Nitrogen Losses on Dairy Farms: Towards Improved Management Practices

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The Pressure to Intensify

The steady increase in the intensity of UK agriculture over the post-war period is well known. Here we will simply outline the economic and policy environment within which UK dairy farming has developed over recent years to provide the business context for the research on which we report. For several decades one area of scientific and management attention in improving the productivity of grazing animal production systems has focussed on the efficiency of forage production, particularly that of grassland but including also the development of alternative (or supplementary) fodder crops, such as maize for silage. For a number of reasons, dairy farming systems have led the way in the adoption of these techniques, which have resulted in average stocking rates on these farms being markedly higher than on other grazing livestock production systems[1]. Moreover, on many dairy farms the economic pressures to intensify management have been such that the farming system is typically heavily dependent on large inputs of nitrogen (N)-based inorganic fertilizer.

Associated with this general pattern are a number of commonly-accepted management standards which reinforce this message. These include, for example, financial and technical benchmarks such as, respectively, 'milk yield from grass and/or forage' and 'timing and total usage of N use on grassland'. Similarly, new techniques have permitted a further boost to total dry matter production through the growing of forage maize, normally for conservation as silage. This crop also typically involves the intensive use of N-based fertilizer. Nevertheless, UK dairy farming is still characterised by a wide variety of approaches with significant numbers of farms operating more traditional lower input systems that are much less dependent on N use.

More recently, the decline in the profitability of dairy farming since 1996 has forced a widespread re-assessment of production systems while, at the same time, reducing the financial viability of increasing numbers of dairy farm businesses[2]. One government response to the evident need of dairy farmers to rethink their production strategies was the setting up of the Inputs Task Force, which commissioned a number of economic studies of the efficiency of input use in the production of major commodities, including milk[3]. One of the principal

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[1] See, for example, information on enterprise gross margins in the University of Exeter's *Farm Management Handbook*.
[2] The scale of, and principal reasons for, the farming recession is well documented in *Farm Incomes in the United Kingdom* (http://www.defra.gov.uk/esg/default.htm).
[3] Published on DEFRA's website (http://www.defra.gov.uk/farm/itfreport/index.htm).

conclusions from this research concerns the scope that many dairy farmers have to improve both grassland management and the efficiency of fodder utilisation in the search for improved economic efficiency and, therefore, more robust business viability in a less profitable marketplace. Of particular relevance here, 'forage variable costs' (an aspect of efficiency not related to scale), 'higher stocking rates' and 'nitrogen application rates' (both of which involve scale and non-scale effects) were identified as targets for management attention in the continuing attempt to drive out economic inefficiency.

The Research Context

In parallel with the intensification of farming systems, it has become increasingly clear that agriculture's interaction with the environment is more complex than was once realised, and that intensification brings greater potential for adverse effects. One example relates to intensively-managed dairy farming systems, which have the potential to generate large nitrogen losses with consequent adverse effects on water and atmospheric quality. Substantial losses of N occur as leached nitrate (NO_3) into waters and as ammonia (NH_3) to the atmosphere, or through de-nitrification (which can include high rates of nitrous oxide - N_2O - emission). At least 50 per cent of the annual N inputs to a typical dairy system are estimated to be lost to the environment and, at the very least, this represents a substantial loss of a valuable resource. Further, one of the government's policy aims is to enhance the rural environment by reducing diffuse water pollution from agriculture (through reduction of NO_3 leaching for example). There are also increasing concerns over the emissions and subsequent atmospheric impact of NH_3 and N_2O arising from agricultural activities, and dairy systems are major sources of both these gases.

The CRR recently co-operated with the Institute of Grassland and Environmental Research (IGER) in studying the environmental and economic implications of N losses from dairy systems, under research commissioned by Defra. Because of the complexity of N-cycling within animal production systems, and in order to be certain of all the interactive effects that occur within a multi compartmental management system such as dairying, is essential that an understanding of the complete system is obtained. In order for Defra to make progress in the further development of policies related to all N emissions, there was a need to examine actual examples of commercial management and to take account of changes in production and recent research results and model development. A desk study/systems analysis approach, based on predictive models, provided a cost-effective means of improving our understanding of these complex interactions. The use of a systems analysis approach has proved an important tool in demonstrating the scale of adverse effects, examining the potential for change, identifying the economic implications and communicating with the farming industry through technology transfer.

The aim of the economic assessment was to provide a 'real world' dimension to the desk research on predicted N losses from dairying systems by modelling the likely financial impacts using actual dairy farm businesses with alongside the identified alternative management options that are designed to reduce N losses. Specific objectives included:

- Estimate the scale of the financial impacts of alternative management options;
- Identify the financial impacts across the range of dairy farming systems examined;
- Provide farm-level 'feedback' as a tool in exploring technology transfer issues related to N loss strategies.

Modelling Alternative Farm Systems

The primary source of data for the economic models was the information obtained from each of the six case study farms, which included detailed cropping and stocking statistics, information on farm management practices including forage production and comprehensive farm systems data. Since the sample farms selected for the desk study were located in the Southwest, the appropriate source of economic data was the University of Exeter's regional Farm Business Survey database, using 2000/01 data to match the period used for modelling N losses. This was augmented as necessary by information obtained from a variety of industry sources. Economic models were then developed for each of the six case study farms, and each baseline model was then run under the six different management options identified as effective alternatives in reducing N losses:

M1 Grass/clover swards (non-organic);

M2 Grass/clover swards (organic);

M3 Improved slurry/fertiliser use;

M4 Maize silage;

M5 Grass/clover swards plus maize silage;

M6 Improved slurry/fertiliser use plus maize silage.

Table 1 summarises for each of the case study farms the predicted changes to the financial margins (before allowance for annual depreciation on additional capital investment) under each of the six management options. The model results make interesting reading. In general terms, and with the exception of the organic option, most of the case study farms are predicted to see only minor changes in margin under any of the alternatives management options. Indeed, under some circumstances, it appears that considerable improvements in margin may be achieved under improved N management regimes (see Farm F, for example).

Moreover, all farms were predicted by the model to achieve higher margins under the organic option (M2), but there are two important caveats to this general conclusion. First, the scale of the improvement in margin is heavily dependent on the size of the premium for organic milk, and as events over the last few years have shown this cannot be taken for granted. Assuming a value closer to the current price (22 p/litre), the change from the base margin would be +2%, +13%, +28%, +14%, +30% and +32% for Farms A to F, respectively. Even so, these margins will also be unrealistically high if the study overestimated the milk production potential of clover-based swards. Secondly, it was particularly difficult to model the organic option due to a shortage of sound empirical data and it may be that, despite close liaison with organic experts at the design stage of the model, the specification of this option could be further improved as more reliable farm-level data on organic systems becomes available.

Table 1: Summary of the economic impacts at farm business level of alternative strategies to reduce N losses

	Management option*						
Farm	Base	M1	M2	M3	M4	M5	M6
	£/farm	% change in financial margin†					
A	30752	-5	+100	-5 (-15)	+2	-4	-4
B	33749	-3	+136	-6 (-15)	+2	-2	+2
C	41954	+4	+154	-3 (-3)	+8	+10	+11
D	59349	-1	+111	-7 (-18)	+5	+2	-4
E	31276	+2	+164	-8 (-25)	+11	+6	+1
F	23809	+25	+229	-8 (-33)	+4	+26	+3

*As identified in the text above.

†This represents the gross margin less contracting and direct labour costs, and includes all items affected by the alternative options except an annual depreciation change on additional capital investment (see main tables). Values in parentheses for Management M3 are margins including the capital cost of increased slurry storage.

Two of the non-organic options show generally consistent impacts on financial margins across all case study farms. Thus, option M3 (improved slurry/fertiliser use) is predicted by the model to result in small decreases in margin, ranging from three to eight per cent, on every farm examined. Unfortunately, although this is one of the most effective options for reducing N losses and involves a significant reduction in fertiliser use, the additional costs of the improved slurry application techniques far outweigh the savings from reduced fertiliser costs. Option 4 (maize silage) is predicted to result in modest improvements in margin, ranging from two to eleven per cent. Though financially attractive, this option was the least effective at reducing N losses. Clearly, these findings have important implications for policy design.

Options 1, 5 and 6 are predicted to have much less uniform effects on financial margins, the exact outcome in each case depending on the specific circumstances of an individual farm. In most cases, however, it would appear that these effects are likely to be quite small and relatively insignificant in relation to the business as a whole. It may be argued, therefore, that the impact of these management options needs to be assessed at case level by a competent adviser or consultant. The models predict that certain farm systems show a greater propensity either to benefit in financial margin terms, or to lose out, under most of the identified management options considered here, and these outcomes are linked to stocking rates and farm system.

Discussion

The economic models highlight some important issues at the level of the individual farm business. Perhaps the two principal findings, which must be regarded as indicative at this stage in view of the small number of case studies examined, are that (a) most dairy farms are unlikely to be significantly adversely affected financially from the adoption of improved management practices to reduce N losses, and some may actually experience modest positive impacts; and (b) targeted advice has the potential to identify farms on which quite significant improvements in margin can result from the adoption of improved N management. Finally, notwithstanding the caveats above, the models suggest that the organic option *could* be financially very attractive under a range of situations but subject, of course, to the exigencies of the market place in terms of the balance between the supply of, and demand for, organic products.

Briefly then, this is the economic context in which the scientific research reported here must be viewed. The scale of the estimated losses of the annual input of N fertilizer on typical dairy systems represents both a substantial loss of a valuable resource (with evident implications for economic efficiency) and a potentially serious negative externality in environmental terms. Not only does N leaching cause particular concern in terms of diffuse pollution of water resources, but also dairy systems are major sources of gaseous emissions which have adverse effects on the atmosphere.

Moreover, there can be little doubt that the continuing pressure for improvements in economic efficiency, now driven by a significantly reduced profitability and with few prospects of any substantial upward movement in production margins, is expected to have far-reaching consequences on milk production systems. Not all of these are likely to be favourable to policy objectives concerned with environmental outputs.