Effect of post grazing residual and concentrate feeding on milk production in early lactation

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Abstract

Two strategies to increase nutrient supply to early lactation dairy cows were compared and the cumulative effects on pasture quality and milk production were investigated. In a farmlet experiment the effect of feeding pasture only, or pasture plus concentrate (4kg/cow/day) at low (3.5 cm) or high (5.0 cm) post-grazing pasture residual (PGPR) was determined using a 2 x 2 factorial combination. Milk production for four groups of eight Friesian x Jersey dairy cows was measured within three consecutive grazing rotations during the first 12 weeks of lactation. PGPR for the low and high treatments remained constant throughout the 12 week period at 3.7 and 4.5 cm respectively. Mean milk solids production in the first, second and third rotation were 1.99 ± 0.12, 2.14 ± 0.10 and 2.01 ± 0.09 kg MS/cow/day respectively. Increasing PGPR from 3.7 to 4.5 cm did not affect pasture quality, milk production or milk composition. Concentrate feeding increased milk solids yield by 0.30 kg ($P < 0.05$) in the third rotation. Concentrate feeding also increased milk protein yield by 68 g ($P < 0.05$), 104 g ($P < 0.05$) and 167 g ($P < 0.001$) in the first, second and third rotation respectively. When pasture quality is not altered by PGPR, feeding a concentrate is more effective at increasing nutrient supply than raising grazing height.

Keywords: *Lolium perenne*; *Trifolium repens*; substitution rate; marginal milk response

Introduction

Meeting the energy demands of dairy cows in early lactation poses a challenge for many pasture-based dairy farmers. Due to intensive grazing practises and climatic conditions in early spring, pasture availability is often low. The consequence of feed restriction is decreased milk production and long term reductions in animal performance. The intensive grazing practises exacerbate feed supply by removing leaf area and slowing regrowth (Korte et al. 1982) but the long term benefits of low pasture residuals are improved herbage quality later in the season (L'Huillier 1987).

Two nutritional factors which can be manipulated to influence nutrient supply are herbage availability and supplementary feeding. Previous studies investigating the effects of pasture allowance show that higher allowances result in increased dry matter (DM) intakes and increased post grazing residuals (Bargo et al. 2002; Perez-Preito et al. 2011). The higher post grazing residual reduces grazing constraints such as low bite mass, associated with short pastures (Gibb et al. 1997) and can also improve subsequent herbage accumulation rates (L'Huillier1987). However, many of these grazing studies are short term and fail to show the cumulative effects of consistently grazing to the same height on animal performance. While the effects of lenient grazing practises on reductions in herbage quality are relatively conclusive regarding accumulation of stem and dead material at the base of the sward (L'Huillier 1987; Korte et al. 1982), the use of modern cultivars, which tend to be later flowering than those studied in the 1980s, could preclude the need for restricted grazing practises post-calving.

The second option to increase energy supply is to offer a supplement, such as a cereal grain, which can reduce the impacts of restricted grazing on energy intake. The reduction in pasture intake per unit of supplement or substitution rate, also allows some conservation of pasture during periods of low pasture growth rate. This study uses a late flowering perennial ryegrass cultivar (cv. Trojan) to examine the cumulative effect of grazing residual and supplementation on herbage quality and animal performance over a 12 week grazing period in early lactation.

Materials and methods

Experimental design and management

Experimental procedures were approved by the Lincoln University Animal Ethics Committee (#482). A farmlet study comprising 32 Friesian x Jersey cows with a mean live weight ± standard deviation of 422 ± 9.9 kg were grazed within a continuous 2 x 2 factorial unreplicated design. The trial was carried out at the Lincoln University Research Dairy Farm between 14 August and 10 November 2012. Cows were blocked into eight groups of four according to their previous season's milk production, live weight, breeding worth and age. The first seven groups included multiparous cows while the eighth group was primiparous cows. One cow per group was assigned at random to each treatment resulting in eight cows per treatment. The four treatments were a factorial combination of two post grazing residuals measured by rising plate meter as heights of 3.5 (Low residual) or 5.0 cm (High residual), and feeding no concentrate, or feeding a cereal concentrate with a mean energy content of 13.7 MJ ME/kg DM and a crude protein (CP) content of 177 g CP/kg DM, at the rate of 4 kg DM/cow/day.

Cows receiving concentrate received half their daily ration at each milking using an automatic feeder. At the start of the experiment the concentrate, which contained sodium bicarbonate, was increased by increments of 0.5 kg per day to allow the rumen to adjust to the diet.

The farmlet area consisted of 6.9 ha which was divided into 72 x 0.096 ha paddocks using permanent and temporary fencing materials. The 18-months-old pasture consisted of *Lolium perenne* (cv. Trojan NEA2, heading date + 16 days) and *Trifolium repens* (cv. Weka). Access to water was available in all paddocks. Nineteen paddocks were allocated to each of the two non-concentrate groups, and 17 paddocks to the two concentrate groups giving respective stocking rates of 4.4 and 5.0 cows/ha. Paddocks were grazed in order of highest pre-grazing mass. Nitrogen was applied in the form of urea at 30 kg N/ha to each paddock following the first and second rotation, with a total application of 60 kg N/ha during the first 12 weeks. Gibberellins (Progibb, Nufarm, Auckland, New Zealand) were applied at a rate of 8 g active ingredient/ha to all paddocks after grazing during the first rotation. A grazing rotation was regarded as the time taken for all paddocks within a farmlet to be grazed before starting at the first paddock again.

Movement of cows to each new paddock occurred on the basis of target residual heights being met. The time spent grazing in each paddock was recorded. Post grazing targets were based on height rather than pasture mass which would require continual recalibration. In the first rotation cows were offered half each paddock and fed lucerne baleage (9.3 MJ ME/kg DM and 224 g CP/kg DM) to increase grazing time to 48 hours per paddock. In the second and third rotations, cows were offered the whole paddock and those on the High residual met their residual targets after 38 hours while those on the Low residual took 45 hours to meet their post grazing target. Consequently rotation length in the second and third rotations cows in the High residual were 24 and 21 days compared with 31 and 26 days in the Low residual treatment.

Measurements

A calibrated rising plate meter (Jenquip Ltd, Fielding, New Zealand) was used to monitor residuals during the day. Similarly, pasture height was also measured pre and post grazing by 30 readings per paddock with a rising plate meter. The rising plate meter was re-calibrated each rotation from 12 quadrat cuts (0.2 m^2 in area) of pasture mass trimmed weekly at ground level.

Nutritional information prior to grazing was determined for herbage twice weekly by sampling the pasture to grazing height. Each new batch of concentrate was sampled approximately fortnightly. Herbage was freeze dried, ground through a 1 mm seive and the chemical composition estimated using near infrared spectrophotometry (NIRS) (FOSS NIRSystems 5000, Maryland, USA) as described by Bryant et al. (2012). Weekly samples of concentrate were also ground and scanned by a near infrared spectrophotometer using a separate calibration for cereal feeds and ME calculated from fat content and DM digestibility (CSIRO 2007). Wet chemistry was performed to determine water soluble carbohydrates and starch within the concentrate using the method described by Hunt et al. (2005).

Milking took place twice daily at 0700 and 1500 hours. Individual refusals were removed after each milking and accumulated. The weight of the accumulated refusals for each cow was recorded twice weekly. Milk yields and live weight were recorded at every milking. Milk samples were collected weekly to estimate milk fat and protein composition using an infrared analyser (Milkoscan^{TM}, Foss Electric, Denmark).

Total DM intake for individual cows was estimated by calculating total energy requirements for maintenance, milk and liveweight change (AFRC 1993). Liveweight change was determined for each cow by regression of live weight against time within each rotation. Dry matter intake of herbage was calculated by the following equation:

$$\text{DM intake} = ((ME_{Maintenance} + ME_{Milk} + ME_{Gain/Loss})/(ME_{Herbage} + ME_{Concentrate}))$$

where ME requirements for liveweight gain or loss were based on respective efficiencies of $k_{+g} = 0.63$ and $k_{-g} = 0.84$ giving ME_{Gain} of 30.3 MJ/kg live weight and ME_{Loss} of -24.2 MJ/kg live weight. Substitution rates for concentrate were calculated for the separate grazing residual treatments within each grazing rotation using the method described by Penno et al. (2006). Briefly the mean herbage DM intake of the respective unsupplemented group, minus the mean herbage DM intake of each concentrate group in the same rotation, divided by the DM intake from the concentrate.

Statistical analysis

Mean milk yield, milk composition and live weight were analysed within each rotation (First rotation = Weeks 1–5, Second rotation = Weeks 6–9, Third rotation = Weeks 10–12) using the residual maximum likelihood procedure of GenStat (Payne et al. 2009). Individual cows were used as experimental units in all analysis. Grazing residual, concentrate treatments and their interaction were used as fixed terms in the model and cow was included as a random effect. Standard errors of the mean for nutritive value were determined for herbage samples across paddocks and subsamples of concentrate.

Results

Pastures

Grazing residual did not affect the chemical composition of herbage above grazing height. Metabolisable energy content of the herbage was 12.6 MJ ME/kg DM during the first two rotations and

Table 1 Mean ± standard error of the mean of herbage mass and nutritional composition of diets when managed at high or low post grazing pasture residual over three successive grazing rotations in spring.

Feed	Component	Rotation 1		Rotation 2		Rotation 3	
		High residual	Low residual	High residual	Low residual	High residual	Low residual
Pasture							
	Pre grazing mass (kg DM/ha)	2,238 ± 43	1,908 ± 53	2,800 ± 42	2,852 ± 58	3,021 ± 69	2,606 ± 48
	Post grazing height (kg DM/ha)	4.3 ± 0.1	3.6 ± 0.1	4.6 ± 0.1	3.8 ± 0.1	4.5 ± 0.1	3.6 ± 0.1
	Acid detergent fibre (g/kg DM)	200 ± 3	207 ± 6	200 ± 4	198 ± 3	217 ± 7	215 ± 4
	Neutral detergent fibre (g/kg DM)	378 ± 5	381 ± 11	372 ± 6	368 ± 6	407 ± 10	392 ± 6
	Crude protein (g/kg DM)	185 ± 3	175 ± 4	202 ± 4	192 ± 5	193 ± 13	198 ± 11
	Water soluble carbohydrate (g/kg DM)	205 ± 5	203 ± 8	192 ± 7	203 ± 5	181 ± 6	177 ± 7
	Dry matter digestibility (g/kg DM)	834 ± 5	822 ± 9	828 ± 4	832 ± 3	811 ± 7	813 ± 4
	Metabolisable energy (MJ/kg DM)	12.6 ± 0.1	12.5 ± 0.1	12.6 ± 0.1	12.7 ± 0.1	12.3 ± 0.1	12.3 ± 0.1
Concentrate							
	Acid detergent fibre (g/kg DM)	75 ± 1		70 ± 2		62 ± 3	
	Neutral detergent fibre (g/kg DM)	175 ± 5		176 ± 3		188 ± 6	
	Crude protein (g/kg DM)	177 ± 2		177 ± 1		172 ± 1	
	Fat (g/kg DM)	22 ± 1		22 ± 1		19 ± 1	
	Starch (g/kg DM)	543 ± 1		537 ± 13		537 ± 16	
	Water soluble carbohydrate (g/kg DM)	70 ± 3		61 ± 1		39 ± 14	
	Dry matter digestibility (g/kg DM)	898 ± 2		904 ± 3		896 ± 4	
	Metabolisable energy (MJ/kg DM)	13.7 ± 0.1		13.8 ± 0.1		13.7 ± 0.1	

decreased to 12.3 MJ ME/kg DM in the third rotation (Table 1). The reduction in ME was reflected by a decrease in water soluble carbohydrates and an increase in neutral-detergent fibre content. Mean crude protein content of the herbage was relatively constant over the 12 week period at 194 g/kg DM while the concentrate contained a lower crude protein content of 175 g/kg DM. Mean dry matter digestibility and fat in the concentrate were 900 and 22 g/kg DM resulting in an estimated ME content of 13.8 MJ ME/kg DM. Soluble carbohydrates accounted for less than 10% of the total DM and decreased progressively over time from 70 to 40 g/kg DM between the first and third rotation. Starch accounted for the main energy source at 540 g/kg DM.

Post grazing compressed heights remained constant across the 12 week period at 3.67 ± 0.04 and 4.47 ± 0.03 cm for High residual and Low residual treatments respectively. Pre grazing herbage mass increased with successive rotation from 2,070 kg DM/ha in the first rotation to 2,810 kg DM/ha in the third rotation (Table 1). Apparent intake from pre and post herbage mass was 9.3, 13.9 and 14.3 kg DM/cow/day in the first, second and third rotations.

Animal performance

Herbage DM intake based on animal performance data for successive grazing rotations are presented in Table 2. Dry matter intake was on average 2.6, 1.2 and 0.6 kg DM/cow/day higher than intakes calculated from pasture mass for each rotation. Animals consumed approximately 3.5 kg of the 4 kg of concentrate they were offered daily. In the first rotation animals fed concentrate also consumed 3.6 kg DM lucerne baleage while those on pasture diets consumed 4.9 kg DM lucerne baleage. There was no treatment effect on total DM intake in the first two rotations though concentrates tended to improve total DM intake in the third rotation (17.6 versus 15.8 ± 0.9 kg DM/cow/day. P = 0.06). Cows fed concentrate consumed less herbage (P <0.05) than those on pasture only diets in the second and third rotation. Substitution rates were variable ranging between 0.43 and 1.09 kg herbage/kg concentrate for the three rotations. There was no difference in the mean substitution rates between High residual and Low residual treatments which were 0.67 ± 0.21 and 0.68 ± 0.12 respectively.

Grazing residual treatment did not affect milk production which was 1.99 ± 0.12, 2.14 ± 0.10 and 2.01 ± 0.09 kg MS/cow/day in the first, second and third rotation respectively. In the first two rotations there was no effect of concentrate feeding on milk yield or milk solids but by the third rotation milk yield and milk solids were greater in the concentrate groups (Table 2). On pasture only treatments milksolids production declined after the second rotation so differences in milk solids yield in the third rotation were 2.16 kg MS/cow/day in the concentrate groups compared with 1.86 kg MS/cow/day in the pasture only group. In the second rotation concentrate fed groups had lower milk fat percentage than pasture only groups (5.4 versus 5.0% milk fat) though total milk fat

Table 2 Effect of grazing at a high or low post grazing pasture residual with or without supplementary concentrate feeding on dry matter intake and milk production parameters over three successive grazing rotations in spring. P values in bold indicate significance (<0.05. P values in italics indicate approaching significance with a P value between 0.05 and 0.10.

Rotation	Component	Residual: High residual, No concentrate	High residual, Concentrate	Low residual, No concentrate	Low residual, Concentrate	Standard error of difference	P value: Residual	P value: Concentrate	P value: Interaction
1	Herbage intake (kg DM/d)	12.3	11.9	12.8	10.5	1.2	0.58	0.11	0.25
	Total intake (kg DM/d)	16.1	17.4	16.2	15.4	1.2	0.30	0.77	0.25
	Milk solids (kg/d)	1.94	2.14	1.92	1.97	0.10	0.20	*0.08*	0.28
	Milk protein (kg/d)	0.80	0.90	0.79	0.83	0.04	0.17	**0.04**	0.40
	Milk fat (kg/d)	1.14	1.24	1.14	1.14	0.06	0.27	0.19	0.25
	Milk protein (%)	3.58	3.57	3.53	3.54	0.10	0.57	0.99	0.96
	Milk fat (%)	5.09	4.92	5.07	4.90	0.21	0.92	0.26	0.99
2	Herbage intake (kg DM/d)	17.3	13.5	15.6	14.0	1.0	0.46	**0.001**	0.14
	Total intake (kg DM/d)	17.3	16.8	15.6	16.8	1.1	0.31	0.74	0.30
	Milk solids (kg/d)	2.06	2.25	2.08	2.15	0.16	0.76	0.28	0.59
	Milk protein (kg/d)	0.84	0.96	0.83	0.91	0.06	0.48	**0.02**	0.67
	Milk fat (kg/d)	1.22	1.29	1.25	1.23	0.11	0.93	0.71	0.56
	Milk protein (%)	3.70	3.71	3.65	3.75	0.11	0.92	0.51	0.50
	Milk fat (%)	5.34	4.92	5.48	5.05	0.23	0.41	**0.02**	0.99
3	Herbage intake (kg DM/d)	16.2	14.5	15.4	12.9	1.1	0.15	**0.02**	0.65
	Total intake (kg DM/d)	16.2	18.1	15.4	16.6	1.3	0.19	0.10	0.69
	Milk solids (kg/d)	1.83	2.19	1.88	2.13	0.16	0.98	**0.02**	0.67
	Milk protein (kg/d)	0.76	0.95	0.77	0.92	0.06	0.94	**<0.001**	0.65
	Milk fat (kg/d)	1.07	1.24	1.11	1.21	0.11	0.99	0.11	0.70
	Milk protein (%)	3.71	3.82	3.61	3.90	0.13	0.92	**0.04**	0.34
	Milk fat (%)	5.20	5.00	5.14	4.99	0.29	0.86	0.41	0.90
Total	Liveweight change (kg/period)	+55.8	+46.9	+40.9	+46.5	13.1	0.42	0.86	0.44
	Milk yield (kg/cow/period)	2,018	2,291	1,976	2,127	161	0.37	*0.08*	0.60

yield did not differ. In contrast total milk protein yield was greater in the concentrate group throughout the 12 week experiment. In the first, second and third rotations concentrate feeding increased milk protein yield compared with pasture only treatments by +68, +104 and +167 g milk protein/cow/day respectively (P <0.05). However the effect of treatment on milk protein composition was only evident in the third rotation (3.86 versus 3.66% milk protein). There were no interactions between residual and concentrate.

Discussion

Grazing residual

There was no statistical evidence that raising the post grazing pasture residual increased nutrient supply to grazing dairy cows. Cows were shifted as soon as their target residuals were met, so grazing time per paddock at High residuals was reduced. However, cows maintained similar herbage DM intakes to those in Low residuals and consequently produced similar milk yields. This is probably the result of herbage having a similar chemical composition above grazing height for the High residual and Low residual treatments. Reductions in quality observed under a lenient grazing regime become increasingly evident around anthesis with the build-up of stem and dead material (L'Huillier1987). Use of a later flowering cultivar in the current study is likely to have delayed the negative effects of lax grazing. These results are consistent with those of Roca-Fernandez et al. (2012) who were also unable to show long term differences in animal performance when using different pasture allowances. Delagarde et al. (2004) demonstrated that it was not post grazing height but rather the proportion of green leafy material which had the greatest impact on herbage DM intake. Although leaf and stem components were not measured here it is likely that similar botanical attributes were available above the set target for both treatments.

Concentrate feeding

There was evidence of an improvement in nutrient supply to dairy cows in the concentrate treatments as shown by the increase in milk protein yield throughout the 12 week experiment. In spite of similar total DM intakes and lower protein content of the concentrate the increase in milk protein indicates improved metabolisable protein supply compared with the pasture only treatments. These findings are consistent with those of Bargo et al. (2002) and Pulido and Leaver (2001) who also showed increased protein yield in concentrate supplemented diets of grazing dairy cows. The total available energy in the rumen is positively linked with microbial protein synthesis and supply of nitrogen to the small intestine (Clarke et al.

1992) and given the high starch, dry matter digestibility and metabolisable energy content of the concentrate this is likely to have contributed to the increased milk protein production on supplemented treatments.

Based on animal energy requirements and metabolisable energy content of diets, estimates of pasture DM intakes in both High residual and Low residual treatments were lower when concentrates were fed. The mean substitution rate of 0.67 for both High residual and Low residual treatments is very similar to the predicted substitution rate of 0.65 using the equation produced by Penno et al. (2006). Substitution rates are largely influenced by changes in pasture quality and pasture allowance, neither of which was greatly altered for herbage mass above grazing height.

Longer term implications

Supplementation with concentrate improved milk yield persistence. The lower milk yield on pasture only treatments compared with concentrate fed animals in the third rotation coincided with a reduction in pasture quality in mid to late October. In a similar study Pulido and Leaver (2001) found either no change or an increase in milk yield persistence in two experiments when concentrate was offered, even though pasture quality was similar in both experiments. While they attributed the variation to differences in sward characteristics there was also considerable variation in the live weight and condition score of animals between experiments which may have affected energy transactions. It is well known that the volatile fatty acids profiles following concentrate fermentation differ to that of pastures (Clarke et al. 1992; Bargo et al. 2002) resulting in increased proportions of propionate which has greater energy partitioning to milk and gain relative to acetate and may also have influenced milk persistence in this study.

The mean accumulated milk yield was 2,100 kg per cow over the 12 week lactation period (84 days). Cows consuming 3.5 kg concentrate per day tended to yield milk more than cows fed pasture only (2,209 versus 1,997 kg milk/cow, $P < 0.10$). This gave a marginal milk response to supplements of 0.72 kg milk/kg supplement consumed. This response is lower than the values of over 1.0 kg milk/kg supplement reported by Wales et al. (2001) and Bargo et al. (2002) but greater than 0.34 to 0.52 kg/kg reported by Sheahan et al. (2013). Experiments where grain and pasture allowance are factors the higher milk response appears to be linked to greater pasture allowance and lower pasture quality though genetic potential of animals will also contribute to the marginal milk response.

Of the two nutritional strategies investigated, increasing post grazing residual did not reveal significant benefits to animal performance. However, there were also no detrimental effects of higher residuals, largely owing to the more consistent herbage quality of a later flowering cultivar. There were however, benefits of including concentrates in the diet and these too could be linked with changes in herbage quality. The benefits of using concentrates may become even more pronounced post-flowering when pasture quality and quantity decline in the autumn. Further work will consider the response to concentrate feeding in the later stages of lactation and any associated economic benefits.

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