The use of herb mix and lucerne to increase growth rates of dairy heifers

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Abstract

Approximately 53% of 6-month-old dairy heifers in New Zealand do not meet liveweight targets, partially due to inadequate growth rates in their first summer. The aim of this experiment was to determine the effect of feeding forage crops on the growth rate of dairy heifers over this critical period. Sixty six-month-old dairy heifers grazed one of three treatments: pasture, lucerne or a mixed-herb crop for a 63-day period. Both lucerne- and crop-fed heifers had similar ($P>0.05$) average daily liveweight gain (0.80 ± 0.02 and 0.75 ± 0.02 kg/day, respectively) and were greater ($P<0.05$) than those of pasture-fed heifers (0.53 ± 0.02 kg/day). Lucerne-fed heifers had a greater ($P<0.05$) increase in body length (18.4 ± 1.3 cm) than heifers fed pasture (14.7 ± 1.2 cm). Heifers fed lucerne had higher ($P<0.05$) concentrations of urea in plasma (4.9 ± 0.1 mmol/L) compared with heifers fed crop (4.1 ± 0.1 mmol/L), which had greater ($P<0.05$) concentrations of urea in plasma than heifers fed pasture (2.5 ± 0.1 mmol/L). Feeding a mixed-herb crop or lucerne during the summer period resulted in higher growth rates of dairy heifer calves compared with feeding them pasture.

Keywords: heifer; growth rate; target; lucerne; chicory; plantain

Introduction

In New Zealand's pasture-based dairy farming system, on average 20% of cows in the herd are replaced annually with two-year-old heifers (Bryant et al. 2004). The growth of replacement heifers can influence their ability to attain puberty before first mating, achieve their genetic potential for milk production, survive in the milking herd and calve every 12 months (Bryant et al. 2004). Poor heifer rearing is a potential factor limiting dairy herd reproductive performance and milk production (McNaughton & Lopdell 2012).

Animal performance on pasture is affected by both the quality and quantity of pasture on offer, both of which decrease in summer because pasture growth is restricted by soil moisture availability (Waghorn & Clark 2004). Providing an adequate pasture allowance over summer may still not support high animal performance, because low pasture quality limits liveweight gain by reducing digestibility and restricting intake (Litherland et al. 2002).

Forages such as chicory, plantain, white clover, red clover and lucerne have higher nutritive and feeding values compared with perennial ryegrass (Burke et al. 2002; Kemp et al. 2010; Waghorn & Clark 2004). Lambs grazing these forages had greater liveweight gain than lambs grazing ryegrass and white clover pastures over summer (Burke et al. 2002; Somasiri 2014). Similarly, six-month-old dairy heifers fed lucerne had greater liveweight gain than pasture-fed heifers (de Clifford et al. 2014).

The aim of this experiment was to determine the effect of feeding different forage crops on the growth parameters and metabolic indices of dairy heifers over the summer period.

Materials and methods

This experiment was conducted at Massey University's Riverside farm located 10 km north of Masterton (40°50'S, 175°38'E), with approval from the Massey University Animal Ethics committee.

Animals and treatments

Sixty six-month-old Friesian-Jersey crossbred heifers were allocated to treatment groups balanced for live weight, live weight breeding value, and date of birth. The experiment had three dietary treatments that were grazed for 63 days, (D_0 to D_{63}) following a 16-day adjustment period (D_{-16} to D_0). The treatments were; 1) an unrenovated ryegrass (*Lolium perenne*) and white clover (*Trifolium repens*)-based pasture; 2) a mixed-herb crop consisting of chicory (*Cichorium intybus,* 70%), plantain (*Plantago lanceolata,* 20%) and white clover (10%); and 3) a monoculture sward of lucerne (*Medicago sativa*). Prior to D_{-16} and from D_{63} onwards, all heifers grazed on pasture.

Animal management

During the acclimatisation period (D_{-16} to D_0), heifers on the pasture and crop treatments continuously grazed their treatments, while heifers on the lucerne treatment underwent an on-off grazing system which started with 3 hours on the lucerne sward and the remaining time on a pasture sward. During the acclimatisation period, the time spent on the lucerne sward gradually increased and by D_{-5} the heifers were continuously on the lucerne sward. Heifers on the lucerne treatment were dosed with a bloat preventative (Bloatenz Plus®, Ecoloab, active ingredient alcohol ethoxylate/propoxylate), via an in-trough dispenser at 3 ml/head/day from D_{-16} to D_{63}.

Based on the average liveweight breeding value of the heifers, the expected mature live weight was estimated to be 495 kg. The estimated mature weight was used to calculate liveweight targets using linear interpolation between industry targets for 6 and 9 months of age (Table 1). The target growth rates were calculated based on difference between the average live weight of the heifers in each treatment and the target live weight at 9 months. These target growth rates were used with each treatment's average live weight to calculate feed requirements. The weekly pasture allowance was calculated based on pre-grazing herbage mass and heifer feed requirements to achieve a post-grazing residual of approximately 1500 kg DM/ha.

All heifers were drenched with Coopers Alliance® triple combination drench (active ingredients oxfendazole, levamisole and abamectin) on D_{-26}, D_0, D_{21}, D_{42} and D_{63} for parasite control. The dose rate was 1 ml per 10 kg of live weight.

Animal measurements

Unfasted live weight was measured on D_{-30}, D_0, D_{21}, D_{42}, D_{63} and D_{70}. Stature measurements and blood samples were taken on D_{-26}, D_{21} and D_{63}. Wither height was measured using an adjustable height stick. Crown-to-rump length was measured from the top of the head, along the spine to the base of the tail using a tape measure. Girth was measured behind the 13^{th} rib, using a tape measure.

Blood samples were taken by jugular venipuncture into EDTA vacutainers. Samples were stored on ice until they were centrifuged at 3000g for 15 minutes. Plasma was harvested and stored at -20°C until further analysis. Plasma urea was determined by urease enzymatic method (Roche, Indianapolis, USA) and read at 340 nm wavelength using Flexor E (Vital Scientific NV, 6956 AV Spankeren/Dieren, The Netherlands). Samples were analysed in duplicate with intra-assay CVs <5%. Concentration of insulin-like growth factor-1 (IGF-1) in plasma was determined by Sandwich enzyme immunoassay using bovine ELISA kits (USCN Life Science, Wuhan, China) and colour change was measured spectroptometrically at 450 nm wavelength using a plate reader (Perkin Elmer, Victor 3, Turku, Finland). Samples were analysed in duplicate with intra-assay CVs <10% and inter-assay CVs 3.7%.

Pasture measurements

Four quadrats (0.1 m^2) were cut to ground level in each break five days before the heifers grazed the break and within 24 hours of removal of the heifers to determine the pre- and post-grazing herbage mass, respectively. Samples were washed then dried in an oven at 75°C for 48 hours and then weighed to measure herbage dry matter mass.

Hand-plucked samples were taken weekly from pre-grazing breaks for herbage quality analysis. Samples were mixed after drying and grinding to form three samples from each treatment. Sample 1 included equal sized samples taken from D_9, D_{16} and D_{23}, sample 2 included samples taken on D_{30}, D_{37} and D_{44} and sample 3 included samples taken on D_{51} and D_{58}. Samples were analysed for *in-vitro* organic matter digestibility (OMD%), dry matter digestibility (DMD%) and digestible organic matter in the dry matter (DOMD%), crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF) and ash (de Clifford et al. 2014). Metabolisable energy (ME) was calculated from DOMD%.

Statistical analysis

Data were analysed using SAS (Version 9.3, SAS Institute Inc, Carey, North Carolina, USA). Live weight, height at withers, girth and crown-rump length were analysed using mixed models allowing for repeated measures on each heifer. The models included the fixed effects of treatment and day, and the interaction of day with treatment. Heifer was included as a random effect. Average daily liveweight gain (from D_0 to D_{63} and from D_{-30} to D_{70}) was analysed using a general linear model that included the fixed effect of treatment, age and initial live weight fitted as a covariate. Increases in stature measurements (height, girth and crown-rump length) were analysed using general linear models that included the fixed effect of treatment and initial stature measurement as a covariate. The concentration of urea and IGF-1 in plasma were analysed using a mixed model allowing for repeated measures on each heifer. The model included the fixed effects of treatment and day, and the interaction of day with treatment. Age of the heifer was fitted as a covariate. Herbage quality measurements were analysed using general linear models that included the fixed effect of treatment.

Results

Over the experimental period the average daily liveweight gain was greater for heifers fed the crop (0.75 ± 0.02 kg/d) and lucerne (0.80 ± 0.02 kg/d) than for heifers fed pasture (0.53 ± 0.02 kg/d) ($P<0.05$; Table 1). Over the total management period (D_{-30} to D_{70}) lucerne-fed heifers had a greater ADG ($P<0.05$) of 0.68 ± 0.02 kg/d than crop-fed heifers (0.60 to ± 0.02 kg/d) which in turn had greater ADG ($P<0.05$) than pasture-fed heifers which gained 0.47 ± 0.02 kg/d.

Lucerne-fed heifers had a greater ($P<0.05$) increase in body length from D_{-26} to D_{63} than heifers fed pasture, with crop-fed heifers intermediate (Table 1). There was no difference ($P>0.05$) in girth, change in girth, wither height or change in wither height among the three treatments.

All heifers had similar ($P>0.05$) concentrations of IGF-1 in plasma throughout the experiment (Table 2). On D_{-26}, before treatment allocation the heifers in the crop treatment had higher ($P<0.05$) concentration of urea in plasma compared with the heifers in the pasture treatment (Table 2). On D_{63}, heifers in the lucerne treatment had a higher concentration of urea in plasma compared with heifers on the crop treatment ($P<0.05$). Crop-fed heifers had higher concentration of urea in plasma than heifers in the pasture treatment on D_{63} ($P<0.05$).

Table 1 Least squares mean live weight, average daily liveweight gain (ADG), change in wither height, girth and crown-to-rump length (CRL) ± standard error of the mean of heifers fed crop, lucerne or pasture for a 16-day acclimatisation period (D_{-16} to D_0) followed by a 63-day experimental period (D_0 to D_{63}) and then a seven-day period on pasture (D_{63} to D_{70}).

	Crop	Lucerne	Pasture	Target
Live weight (kg)				
D_{-30}	114.6 ± 2.6	115.3 ± 2.6	114.7 ± 2.6	132.2
D_0	124.8 ± 2.7^{ab}	118.4 ± 2.7^{a}	127.1 ± 2.7^{b}	148.5
D_{21}	139.3 ± 3.2	139.9 ± 3.2	139.8 ± 3.2	159.6
D_{42}	162.2 ± 3.4^{b}	160.2 ± 3.5^{b}	150.2 ± 3.4^{a}	171.1
D_{63}	171.3 ± 3.7^{b}	168.9 ± 3.5^{ab}	160.1 ± 3.5^{a}	182.6
D_{70}	174.9 ± 3.5^{b}	183.2 ± 3.5^{b}	162.0 ± 3.5^{a}	186.5
Average daily gain (kg/day)				
D_0 to D_{63}	0.75 ± 0.02^{b}	0.80 ± 0.02^{b}	0.53 ± 0.02^{a}	
D_{-30} to D_{70}	0.60 ± 0.02^{b}	0.68 ± 0.02^{c}	0.47 ± 0.02^{a}	
Change in stature (cm) from D_{-26} to D_{63}				
Wither height	5 ± 1	5 ± 1	4 ± 1	
Girth	21 ± 1	18 ± 1	18 ± 1	
CRL	17.5 ± 1.3^{ab}	18.4 ± 1.3^{b}	14.7 ± 1.2^{a}	

[ab] Means within rows without letters in common are significantly different (P<0.05).

Table 2 Least squares mean concentration ± standard error of the mean of insulin-like growth factor-1 (IGF-1) in plasma on D_{-26}, D_{21} and D_{63} and plasma urea on D_{-26} and D_{63} of heifers fed crop, lucerne or pasture for a 16-day acclimatisation period (D_{-16} – D_0) followed by a 63-day experimental period (D_0 – D_{63}).

	Crop	Lucerne	Pasture
IGF-1 (ng/mL)			
D_{-26}	84.5 ± 4.5	85.7 ± 4.5	88.2 ± 4.5
D_{21}	96.8 ± 5.4	97.2 ± 5.1	104.3 ± 5.3
D_{63}	95.3 ± 5.5	102.0 ± 5.5	101.6 ± 5.5
Urea (mmol/L)			
D_{-26}	4.6 ± 0.1^{b}	4.3 ± 0.1^{ab}	4.1 ± 0.1^{a}
D_{63}	4.1 ± 0.1^{b}	4.9 ± 0.1^{c}	2.5 ± 0.1^{a}

[abc] Means within rows with differing superscripts are significantly different (P<0.05).

Forage quality measures were similar for the crop and lucerne treatments except for CP%, which was greater (P<0.05) in lucerne than crop (Table 3). Organic matter digestibility, DMD%, DOMD%, Ash and ME concentrations were greater (P<0.05) in the lucerne and crop treatments than in the pasture treatment. The NDF% was greater (P<0.05) in the pasture treatment than in the lucerne and crop treatments and ADF% was similar (P>0.05) among the three treatments.

Table 3 Herbage quality parameters for hand-plucked samples of the crop, lucerne and pasture diets offered to heifers (LSM ± s.e.m of eight samples for each treatment).

Herbage Quality	Crop	Lucerne	Pasture
OMD[1] (%)	78.4^{b} ± 1.6	76.6^{b} ± 1.6	65.4^{a} ± 1.6
DMD[2] (%)	75.5^{b} ± 1.4	73.9^{b} ± 1.4	64.2^{a} ± 1.4
DOMD[3] (%)	69.7^{b} ± 1.3	68.5^{b} ± 1.3	59.2^{a} ± 1.3
CP[4] (% DM)	15.2^{a} ± 1.8	21.9^{b} ± 1.8	14.0^{a} ± 1.8
NDF[5] (% DM)	25.4^{a} ± 2.9	27.0^{a} ± 2.9	51.0^{b} ± 2.9
ADF[6] (% DM)	18.7 ± 3.2	17.7 ± 3.2	25.9 ± 3.2
Ash (% DM)	10.8^{b} ± 0.5	9.7^{b} ± 0.5	7.5^{a} ± 0.5
ME[7] (MJ/kg DM)	11.1^{b} ± 0.2	11.0^{b} ± 0.2	9.5^{a} ± 0.2

[ab] Means in the same row with different superscripts are significantly different (P<0.05).0

[1]Organic matter digestibility (OMD), [2]dry matter digestibility (DMD), [3]digestible organic matter in the dry matter (DOMD), [4]crude protein [5]neutral detergent fibre (NDF), [6]acid detergent fibre (ADF), [7]metabolisable energy (ME).

Discussion

Heifers that grazed lucerne and crop grew faster than heifers that grazed pasture. This is in agreement with the results of de Clifford et al. (2014) who reported that six-month-old dairy heifers that were fed lucerne and meal over the summer period had greater liveweight gain than those that were fed pasture and meal. It is also in agreement with the results of Berry (2013) who reported that Friesian bull calves grazing a mixed-herb sward of chicory, plantain, red and white clover, had greater growth rate than those grazing pasture. The superior growth rates reported by Berry (2013) and de Clifford et al. (2014) were attributed to a greater ME content, CP% and digestibility and lower NDF% of the forages compared with pasture. The lucerne and crop treatments in the current study also had greater ME content, CP% and digestibility and lower NDF% than the pasture treatment, which partially explains the greater growth rate of the lucerne-fed and crop-fed heifers compared with the pasture-fed heifers.

Dry matter intake could not be reliably measured under the grazing conditions of this experiment, but if differences in intake existed, this may also contribute to the differences in growth rate. A review on the association between NDF% and DMI concluded that forages that have lower NDF% result in higher DMI (Niderkorn & Baumont 2009), which indicates that intake may have been greater for the lucerne- and crop-fed heifers than for the pasture-fed heifers. This supposition is supported by the lower plasma urea concentration of pasture-fed heifers compared with crop- or lucerne-fed heifers on D_{63}. The CP% of crop was similar to pasture, and CP% of lucerne 1.5 times greater than pasture. In order for the plasma urea concentration of crop- and lucerne-fed heifers to be almost double that for pasture-fed heifers, they must have consumed more herbage.

Live weight of the heifers grazing lucerne was not different to that of those grazing pasture at the end of the experimental period (D_{63}), however, they were likely to have had considerably less gutfill than the pasture-fed calves at this time. Seven days later, when all heifers were grazed on pasture, the lucerne-fed heifers were significantly heavier than the pasture-fed heifers.

There were no differences in plasma IGF-1 concentrations among treatments but values were similar to those reported for six-month-old dairy heifers (Brickell et al. 2009).

In conclusion, feeding a mixed-herb sward of chicory, plantain and white clover or a pure-sward of lucerne during the dry summer period resulted in growth rates of dairy heifers that were greater than those of heifers fed pasture. Farmers could consider using lucerne or a mixed-herb crop to increase the growth rates of replacement dairy heifers during their first summer.

Acknowledgements

This experiment was supported by the McGeorge Research Fund, IVABS Postgraduate fund, Dave Milne and staff of Massey Riverside farm, Geoff Purchas and Dean Burnham of IVABS.

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