Amazing Grazing; N use efficiency of 60 individual dairy cows under intensive grazing

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Abstract

The Dutch dairy sector aims to improve nitrogen (N) use efficiency (NUE_N) of intensive dairy farms while supporting grazing. To gain insight into the NUE_N of intensive dairy farms, we need insight into the NUE_N at cow level. We performed a 2 × 2 factorial grazing trial with 60 Holstein Friesian cows (7.5 cows ha^{-1}), in which we compared NUE_N of individual cows under two grazing systems, i.e. compartmented continuous grazing (CCG) and strip grazing (SG) and two levels of dietary rumen-degradable protein balance (OEB), i.e. low and high (a difference of 500 g OEB cow^{-1} day^{-1}). Grass and supplementary intakes and faecal and milk outputs were quantified and analysed for N content, during two weeks in July and September 2016. Results showed a higher NUE_N for cows in CCG (39%) compared to cows in SG (36%) in July, due to a lower grass (N) intake in CCG. Low OEB showed a higher NUE_N (40%) compared to high OEB (34%). Our results are key to exploring strategies to improve NUE_N of farms that apply innovative grazing systems.

Keywords: Amazing Grazing, intensive, nitrogen, efficiency, system

Introduction

The Dutch dairy sector aims to improve nitrogen (N) use efficiency (NUE_N) of intensive dairy farms, while supporting grazing. Managing NUE_N is challenging, especially in grazing systems, due to seasonal variation in grass quantity and quality. An imbalance between grass intake and supplementation (concentrates and roughages) at cow level can result in inefficient grassland utilisation or suboptimal feeding. Whereas underfeeding will decrease milk production levels, overfeeding will lead to excessive nutrient excretion. During grazing, the concentrated excreta patches exceed plant requirements locally and increase the risk of nutrient losses to the environment. Improving NUE_N can be extra challenging under intensive grazing as there is knowledge deficit regarding grass intake and utilisation in novel intensive grazing systems. The aim of this study was to analyse the NUE_N of 60 individual dairy cows under intensive grazing, testing two novel grazing systems and two levels of protein intake from supplementary feed.

Materials and methods

A grazing trial was performed with 60 mid-lactation Holstein Friesian cows (7.5 cows ha^{-1}) at Dairy Campus, Leeuwarden, the Netherlands. The grazing trial was set up as a 2 × 2 factorial design, in which we compared NUE_N of two novel intensive grazing systems, i.e. compartmented continuous grazing (CCG) and strip grazing (SG), and two levels of dietary rumen-degradable protein balance (OEB), i.e. low and high (a difference of 500 g OEB cow^{-1} day^{-1}). The novel grazing systems (Holshof *et al.*, 2018) were rotational systems in which the cows were offered fresh grass daily to maximise grass intake and utilisation. The CCG system was set up as a six day rotation system in which the average grass height was kept constant and the size of the plot was sufficient to match grass growth with grass intake. The SG system was set up as a 30 day rotation system in which daily grass allowance matched grass intake. The OEB contrast was created by feeding concentrates with different ingredient formulations, one with sugar beet pulp (- 50

OEB) and one with rapeseed meal (+ 50 OEB). Further details on cow characteristics, treatment groups and diet compositions are provided by Zom *et al*. (2018). The cows were pastured from 09:00 - 16:00 h and supplemented with a mixture of maize silage and soybean meal and concentrates (5.5 kg DM) in the cubicle house.

The NUE_N per cow was determined during two intensive measurement periods of 13 d in July (P1) and September (P2) in 2016. Individual grass and supplementary intakes, and faecal and milk outputs were quantified as described by Zom *et al*. (2018). The N content of these inputs and outputs was analysed. Urinary N excretion was considered to be the balancing item. Nitrogen use efficiency was calculated as: milk N / feed N and, to explain the results, N digestibility was calculated as: (feed N – faeces N) / feed N. The statistical programme GenStat 18 was used for a two-way ANOVA with grazing system and OEB level as factors.

Results and discussion

In P1, NUE_N was higher in CCG (39%) than in SG (36%) ($P = 0.003$), mainly because the N intake via grass was lower in CCG than in SG (Table 1). The higher grass intake in SG compared to CCG confirms our expectations, as SG is expected to ensure a higher constant supply of fresh grass. In P2, however, NUE_N did not differ between CCG and SG ($P = 0.723$), because the lower grass intake in CCG was compensated for by higher OEB content of the grass (84 g kg DM^{-1} in CCG vs 65 g kg DM^{-1} in SG). High OEB resulted in a lower NUE_N (34%) compared to low OEB (40%) ($P < 0.001$; Table 1), despite the higher N output via milk for high OEB (160 g cow^{-1} day^{-1}) compared to low OEB (144 g cow^{-1} day^{-1}).

Table 1. The effects of grazing system and dietary rumen degradable protein balance on the nitrogen (N) use efficiency of 60 individual dairy cows under intensive grazing.

	P[1]	Treatment groups[2]				GS[3]	OEB[4]	GS*OEB[3,4]
		CCG-H	CCG-L	SG-H	SG-L	*P*	*P*	*P*
Total feed (kg DM cow^{-1} day^{-1})	1	19.3	18.3	18.8	18.1	0.249	0.01	0.678
	2	18.9	18.0	18.9	17.5	0.579	0.006	0.518
Total feed N (g cow^{-1} day^{-1})	1	472	354	480	375	0.071	< 0.001	0.424
	2	447	360	454	351	0.924	< 0.001	0.419
Grass (kg DM cow^{-1} day^{-1})	1	4.1	4.2	4.6	4.9	0.014	0.477	0.559
	2	2.8	3.4	3.6	3.8	0.033	0.159	0.547
Grass N (g cow^{-1} day^{-1})	1	140	132	161	166	0.002	0.881	0.44
	2	113	139	128	141	0.395	0.058	0.502
Milk (kg cow^{-1} day^{-1})	1	30.8	25.8	31.0	25.9	0.834	< 0.001	0.937
	2	28.9	25.2	29.4	25.5	0.619	< 0.001	0.903
Milk N (g cow^{-1} day^{-1})	1	170	148	166	144	0.255	< 0.001	0.986
	2	150	144	153	142	0.921	0.081	0.618
Faecal N (g cow^{-1} day^{-1})	1	162	152	146	140	< 0.001	0.023	0.481
	2	136	148	146	131	0.67	0.811	0.054
Urine N (g cow^{-1} day^{-1})	1	140	54	168	91	< 0.001	< 0.001	0.541
	2	159	68	155	78	0.758	< 0.001	0.484
NUE_N[5] (%)	1	36	42	34	39	0.003	< 0.001	0.24
	2	34	40	34	41	0.723	< 0.001	0.817
N digestibility[6] (%)	1	66	57	70	63	< 0.001	< 0.001	0.281
	2	69	58	68	63	0.463	< 0.001	0.179

[1] P = period; 1 = July, 2 = September; [2] CCG = compartmented continuous grazing, SG = strip grazing, H = high rumen degradable protein balance, L = low rumen degradable protein balance; [3] GS= grazing system; [4] OEB = rumen degradable protein balance; [5] NUE_N = nitrogen use efficiency in milk N/ feed N; [6] N digestibility = (feed N – faeces N) / feed N.

Differences in NUE_N between the four treatment groups were influenced by differences in N digestibility of the diet. A high NUE_N was associated with a relatively low N digestibility of the diet, whereas a low NUE_N was associated with a relatively high N digestibility of the diet. This is because a higher N digestibility resulted in a relatively larger share of N excretion via urine than via milk. In P1, N digestibility was higher in SG than in CCG ($P < 0.001$), which can be explained by the relatively higher N intake via grass (Table 1). Period 2 did not show a similar result due to a lower grass N content for SG. Nitrogen digestibility was higher for high OEB than for low OEB ($P < 0.001$), which can be explained by the higher N intake from concentrates in high OEB. Compared to other studies, we found relatively high values for NUE_N (average 37%), and relatively low values for N digestibility (average 64%). Milk N output was relatively low, especially for low OEB (144 g cow^{-1} day^{-1}), but in proportion to the low feed N intake this results in a high NUE_N. The low N digestibility, can be explained by a relatively large share of N excretion via faeces (143 g cow^{-1} day^{-1} for low OEB and 148 g cow^{-1} day^{-1} for high OEB), and a relatively small share of N excretion via urine (73 g cow^{-1} day^{-1} for low OEB and 156 g cow^{-1} day^{-1} for high OEB). The relatively low digestibility and high N excretion in faeces might partly result from our assumption regarding N recovery rate of grass. Van den Pol-Van Dasselaar *et al*. (2006) indicated that the recovery rate of grass supplemented with maize silage might be higher than the one we assumed based on Mayes *et al*. (1986b). Differences in urinary N between the low and high OEB groups might partly be explained by an increasing efficiency in urea-N recycling with a decreasing protein content of the diet (Russell *et al*., 1992).

Conclusions

Results showed a higher NUE_N in CCG (39%) compared to SG (36%) in P1 due to a lower grass N intake. Low OEB showed a higher NUE_N (40%) compared to high OEB (34%). In general, we found an increase in urinary N excretion, an increase in N digestibility and a decrease in NUE_N with an increase in total N intake. We found a relatively large share of N in faeces and low share of N in urine. This might have implications for the actual local environmental impact of intensive grazing as urine N is the major contributor to nitrate leaching. The results of this study are key to exploring strategies to improve NUE_N of farms that apply innovative grazing systems.

Acknowledgements

We thank the Province of Fryslân (the Netherlands) and Melkveefonds (LTO Nederland and Wageningen University & Research; the Netherlands) for financially supporting this research.

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