

Management of *Lotus corniculatus* under dairy cow grazing

E.M.K. MINNEÉ, S.J. BLUETT, S.L. WOODWARD and P.G. LABOYRIE
 Dexcel, Private Bag 3221, Hamilton.
 elena.minnee@dexcel.co.nz

Abstract

The effect of lax or hard dairy cow grazing (residual stubble height of 10 and 5 cm) and grazing frequency (grazing when sward height reached 35 or 20 cm) on persistence, productivity and forage quality of pure pastures of *Lotus corniculatus* was evaluated over two growing seasons. Herbage accumulation was not affected by grazing frequency or severity. In year one, hard, infrequent defoliation significantly increased forage fibre content and reduced concentration of crude protein, soluble sugars, organic matter digestibility and metabolisable energy. Under frequent grazing, condensed tannin concentration was reduced by 15% ($P < 0.001$). Differences in forage quality are likely to be associated with increased amounts of fibrous stem material in infrequently grazed pastures ($P < 0.001$). Plant populations declined in all treatments after 2 years.

Keywords: *Lotus corniculatus*, dairy cows, grazing management

Introduction

The New Zealand dairy industry has set a goal to increase dairy farmer profit and create wealth for the New Zealand economy by achieving a 50% gain in productivity by 2015. Experiments at Dexcel showed that feeding *Lotus corniculatus* (lotus) to dairy cows increased milk production per cow (Harris *et al.* 1998; Woodward *et al.* 1999). Lotus is a high quality, non-bloating perennial legume that is tolerant of drought and low soil fertility. The main growth period is from spring until late autumn, with almost no growth over winter. Yields from pure stands of lotus can reach 10 to 15 t DM/ha/yr under good growing conditions and careful management (Waghorn *et al.* 1998). However, factors limiting the use of lotus in New Zealand dairy farm systems include poor productivity and persistence. Yields of 7.5 t DM/ha/yr were reported by Bologna *et al.* (1996) while Scheaffer *et al.* (1992) reported that monocultures of lotus, initially more than 95% pure deteriorated to 20% (80% broadleaf weeds) by the fourth year of grazing by sheep. Much of the published literature on managing lotus is based on cutting experiments, overseas research and experiments involving sheep. Although lotus has shown promise as high quality forage for dairy cows that may help achieve industry goals, management guidelines for grazing must be developed specifically for New Zealand dairying systems.

The objective of this study was to evaluate the effects of severity and frequency of grazing by dairy cows on the productivity and persistence of lotus over two growing seasons.

Materials and Methods

Experimental design

Plots were arranged in a randomised complete block design with four treatments replicated three times, each plot measuring 20 m². Treatments were: Frequent Hard grazing (FH); Frequent Lax grazing (FL); Infrequent Hard grazing (IH); Infrequent Lax grazing (IL). Treatment selection was based on research by Alison and Hoveland (1989a, b) and Pierre and Jackobs (1953). These treatments were arranged in a 2 x 2 factorial design with either lax or hard grazing (residual stubble height of 10 or 5 cm, respectively) combined with infrequent or frequent grazings (sward height of 35 or 20 cm, respectively).

Experimental site and establishment

The experiment was conducted from February 2002 to March 2004 at Dexcel's No. 5 Dairy near Hamilton, (37°47'S, 175°19'E). The soil type at the site was Te Kowhai clay loam (Singleton 1991), classified (Hewitt 1998) as a Typic Orthic Gley. Rainfall and temperature data were recorded at the Ruakura Climatological Station c. 1 km north-west of the site.

Existing pastures were sprayed out in February 2002 with 4 L/ha Roundup®, before ploughing. Fertiliser (4 t/ha lime, 550 kg/ha 10% potash super, 50 kg/ha magnesium) and a pre-emergent herbicide spray (2.5 L/ha Treflan) were applied before power harrowing and rolling to form a fine seedbed. Bare *L. corniculatus* (cv. Grasslands Goldie) seed was inoculated with *Rhizobium loti* immediately before sowing which was carried out at 6 kg/ha by roller drill. In July 2002 after seedling emergence, a post-emergent herbicide (4 L/ha 2-4-DB and 0.5 L/ha Combine) was applied.

Measurements

Experimental data were collected throughout the growing season (September to April) of each year. Plots were 'rested' during winter (May to August) to avoid depleting plant carbohydrate reserves (Ayala *et al.* 2000).

Average mean sward height of each plot was monitored weekly, using an automated sward stick, taking 20

random measurements per plot. Dairy cows grazed treatment plots when the average sward height was at target pre-grazing height. Sward height was monitored throughout grazing and cows were removed when target residual height was achieved.

Herbage accumulation was determined by cutting 10 x 0.2 m² quadrats per plot to ground level before and after grazing (residual) using an electric shearing handpiece. Herbage samples were washed, oven-dried at 95°C for 48 hours, and weighed. Herbage accumulation was defined as: $\Sigma(\text{present pre-grazing herbage mass} - \text{previous residual herbage mass})$.

Prior to grazing, 10 herbage samples were hand-clipped to residual grazing height (5 or 10 cm) from random locations within each plot before bulking. A 150 g sub-sample of herbage was frozen, freeze dried and ground to pass a 1 mm diameter sieve, and analysed by NIRS (near infrared reflectance spectroscopy) for indicators of feed quality (Corson *et al.* 1999) and condensed tannin concentration. A second sub-sample (~ 100 g) was dissected into lotus leaf, stem, flowers, seedpods, weeds and dead material. Dissected samples were dried at 95°C for 48 hours before weighing to estimate botanical composition on a dry matter basis.

Plant density was measured bi-monthly during the experimental periods by removing 10 x 0.12 m² (15 cm

deep) turves from each plot. Soil was washed from each turf, and the number of plants per turf recorded.

Data were analysed as a factorial design. Analysis of variance was used to test for treatment differences and interactions using Genstat 8.1.

Results

Rainfall during each growing season was generally similar to the 10-year average (1160 mm). However in February 2004, rainfall was 420% greater than the 10-year average (69.5 mm). Soil temperatures (10 cm below surface) were also similar to the 10-year average (13.8°C) (AgResearch, Ruakura).

There were no significant differences in herbage accumulation between treatments in either year, although there was a substantial drop in yield across all treatments from year one to year two (between 42 and 59%) (Table 1). Average grazing interval for each treatment across both seasons was 37 days for FH, 30 days for FL, and 45 days for both IH and IL plots.

Nutritive characteristics as indicators of feed quality are summarised in Table 2. A significant interaction for grazing frequency x severity was detected in year one for concentration of soluble sugars (SS) ($P < 0.01$), neutral detergent fibre (NDF) ($P < 0.01$) and organic matter digestibility (OMD) ($P < 0.05$). Under infrequent grazing concentrations of SS and OMD were reduced, while NDF increased compared to frequently grazed pastures. Under hard grazing, NDF concentration increased while OMD was reduced compared to lax grazed treatments. Crude protein (CP) and metabolisable energy (ME) concentration were higher on frequently grazed treatments and under lax grazing ($P < 0.001$), while concentration of condensed tannins were greatest under infrequent ($P < 0.001$) and lax grazing ($P < 0.05$).

Botanical composition for year one is described in Figure 1. A significant ($P < 0.01$) interaction for grazing frequency x severity was detected for the proportion of lotus stem material in the forage in season one. Proportion of stem material was higher under infrequent grazing

Table 1 Herbage accumulation (t DM/ha) of *Lotus corniculatus* comparing levels of frequency (frequent, infrequent) and levels of severity (lax, hard) of grazing by dairy cows.

Treatment	Year 1	Year 2
Frequent Hard (FH)	10.4	6.0
Frequent Lax (FL)	11.8	5.7
Infrequent Hard (IH)	12.2	6.0
Infrequent Lax (IL)	13.0	5.4
SED	1.8	1.0
P (Grazing frequency)	0.272	0.535
P (Grazing severity)	0.416	0.254
P (interaction)	0.821	0.514

Table 2 Nutritive characteristics (g/100 g DM, unless otherwise stated), averaged over all harvests in Year 1 (2002/2003), of *Lotus corniculatus* comparing frequency (frequent, infrequent) and severity (lax, hard) of dairy cow grazing on forage quality.

Treatment	NDF ¹	CP ²	ME ³	OMD ⁴	SS ⁵	CT ⁶
Frequent Hard (FH)	23.7	24.7	11.3	79.6	13.5	4.5
Frequent Lax (FL)	22.5	26.3	11.5	81.5	13.2	4.6
Infrequent Hard (IH)	28.0	21.6	10.6	74.2	11.2	5.1
Infrequent Lax (IL)	23.6	23.3	11.1	77.9	12.7	5.5
SED	0.61	0.25	0.08	0.47	0.28	0.09
P (Grazing frequency)	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
P (Grazing severity)	0.001	<0.001	<0.001	<0.001	<0.018	0.017
P (interaction)	0.009	0.970	0.061	0.040	0.004	0.101

¹NDF, neutral detergent fibre; ²CP, crude protein; ³ME, metabolisable energy, MJ/kg DM; ⁴OMD, organic matter digestibility; ⁵SS, soluble sugars; ⁶CT, condensed tannins.

Figure 1 Sward botanical composition (%) comparing frequency (frequent, infrequent) and severity (lax, hard) of grazing by dairy cows over 2 years.

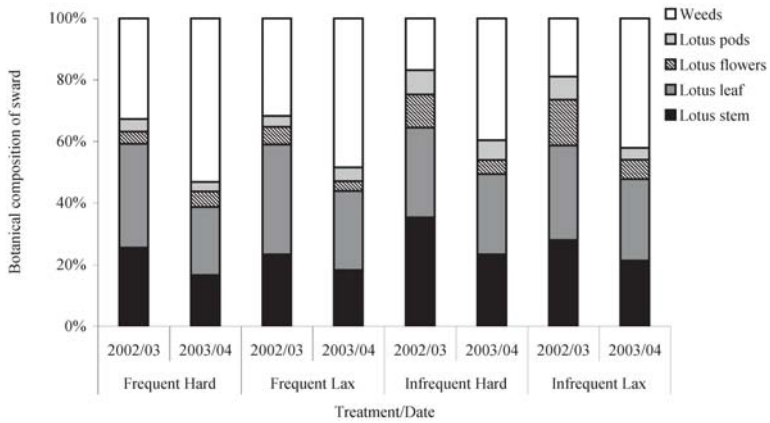
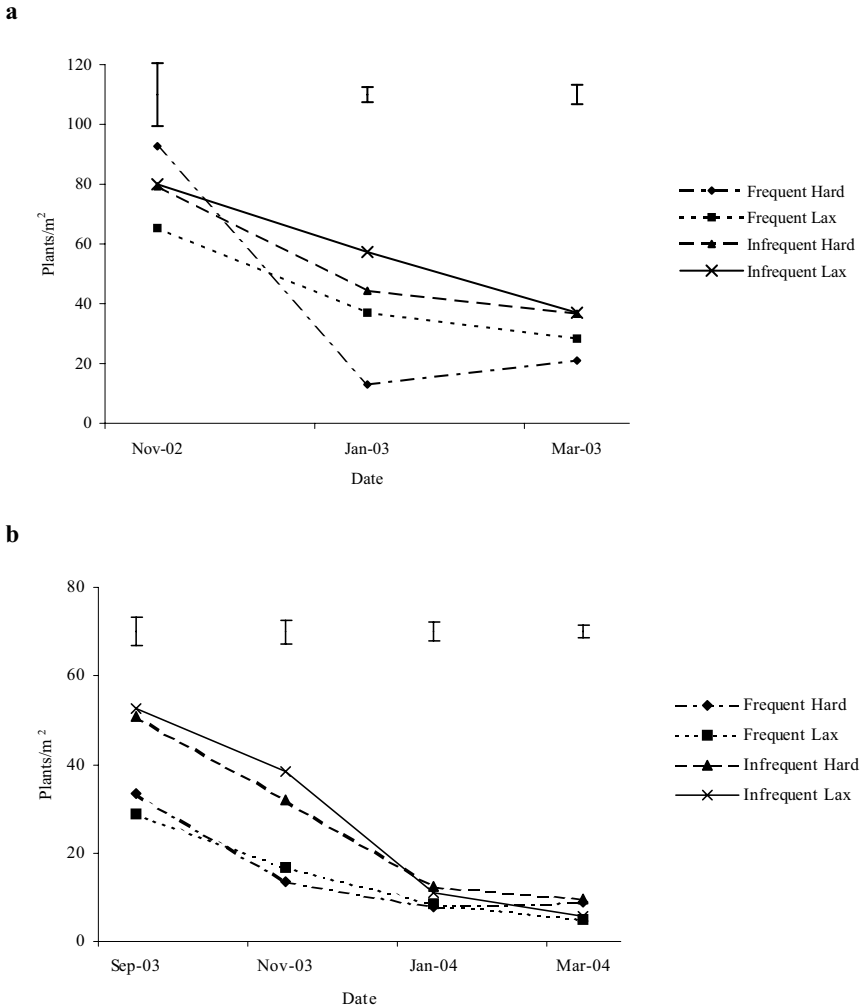


Figure 2 Changes in *Lotus corniculatus* plant density (plants/m²) comparing frequency (frequent, infrequent) and severity (lax, hard) of grazing by dairy cows in (a) year one and (b) year two. Error bars represent SED.



compared with frequent grazing, and was greater on hard grazed treatments compared to lax grazed treatments. In year one, proportion of flowers increased under infrequent grazing ($P < 0.001$), but seedpod proportion was not affected by treatment. Weed content was greatest under frequent defoliation for both years ($P < 0.001$ and $P < 0.05$). At the end of the year two, lotus accounted for only 43% of pasture dry matter.

Initially (November 2002), plant density of lotus was similar across all treatments, averaging 80 plants/m². Between November 2002 and January 2003 a substantial linear decline in plant density was observed (Fig. 2a). Plant density was significantly affected by grazing frequency with IH and IL > than FH and FL ($P < 0.001$ in January 2003, $P < 0.05$ in March 2003, $P < 0.001$ in September 2003 and $P < 0.001$ in November 2003). Plant density was also affected by grazing severity in March 2004 when FH and IH had higher density than FL and IL ($P < 0.05$). By March 2004, plant density was only 5 to 12% of the original plant population across all treatments (Fig. 2b).

Discussion

In this study, herbage production was not affected by grazing management. Yields observed in year one were moderate (10.4 to 13 t DM/ha) and similar to those reported by Bologna *et al.* (1996). The reduction in yield from year one to year two was associated with the decline in lotus stand density and ingress of weeds into the pasture. These results support the statement made by Pierre and Jackobs (1953) that lotus is essentially a "... short-lived perennial legume under grazing". While, lotus did not show potential as a crop for high forage production, it may still be worthy of inclusion in dairy farming systems because of the nutritional benefits of lotus forage and animal production gains previously observed in other studies (Harris *et al.* 1998; Woodward *et al.* 1999).

In this study, both grazing severity and grazing frequency influenced forage quality. Infrequent and hard defoliation reduced forage quality. This was associated with an increase in fibrous stem material under infrequent defoliation. However, concentrations of the nutritional indicators were all within the ranges regarded as good quality forage for high producing ruminants (Kolver 2000). Concentrations of condensed tannins from forage from all grazing strategies were moderate and within the range likely to provide additional nutritional benefit to ruminants without depressing intake (Waghorn *et al.* 1998).

Competition between individual lotus plants may explain the substantial decline in plant numbers in the early part of this experiment. Most substantial plant losses were associated with frequent grazing. Regular treading

damage to the plant crown, (the primary site for shoot regeneration after grazing) probably contributed to plant loss. In this study, after 2 years under dairy cow grazing, lotus stands were defunct.

Studies of grazing lotus by sheep under dryland farming showed that lotus stands persisted satisfactorily (i.e. maintaining at least 60% lotus in the sward) for 3 years (Widdup *et al.* 2004; Ramirez-Restrepo *et al.* 2006). Further investigation into whether lotus persists better under dairy cow grazing in dryland areas is required.

Conclusion

Grazing strategies imposed in this study did not influence herbage yield but did affect forage quality and stand persistence. Across all treatments, lotus dry matter production and plant density declined with time, but could be slowed using infrequent grazing, which also slowed ingress of weeds. Infrequent hard grazing resulted in a reduction in nutritive value, due to an increased proportion of stem material in the forage, and therefore infrequent lax grazing is the preferred grazing method.

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