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Effect of pre-grazing herbage mass on grazing behaviour, grass dry matter intake and milk production of dairy cows

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ABSTRACT

Identifying the optimum level of pre-grazing herbage mass (HM) across the grazing season is critical to maximising dry matter intake (DMI) and milk production from dairy cows. From 27 April to 17 October 2010, in Moorepark, Ireland, 45 Holstein-Friesian dairy cows (mean calving date 23 March 2010) were randomly assigned to Low (L), Medium (M) or High (H) pre-grazing HM treatments (targets 800, 1,500 or 2,200 kg DM/ha, above 4 cm, respectively) using perennial ryegrass-based pastures. Pre-grazing HM was determined twice weekly. Grazing behaviour was measured once and herbage DMI twice. Milk production was recorded daily. The experiment was divided into Period 1 (Mid-season; 27 April to 25 July) and Period 2 (Autumn; 26 July to 17 October). In the autumn, cows on L HM swards grazed for 90 minutes more and had 15% more grazing bites on a daily basis than did the cows on the other treatments. Cows grazing M HM swards tended to have highest DMI (L-15.2, M-16.5, H-15.7 kg DM/cow/day); while cows grazing H HM swards tended to have lowest milksolids yields (L-1.43, M-1.43, H-1.31 kg milksolids/cow/day). Pre-grazing HM levels of 2,200 kg DM/ha may impair DMI and milksolids production per cow, most likely due to decreased sward quality.

Keywords: pre-grazing; herbage mass; dry matter intake; milksolids.

INTRODUCTION

Milk production costs are increasing worldwide, yet grass remains the cheapest source of feed for dairy cows. In Ireland, Dillon *et al.* (2005) showed a reduction of NZ$0.60 in the cost to produce 1 kg of milksolids (MS) when the proportion of pasture harvested by the cows was increased by 10%. Achieving maximum daily intake of highly digestible pasture to produce high milk yields per cow and per hectare is the objective of pasture-based systems (Holmes *et al*., 2003). The intake of pasture by cows is the product of the time spent grazing, the rate of biting during grazing and the weight of pasture per bite (Hodgson, 1990). Herbage mass (HM) influences bite weight and, therefore, the efficacy and profitability of pasture-based dairy systems (Peyraud *et al.*, 1996).

A balance between optimum sward production and quality must dictate the level of pre-grazing HM. A relatively high HM results in increased rotation length (McEvoy *et al.*, 2009) but also results in increased accumulations of stem and dead material, leading to a reduction of overall quality of the pasture available (Hoogendoorn & Holmes, 1992). In contrast, a lower HM may lead to shorter rotation length but increased sward quality, as dead material and stem do not accumulate in the sward. These characteristics, which are inherent in rotational grazing systems, influence the interaction between plant and animal factors, having an impact on milk production. Even at a common pasture allowance, milk yield per cow will be depressed with high HM swards (Holmes *et al.,* 1992).

The objective of this experiment was to identify the optimum pre-grazing HM across the main grazing season by assessing the effects of HM on grazing behaviour, dry matter intake (DMI) and MS production.

MATERIALS AND METHODS

The experiment was conducted at the Animal and Grassland Research and Innovation Centre, Teagasc, Moorepark, Fermoy, Co. Cork, Ireland (50º 09'N; 8º16'W) on a free-draining acid-brown earth soil of sandy-loam to loam texture. The area used was under permanent pasture with a predominately perennial ryegrass sward (*Lolium perenne* L.). The swards were, on average, eight years old.

Treatments and experiment

The experiment was conducted from 27 April to 17 October 2010, and investigated the effect of three levels of pre-grazing HM (above the 4 cm horizon): Low (L HM; 800 ± 100 kg DM/ha), Medium (M HM; 1,500 ± 200 kg DM/ha) and High (H HM; 2,200 ± 300 kg DM/ha) on grazing behaviour, herbage DMI, and MS production of dairy cows in a randomised block design. For a better understanding of the findings, the experiment was split into two periods: Period 1 (Mid-season; 27 April to 25 July) and Period 2 (Autumn; 26 July to 17 October).

Animals

Prior to the experiment, 45 Holstein Friesian dairy cows (15 primiparous and 30 multiparous) were selected and blocked using records of daily milk yield, lactation number, body condition score and body weight. From calving until the start of the experiment, animals were grazing as a single herd. Animals were randomly assigned to the three HM treatments on 27 April (32 days in milk) and remained in their assigned treatment groups until the end of the experiment.

Grazing management

The experimental grazing area comprised 16.5 ha, divided into 24 paddocks; each herd was assigned eight paddocks which were rotationally grazed for the duration of the experiment. Overall grazing stocking rate (SR) was 2.7 cows/ha. Before the trial commenced, the entire experimental area was grazed to a similar post-grazing sward height (4 cm); the target pre-grazing HMs were created by varying the interval (days) between pre-experimental grazing and the first experimental grazing. Thus, the H HM paddocks were grazed initially, followed by the M HM pasture, thereby creating different re-growth intervals. Cows were offered fresh grass daily after morning milking. Pasture allocation was 16.9 ± 0.15 kg DM per cow per day (above 4 cm). Total nitrogen (N) applied was approximately 250 kg N/ha.

Pasture measurements

Pre-grazing HM (above 4 cm) was calculated twice weekly by cutting four strips (1.2 m × 10 m) with a motor Agria (Etesia UK Ltd., Warwick, UK). Pre- and post-grazing sward heights were measured using a rising plate mater (Jenquip, New Zealand), before and immediately after grazing, for each of the three individual treatments.

Grazing behaviour

Six animals from each grazing treatment were fitted with IGER (Institute of Grassland and Environmental Research) behaviour recorders (Rutter *et al.*, 1997). Data were collected over two 24-hour periods. Behaviour measurements were taken on two occasions from each cow over a 14-day period. Following recording, jaw movements were analysed using Graze analysis software (Rutter, 2000).

Herbage dry matter intake

Herbage DMI was measured in two periods, 14 to 19 June (Mid-season) and 13 to 18 August (Autumn) using the n-alkane technique described by Mayes and Lamb (1986), as modified by Dillon and Stakelum (1989). All cows were dosed before morning and afternoon milking with a pellet containing 500 mg of C32 (dotriacontane; Carl Roth, GMbH and Co, KG, Karlesruhe, Germany) for a 12-day period. Faecal grab samples were collected morning and evening, after milking, from each cow in the last six days of n alkane dosage. For each cow, the faecal grab samples of the six-day period were bulked for analysis. The ratio of herbage C33 (tritriaconane) to dosed C32 n alkane was used to estimate DMI.

Milk yield and composition

Individual milk yields were recorded at each milking (Dairymaster, Causeway, Co. Kerry,

TABLE 1: Mean air temperature and rainfall for the period of April to October 2010 compared with the 10-year average 1999-2009.

Measurement	April	May	June	July	Aug	Sept	Oct
Mean air temperatures 2010 (°C)	8.5	10.9	15.4	15.8	14.3	13.6	9.9
Mean air temperatures 1999-2009 (°C)	8.8	11.6	13.9	15.5	15.6	13.7	10.6
Monthly rainfall 2010 (mm)	59.3	38.3	52.5	142.7	23.1	102.1	82.6
Mean monthly rainfall 1999-2009 (mm)	65.5	74.6	67.7	70.1	85.6	89.8	116.6

TABLE 2. Grazing behaviour, herbage dry matter intake (DMI) and daily milksolid (MS) yield for the Autumn (26 July to 17 October 2010) of cows grazing the Low, Medium and High pre-grazing herbage mass treatments of 978, 1,521 and 2,330 kg DM/ha, respectively. Bolding of P value indicates significance (P<0.05).

Measurement	Pre-graze herbage mass			Standard error	P value
	Low	Medium	High		
Grazing time (h/day)	10.8^{a}	9.3^{b}	9.3^{b}	0.7	**0.001**
Rumination time (h/day)	8.4^{a}	9.0^{b}	9.9^{c}	0.8	**0.03**
Bites (n/day)	$42{,}148^{a}$	$36{,}180^{b}$	$35{,}543^{b}$	3,614	**0.01**
DMI (kg/cow/day)	15.2	16.5	15.7	0.5	0.09
MS yield (kg/cow/day)	1.42	1.43	1.31	0.06	0.24

Ireland). Milk fat, protein and lactose concentrations were calculated weekly from one successive evening and morning milking sample for each animal. Protein and fat yields were added to estimate MS yields.

Statistical analysis

All statistical analyses were carried out using the MIXED procedure of SAS (Statistical Analysis System, version 9.2; SAS Institute Inc., Cary, NC, USA). Repeated measures on the same cow for DMI, fat, protein and MS yields, as well as grazing behaviour variables, were analysed with a mixed linear model that included the fixed effect of treatment, week of lactation and their interaction and the random effect of cow. Using the Akaike's information criterion, a compound symmetry error structure was determined as the most appropriate residual covariance structure for repeated measures over time within cow. Pre-experimental milk yield was included as a covariate. Least squares means and their standard errors were obtained for each treatment for each week in lactation.

RESULTS

Table 1 shows mean temperatures and monthly rainfall for the experimental period and for the 10−year average 1999-2009.

Grass and grazing management

On average, ten rotations were completed by the L HM herd, eight by the M HM herd and five by the H HM herd. The mean rotation lengths were 14.5, 20.3 and 29.0 days for the L, M and H HM treatments, respectively. Mean pre-grazing HM were 978, 1,521 and 2,330 kg DM/ha for L, M and H HM treatments, respectively, and were different from each other (P <0.001; standard error (SE) 50.1 kg DM/ha). Areas of pasture allocated were 176, 113 and 74 m^2/cow/day for L, M and H HM treatments, respectively (P <0.001; SE 91.7 m^2/cow/day). Mean post-grazing sward heights were 4.0, 4.2 and 4.3 cm for the L, M and H treatments, respectively, and were not significantly different (P <0.096; SE 0.093 cm). Total surplus grass was 2.7 (L HM), 3.3 (M HM) and 3.7 t DM/ha (H HM).

Grazing behaviour

Grazing time was 90 minutes longer for the cows grazing L HM swards than the other two groups (P <0.001, Table 2). Rumination time was 90 minutes longer for the cows grazing H HM swards than the other two groups (P <0.05). The number of bites per day was greater for cows grazing L HM swards by 6,286 compared to the other two treatments (P <0.05).

Grass dry matter intake

Mean DMI was 16.03 kg DM/cow/day for the whole experimental period. Dry matter intake did not differ between treatments in Period 1 (14 June, 16.03 kg DM/cow/day) but there was a tendency (P = 0.09) in Period 2 (13 August) for cows on M HM swards to have a higher DMI than the other groups (+1.05 kg DM/cow/day, Table 2).

Milksolids yield

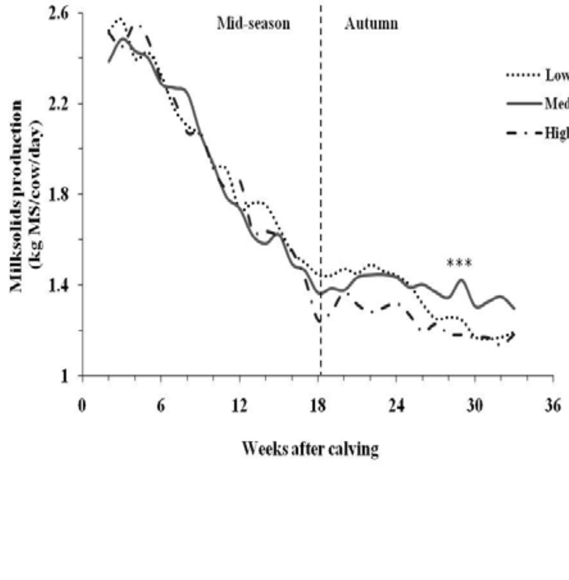
Mean MS production per day was 1.66 kg MS/cow/day for the three treatments. Milksolids production was similar across treatments in Mid-season (1.94 kg MS/cow/day; Table 2) and in Autumn (1.39 kg MS/cow/day). There was a Treatment by Week interaction in autumn (P <0.05).

DISCUSSION

Identifying the optimum level of pre-grazing HM across the grazing season is critical to maximising DMI and MS production of spring-calving dairy cows in any pastoral environment.

How HM is expressed differs between countries. This study was carried out in Ireland, where HM is determined as DM above 4 cm from ground level. In contrast, New Zealand HM values are expressed as DM from ground level. Therefore, the treatments of the present study could be expressed as ground level values provided they are added to HM values below 4 cm. However, HM below 4 cm can be very variable. G. Tuñon (Unpublished data), working with Irish pure perennial ryegrass swards during a year, estimated a mean of 2,376 kg DM/ha for HM below 4 cm, with a range going from 1,618 to 3,134 kg DM/ha. Likewise, other experiments in Ireland and France, also using pure perennial ryegrass swards, reported

FIGURE 1: Mean weekly milksolid (MS) production of cows during each week of the trial while grazing Low, Medium and High pre-grazing herbage masses of 978, 1,521 and 2,330 kg dry matter per hectare, respectively, measured at 4 cm above ground level. *** indicates a significant Treatment by Week interaction (P <0.001).



2,200 to 3,700 kg DM/ha below 4 to 5 cm (Delagarde *et al.*, 1997; Kennedy *et al.*, 2007; Ribeiro *et al.*, 2005). The L, M and H HM treatments of the present study (800, 1,500 and 2,200 kg DM/ha above 4 cm, respectively), if added to a standard value of 2,200 kg DM/ha for below-4cm HM, could be converted into HM values of 3,000, 3,700 and 4,400 kg DM/ha from ground level, respectively. In New Zealand, Macdonald *et al.* (2008) reported pre-grazing HM of 2,500, 4,000 and 3,000 kg DM/ha, measured to ground level, for spring, summer and autumn, respectively. Nonetheless, although it appears that the low HM treatment is the most comparable to the New Zealand scenario, it also remains difficult to compare the treatments with the present study, perhaps due to the variability found in the below-4 cm HM. Any extrapolation should be made with care.

Grazing time and number of bites were greatest (+90 min and +18%, respectively) for the cows grazing L HM swards although they tended to have lowest DMI. Bite weight was lowest for the cows on the L HM swards (0.36 versus 0.45 g, respectively). Sward height could have had an influence on bite weight. Pre-grazing heights were 6.9, 8.8 and 11.8 cm for the L, M and H HM treatments, respectively (G Tuñon, Unpublished data). Hodgson (1990) stated that the level of pasture height from which DMI begins to be limited is between 9 and 10 cm. Thus, it seems that cows on L HM swards (978 kg DM/ha) were at risk of significantly decreasing their DMI due to failure of compensatory mechanisms of grazing behaviour (Hodgson, 1990). Cows' ability to graze is affected by HM.

The cows grazing M HM swards tended to eat more (+1.05 kg DM/cow/day; P = 0.09) when compared with the other treatments in the autumn. This is supported by previous work which reported that grass DMI decreased when HM was high (Hodgson & Wilkinson, 1968; Stakelum & Dillon, 1990). When HM increases, the proportion of stem in the sward also increases (Hoogendoorn & Holmes, 1992) creating a barrier effect to intake (Wade, 1991). In contrast, lower HM swards contain higher proportions of grass leaf and lower proportions of stem and dead material as is the case of the M HM treatment in the present study (G Tuñon, Unpublished data). This, in turn, results in higher DM digestibility values and, consequently,increased DMI (Holmes *et al.*, 1992; Stakelum & Dillon, 2007). However, Peyraud *et al.* (1996) and Wales *et al.* (1999) found that DMI actually increased with higher HM because cows were able to harvest greater amounts of material before they needed to graze the deeper and stemmier horizons. Herbage mass must be sufficiently high to allow effective grazing but not too high so as to impair grazing and sacrifice quality too. It remains to be clarified where HM starts to be too low and where too high.

Recent studies performed in Ireland, also measured the effect of HM on DMI. In contrast with the present study, Curran *et al.* (2010) did not find a difference in DMI between grazing HMs of 1,600 or 2,400 kg DM/ha (above 4 cm) during the main grazing season (Mid-season and Autumn). However, Wims *et al.* (2010). reported that cows on swards with 1,000 kg DM/ha pre-grazing HM achieved higher grass DMI than cows grazing 2,200 high HM swards in summer, which supports the trend towards higher DMI for cows grazing M HM swards in this experiment.

There was a trend towards decreased MS yield and increased rumination time for the cows grazing the H HM treatment during autumn. This suggests that the H HM swards had a lower feeding value than the L and M HM treatments. The organic matter digestibility in the leaf fraction is higher than in live stem and dead material (Tilley & Terry, 1963). Leaf proportion was, in effect, lowest for the H HM, intermediate for the M HM and highest for the L HM swards in the present experiment (G Tuñon, Unpublished data). Contrasting results were found by Wales *et al.* (1999), who reported that cows grazing swards with low pre-grazing HM (3,100 kg DM/ha; from ground level) produced less milk than cows grazing swards with high pre-grazing HM (4,900 kg of DM/ha). In that study, pre-grazing height of the low and high treatments were 6.3 and 12.9 cm, respectively. Hence, comparing to the pre-grazing heights of the present study (6.9, 8.8 and 11.8 cm), it appears that cows on the lower HM could not compensate for smaller bites and decreased DMI and MS. Conversely, Curran *et al.* (2010) and McEvoy *et al.* (2009) reported higher milk production from lower HM swards, particularly in the second half of the grazing season, and they concluded this was due to enhanced grass quality. These two last experiments agree with the findings of the present study because what they called low was comparable to the M HM treatment.

In summary, if pre-grazing HM is too high, DMI, sward quality and milk production are reduced. However, if pre-grazing HM is too low, sward quality will be high, DMI may be affected, even after compensatory grazing behaviour, and milk production may be sacrificed. Even so, theredoes not seem to be a reason to discourage grazing L HM swards to the level of the present study. However, if grazing time needs to be restricted due to potential treading damage (Kennedy *et al.*, 2009), conditions for heat stress (Blackshaw & Blackshaw, 1994) or due to the aim to minimise N leaching from urine deposition in the paddock (Christensen *et al.*, 2010), the cows grazing

L HM will not be able to compensate for smaller bites and will reduce their grass DMI. Furthermore, less surplus grass in the L HM system (-0.6 and -1 t DM/ha when compared to the M and H HM systems, respectively) means that there are potential feed deficits if stocking rate is increased or less grass available for conservation. The level of pre-grazing HM for maximum DMI and milk production seems to be between 1,300 and 1,700 kg DM/ha (above 4 cm from ground level).

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