Spring grass availability and silage supplementation impact on dry matter intake and enteric methane emissions in grazing dairy cattle.

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Abstract
Enteric methane (CH_4) emissions were measured in forty spring calving cows offered one of two (n=20) contrasting diets (High Grass; HG, Low Grass; LG) over 10 weeks in early lactation (8th February – 18th April 2021). All cows were blocked for breed and parity and balanced on milk production, economic breeding index (EBI), bodyweight and body condition score and randomly allocated to treatments. The HG grazing treatment cows were offered their full daily nutrient requirement from grazed grass and concentrate with no silage supplementation. The LG grazing treatment cows were offered a restricted (~60%) amount of their daily nutrient requirement from grazed grass with the deficit being supplied by 3 kg DM/cow of grass silage fed daily. Concentrate supplementation was the same for both treatments at 2.7 kg DM/cow/day. All forage samples were analysed using near – infrared spectrometry to evaluate quality parameters. Milk yield was recorded daily with milk composition determined weekly. Daily CH_4 emissions were monitored using Greenfeed technology. Individual animal dry matter intake (DMI) was determined at five time points using the n-alkane technique. Over the 10 week experiment collected data was averaged fortnightly in 5 periods (period 1-5) prior to analysis. Milk yield and milk solids (fat plus protein) production were similar for both treatments. The HG treatment tended to have greater total DMI (TDMI) with a significant diet by period interaction evident. Daily CH_4 emissions (g/d) were not effected by treatment, however there was a treatment by period interaction. This resulted in a significant treatment effect for CH_4 yield (g/kg TDMI). This was complemented with a significant treatment by period interaction with the greatest difference in CH_4 yield evident in period 4. Increasing the proportion of highly digestible grazed grass in the diet in early lactation can aid in reducing enteric CH_4 emissions in pasture based dairy systems.

Introduction
Demand for global dairy products is set to increase by 47 % by 2050 compared to 2005 levels (FAO, 2017), with increased consumption per capita of 1.4 – 2.0 % per annum in developing countries (OECD et al., 2015). Increasing dairy production to meet this demand will have both environmental and economic constraints, however these constraints will depend on the dairy system used to meet this demand (Herron et al., 2022). Pasture based dairy systems are categorised by the primary feed source being grazed grass, typically ≥ 60% of the diet (Delaby et al., 2020). Pasture based dairy systems provide an economic resilience (Horan and Roche, 2020) with animal welfare and environmental benefits (Delaby et al., 2020). Although these dairy systems are a minority in milk production globally there efficient implementation can provide a key role in the mitigation of greenhouse gas emissions due to the potential of permanent grassland to provide highly digestible forage and sequester carbon (Conant et al., 2010). Ireland's agricultural greenhouse gas emissions are dominated by enteric CH_4 accounting for 64% (Teagasc et al., 2019). Increasing the proportion of grazed grass and limiting silage supplementation in the diet is reported to improve animal performance (Claffey

et al., 2019), although the effect on enteric CH_4 is still not fully quantified. Efficiently managed rotational grazing systems have been seen as an important CH_4 mitigation tool (FAO et al., 2013) with forage quality and digestibility key factors that dictate the level of emitted CH_4 (Gastelen et al., 2019). At pasture the measurement of individual cow enteric CH_4 and dry matter intake (DMI) have proven challenging with few measures reported in early lactation. Increasing the utilisation of grazed grass in the diet of dairy cattle is reported to be imperative to improving farm profitability (Hanrahan et al., 2018), however the potential to reduce enteric CH_4 is still under investigation. The objective of the current experiment was to investigate the effect of grass availability and silage supplementation on animal performance and enteric CH_4 in early lactation spring calving dairy cows.

Materials & Methods

An early lactation grazing experiment took place at the Teagasc, Animal and Grassland Innovation Centre, Moorepark, Fermoy, Co. Cork, Ireland over a 10 week period from the 8^{th} February to the 18^{th} of April 2021. All animals used for the experiment were blocked for breed and parity and balanced for EBI, pre experimental milk production, bodyweight and body condition score. One week after calving cows were randomly allocated to one of two grazing treatments (High Grass; HG, Low Grass; LG) with a total of 20 animals per treatment. The HG treatment received a high allocation of daily herbage allowance (DHA) (12.1 ± 4.1, kg DM/cow) with no silage supplementation, while the Low Grass (LG) treatment received a low allocation of DHA (9.1 ± 3.5, kg DM/cow) with grass silage supplemented daily after morning milking (4.1 ± 2.4, kg DM/cow). Concentrate supplementation was kept consistent for both treatments. The grazing area used was divided into individual plots where both treatments grazed separately. Animals were allocated fresh pasture after each am and pm milking with access to water at all times. During periods of adverse weather all cows were housed and fed grass silage, however a 3 kg DM/cow differential in silage offered was maintained between treatments. Prior to each grazing, herbage mass (kg DM/Ha, >3.5cm) was determined by harvesting two strips (1.2m x 8m) in each treatment paddock using an Etesia Mower (Etesia UK Ltd., Warwick, UK) to determine DHA at each grazing. Herbage samples were collected from harvested strips to be used for forage analysis. Pre grazing herbage mass was consistent for both treatments (HG 1775, LG 1695, kg DM/ha, respectively). All forage samples were analysed using near-infrared spectrometry. Daily individual milk yields (kg) were measured at each milking with milk composition determined weekly from one successive am and pm milk sample. Individual cow DMI was determined over 5 measurement periods using the n-alkane technique as described by Mayes et al (1986) and modified by Dillon and Stakelum et al (1989). Gaseous emissions were monitored using Greenfeed technology with one Greenfeed unit allocated to each treatment. All data was averaged fortnightly across five periods and checked for normality with all statistical analysis performed using SAS 9.4. Data was subjected to linear mixed model analysis using the proc mixed procedure, Breed, parity, period, treatment and their relevant interactions were used as fixed effects with animal as the random factor. All least square mean values are reported with significant effects declared when $P \leq 0.05$, and tendencies ranging from $0.05 \leq P \geq 0.10$.

Results & Discussion

All forage quality parameters are reported in table 1. Grazed grass OM digestibility increased over the experimental period with the greatest level evident in the final two weeks of the experiment (P5; 884.27 g/kg DM). There was a tendency ($P = 0.072$) for HG treatment to have greater total DMI (TDMI), which was driven by a greater (*P<0.001*) grass DMI (GDMI) on the HG treatment. Neither milk yield or milk solids production were affected by treatment. Daily CH_4 emissions were not affected by treatment, although the HG treatment had significantly (*P = 0.021*) lower CH_4 emissions in period 4 of the experiment resulting in a treatment by period interaction. There was no effect of treatment on CH_4 intensity (g/kg MS) however a treatment by period interaction (*P = 0.012*) was evident. Methane yield (g/kg TDMI) was significantly (*P = 0.016*) lower in the HG treatment. The significant effect of treatment on GDMI (*P<0.001*) and tendency for greater TDMI in the HG treatment resulted in lower CH_4 yield (g/kg TDMI), particularly in period 4 and period 5 of the experiment (Fig.1). Early lactation is reported as a period with the lowest levels of enteric CH_4 (g/d) mainly due to the suppression of feed intake post-partum, transition of diets (Lyons et al., 2018) but also due to increased grass digestibility (Muñoz et al., 2021). Findings from the current experiment show as pasture based dairy cow's progress through early lactation spring grass OM digestibility significantly increased GDMI, however CH_4 emissions (g/d) and CH_4 yield declined. The LG treatment had greater CH_4 emissions in period 4 which resulted in significantly greater CH_4 yield when compared the HG treatment. Although in Period 5 the difference in CH_4 yield was driven by the HG treatment having significantly greater TDMI (P5; HG 17.7 LG 15.6 kg, respectively) mainly driven by GDMI due to greater grass OM digestibility. Forage digestibility particularly OM digestibility plays an integral role in the level of animal DMI and enteric CH_4 emissions and CH_4 yield in dairy cattle (Gastelen et al., 2019). Cows offered a greater proportion of grazed grass tended to have greater TDMI and lower CH_4 yield when compared to cows supplemented with grass silage in early lactation.

Conclusions

Increasing the proportion of highly digestible grazed grass in the diet in early lactation enhanced TDMI and significantly reduced CH_4 yield improving the sustainability of pasture based dairy cows.

Table 1. Quality parameters of grazed grass and grass silage fed over the experimental period.

Item	Grass	SD	Silage	SD
Dry Matter (%)	19	1.6	33	6.4
Crude Protein (g/kg DM)	213	29.1	199	11.4
Ash (g/kg DM)	105	18.4	62	5.3
Neutral Detergent Fibre (g/kg DM)	343	35.7	369	51.2
Acid Detergent Fibre (g/kg DM)	186	27.2	213	24.7
Organic Matter Digestibility (g/kg DM)	832	31.4	745	46.0

Table 2. Concentrate DMI (CDMI), silage DMI (SDMI), grass DMI (GDMI), total DMI (TDMI), milk production, Greenfeed visits, methane emissions (g/d), methane intensity (g/kg MS) and methane yield (g/kg TDMI) of dairy cattle within the HG and LG treatment analysed for the effect of treatment, period and their relative interaction.

				P value		
Item	HG	LG	SEM	Treat	Period	Treat x Period
CDMI (kg)	2.8	2.7	0.04	0.203	0.001	0.006
SDMI (kg)	1.8	5.3	0.27	0.001	0.001	0.001
GDMI (kg)	10.2	6.5	0.27	0.001	0.001	0.001
TDMI (kg)	15.1	14.3	0.32	0.072	0.001	0.018
Milk Yield (kg)	23.9	23.6	0.67	0.764	0.001	0.482
Milk Solids (kg)	2.1	2.1	0.06	0.980	0.001	0.239
Methane (g/d)	308.6	319.3	8.96	0.350	0.001	0.003
Methane/Milk Solids (g/kg MS)	151.4	154.7	4.64	0.590	0.001	0.012
Methane/DMI (g/kg TDMI)	21.3	22.9	0.48	0.016	0.001	0.006

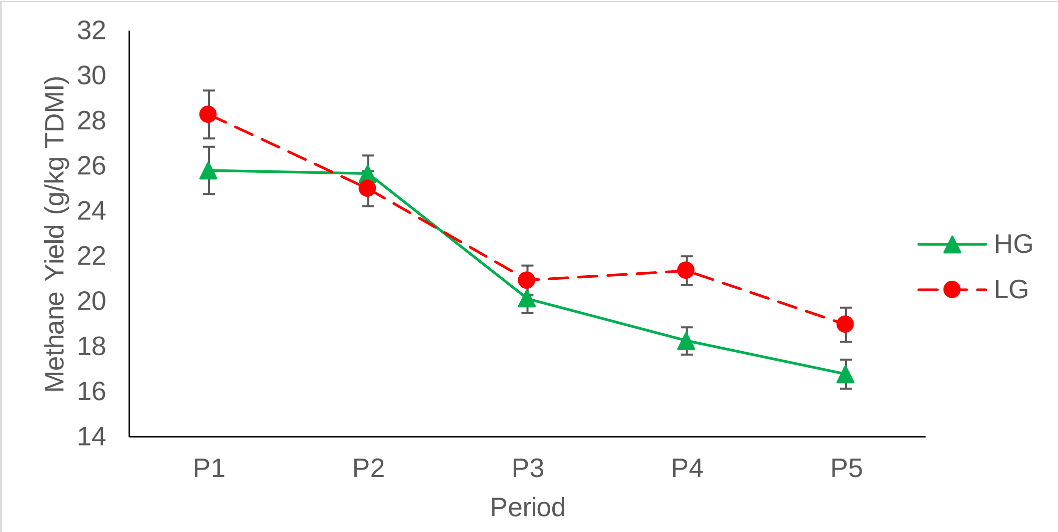

Figure 1. Methane Yield (g/kg TDMI) of cows within the HG and LG treatment over the experimental period (P1; 08/02 - 21/02, P2; 22/02 – 07/03, P3; 08/03 – 21/03, P4; 22/03 – 04/04, P5; 05/04 – 18/04)

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