrient heterogeneity appears to be stock density and resultant nutrient deposition from excreta. A greater consideration of animal movements, time spent in specific locations, predicted cow nutrient excreta concentrations and expected patterns of within-farm nutrient distribution is essential for improving nutrient cycling, fertiliser management and reducing off farm losses.

Acknowledgements

References

Aarons, S.R., Gourley, C.J.P. (2012). Sustainable management of nutrient returns in excreta on grazed dairy soils. In: Proceedings of the 5th Joint Australian and New Zealand Soil Science Conference: Soil solutions for diverse landscapes. Hobart. (Eds LL Burkitt and LA Sparrow). [pp461]. (Aust. Society of Soil Science Inc.).

Gourley, C.J.P., Dougherty, W., Weaver, D.M., Aarons, S.R., Awty I.M., Gibson, D.M., Hannah, M.C., Smith, A.P., Peverill, K.I. (2012a) Farm-scale nitrogen, phosphorus, potassium and sulphur balances and use efficiencies on Australian dairy farms. Animal Production Science. 52, 929–944.

Gourley, C.J.P., Aarons, S.R., Powell, J.M. (2012b) Nitrogen use efficiency and manure management in contrasting dairy production systems. Agriculture Ecosystem and Environment 147: 73 – 81.

Powell, J.M., Gourley C.J.P., Rotz, C.A., Weaver, D.M. (2010) Nitrogen Use Efficiency: A Measurable Performance Indicator for Dairy Farms. Environmental Science and Policy 13, 217- 228.

Rotz, C.A., Taube, F., Russelle, M.P., Oenema, J., Sanderson, M.A., Wachendorf, M. (2005) Whole-farm perspectives of nutrient flows in grassland agriculture. Crop Science 23, 2139-2159.

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., de Haan, C. (2006) Livestock's long shadow: environmental issues and options. Food and Agriculture Organisation, Rome.