Comparison of three gradients of grazed grass in dairy cows' diet in terms of environmental and zootechnical performances

Lessire F. [1], Dufrasne I.[12]
[1]University of Liège. Animal Nutrition Unit. Quartier Vallée 2 Avenue de Cureghem. 6. 4000 Liège. Belgium; [2]Centre des Technologies Agronomiques (CTA), Rue de la Charmille, 16 4577 Modave, Belgium.

flessire@uliege.be

Abstract

Climatic change induces challenges in grazing management, which could tempt farmers to keep their cows indoors. To assess the environmental and economic impact of diets with different percentages of grazed grass, thirty-three Holstein cows in early lactation were divided into three groups from 27 April to 7 July 2018. These groups were allocated an increasing proportion of grazed grass in their diet. No access to grazed grass was possible for Group 1 (0%), while Group 2 and 3 were granted access to pasture 21w. Group 2's (100%) diet was composed of 100% grass. Group 3 (50%) received silage in the barn as well as grazed grass. The access to pasture was adapted to achieve a proportion of 50% grass in the diet. Sward height was measured every week with an electronic rising plate meter (EC 20®), and the nutritional composition of grazed grass was evaluated. All the groups' diet was complemented with concentrates delivered by the automatic concentrate supplier, where the Guardian® was located in order to measure the methane emitted at each visit. Methane emissions were also assessed by predictions based on the mid infra-red (MIR) spectrum of milk samples. Animal performance was recorded and the milk carbon footprint was estimated by the Feedprint®. No difference in milk yield between the groups was recorded. Predictions based on the MIR spectra analysis showed a slight decrease in methane emission per cow and per day in the 100% group, but this decrease was not confirmed by the breath samples measurements. The feeding costs were in favour of the 100% group. The carbon-footprint of the milk produced with 100% or 50% of grazed grass was lower than for the zero-grazing cows.

Keywords: grazing, methane emissions, milk carbon footprint, grazing practices, dairy cows

Introduction

Grasslands are recognized as playing the role of carbon sink, allowing the mitigation of a substantial amount of greenhouse gases from the agricultural sector (Soussana *et al.*, 2010). Yet, grazing may contribute to the preservation of these areas. A survey undertaken during the Life project Dairyclim showed that the difficulty in managing grazing was a decisive factor for stopping grazing (Lessire *et al*., 2018_a). Other invoked reasons for abandoning this practice are economic and climatic. Especially in intensive farms, farmers prefer to feed the cows with a controlled diet indoors, even during the summer period. In this context, the aim of this trial was to assess how the percentage of grazed grass in cows' diet could influence production performances and environmental indicators such as methane emissions and the carbon footprint (CF) of milk. The economic impact of grazing was also estimated through the calculation of feeding costs linked to the different diets.

Material and Methods

The study was conducted at the Centre of Agronomic Technologies (CTA) in Belgium from 19 May 2018 to 6 July 2018, after a 3-week transition period. Thirty-three Holstein cows in early lactation were divided into three groups balanced on milk yield (MY), days in milk (DIM) and lactation number (LN) (Table 1). Each group received a different amount of grazed grass in the ration. The first group was kept indoors. The percentage of grass was therefore 0%. The second group (100%) had access to pasture. For the third group, the allocation of grazed grass was estimated at 50% on the basis of sward height measurements and grazing time. This group was offered a partial mixed ration in the barn. The different rations are described in Table 2.

Table 1. Description of the three groups at the beginning of the trial.

	Nbr cows	DIM	LN	MY (kg $cow^{-1}d^{-1}$)
Group 0%	11	133 ± 58	1.9 ± 0.9	29.5 ± 4.9
Group 50%	11	134 ± 59	2.1 ± 1.0	28.0 ± 6.8
Group 100%	11	133 ± 43	2.0 ± 0.9	26.4 ± 6.0

Abbreviations: DIM: days in milk; LN: lactation number; MY: milk yield

All the rations were calculated to ensure energy inputs of 20 KVEM (142 NEL). The Groups 0 and 50% received a ration mainly composed of forages: (Group 0 - 78.8% and Group 50 - 35%).

Table 2. Description of the diet allocated to each group.

% DMI	Group 0% grazing	Group 50% grazing	Group 100% grazing
Grass silage	33.7	-	-
Alfalfa silage	19.5	20	-
Maize silage	17.6	7	-
Beet pulp silage	8	8	-
Barley	4.2	4	-

Concentrate rich in protein (40%)	8.5	2	-
Grazed grass	-	50	91
Concentrates ACS	8.5	9	9
Total DMI	21.6	20.4	19.8
Foreseen production	25.6 L (energy) 29.7 L (protein)	24.3 L (energy) 29.1 L (protein)	24.8 L (energy) 31.2 L (protein)

Abbreviations: ACS: automatic concentrate supplier; DMI: dry matter intake

The milk production and the concentrate consumption were recorded daily. Methane and CO2 in breath samples were analysed by the Guardian® inserted in the automatic concentrate supplier. Methane productions were estimated following the method described by Haque *et al*. (2014). Individual milk samples were analysed twice per month for milk quality and for methane emissions, evaluated by milk spectra analysis based on the method described by Vanlierde *et al.* (2016).

Sward height was measured by the EC20® rising plate meter every week, in order to have an estimation of the grass availability and growth. The grass density was measured in a plot excluded from grazing, where grass was mowed on a 10m-length band every week. The mowed grass was weighted and dried to calculate the grass density. The difference between sward height at the paddock entrance and exit, multiplied by the grass density and the surface of the paddock, provided the amount of grass eaten. This amount was then divided by the number of cows present on the paddock. Hand-plucked samples of grass were taken from the grazed paddock to determine its nutritional value. Meteorological data collected in a CTA weather station were also compiled to establish a link between the weather and the recorded grass growth.

The carbon footprint of feeding was estimated first by calculating the emission factors (kg-eq CO_2) of each feed component using the Feedprint® (Vellinga *et al*., 2014), and then by adding them on a *prorata* basis of their % in the ration.

Feeding costs were calculated on the basis of purchase invoices. The silage production costs were estimated with the software "Dégâts du gibier", developed by Fourrages Mieux. The costs of grazed grass took into consideration the grass yield and the inputs to the pastures.

Descriptive data analysis was made using the software R (R-core Team 2016). Further analysis of methane emissions and animal performance was performed with Proc mixed (SAS 9.3). The model included a repeated statement (repeated days/subject animal) and a covariance analysis type cs.

$Y_{ij} = \mu + Gr_i + NL_j + period_k + concentrate_l + DIM_m + period_k \text{ X } Gr_i + e_{ijklm}$
where μ = the overall mean with fixed effects being Gr_i = group effect (i = 1 to 3 for group 1 = 0% to group 3 = 100%); NL: effect of lactation number (k =1 to 3 - 1 = primiparous, 2: 2[d] lactation and 3 = over the second lactation); concentrate: concentrate consumption (kg $cow^{-1}.d^{-1}$); DIM_m:days in milk; $period_k$: period of measurement (May - June); $period_k$ X Gr_i: interaction group X $period_l$; e_{ijklm}: residual error.

The model calculating the methane from breath samples took also in consideration the weight of the cow (kg), the sampling duration (min) and the number of samplings (n per day) in the automatic concentrate supplier.

Results

The meteorological data showed that the average temperature was higher than usual during the three months of the trials: 15.7°C; 17.2°C and 20.9°C respectively in May, June and July, compared to the values from the last 25 years: 12.9°C; 15.45°C and 17.5°C respectively in the same months. The rainfalls were more intense in May (78 mm in May vs 63.6 mm (25 year value)) while a drought occurred in July (10.1 mm vs 85.7 mm (25 year- value)). It must be noted that the precipitations observed in May and June (55.8 mm) were boosted by some days with intense rainfalls (>10 mm: 1 d in May – 2 d in June). These weather conditions favoured a higher grass growth rate in May and June (72.2 kg DM $ha^{-1}.d^{-1}$ in May; 40.3 kg DM $ha^{-1}.d^{-1}$ in June vs 56.4 kg DM $ha^{-1}.d^{-1}$ in May and 28.7 DM $ha^{-1}.d^{-1}$ in June 2017). During the trial period, the grass density was 280 DM ha^{-1}.

The mean grass intake was 16.2 kg DM for Group 100% and 10 kg DM for Group 50%. The nutritional values of grass were very good, with an energy supply of more than 1 KVEM (7.10 NEL) per kg DM and a protein content of over 20%. The values of 2017-2018 were very close (212 g kg DM^{-1} in 2018 vs 215 g kg DM^{-1} in 2017; VEM: 1003 g kg DM^{-1} in 2018 vs 1014 g kg DM^{-1} in 2017).

No statistical difference in milk yield (MY) or in energy corrected milk (ECM) yield was observed during the trials' period (Table 3). The methane emissions predicted by MIR were lower in the groups 100% and 50% compared to 0%, but the breath samples analysis did not confirm this result.

Table 3. Production recorded in the three groups during the trial period.

	Group 0%	Group 50%	Group 100%	Signification stat
MY ($kg.cow^{-1}.d^{-1}$)	28.5 ± 1.3	27.2 ± 1.2	25.2 ± 1.3	ns
F%	3.78 ± 0.15	3.81 ± 0.15	3.60 ± 0.15	ns
Prot%	3.21 ± 0.07	3.18 ± 0.06	3.06 ± 0.07	ns
ECM ($kg.cow^{-1}.d^{-1}$)	27.5 ± 1.5	25.2 ± 1.4	24.2 ± 1.5	ns
Methane MIR ($g.cow^{-1}.d^{-1}$)	475 ± 9	440 ± 9	430 ± 9	*
Methane Guardian ($g.cow^{-1}.d^{-1}$)	453 ± 47	459 ± 31	472 ± 45	ns

Values are LS means ± SE.
Abbreviations: MY: milk yield; F: milk fat content; ECM: energy corrected milk; MIR: mid infra-red; ns: not significant; *: $p<0.05$.

The drought induced a reduction in the annual grass production so that the production costs of grazed grass were higher than in past years. For example, it was estimated at €60 per TDM in 2017, while it reached €90 per TDM in 2018. Despite this, the feeding costs of group 100% were approximately half those of 0% group. The 50% group had intermediary values (Table 4). The milk revenue was calculated on the basis of milk sale prices during the trials' period. Although we observed a lower milk, fat and protein production, the net margin was favourable for grazing groups.

The Carbon Footprint of the 100% and 50% ration was lower than that of the 0% (8549 g $eqCO_2$ - 8765 g $eqCO_2$ in groups 100% and 50% respectively vs 10360 g $eqCO_2$ in group 0%). Due to a lower MY in group 100%, the reduction of the Carbon Footprint g $eqCO_2$ per kg milk or per kg ECM was attenuated.

Table 4. Feeding costs, milk revenue and CF (Climate impact) calculated in the different groups.

	Group 0%	Group 50%	Group 100%
Costs per cow.d	4.72 €	3.36 €	2.19 €
Costs per 100 kg milk	16.6 €	12.3 €	8.7 €
Sale price 1kg ECM	7.99 €	7.63 €	6.73 €
Net margin per cow.day	3.26 €	4.27 €	4.54 €
Total CF in daily diet	10360 g $eqCO_2$	8765 g $eqCO_2$	8549 g $eqCO_2$
CF. kg $milk^{-1}$	356 g $eqCO_2$	322 g $eqCO_2$	339 g $eqCO_2$
CF. kg ECM^{-1}	369 g $eqCO_2$	361 g $eqCO_2$	353 g $eqCO_2$

Discussion

The grass growth rate observed in May and June allowed the group 100% to reach the same milk production level as groups 0% and 50%. Statistically, significant differences in methane emissions between treatments were not recorded, while these were recorded between Groups 0% and 100% using MIR predictions. This is consistent with the results observed in 2017 (Lessire *et al.*, 2018_b). Discrepancies in methane estimations obtained with the methods based on breath samples and MIR spectroscopy were also reported in another study (Shetty *et al.*, 2017) and could be attributed to several factors. One is that the methane in breath samples was measured over several days, and breath samples were taken every 3 seconds during the visits in the concentrate supplier. By comparison, only two milk samples per period were made. Finally, the methods to assess methane emissions are different: one is based on $CH_4:CO_2$ ratio in breath samples, and the other one on milk spectra analysis.

A slight decrease in the carbon footprint of produced milk was observed for both rations based on 100% and 50% grazed grass. It has to be noted that only the climate impact was taken into consideration and not the other indicators like LULUC changes or biodiversity index. This evaluation has yet to be completed.

Feeding costs were reduced as grazed grass intake increased. Even with the slight numerical reduction in MY for group 100%, costs were quite divided by two, allowing the group 100% to record the highest net margin.

Conclusion

Full grazing was beneficial in terms of economic performances. No statistically significant difference in zootechnical performance was observed. These results arose from the analysis of data collected in May and June, a period of intense growth rate. The follow up of the whole season suggests that these results would not be as beneficial in July and August because of droughts and their effect on grass growth. No difference in methane emissions per cow per day was registered. The carbon footprint calculated on the daily diet was favourable to the grazing groups but when reported by kg milk or kg ECM, this was less advantageous. Due to climatic uncertainties, complementing grass with forages has to be recommended to maintain animal performances, preserve grazing, and still contribute to decreasing the feeding costs and the environmental impact of dairy products.

Acknowledgements

This study was carried out during the Life Dairyclim project funded by the EU.

References

Haque M. N., Cornou C., Madsen J. (2014). Estimation of methane emission using the CO2 method from dairy cows fed concentrate with different carbohydrate compositions in automatic milking system. *Livestock Science* 164(0), 57–66.

Lessire F., Scohier C., Kristensen T., Reding R., Lioy R., Reuter W., Elias E., Dufrasne I. (2018_a) Grazing practices in three European countries: results of a survey in dairy farms. *Grassland Science in Europe*. 23 619-621.

Lessire F., Scohier C., Dufrasne I. (2018_b) Methane emissions and milk carbon footprint of dairy cows at grazing or fed with a concentrate diet. *Grassland Science in Europe*. 23, 616-618.

Shetty N., Løvendahl P., Lund M. S., Buitenhuis A. J. (2017) Prediction and validation of residual feed intake and dry matter intake in Danish lactating dairy cows using mid-infrared spectroscopy of milk. *Journal of Dairy Science* 100, 253–264.

Soussana. J. F., Tallec. T., Blanfort. V. (2010). Mitigating the greenhouse gas balance of ruminant production systems through carbon sequestration in grasslands. *Animal*. 4(3). 334–350.

Vanlierde. A., Vanrobays, M. L.. Gengler. N.. Dardenne. P.. Froidmont. E.. Soyeurt. H.. … Dehareng. F. (2016). Milk mid-infrared spectra enable prediction of lactation-stage-dependent methane emissions of dairy cattle within routine population-scale milk recording schemes. *Animal Production Science*. *56*(3), 258–264.

Vellinga T.H.V, Blonk H., Marinussen M., Zeist W.J., van. Starman D.A.J. Methodology used in FeedPrint: a tool quantifying greenhouse gas emissions of feed production and utilization (2014) Wageningen UR Livestock Research SN - 1570-8616.UR - http://edepot.wur.nl/254098