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Liveweight gain and urinary nitrogen excretion of dairy heifers grazing perennial ryegrass/ white clover pasture, wheat and canola

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ABSTRACT

The objective of this study was to compare liveweight gain and urinary nitrogen excretion of heifers grazing perennial ryegrass/white clover pasture, wheat and canola in autumn. A 35-d trial was conducted with thirty Friesian x Jersey dairy heifers, equally blocked into three groups balanced for their initial liveweight and breeding worth. Heifers were allocated to one of three dietary treatments (canola, wheat or pasture). Feed was offered every 4 days with allowance calculated according to feed requirements for maintenance based on initial liveweight plus gain of 0.8 kg liveweight/day. The metabolisable energy (ME) content of canola, pasture and wheat were 11.8, 10.1 and 9.9 MJ/kg DM, respectively. Apparent dry matter intake and estimated ME intake were not different among the three treatments. Estimated nitrogen intake was lower in wheat (98.3 g/d) than pasture (155.5 g/d) and canola (158.6 g/d). Average daily liveweight gain was higher in wheat (0.73 kg/d) than canola (0.58 kg/d) and pasture (0.56 kg/d). Urinary nitrogen concentration and estimated urinary nitrogen excretion were higher in pasture (0.21 %; 41.8 g/d) than wheat (0.13 %; 21.3 g/d) and canola (0.15 %; 18.4 g/d), with no difference between wheat and canola. Data from this study indicates that offering wheat to heifers as grazing forage can improve the liveweight gain in comparison to autumn pasture. The lower estimated urinary nitrogen excretion in wheat and canola compared with pasture demonstrated the potential to use these dual-purpose crops to reduce the environmental pollution from heifer production systems.

Keywords: Metabolisable energy; dairy heifer; urea nitrogen; dual-purpose crop; pasture; sustainability.

INTRODUCTION

The rearing of dairy heifers as replacements for the milking herd is important for successful dairy businesses. Reaching liveweight (LW) targets at critical growth stages, such as at mating, enhances the chances of successful conception and can increase milk production in subsequent lactations (McNaughton and Lopdell, 2012). However, recent analyses report up to 70 % of the heifers in New Zealand fail to achieve such target LW at mating (McNaughton and Lopdell, 2012). Further, the rearing of dairy heifers also contributes to the environmental footprint of dairy systems, particularly nitrate leaching through urinary nitrogen excretion. This study examined the role of alternative forages, specifically dual-purpose crops, in increasing LW gain and reducing urinary nitrogen excretion.

A dual-purpose crop refers to the use of a crop for grazed forage before subsequent seed production (Sprague *et al.* 2014). In Australia, dual-purpose cereal and brassica crops have been used for winter forage for livestock production, due to their potential to promote high LW gain and subsequently high grain yields. Previous work has investigated LW gain of beef cattle (Pitta *et al.* 2011) and lambs (McGrath *et al.* 2014) grazing wheat, and also compared grazing canola and cereal crops for sheep production (Dove *et al.* 2012). However, there is limited comparative data on the performance of dairy heifers grazing perennial ryegrass/white clover pasture compared to dual-purpose cereal and brassica crops. Also, there is little information on the environmental impact of grazing dual-purpose cereal and brassica crops as indicated by urinary nitrogen excretion. The objective of this study was to compare LW gain and urinary nitrogen excretion of dairy heifers offered wheat and canola forages or perennial ryegrass/white clover pasture in autumn.

MATERIALS AND METHODS

The study was undertaken at Ashley Dene Pastoral Systems Research Farm, Lincoln University, New Zealand under the approval of Lincoln University Animal Ethics Committee (No. 556). A 35-d trial was conducted from 15 February 2014 to 21 March 2014, with a 7-d feed adaptation period and a 28-d measurement period. Thirty Friesian x Jersey dairy heifers aged 6-7 months were blocked for their LW (143.9 ± 3.73 kg) and breeding worth ($ 140.6 ± 4.95) into three dietary treatments: canola, wheat or perennial ryegrass/white clover pasture (pasture). Feed was offered every 4 days with allowance calculated according to feed requirements for maintenance based on initial LW plus gain of 0.8 kg LW/day. Pre- and post-grazing herbage mass was measured with three randomly selected 0.1 m^2 quadrat cuts per treatment every 4 days. Group apparent dry matter intake (aDMI) was calculated from forage disappearance using pre- and post-grazing measurements. All forage samples were oven-dried (60 °C), then ground for quality analysis using wet chemistry methods. Nitrogen was analysed according to (Cheng *et al.* 2013). Modified acid detergent fibre (MADF) was measured using method described by Clancy and Wilson (1966). Metabolisable energy (ME) was then estimated using the equation from (Barber *et al.* 1984): ME (MJ/kg DM) = 14.6 – 0.13× MADF (%). For each heifer, LW was measured at the start and at the end of the measurement period after 12 hours fasting. One urine sample was collected per heifer on d 19 and d 33, and analysed for nitrogen concentration. One blood sample was collected from each heifer on d 19 and d 33, and centrifuged to harvest plasma for plasma urea nitrogen (PUN) analysis. Urinary nitrogen excretion was estimated using equation from (Kohn *et al.* 2005): estimated urinary nitrogen excretion (g/d) = 1.3 x PUN (g/l) x LW (kg). The Genstat statistical analysis package (version 15.1) was used for general ANOVA with individual animal as block and forage type as treatment. As aDMI and forage chemical composition were measured per treatment over time, general ANOVA was conducted with sampling date as block and forage type as treatment. Multiple comparison test was performed to differentiate the mean values among treatments when $P < 0.05$.

RESULTS

Canola had greater ME than pasture and wheat (Table 1). The nitrogen content of forage was greatest in pasture and lowest in wheat (Table 1). The aDMI and estimated ME intake were not different among treatments (Table 2). Estimated nitrogen intake was lower in wheat than pasture and canola. Average daily LW gain was higher in wheat than pasture and canola (Table 2). Urinary nitrogen concentration from spot urine samples and estimated urinary nitrogen excretion from PUN were higher for pasture than wheat and canola, with no difference between wheat and canola (Table 2).

DISCUSSION AND CONCLUSION

The average daily gain of heifers over 28 days ranged from 0.56 kg/d to 0.73 kg/d. These values are greater than the target gain of 0.55 kg/d for heifers aged 6-9 month old (McNaughton and Lopdell, 2012). The average daily gain was greater in heifers fed wheat compared with pasture and canola. This was despite no differences in aDMI or estimated ME intake due to large variation among sampling dates. The higher average daily gain may reflect a higher ME : nitrogen ratio in wheat than canola and pasture (Lee *et al.* 2001).

Both estimated urinary nitrogen excretion and urine nitrogen concentration were higher in heifers grazing autumn pasture than wheat and canola. The difference in estimated urinary nitrogen excretion may be due to the higher estimated nitrogen intake in autumn pasture than wheat (Castillo *et al.* 2001). However this cannot explain differences between autumn pasture and canola as estimated nitrogen intake was similar. In this case, differences might reflect the higher ME : nitrogen ratio in canola (Vibart *et al.* 2009). In conclusion, data from this study indicates that offering wheat to 6-7 month old heifers as grazing forage increased average daily gain in comparison to autumn pasture and canola. Heifers grazing canola and wheat had lower estimated urinary nitrogen excretion than heifers grazing autumn pasture. Further work is needed to consider the effect of grazing on grain yield of the dual-purpose crop.

Table 1: Chemical composition of autumn pasture, wheat and canola.

Item	Pasture	Wheat	Canola	LSD	*P-value*
Nitrogen (g/kg of DM)	37.4[a]	24.2[c]	31.8[b]	4.39	*<0.001*
Metabolisable energy (MJ/kg DM)	10.1[b]	9.9[b]	11.8[a]	0.517	*<0.001*
Metabolisable energy : nitrogen ratio (MJ/g)	0.27[b]	0.42[a]	0.38[a]	0.046	*<0.001*

Table 2: Effects of forage type on intake, liveweight gain, plasma urea nitrogen, estimated urinary nitrogen excretion, and urinary nitrogen concentration.

Item	Pasture	Wheat	Canola	LSD	P-value
Liveweight at the start (kg)	139.0	140.0	137.3	11.87	0.895
Liveweight at the end (kg)	154.7	160.3	153.6	13.43	0.544
Apparent dry matter intake (kg/d)	4.2	4.1	5.0	1.56	0.456
Estimated metabolisable energy intake (MJ/d)	42.7	40.3	57.6	16.18	0.079
Estimated nitrogen intake (g/d)	155.5[a]	98.3[b]	158.6[a]	49.32	*0.035*
Estimated urinary nitrogen excretion (g/d)	41.8[a]	21.3[b]	18.4[b]	3.85	*<0.001*
Average daily gain (kg/d)	0.56[b]	0.73[a]	0.58[b]	0.122	*0.017*
Plasma urea nitrogen (g/l)	0.22[a]	0.11[b]	0.10[b]	0.013	*<0.001*
Urinary nitrogen concentration (%)	0.21[a]	0.13[b]	0.15[b]	0.056	*0.013*

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