Assessment and improvement of the efficiency of nitrogen use on commercial dairy farms

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Introduction Dairy farming systems have a low efficiency of converting nitrogen (N) into milk protein, due to the many transfers which occur in the production process. Losses of N from the system can be detrimental to the environment and represent wasted inputs. At SAC, in a systems research project, management changes achieved increases in nitrogen efficiency (milk N output/ N inputs) (NE) from 23 to 34% in a grass-clover based system (GC), and 13 to 21% in a purchased fertiliser based system (GN) (Leach & Roberts, 2002). Nitrogen surplus (NS = N inputs - N output in sold produce) was reduced from 184 to 90 kg N/ha in GC and from 369 to 258 kg N/ha in GN. This work was then incorporated into a participatory research project, to obtain data on N balances in commercial dairy systems and investigate the effects of suggesting management changes to improve NE.

Materials and methods Nine dairy farmers agreed to participate in this project from 1997 to 2001. All were subscribers to a detailed enterprise recording system, which included milk sales, feed and fertiliser inputs and stocking rate. Farmers were provided with information from the SAC dairy systems project and possible strategies to improve NE were discussed with them. Nitrogen efficiency and NS were evaluated each year for each dairy unit, excluding youngstock and any other farm enterprises. Nitrogen output/ha was estimated from annual milk sales, milk protein content and stocking rate. Nitrogen input was calculated from nitrogen fertiliser used, amount and protein content of purchased animal feed and estimates of deposition in rain and fixation (where there were clover based swards receiving less than 250 kg N/ha per year).

Results The largest changes in nitrogen output/ha were due to changes in stocking rate rather than changes in milk yield/cow or milk protein content. Reductions in nitrogen input/ha were mainly due to reductions in fertiliser use. Farm 1 - was unable to make changes to the system due to other farming constraints. Farm 2 - increased forage area by 20% and reduced nitrogen fertiliser use over whole unit by 24%. Farm 3 - reduced fertiliser nitrogen use (kg/ha) by 28% in year 2, but then increased forage area, cow numbers and fertiliser use in subsequent years. Farm 4 - converted to organic status milk output remained the same with forage area increasing by 36% and nitrogen fertiliser use falling to zero by year 4. Farm 5 - had the lowest fertiliser use at the start of the project and this was further reduced in year 2 but in year 4 there was a fall in output and a decision made to increase fertiliser use to grow more home-grown forage. Farm 6 - also moved to organic status from year 1; the decrease in efficiency in year 4 was due to increased nitrogen fixation, more purchased feed and a decline in milk sales. Farm 7 - improvements in nitrogen efficiency were due to reductions in nitrogen fertiliser use in years 2 and 4. Farm 8 - increased purchased feed use by 33%, although from a low level of 725 kg DM/cow per year but increased forage area and reduced fertiliser use by 77%. Farm 9 - increased cow numbers at start of project and in year 4 reduced nitrogen fertiliser use from 351 to 207 kg/ha.

Table 1 Nitrogen efficiency on farms (NE, %) over four years

Farm	1	2	3	4	5	6	7	8	9
Year 1	17	13	15	15	23	10	13	17	17
Year 2	16	14	24	18	28	21	18	20	21
Year 3	17	15	16	22	22	27	15	21	19
Year 4	Na	18	19	31	13	23	18	23	25

Conclusion The results of the study demonstrate the low N efficiencies of UK commercial dairy farms, which were closely linked to N fertiliser application rate. Improvements were made in N efficiency on most farms but not up to the levels from the research systems. The main effects were due to increases in stocking rate and reduction in fertiliser use rather than increases in output per cow. There were year to year variations that arose from effects of season on forage yield and quality and farmers deciding to make other management decisions based on short and long term economic considerations at the expense of nitrogen use efficiency.

Reference

Leach K.A. & D.J. Roberts (2002). Assessment and improvement of the efficiency of nitrogen use in clover based and fertilizer based dairy systems. 1. Benchmarking using farm gate balances. *Biological Agriculture and Horticulture*, 20, 143-155.