Nitrogen excretions in dairy cows on a rotational grazing system: effects of fertilization type, days in the paddock and time period.

Dufrasne I., Robaye V., Istasse L. and Hornick J.-L.
Nutrition Unit, Veterinary Medicine Faculty, Liège University, B-4000 Liège, Belgium
Corresponding author: Isabelle.Dufrasne@ulg.ac.be

Abstract

The present study aims to quantify nitrogen (N) excretions in dairy cows on a rotational grazing system with different types of fertilization (mineral N, slurry and compost) after 3 or 5 days in the paddock and during two different periods in June and September. Individual samples of faeces and urine were collected to assess N excretions from cows in the paddocks. The urea content in milk from the tank or from the individual cows was also measured. N intake was higher on day 3 compared to day 5 (465 vs. 425 g d^{-1}, $P < 0.001$) and in September as compared to June (488 vs. 400 g d^{-1}, $P < 0.001$) but was not influenced by the fertilization type. The amount of excreted urinary N was significantly higher in the mineral N group than in the two other groups (272 vs. 226 g d^{-1}; $P < 0.001$). The N excretion in faeces and urine decreased with days (92 vs. 84 g d^{-1}, $P < 0.01$; 256 vs. 228 g d^{-1}, $P < 0.001$ respectively for days 3 and 5). Urinary N excretion was lower in June than in September (181 vs. 302 g d^{-1}, $P < 0.001$) while the N excretion in the faeces was higher (96 vs. 80 g d^{-1}, $P < 0.01$).

Keywords : Nitrogen, dairy cows, grazing, urine

Introduction

In pastures composed of different grasses and white clover, nitrogen (N) intake generally exceeds animal requirements and the N surplus is excreted in the faeces and urine. In order to reduce pollution, the European Community aims to limit these N losses but the calculation of amounts can nowadays vary between countries. Fertilization with manures can lead to low N efficiency and N losses owing to N emissions (Stevens and Laughlin, 1997). The present study aims to investigate the effects of three fertilisation types (slurry, compost or mineral N), two different periods of grazing (June or September) and different days (day 3 or day 5) in the paddock on the N excretions in rotationally grazing dairy cows. The days were studied as a control of the measured parameters in the same paddock in which the grass composition changed.

Materials and methods

Three grazed paddocks were used in this experiment. The first grazed paddock was fertilized with mineral N fertilizer, the second with pig slurry and the third with cattle compost. The paddocks were grazed for the fourth and the second times in the rotation, respectively in September and in June of the following year. The total inputs of N by fertilisation were 78 and 56 kg ha^{-1} in the mineral N paddock, 105 and 69 kg ha^{-1} in the slurry paddock, 105 and 78 kg ha^{-1} in the compost paddock, in September and in June respectively. Mineral N and slurry were applied after each grazing, and cattle compost in spring. The measurements were obtained from a herd which comprised 35 Friesian Holstein cows in late lactation in the September trial, and 15 Friesian Holstein cows in mid-lactation from a herd of 40 cows were used in the June trial. Their days in milk were 254 ±72 days in September and 164 ± 93 days in June. In the week prior to the trials, mean daily milk yield was 14.9 ± 4.7 kg d^{-1} in September and 18.5 ± 3.7 kg d^{-1} in June. The cows received 1 kg dry sugar beet pulp per day in the milking parlour distributed with a handling distributor. N contents were determined in grass, urine and faeces, and urea was determined in the milk. Two grass samples were taken at each time. Tank milk samples were taken at each milking in order to determine N and urea contents. A sample of urine (vulval stimulation) was taken on the paddock between 9 h and 10 h a.m. on days 3 and 5 from 35 cows in September and from 15 cows in June. The cows were removed from their grazed paddock to the barn located at 300 meters just for the time of the sample collection. Samples were divided into two parts; one was analysed for creatinin the day of the collection and the other was frozen at -20 °C. At the same time, a faeces sample was taken from each cow by manual collection in the rectum. In June, on collection days, individual milk was sampled at the morning and evening milkings and aliquoted as an individual day sample. The N intake was assessed on the basis of the energy requirement of the cows calculated by the UFL system (INRA, 1980). Grass dry matter intake (DMI) was calculated by dividing the energy provided by grass and grass energy content. N intake was calculated as the sum of N concentrate intake and N grass intake. Urinary creatinin was used to estimate the daily urinary volumes. The insoluble ash contents determined in grass, dry sugar beet pulp and faeces were used to estimate the faeces output (on the basis that the insoluble ash intake is equivalent to the insoluble ash excreted in faeces, since insoluble ash is indigestible). The N faeces output was calculated by multiplying N content in faeces by faeces output. Milk N output was calculated as the milk protein yield/6.38. N retention was calculated as N intake – (Milk N+Faecal N+ Urinary N). The data were analysed with a mixed model (PROC MIXED, SAS, 1999) allowing the inclusion of an autocorrelation between successive measurements made on the same animal within a treatment. The effects of the treatments, the collection days, the month, the interaction between the treatments and collection days, the interaction between treatments and month and the interaction between month and collection days were taken into account in the model.

Results and discussion

Milk urea concentration considered as an indicator of N excretion, was at 248 mg l^{-1} in June and 393 mg l^{-1} in September (Table 1). According to de Brabander *et al.* (1999), the milk urea concentration is deemed satisfactory between 175 and 300 mg l^{-1}. The September values were too high, compared to these recommended values. The significantly higher N intake at day 3 compared with day 5, and in September compared with June, were the results of a higher N intake at day 3 and in September. Milk N excretion was not influenced by the fertilizer treatment, the day on the paddock or the time period. Mean faecal N excretion was within values reported by Leonardi *et al.* (2003) and was higher on day 3 than on day 5 and in June than in September. With mineral N fertilizer, the increased urinary N excretion and increased urinary N proportion in N excretion have to be related to the higher milk-urea content. It should be noted that with compost, the urinary N excretion was lower along with lower N content in urine and lower milk urea content. A more complete chemical analysis of grass with the different fractions of N could explain these results. Fertilization with mineral N could lead to higher nitrate concentrations in the sward, as compared with fertilization with manure. Dieguez *et al.* (2001) reported higher nitrate content in grass fertilized with mineral N as compared to no fertilization and observed also an increase in urea in blood and milk. The significantly higher urinary N excretion at collection day 3 and in September can be associated with the higher N intake. The urinary N excretion relative to DM intake decreased sharply from 12 g kg^{-1} in June to 22 g kg^{-1} in September. It should be noted that the urinary N proportion in N excretion was much higher in September than in June, indicating that the N grass content in September was too high. The very high urinary N excretion, the high milk urea level and the low efficiency in N utilisation in milk in September indicate that the crude protein intake at 230 g kg^{-1} DM content lead to an N intake that was too high for cows with low production. Such high crude protein is not appropriate for cattle. Usual recommendations for dairy cows fed with a forage diet are about 16-18% crude protein (NRC, 2001). With a grass crude protein content at 167 g kg^{-1} DM in June, the N excretion, the milk urea content and the efficiency in N utilisation in milk was improved.

Conclusion

N excretion by grazing dairy cows was comprised mainly of urinary N. High N intake leads to high N excretion and there can be an excess of N in the sward especially at the end of the grazing season. At this time, to improve milk production at grazing, it should be recommended to give an energy supplement, and not an N supplement as is made in practice.

Table 1. Grass nitrogen content, milk urea content, nitrogen balance and partition with grazing dairy cows

	Treatment			Day		Month		SEM
	MinN	S	C	3	5	June	Sept.	
Grass CP in DM (g kg^{-1})	200	202	194	210^a	186^a	167^a	230^b	3.8
Milk yield (kg d^{-1})	16.5	17.2	17.0	17.2	16.7	18.7	15.1	0.4
June milk urea (mg l^{-1})	277^a	240^b	227^b	254	242			6.7
Sept.milk urea (mg l^{-1})	425	375	380	383	403			
N intake (g d^{-1})	448	449	436	465^a	425^b	400^a	488^b	7.1
Milk N excr. (g d^{-1})	88	93	93	93	90	93	89	2.4
Faecal N excr. (g d^{-1})	81^a	94^b	89^{ab}	92^a	84^b	96^a	80^b	2.0
Ur. N excr. (g d^{-1})	272^a	235^a	217^c	256^a	228^b	181^a	302^b	5.1
Total N excr. (g d^{-1})	353^a	329^b	306^b	347^a	312^b	276^a	382^b	5.9
Retention N (g d^{-1})	4.31^a	32.4^b	29.3^b	26.3	17.8	31.2	12.8	7.6
Ur. N/N excr. (%)	74.4^a	70.8^b	70.8^b	72.3	71.6	65.4^a	78.6^b	0.5

For a similar parameter (fertilisation treatment, day or month) means with different superscripts differ significantly ($P < 0.05$)

CP: crude protein. MinN: mineral nitrogen. S: slurry. C.: compost. Sept.: September. excr. : excretion. Ur. : urinary

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