Farm system N balances for contrasting intensive grassland dairy production systems

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Introduction Nitrogen (N) use efficiency is one of the key drivers of environmentally and economically sustainable agricultural production systems. However, the poor efficiency with which N is utilised within animal based systems is well documented (Jarvis, 1993). In recent years efficient N utilisation has become increasingly important because of economical and environmental concerns, combined with European Union policy such as the Water Framework Directive and Nitrates Directive. The objective of this work was to develop a N balance model to assess N use efficiency, N surpluses and N losses from spring calving grass based dairy production systems. This model was linked with the Moorepark Dairy Systems Model (MDSM; Shalloo *et al*., 2004). Data from a five year study carried out at Moorepark and reported by McCarthy *et al*. (2007) was used to evaluate the N use efficiency of contrasting spring calving dairy systems. The model was validated by comparing data from Ryan *et al*., (2006) against model outputs.

Material and methods The model simulates and determines the fate of N circulating within the farm system using a whole farm N balance model formulated in an Excel spreadsheet (Microsoft, 2003). The rationale for the development of the model presented in this paper is to assess the production efficiency of dairy farming systems in relation to N use efficiency by combining this model with the MDSM (Shalloo *et al*., 2004).This allows the strategies and biological processes of agricultural systems to be evaluated. To integrate a set of alternative management strategies and accurately capture the consequences of contrasting systems from a variety of scenarios, a comprehensive range of feed and animal production alternatives for Irish grass based milk production systems were examined. The physical performance data were obtained from a five year study McCarthy *et al*. (2007) conducted at Curtins Research Farm, at Moorepark Dairy Production Research Centre. The study consisted of 3 divergent strains of Holstein-Friesian cows consisting of high-production North American (HP), high-durability North American (HD), and New Zealand (NZ), managed across a variety of Irish pasture-based production systems - the Moorepark Blueprint system (MP), a high concentrate input system (HC), and a high stocking rate system (HS). Farm system N balances on an individual cow basis were calculated for each dairy production system simulated from the MDSM, at monthly stages during the year. All N imported into the dairy system, circulated within and exported from the dairy system was accounted for. Nitrogen input into to the individual cow consists of N in feed consumed (grazed grass, silage and concentrates) and N required to replace the individual cow. The N outputs from the farm system are N leaving the system in products (milk, meat), not including N retained in the soil and crops. The sum of the annual inputs less outputs in the form of agricultural products is the annual N balance. Imports and exports of N were expressed as kg N cow^{-1}. Nitrogen use efficiency was calculated as the proportion of imported N recovered in agricultural products.

Results The N input for the whole system, including the rearing of replacement heifers increased as the replacement rate of the different systems increased from 0.18, to 0.25, and 0.37 for the NZ, HD and HP, respectively. As replacement rate increased, the total N input per cow increased from 167.8 kg N cow^{-1} for NZ strain, 183.0 8 kg N cow^{-1} for HD strain and 199.6 kg N cow^{-1} for HP strain (Table 1).The N surplus per cow was greater for the HD and HP strains (140.0 and 155.5 kg N cow^{-1}, respectively) than for the NZ strain (127.7 kg N cow^{-1}) (Table 1).

Table 1 The annual farm system Nitrogen balance per cow

Genetic strain	**HP**	**HD**	**NZ**
Total kg input (kg N cow^{-1})	199.7	183.0	167.8
Total N output (kg N cow^{-1})	44.1	42.9	40.1
N surplus (kg N cow^{-1})	155.6	140.1	127.8
N use efficiency cow^{-1}	0.221	0.234	0.239

Conclusion The results demonstrated that within pasture-based systems the lowest N surpluses were observed with the Holstein-Friesian cows combining high genetic potential for both production and fertility traits (HD and NZ strains), rather than those selected solely for increased milk production potential (HP strain).

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References

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