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# Effect of forage allowance and forage system during the dry period on the performance of dairy cows

B.K. KEOGH, P. FRENCH, T. McGRATH, T. STOREY and F.J. MULLIGAN

Moorepark Dairy Production Research Centre, Teagasc, Fermoy, Co. Cork, Ireland

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## ABSTRACT

Sixty multiparous Holstein-Friesian dairy cows were allocated one of three forages (fodder beet, kale or grass silage) at one of two feeding allocations (high and low). Cows offered the high allowance system received 9 kg of kale or fodder beet DM *in-situ* plus 5 kg of bale grass silage DM per day, or *ad libitum* grass silage offered indoors. Cows on the low allowance system were offered 6 kg of kale or fodder beet DM *in-situ* plus 3.5 kg of bale grass silage DM per day, or 9.5 kg of grass silage DM offered indoors. Treatments were imposed for 70 ± 16 days before parturition. Post-partum, all cows were turned out to pasture and received 14 kg of perennial ryegrass DM plus 4 kg of concentrate/cow/d for the first five weeks of lactation. Cows offered grass silage had a greater gain in body condition score pre-partum than animals offered kale or fodder beet systems. Cows offered the fodder beet system pre-partum had a greater fat yield compared to those offered kale and a greater protein yield compared to those offered grass silage, resulting in a 9 % increase in solids corrected milk yield during the first five weeks of lactation.

## INTRODUCTION

Forage brassicas and fodder beet are alternative forage sources offered to dairy cows for *in – situ* grazing. Forage brassicas have the ability to accumulate dry matter (DM) yields of up to 20 t/ha while fodder beet can accumulate DM yields of up to 30 t /ha. Forage brassicas and fodder beet can maintain high forage quality (11.5 – 13.5 MJ of metabolizable energy (ME)/kg DM) (Jarrige, 1989) over the winter period. A previous study carried out in 2006 to examine *in situ* forage utilisation of forage brassicas reported that cows over-wintered on kale and swedes had increased body condition score (BCS) pre-partum, while animals grazing perennial ryegrass pasture lost BCS over the dry period (Keogh *et al.,* 2007). There was no effect of pre-partum forage system on milk production variables post-partum with the exception of a lower milk fat content for animals offered perennial ryegrass pasture.

The objective of this experiment was to evaluate the effect on spring-calving dairy cows offered two forage allowances of kale (*Brassica oleracea*), fodder beet (*Beta vulgaris*) and grass silage (*Lolium perenne*) during the dry period, on the periparturient physiology variables and post-partum milk production parameters.

## MATERIALS AND METHODS

### Experimental design

The experiment was a completely randomized block design with a 3 × 2 factorial arrangement of treatments. Sixty multiparous pregnant non-lactating Holstein-Friesian dairy cows were blocked on BCS (2.7 ± 0.3), live weight (LW) (595 ± 58 kg), expected calving date (14 February 2007 ± 20.7) and parity (2.1 ± 0.3).

### Systems

Cows were randomly assigned from within blocks to one of three forages (fodder beet, kale or grass silage) at one of two feeding allowances (high or low). Fodder beet (*cv.* Feldherr; 1 ha) and kale (*cv.* Maris Kestrel; 1.3 ha) were sown on the 25 April and 4 June 2006, respectively, and resulted in DM yields of 27 and 10 t/ha on the 10 December 2006, respectively. System allowances are presented in Table 1.

All allowances were calculated and offered daily on a group basis. Systems were imposed from 10 December 2006 until parturition in February 2007. To achieve different forage allowances, cows fed fodder beet and kale in outdoor systems were allocated different sized areas of forage plus bale grass silage *in-situ* with the movement of an electric wire fence while an electric wire back fence was erected to minimise poaching by the cows. Cows

**TABLE 1.** Experimental allowances of fodder beet, kale and grass silage systems pre-partum.

| Allowance (kg DM/cow/day) | Forage system | | |
|---|---|---|---|
| | Fodder Beet | Kale | Grass silage |
| High | | | |
| Forage | 9 | 9 | |
| Grass silage | 5 | 5 | *Ad-libitum* |
| Total forage offered | 14 | 14 | *Ad-libitum* |
| Low | | | |
| Forage | 6 | 6 | |
| Grass silage | 3.5 | 3.5 | 9.5 |
| Total forage offered | 9.5 | 9.5 | 9.5 |

**TABLE 2.** Least squares mean production variables for cows offered fodder beet, kale or grass silage system at high or low allowances during the dry period. SE = Pooled standard error.

| Response variable | Pre-partum treatments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Forage system | | | Allowance | | | Probability of effect | | |
| | Fodder Beet | Kale | Grass Silage | High | Low | SE | Forage | Allowance | Interaction |
| Crop (kg/ DM day) | 6.65 | 6.40 | - | 7.97 | 5.64 | - | - | - | - |
| Grass silage (kg/ DM day) | 4.04 | 4.03 | 10.37 | 3.16 | 2.22 | - | - | - | - |
| Total dry matter intake (kg/cow/day) | 10.69 | 10.43 | 10.37 | 11.13 | 7.86 | - | - | - | - |
| Total energy intake (ME MJ/kg DM) | 114 | 107 | 109 | 128 | 91 | - | - | - | - |
| Liveweight change (kg/day) | | | | | | | | | |
| - 70 to - 1 days pre-partum | 0.67 | 0.51 | 0.72 | 0.84[a] | 0.43[b] | 0.13 | 0.30 | 0.001 | 0.26 |
| 1 to 35 days post-partum | - 3.30 | - 3.33 | - 2.36 | - 3.16 | - 2.77 | 0.37 | 0.05 | 0.26 | 0.75 |
| Milk fat, kg/day | 1.22[a] | 1.06[b] | 1.12[ab] | 1.19[a] | 1.08[b] | 0.04 | 0.01 | 0.05 | 0.20 |
| Milk protein, kg/day | 0.96[a] | 0.92[ab] | 0.86[b] | 0.94 | 0.88 | 0.03 | 0.05 | 0.06 | 0.71 |
| SCM, kg/day | 27.7[a] | 25.4[b] | 25.4[b] | 27.3[a] | 25.1[b] | 0.91 | 0.05 | 0.01 | 0.43 |

Superscripts [a, b, c] denote within treatment means differ significantly P < 0.05.

fed grass silage in an indoor system were housed in cubicles bedded with rubber mats at a 1:1 ratio, with partially slatted concrete floors cleaned with an automatic scraper. Forage was offered on a concrete feeding passage daily. Immediately post-partum, all cows were turned out to pasture, milked twice daily and received an allowance of 14 kg DM (>4 cm high) of perennial ryegrass (*Lolium perenne*) plus 4 kg concentrate/cow/d for the first five weeks of lactation.

### Measurements

**Animal:** Body condition score was assessed and recorded weekly by a single experienced technician on a 1 to 5 scale (1 = Thin; 5 = Obese), (Lowman *et al.,* 1976) while LW was recorded weekly using an electronic portable weighing scales. Blood plasma samples were collected from all cows via coccygeal venepuncture one day every week for five weeks pre- and post-partum and stored at -20°C for subsequent plasma analysis when concentrations of non-esterified fatty acids (NEFA), β-hydroxybutyrate (BHBA) and glucose were measured.

**Forage**: Mean pre-calving DM intake was calculated as the difference between pre- and post-grazing herbage mass and area grazed, by harvesting 6 x 1 $m^2$ quadrants to ground level using a serrated knife for the kale and fodder beet treatments. Uneaten grass silage was weighed to determine utilisation.

### Statistical analysis

Body condition score and LW change pre-partum, being the change from -70 to -1 days pre-partum, were analysed using PROC GLM (SAS, 2007). The model included the fixed effects of forage system and allowance, the interaction between forage system and allowance, and pre-experimental covariates of BW or BCS, and parity included as covariates. Post-partum milk production variables were analysed using PROC MIXED. The model included the fixed effects of forage system and allowance, the interaction between forage system and allowance and parity. Pre- and post-partum plasma metabolites were analysed by stage using PROC MIXED with repeated measures using a first order autoregressive covariance structure (SAS, 2007). The model included the fixed effects of forage system, allowance, sampling week and all possible interactions. Cow was included as a random effect. Time was included as a repeated effect nested within each cow.

## RESULTS

The mean gestation length for all treatments was 283 ± 17 days while the mean dry period length was 70 ±16 days. Forage analysis established a DM content of 144, 118, 265 and 301 g/kg, a crude protein content of 147, 160, 145 and 140 g/kg DM, a neutral detergent fibre NDF) of 291, 274, 599, 608 g/kg DM and a ME of 12.2, 11.1, 11.4 and 11.4 MJ/kg DM for fodder beet, kale, grass silage and bale grass silage forages, respectively.

Estimated pre-partum DM intake increased with greater forage allocation (Table 2). On average, cows offered higher allowances consumed 11.2 kg/d (8.0 kg/d of forage DM plus 3.2 kg/d of grass silage) and lower allowances consumed 7.8 kg/d (5.6 kg/d of forage DM plus 2.2 kg/d of grass silage) during the pre-partum period (Table 2). Cows on fodder beet, kale and grass silage gained (P <0.001; 0.22, 0.09 and 0.37 BCS units realising 2.90, 2.77 and 3.05 BCS units at parturition, respectively) BCS over the pre-partum period. Body condition score and LW at calving were observed to be positively (P <0.05) associated with pre-partum forage allowance (3.05 and 2.73 BCS units and 656 and 627 kg of LW for high and low forage allowances, respectively). Changes in LW post-partum were related to pre-partum forage system, with cows consuming fodder beet and kale systems pre-partum losing 29 and 35 kg of LW more during the first five weeks of lactation compared to cows offered grass silage system pre-partum.

Cows offered the fodder beet system pre-partum had a greater (P <0.05) fat yield compared to offering kale (1.22 vs. 1.06 kg/d) and protein yield compared to cows offered the grass silage system pre-partum (0.96 vs. 0.86 kg/d), resulting in a greater (P <0.01) solids corrected milk (SCM) yield (27.7 kg/d) compared to kale or grass silage (25.4 and 25.4 kg/d, respectively). Milk fat and SCM yield increased with a high forage allowance pre-partum. Cows offered fodder beet and kale had greater (P <0.001) pre-partum plasma NEFA concentrations (0.34 and 0.41 mmol/L) compared to the grass silage system (0.14 mmol/L) (Table 3). While the fodder beet system resulted in greater (P <0.01) plasma glucose concentrations pre-partum (3.78 mmol/L) compared to the kale and grass silage systems (3.50 and 3.50 mmol/L, respectively).

Offering cows high forage allowances pre-partum increased (P <0.05) plasma glucose concentrations and tended to increase post-partum plasma NEFA concentrations (P = 0.08). A significant interaction between forage allowance and time was observed (allowance x time, P <0.001) post-partum for plasma NEFA concentration.

## DISCUSSION

The current study examined the effect of pre-partum forage system and forage allowance on periparturient physiology variables and post-partum milk production parameters of non-lactating dairy cows. The interaction between forage system and allowance was observed for BCS change over the pre-partum period due to the large relative reduction in BCS of cows offered the lower allowances of grass silage or fodder beet systems while feed allowance had no effect on BCS of cows offered kale pre-partum. Cows offered the high allowances of grass silage system (indoors) and fodder beet (*in-situ*) had gained BCS pre-partum relative to offering cows high allowances of kale. Cows offered the high allowance grass silage and fodder beet systems had consumed an estimated 127 and 133 MJ ME /day (11.13 kg DM/day at 11.40 MJ/kg DM and 7.97 kg of fodder beet DM/day at 12.20 MJ/kg DM plus 3.16 kg of bale silage DM at 11.40 MJ/kg DM, respectively; Table 2). Maintenance plus pregnancy requires 77 – 87 MJ ME/day (depending on liveweight and stage of pregnancy) (AFRC, 1993) thus leaving 40 – 56 MJ ME/day surplus for the grass silage system which could realise BCS and liveweight gain. While cows offered the high allowance kale system (*in-situ*) had similar estimated energy intakes (117 MJ ME/day) relative to offering grass silage and fodder beet, cows had only poor BCS gain suggesting there may be constraints within the kale system such as forage utilisation inefficiencies or forage chemical composition. Cows utilised 80 % of the high allowance kale system relative to 84 and 92 % for the fodder beet and grass silage systems which may explain BCS differences. Furthermore, kale like all brassicas contains a free amino acid (S-methyl-L-cysteine sulphoxide - SMCO) which is fermented in the rumen and can cause haemolytic

**FIGURE 1:** Body condition score for cows offered fodder beet, kale or grass silage system at high or low feed allowances during the dry period. BCS on a 1 = thin to 5 = obese scale with quarter-point increments.

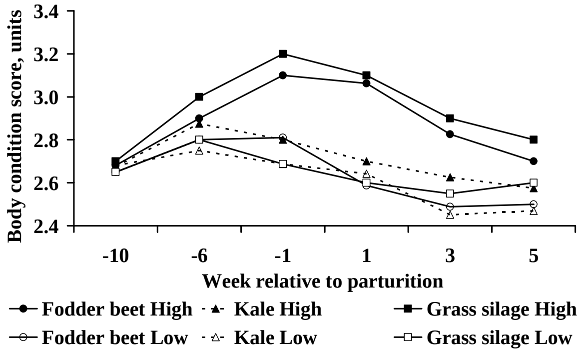


**TABLE 3.** Least square mean metabolite and glucose concentrations in blood plasma from cows offered fodder beet, kale or grass silage systems at high or low feed allowances during the dry period. SE = Pooled standard error.

| Response variable | Pre-partum treatments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Forage system | | | Allowance | | | Probability of effect | | |
| | Fodder Beet | Kale | Grass Silage | High | Low | SE | Forage | Allowance | Interaction |
| -35 to -1 days pre-partum (mmol/L) | | | | | | | | | |
| Plasma NEFA | 0.34[a] | 0.41[a] | 0.14[b] | 0.28 | 0.30 | 0.02 | 0.001 | 0.54 | 0.51 |
| Plasma BHBA | 0.41 | 0.44 | 0.47 | 0.44 | 0.45 | 0.03 | 0.44 | 0.81 | 0.44 |
| Plasma Glucose | 3.78[a] | 3.50[b] | 3.50[b] | 3.69[a] | 3.50[b] | 0.05 | 0.01 | 0.05 | 0.65 |
| 1 to 35 days post-partum (mmol/L) | | | | | | | | | |
| Plasma NEFA | 0.41 | 0.34 | 0.43 | 0.43 | 0.36 | 0.02 | 0.15 | 0.08 | 0.40 |
| Plasma BHBA | 0.57 | 0.50 | 0.56 | 0.57 | 0.51 | 0.02 | 0.26 | 0.10 | 0.80 |
| Plasma Glucose | 3.30 | 3.32 | 3.30 | 3.34 | 3.27 | 0.07 | 0.23 | 0.34 | 0.93 |

Superscripts [a, b, c] denote within treatment means differ significantly P < 0.05

anaemia, depressing intake and consequently animal growth (Barry & Manley, 1985). Though haemolytic anaemia was not observed in cows offered kale, SMCO may have had an antagonistic effect on animal performance, potentially explaining the lower BCS gain relative to the fodder beet and grass silage systems.

In the immediate post-partum period, forage allowance only had a significant effect on fat and SCM yields. The lack of impact of the dry cow feeding strategies on subsequent lactation performance has been previously observed, where restricted feeding pre-partum has resulted in a lower milk fat yield post-partum (Holcomb e*t al,*. 2001; Roche *et al,*. 2005). Conversely, pre-partum forage system had a greater impact on milk production variables post-partum. A higher milk fat yield was observed immediately post-partum for cows offered fodder beet relative to kale. This may have resulted from greater rates of body tissue mobilisation increasing milk fat because of a greater uptake and incorporation of NEFA into milk fat triglycerides (Palmquist *et al.,* 1993). In addition, offering the fodder beet system to dry cows pre-partum resulted in greater milk protein yield relative to grass silage system. Gibb *et al*. (1992) suggested that differences in post-partum milk protein may have been due to effects of dry period treatment on labile body protein content and that cows may have been protein deficient, but considering all animals received a similar diet and allowance post-partum this is probably unlikely. Garnsworthy and Jones (1993) reported that greater mobilisation of energy reserves occurred in cows that were fat at calving while enhanced DM intakes occurred in those that were thin. Higher intakes from thinner cows would compensate for reduced body reserves and result in similar lactation yields.

Cows offered the grass silage system pre-partum had a lower plasma NEFA concentration compared to cows offered fodder beet or kale systems which may be attributed to the relationship between BCS at calving and post-partum LW loss. As cows gain BCS, NEFA is absorbed into the blood (Stockdale, 2001), potentially explaining the low plasma NEFA concentrations of cows offered grass silage relative to cows offered fodder beet or kale systems. There was no effect of forage allowance on pre- and post-partum plasma NEFA and BHBA concentrations indicating that cows offered the lower allowances were not in negative energy balance during the periparturient period. This is further supported by LW data, where the extent of LW loss post-partum was not affected by pre-partum forage allowances which concur with the observations of Holtenius *et al*. (2001) and Roche *et al*. (2005).

## CONCLUSION

In conclusion, the results of this study indicate that offering animals higher allowances of fodder beet *in-situ* resulted in a greater BCS gain compared to cows offered kale over the study period. In addition, offering non-lactating dairy cows fodder beet *in situ* pre-partum increased SCM yield by 2.30 kg/d (9 %), compared to grass silage or kale during the first five weeks of lactation.

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