Improving grassland management on commercial pilot dairy farms: the role of intensive coaching

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Abstract

In the Netherlands, more than 60% of agricultural land is used for dairy farming. Grass is the most important crop, followed by maize silage. To explore possibilities to increase nutrient-use efficiency and reduce nutrient losses, the method of prototyping a combination of system modelling and system implementation was applied on the experimental farm 'De Marke'. To promote development and adoption of similar systems in commercial dairy farming, the project 'cows & opportunities' (C&O) was initiated in 1999 to bridge the gap in nutrient-use efficiency between experimental farms and commercial pilot farms. Total nitrogen (N) and phosphorus (P) application rate declined from 530 in 1998 to 400 kg N ha^{-1} in 2013 and from 57 in 1998 to 48 kg P ha^{-1} in 2013. Average grass dry matter yields were 11 Mg ha^{-1} but with a huge variation amongst pilot farms. Substantial improvements in grassland management are possible on many commercial dairy farms, but strategies differ amongst farms.

Keywords: dairy farming systems, N-use efficiency, P-use efficiency, dry matter yields

Introduction

In north-western Europe, most cattle production systems are characterized by high stocking densities and intensive use of grassland with high nitrogen (N) and phosphorus (P) inputs through manure and chemical fertilizers (cf. Aarts, 2000). Grassland and crops use these nutrient inputs inefficiently. Generally, more than 50% of the N applied is not assimilated by plants (Mosier *et al.*, 2004) and is a potential source of environmental pollution that compromises the quality of groundwater and surface waters (Galloway *et al.*, 2008). In addition to pollution, nutrient losses represent a waste of energy and money. Losses can be reduced by improved grassland management. The objective of this paper is to present the results of dry matter (DM) yields, N-use efficiency (NUE) and P-use efficiency (PUE) on the commercial pilot farms in the project 'cows & opportunities' (C&O), each of which applied their own strategy. By considering the spectrum of farms, we demonstrate the possibilities for improvement in grassland management.

Materials and methods

The project C&O was initiated in 1999 to promote adoption of proven and tested measures to reduce nutrient losses on the experimental farm 'De Marke'. It is characterized by agreements with the farmers on realization of measurable targets and intensive coaching through frequent interaction between researchers, extension agents and farmers. The project started with a group of 17 motivated farmers. In 2003, one farm left the project because of difficulties in collecting data. In 2009, five farms were replaced. An intensive monitoring programme was used to collect data on the pilot dairy farms (Oenema, 2013). To benchmark results of the pilot farms, a 'national average' was calculated for specialized dairy farms from the Dutch Farm Accountancy Data Network (FADN) (land area >15 ha; at least 80% grassland and fodder crops; >30 milking cows) (Aarts *et al.*, 2008; Oenema *et al.*, 2013). Farm milk production in C&O ranged from 11 to 23 Mg ha^{-1} and grassland occupied ca. 80% of the total land area. Total milk production on the pilot farms was higher than the 'national average' at a similar farm size. Hence, production intensity of the pilot farms was on average higher (by around 2,800 kg milk ha^{-1}), as was milk

production per cow (approximately 500 kg). The N and P application rate on grassland (kg ha^{-1} $year^{-1}$) is defined as the applied amount in organic manure (total N) and mineral fertilizer, in excreta during grazing, biological N fixation by clover (estimated from % clover in grassland × total yield (Mg DM) × 45) and atmospheric N deposition, minus ammonia losses during application and grazing. The NUE and PUE are defined as the input/output ratio (expressed as a percentage) of N or P in the yield over the N and P in the total application.

Results and discussion

The N and P application with manure in C&O remained almost constant during the entire period (245 kg N and 43 kg P ha^{-1}), while the N and P in excreta during grazing showed a decrease over time (from 85 to 25 kg N ha^{-1} and from 12 to 4 kg P ha^{-1}, respectively). The N application from mineral fertilizer decreased from 225 kg ha^{-1} in 1998 to 130 kg ha^{-1} in 2001, while in the remainder of the period the inter-annual variation was very low. The P application from mineral fertilizer decreased threefold in the initial years (from 12 to 4 to 1 kg ha^{-1} in the last two years). On average, total N and P application rates in C&O were almost equal to the 'national average'. Differences were found in the share of the different sources, i.e. pilot farms applied more manure and less mineral fertilizer and a lower input in excreta during grazing. The N fixation by clover in C&O was low (between 5 and 12 kg N ha^{-1}) and was not monitored in the 'national average' (but assumed to be negligible; Aarts *et al.*, 2008).

Table 1. Average dry matter (DM) yield (Mg ha^{-1}), N- and P-use efficiency on grassland in the period 2000-2013 on commercial pilot dairy farms.

Farm	Soil type	Years	DM yield (Mg ha^{-1})	Use efficiency (%)	
				N	P
1	clay	4	15.2	69	137
2	sand	8	9.6	91	103
3	clay on peat	4	10.9	63	103
4	clay	14	14.2	65	89
5	sand	10	11.9	78	102
6	peat	4	9.2	68	78
7	sand	14	11.4	66	88
8	sand	4	10.7	61	90
9	loess	14	10.3	66	94
10	sand	14	10.1	63	72
11	sand	12	10.0	61	83
12	sand	10	11.4	68	80
13	sand	14	10.2	54	73
14	clay on peat	7	10.6	70	68
15	sand	14	11.7	63	93
16	sand	14	11.3	63	82
17	sand	9	12.4	62	89
18	clay	14	9.3	67	82
19	peat	11	10.6	80	94
20	clay	14	11.2	64	69
21	clay on peat	4	11.3	69	93
AVG C&O[1]			11.1	67	89
AVG NatAver[2]			10.1	61	80

[1] Average of the dairy farms in the project 'cows & opportunities'.

[2] National average.

Average DM yields on grassland in the period 2000-2013 in C&O were 11 Mg ha^{-1} (Table 1) and 20% of the total DM yield was grazed. Dry matter yields in the 'national average' were always lower apart from the years 2010 and 2011, resulting in a lower average DM yield (10 Mg ha^{-1}) with a slightly higher share for grazing (28%). Average NUE and PUE in C&O were higher than the 'national average' (10% higher for N and 28% for P). Variation in mean DM yields, NUE and PUE between farms were substantial. Mean DM yields varied from 9.2 to 15.2 Mg ha^{-1}. The NUE and PUE varied from 54 to 91% and from 68 to 137%, respectively.

Conclusions

Dry matter yields, NUE and PUE on commercial pilot dairy farms in C&O in the period 1998-2013 were higher than the 'national average' (1 Mg ha^{-1}, 6% NUE and 9% PUE, respectively), while the total N and P application rates (applied manure, mineral fertilizer and excreta during grazing) were almost equal. Variation among the pilot farms in DM yields (between 9.2 to 15.2 Mg ha^{-1}), NUE (between 54 to 91%) and PUE (between 68 to 137%) were substantial. Results on and for a specific farm cannot be interpreted without the context of that farm and hence cannot readily be extrapolated to other farms. Management options that result in improved NUE include reduced grazing time which results in increased dry matter yields, NUE and PUE as a consequence of better utilization of organic manure (less excreta voided during grazing and more collected manure which can be distributed and applied when needed).

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