Tools for managing manure nutrients

Mark Shepherd, John Webb
ADAS, Gleadthorpe Research Centre, Meden Vale, Mansfield, NG20 9PF, UK

Lois Philipps
Elm Farm Research Centre, Hamstead Marshall, Newbury, RG20 0HR, UK

ABSTRACT

Manures are a valuable source of nutrients (and organic matter), and can be seen as a method of transferring nutrients around the farm (for home-produced manures) or as a method of importing fertility (imported manures or composts). Good manure management offers a 'win-win' opportunity: benefits to soil fertility and benefits to the environment (less pollution). This paper describes two tools for manure nutrient planning: the use of look-up tables to assess nutrient content, and the development of a Decision Support Tool for describing nutrient transformations during manure management.

Keywords: Manures, nutrient management, environmental impact, resource use.

INTRODUCTION

Knowledge of manure composition is important for farm nutrient management, either if importing manure onto a farm or transferring nutrients around the farm in 'home produced' manures. Many factors affect the nutrient content of the manure ready to spread onto the land (Smith & Frost, 2000). Dietary input and quality affect nutrient excretion. Once excreted, nutrient losses (especially of N as ammonia) can occur during housing (Pain *et al*., 1998) and during manure storage (Kirchman, 1985). Additions of bedding material and/or water will also modify nutrient content.

It is well recognised that, for these reasons, manures can vary greatly in composition. Whilst analysis of manure on an individual holding is often suggested as a method to characterise nutrient composition, there is also a need to provide 'typical' values for guideline purposes. This could be important information for nutrient budgeting on a farm. It is also important information for assessing the likely environmental impact of manures applied on organic holdings: manures have been implicated with nitrate leaching (Smith & Chambers, 1998), ammonia loss (Pain *et al*., 1998), nitrous oxide emissions (Robertson, 1991) and phosphorus pollution (Edwards & Withers, 1998). Conversion to organic farming offers potential to reduce nutrient pollution since less input is used per hectare than in conventional farming.

This paper therefore reviews two tools which might contribute to better manure management on organic farms: (a) information on 'typical' nutrient values of cattle manures and (b) an interactive Decision Support System (DSS) that aims to provide information on the fate of manure nutrients based on simple management details.

MATERIALS AND METHODS

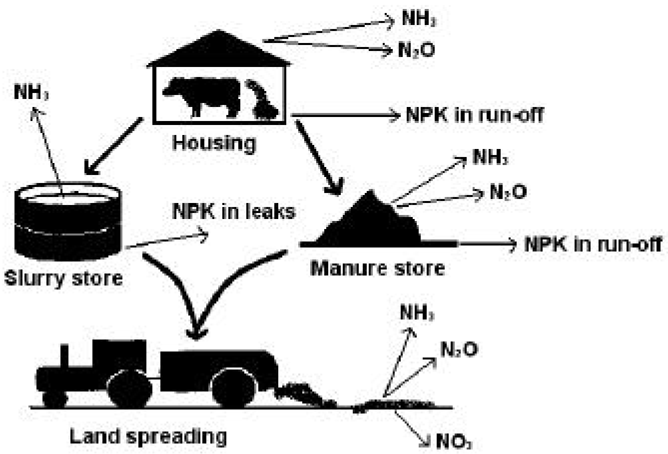
1. Manure analysis

The study focused on cattle manures because this is currently the largest organic livestock sector in the UK. Forty-three FYM samples and fourteen slurry samples were collected by visiting organic farms and taking a representative sample (c. 3 kg) from the manure store or slurry pit. The manure nutrient content was determined by standard analytical techniques in the laboratory on a sub-sample of the collected manure.

MANMOD – Manure management model

Within the project described above, a simple spreadsheet based model was developed to estimate the main nutrient losses during manure production and storage that would impact on the final manure nutrient content. Figure 1 shows the scheme for the DSS and the main pathways for nutrient loss. Sophisticated programming now means that the user can easily produce a simple on-screen representation of even a quite complex manure management system. The underlying programme contains information on nutrient production in excreta, and nutrient loss factors for each management stage. Thus, a user can see how management (e.g. storing slurry or manure with or without a cover) will impact on nutrient losses. The software is now at the testing stage, ready to be presented to a 'Farmer focus group' during Spring.

Figure 1. Nutrient loss pathways during production, storage and spreading



RESULTS AND DISCUSSION

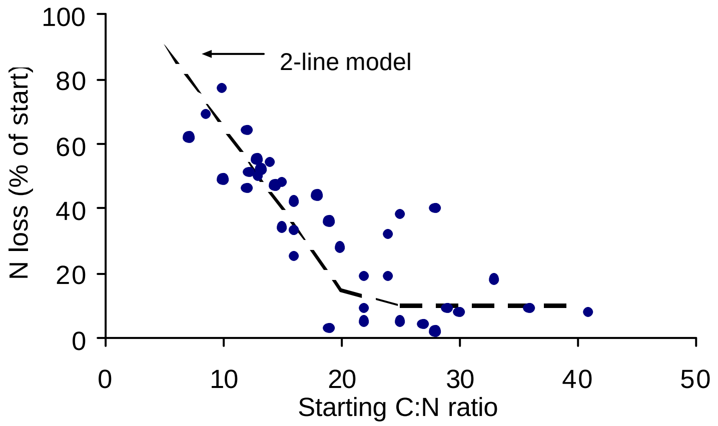
Table 1 shows the average nutrient contents of slurry and FYM, and compares these with average values based on over 100 samples previously collected from conventional farms. The slurry nutrient content varied widely between slurry samples. This was not surprising. For slurries, variation in nutrient content was generally explained by differences in dry matter content. The relationship did not hold for potash because most K is excreted in urine whereas N and P are more closely associated with faecal deposition. Using a regression analysis it was possible to demonstrate that organically produced slurries, on average, contained less total N, P and K than the slurries in our data set from conventional holdings. Although the slope of the relationship between dry matter and nutrient concentration was the same for both, the intercept was always significantly less for the organic slurries, suggesting a lower baseline nutrient content.

Table 1. Nutrient content of cattle slurries and cattle FYM from organic farms in comparison with data from conventional farms.

	Slurry					FYM				
		Organic		Conventional			Organic		Conventional	
Nutrient	Unit	Mean	sd	Mean	sd	Unit	Mean	sd	Mean	sd
pH		7.7	0.52	-	-		8.5	0.28	-	-
DM	%	7.9	3.57	7.5	3.7	%	21	5.83	26	9.4
Total N	kg/m^{-3}	2.5	1.19	3.4	1.4	$kg\ t^{-1}$	5.2	1.16	6.3	2.5
P_2O_5	kg/m^{-3}	0.96	0.433	1.5	0.8	$kg\ t^{-1}$	2.4	0.84	4.1	2.5
K_2O	kg/m^{-3}	2.5	1.16	4	1.7	$kg\ t^{-1}$	6.6	2.29	10.8	6.7
MgO	kg/m^{-3}	0.53	0.24	-	-	$kg\ t^{-1}$	1.6	1.6	-	-
SO_3	kg/m^{-3}	0.72	0.326	-	-	$kg\ t^{-1}$	2	0.75	-	-
NH_4-N	kg/m^{-3}	0.74	0.348	1.4	0.7	$kg\ t^{-1}$	0.26	0.267	0.77	0.8

Despite apparently lower phosphate and potash concentrations in the 'organic' cattle FYM, they could not be proven statistically because of the large variation between samples (as would be expected). However, based on findings for the slurry samples, it is likely that the excreta contributing to the FYM also contained smaller concentrations of nutrient than would have been the case on conventional holdings. Many nutrient transformations (including losses) occur in FYM between excretion and removal from the store (Figure 1), and it may be that any differences at the start may be lessened by the time the FYM leaves storage.

Figure 2. Range of losses of ammonia during manure storage reported in the literature.



MANMOD aims to calculate manure nutrient content. When the NPK excretal rates from Table 1 were taken, NPK applied in straw was added, and standard ammonia emission factors were applied, the resulting composition of the theoretical cattle FYM was similar to standard values shown in Table 1. This suggested the approach was basically correct. However, there is a limitation to applying simple emission factors: if we have no mathematical representation of how a management factor influences losses, then the DSS cannot take into account the effect of such management on nutrient cycling around the farm. The different approaches to manure storage across farms are a good example: the amount of straw added and whether the heap is composted or simply stacked will have major effects on gaseous N losses. Using a simple emission factor based on a fixed proportion of the manure's nitrogen content will not show that widening the C:N ratio of the manure will decrease losses (Fig. 2), for example. MANMOD aims to take these factors into account.

CONCLUSIONS

Manures play a key role in fertility building and maintenance in many organic rotations. Understanding their nutrient composition and nutrient availability is therefore important for optimising their use on farm. The measurements show that cattle manures from organic holdings can have slightly lower nutrient contents than their conventional equivalents, but variability is large. Therefore, much of what we know about managing conventional manures can be adapted to organic agriculture. In terms of nutrient budgeting, conventional nutrient values offer a general guide, but it would be advisable to build up a library of analyses over time from an individual farm to gather more robust data on nutrient content.

Management of solid manures (composting versus stacking, for example, covering during storage, etc.) could have an impact on nutrient loss and, therefore, final composition, though our analytical data did not confirm this. The MANMOD DSS, currently at the testing phase, should help growers understand the nutrient value of manures, the major loss pathways, and the methods of decreasing losses. Result: better use of this valuable resource.

ACKNOWLEDGEMENTS

Funding for this work from the Department of Environment, Food and Rural Affairs (Project OF0197) is gratefully acknowledged.

REFERENCES

Edwards A C; Withers P J (1998) Soil phosphorus management and water quality: a UK perspective. *Soil Use and Management* **14**, 124-130.

Kirchman, H (1985). Losses, plant uptake and utilisation of manure nitrogen during a production cycle. *Acta Agriculturæ Scandinavica* **24**.

Pain B F; Van der Weerden T J; Chambers B J; Phillips V R; Jarvis S C (1998) A new inventory for ammonia emissions from UK agriculture. *Atmospheric Environment* **32**, 309-313.

Robertson K (1991) Emissions of N_2O in Sweden - Natural and anthropogenic sources. *AMBIO* **20**, 151-155.

Smith K; Chambers B J (1998) Nutrient losses to water following land applications of farm manures. In: *Environmentally Friendly Management of Farm Animal Waste*, ed T Matsumaka, pp. 79-83. Kikanshi Insatsu Co. Ltd., Japan.

Smith K A; Frost J.P (2000) Nitrogen excretion by farm livestock with respect to land spreading requirements and controlling nitrogen losses to ground and surface waters: I. Cattle and sheep. *Bioresource Technology* **71**, 173-181.

From: Powell et al. (eds), *UK Organic Research 2002: Proceedings of the COR Conference, 26-28th March 2002, Aberystwyth*, pp. 165-168.