"Late control" spring grazing management of perennial ryegrass swards: effect on sward structure and botanical composition

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Abstract

Results from a series of experiments conducted at Massey University between 1985 and 1997, and which investigated the increased herbage accumulation rate observed under laxer spring grazing are summarized. This approach to spring grazing management was popularly termed "late control". One of the experiments is described in more detail and previously unpublished point quadrat data on sward botanical composition are presented. The objective of this experiment was to study the influence of spring grazing management on sward structure, and on herbage production, in perennial ryegrass (*Lolium perenne* L.) dominant swards with and without white clover (*Trifolium repens* L.). In one grazing treatment, swards were grazed by sheep to 30-50 mm every 14 days from 15 September to late March (Early Control - EC). In two other grazing treatments, swards were grazed every 21 days to 70-90 mm for periods of 6 weeks (short release – SR) or 12 weeks (long release - LR) before returning to 30-50 mm grazing as in EC from 8 December. The three grazing treatments were applied to plots with or without white clover (N applied to replace clover fixation) making six treatments in all, arranged in a randomized block design with three replicates. Changes in sward structure were reflected in herbage production before (spring) and after 8 December (summer-autumn). During spring, herbage mass and herbage production on the release treatments was increased as a consequence of an increase in tiller weight. During the summer, herbage production was increased in release treatments, and this was attributable primarily to increased tiller production. Release treatments decreased *Poa* content of swards, especially on plots without clover. A significant increase in ryegrass stem occurrence was detected in only one of the four release treatments, and there was no indication of clover suppression.

Additional key words: *tiller population density, tiller weight.*

Introduction

The series of experiments conducted at Massey University between 1985 and 1999, to investigate beneficial effects of laxer spring grazing, also known popularly as late control, were reported in four Ph.D. theses (Matthew, 1992; da Silva, 1994; Hernández Garay, 1995; Bishop Hurley, 1999). Some 15 scientific papers have also been published but there has not been a concise summary. We therefore provide a brief overview.

The first experiments in the series showed that root production of perennial ryegrass swards was increased following lax spring grazing, the increase in root production apparently linked to an increase in tillering activity (Matthew *et al.*, 1986; Matthew, 1992). Subsequent studies investigated the tillering response to laxer spring grazing at the single tiller level, at the paddock scale (effectively using animals as lawnmowers to achieve a specified grazing intensity) and at the systems level.

At the single tiller level, the numbers of spring daughter tillers formed from flowering ryegrass tillers, and the total dry weight of those daughter tillers, varied five-fold as a result of differences in timing and intensity of defoliation. Laxer or later defoliation increased daughter tiller formation (Matthew *et al.*, 1991; Matthew, 1992). A similar effect was seen with the cultivars Grasslands Ruanui and Ellett in two different experiments. However, these two cultivars had statistically significant differences in the site of tiller production with cv. Grasslands Ruanui tending to form secondary tillers on existing tillers, and cv. Ellett tending to form new primary tillers (Matthew *et al.*, 1991; Matthew, 1992).

The next step in the research programme was to confirm that differences achieved at the single tiller level would have significant impact on herbage production on a paddock scale. Reports of the paddock scale studies include those of da Silva *et al.* (1994) and Hernández-Garay *et al.* (1997a, b). In all, these authors conducted five experiments with sheep and dairy cattle. Across these five studies the mean herbage production of the laxer grazing treatments was consistently increased by around 20% in both October – November and December - March periods (Table 1). A combined experiments statistical analysis has not been carried out, but production increases in both spring and summer under laxer spring grazing in the individual experiments were statistically significant (Da Silva *et al.*, 1994; Hernández-Garay *et al.*, 1997a).

Table 1. Seasonal herbage production (kg DM/ha) averaged over five separate experiments with sheep and dairy cattle, in which variations of a 'normal' (Early Contol) and laxer spring grazing management regime (Late Control) were applied. For details of individual experiments, see da Silva (1994) and Hernández Garay (1995).

Grazing	Seasonal production (kg DM/ha)	
	Spring (Oct/Nov)	Dec-March
Early Control	4216	4131
Late control	5082	5000

A final phase of the experimental programme was an attempt to implement late control in a self-contained system (Bishop Hurley *et al.*, 1997). In a farmlet study over three years, the prescribed differences in herbage mass for "early" and "late" control were not achieved, and herbage production responses were confined to non-significant trends, commensurate with the small differences in herbage mass. In a farm system, timing and intensity of grazing are constrained by other considerations. Also, control of reproductive development implies grazing should occur within a narrow time window. The fact that grazing of paddocks in a system is necessarily staggered makes it difficult to achieve this time window on a whole farm basis. However in this trial there were also less fundamental reasons why prescribed differences in herbage mass were not achieved. These include higher than optimal stocking rate, unusual weather patterns during two of the three years of the trial, and the specific grazing strategies adopted to achieve differences in herbage mass on the two farms.

The purpose of this paper is to present previously unpublished botanical composition data from the experiment of Hernández-Garay *et al.* (1997a) and to clarify the mechanism of sward structure responses under laxer spring grazing, which have been the subject of discussion in the literature. The particular objective of this experiment was to test the effect of duration of the lax grazing period on the herbage production response.

Methods

The experiment was conducted between September 1992 and March 1993 at Massey University, Palmerston North on swards of perennial ryegrass (*Lolium perenne* L., cv. Grasslands Nui) with or without white clover (*Trifolium repens* L., cv. Grasslands Tahora). Plots of 86.5 m^2 were grazed by sheep every 14 days (hard grazing) or 21 days (lax grazing) to maintain post-grazing sward surface height at 30-50 mm (hard) and 70-90 mm (lax), respectively. Two durations of lax grazing (short release - SR from 26 October to 8 December and long release - LR from 15 September to 8 December) were compared with conventional hard grazing throughout (early control - EC). All treatments were grazed to 30-50 mm every 14 days from 8 December until the end of the experiment in late March. These grazing treatments were applied to plots with white clover still present (ECW, SRW, LRW, respectively), and to plots from which white clover had been sprayed out and to which nitrogen was applied at 28 kg N ha^{-1} every two weeks as urea (ECN, SRN, LRN, respectively). There were three replicates, making a total of 18 plots.

Ryegrass tiller population density was determined from 30 cores of 53 mm diameter per plot on three occasions (Table 2) throughout the experimental period. At the same times, four 0.1 m^2 quadrats per plot were cut to ground level for determination of herbage accumulation and one pooled sub-sample of herbage per

Table 2. Chi-square contingency table for botanical composition as indicated by total point quadrat hits on each herbage component per treatment (see Fig. 1). Upper figure in each row is the actual count and the lower figure the expected count if no treatment differences existed. Cells making the greatest contribution to the chi-square statistic are shown in bold. Counts for the weed component are not shown. Chi-square statistic was 35.7 (df = 8, P < 0.001) for white clover plots and 59.3 (df = 6, P < 0.001) for nitrogen plots.

Treatment[1]	Ryegrass leaf	Ryegrass stem	Other Grass (mainly *Poa* spp.)	Clover	Dead
ECW	187	83	136	92	79
	206	87	120	91	72
SRW	203	**115**	136	82	60
	213	**90**	124	94	74
LRW	**221**	**61**	**85**	97	73
	192	**81**	**112**	85	67
ECN	**256**	99	**172**	-	53
	319	90	**119**		51
SRN	347	79	103	-	44
	315	89	88		51
LRN	342	89	**79**	-	55
	311	88	**116**		50

[1] EC = early control, SR = short release, CR = long release, W = white clover present, N = Nitrogen applied

plot was used to determine tiller weight. Sward structure was determined, before the change from lax to hard grazing on 6 December, using the inclined point quadrat technique (Warren-Wilson, 1959); 200 contacts per plot were taken.

Point quadrat data were analyzed as two chi-square contingency tables for the total count per treatment (comparing ECW, SRW and LRW or ECN, SRN and LRN). This analysis of total point quadrat counts per treatment was unaffected by vertical height distribution of herbage, but tested whether or not statistically significant differences among treatments existed for individual herbage components.

Results and Discussion

The effect of laxer grazing on sward height is clearly evident (Fig. 1), with few point quadrat hits above 9 cm height in ECW and ECN treatments and some point quadrat hits above 20 cm height in LRW and LRN swards. As mentioned above, statistical analysis of botanical composition data in Fig. 1 obtained from a chi-square contingency table (Table 2) is based on total counts per treatment, and therefore is unaffected by vertical height distribution of the components in the sward. There is no evidence of clover suppression in SRW and LRW treatments (Table 2). This result was unexpected since conventional wisdom is that laxer grazing suppresses clover. However, it is widely recognized that with adequate moisture supply, clover becomes dominant in swards in summer. We interpret this result (Table 2) as indicating that the popular view that white clover is susceptible to shading in less frequently grazed swards applies more to winter when clover is dormant, than to spring and summer when clover is actively growing. There was no detected increase in dead material in the four Release treatments, but SR and LR treatments did increase the ryegrass leaf and decrease other grass counts (mainly *Poa trivialis)*, compared with EC (Table 2). The SRW treatment had a high count of ryegrass stem (Table 2) and this datum made the largest single contribution to the chi-squared statistic. However, since no such effect is seen in the other three release treatments, this is assumed to be a chance effect. In general counts for ryegrass leaf and other grass in the SR plots were intermediate between

EC and LR (Table 2), indicating that effects of laxer grazing in changing sward composition act in proportion to their duration rather than as simple threshold effects.

Dissection of samples collected to determine herbage accumulation supported the results from point quadrat analysis presented here. In these samples there was

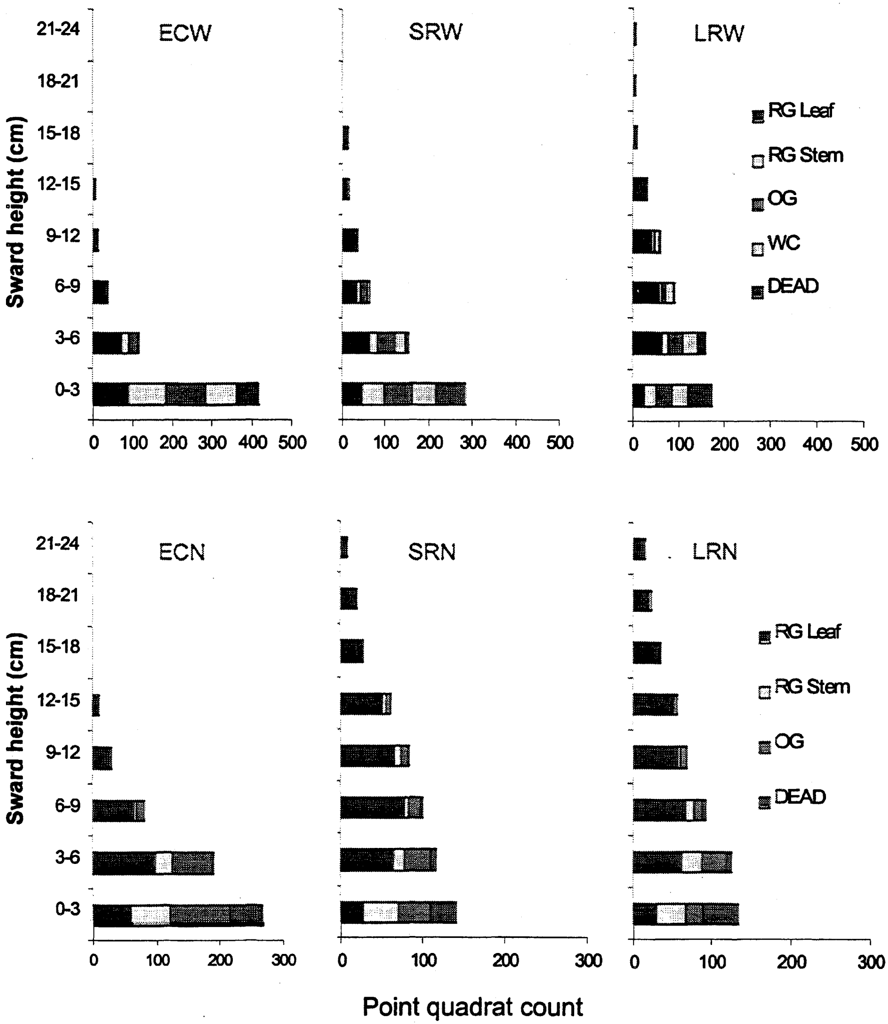

Figure 1. Herbage components and their vertical distribution in swards at the end (December 6) of a period of spring harder grazing (Early control, EC), 6 weeks laxer grazing (Short release, SR), or 12 weeks laxer grazing (Long release, LR), with white clover (W) or without clover but with nitrogen fertiliser (N). A total of 600 point quadrat counts per treatment was taken. Failure to sum to 600 is mainly due to the weed component, not graphed. Total counts per treatment for each herbage component are analysed as a chi-square contingency table (Table 2).

parallel evidence of a decrease in other-grass:ryegrass ratio on the release treatments and no evidence for clover suppression (Hernández Garay, 1995). The only difference in results between the two techniques was that herbage dissection detected an increase in leaf:stem ratio of ryegrass, not detected by point quadrat analysis. Leaf:stem ratios of the ryegrass component for EC, SR and LR were respectively 2.03, 1.17 and 1.38 at the end of the period of laxer grazing (Hernández Garay, 1995). In the experiments of da Silva (1994), similar differences in expression of reproductive growth resulted in a loss of digestibility of approximately 2%. Despite the reduction in digestibility, there was still an increase in animal production arising from the increased total herbage production on more laxly grazed treatments (da Silva, 1994).

Overall, the picture is one of minimal effect of laxer spring grazing on sward botanical composition, as measured by point quadrat analysis at the end of a lax grazing period of six or twelve weeks in the first season. The one effect that was observed, an increase in the ryegrass:other grass ratio, can be regarded as a beneficial effect of laxer spring grazing. This is reassuring because one concern as the experimental programme moved from the single tiller to the paddock stage was that negative effects of lax spring grazing on botanical composition, in particular white clover suppression, might negate herbage accumulation advantages. Two further points can be made from anecdotal observation. While data in Table 2 show "other grasses", mainly *Poa* spp. in this case, tended to be suppressed by SR and LR treatments, visual observation suggested that Yorkshire fog (*Holcus lanatus* L.) became more competitive under laxer spring grazing, so responses are likely to be species specific. Finally, laxer grazed swards do tend to show more spatial heterogeneity in herbage mass than harder grazed swards, but the point quadrat method of analysis, as used here, does not allow for sward heterogeneity to be described.

The data in Table 3 show the seasonal change in sward structure (as represented by tiller weight and tiller population density) through the late spring and summer. For the swards with white clover present, during spring, the SRW and LRW treatments did tend to reduce tiller density, but not significantly so, while tiller weight was approximately 100% greater in SRW and LRW treatments than in ECW. The greater herbage production observed in SRW and LRW treatments during the pre-control phase (Table 3) can therefore be attributed to greater individual tiller weight in these treatments being more important than tiller population density in determining productivity. This response is presumably associated with increased reproductive stem development. As the season progressed, tiller weight in all sward treatments declined though some size difference remained in late March (Table 3). However, by this time the initial high tiller weight in the SRW and LRW treatments had

Table 3. Tiller population density (TP, tillers/m^2 from tiller cores), mean dry weight (TW, mg) and herbage accumulation (kg DMha) of perennial ryegrass growing with white clover under contrasting spring grazing managements.

	2 Dec		28 Jan		23 Mar		DM	
Treatment[1]	TP	TW	TP	TW	TP	TW	Pre-c[2]	Post-c
ECW	3830	15.7	7760	17.4	5050	8.4	3420	3620
SRW	3280	36.5	8820	19.9	8050	11.4	4090	4010
LRW	3740	29.0	11800	16.3	7210	11.7	4440	4290
ECN	4370	15.6	9910	17.7	10500	9.3	4880	4310
SRN	5030	48.1	11700	21.0	9770	9.2	6560	4840
LRN	5100	42.5	12120	15.8	7970	9.1	7790	4680
SEM[3]	490	4.3	1680	2.1	1090	0.6	200	190
Signif. (Trt)	ns	***	*	ns	*	*	***	*
Signif. (W v. N)	**	*	ns	ns	**	*	***	**
Signif. (Trt x N)	ns	ns	ns	ns	ns	*	**	ns

*:P<0.05; **:P<0.01; ***:P<0.001; ns:no significant differences

[1] EC = Early Control, SR = Short Release, LR = Long Release, W = white clover, N = Nitrogen

[2] Pre-c = Pre-control period (15 Sept. to 7 Dec.), Post-c = Post-control period (25 Dec. to 29 Mar.).

[3] = Standard error of least square means.

translated into a tiller population increase of about 50% on these treatments, compared with ECW. In contrast with the early season, the greater herbage accumulation rate observed in SRW and LRW treatments during the post-control or summer-autumn period arose from both greater tiller population density and greater tiller weight (Table 3).

For the swards without white clover and receiving nitrogen fertilizer, the seasonal tiller dynamics were more complex. There appeared to be more rapid release of new tillers on the SR and LR grazing treatments, a greater increase in tiller size on these treatments in spring, and a more rapid return to a common tiller size across treatments.

SR and LR treatments increased herbage production, both before and after the control period (Hernández Garay *et al.,* 1997a; see also Table 3). In assessing the wider relevance of these results, two points should be noted. Firstly, the fundamental physiological principles were demonstrated at tiller level (Matthew *et al.*, 1991) and the associated paddock scale responses were consistent across a series of five experiments using both sheep and dairy cattle, and despite the variations in criteria for implementation of laxer spring grazing (Table 1). Secondly, there are two distinct phases in the response to laxer spring grazing – the facilitation of reproductive development pre-December and the enhancement of early-summer tillering, leading to improved summer and early-autumn production from December to March.

In general, laxer grazing of vegetative or reproductive swards will increase productivity. In vegetative miniature swards, Hernández Garay *et al.,* (1999) found herbage production was optimized at 120 mm cutting height, with the tiller population density of swards cut to 160 mm markedly lower than in the 120 mm swards. Many authors have reported increased productivity under laxer defoliation in late spring when reproductive growth is occurring (da Silva et al., 1994). These principles are quite general. For example, Roggero *et al.* (1993) studying swards of annual ryegrass (*Lolium rigidum* Gaudin) observed that cutting at a surface height of 100 mm resulted in significantly lower yields but a better canopy structure (denser sward, higher percentage of leaves in the bottom layers, higher leaf:sheath ratio) than in swards cut at either 150 mm or 200 mm.

There has been some ambiguity in the literature of the relative importance of tiller size and tiller weight to herbage production. Nelson and Zarrough (1981) recognized that either tiller size or tiller weight could be important at different times. The present results need not be taken to contradict studies that illustrate size/density compensation in tiller populations. An example of results which can be interpreted in terms of the size/density effect was reported by Penning *et al.* (1991), who showed that sward surface height had a direct effect on tiller number, mass and leaf area. They found that as stem elongation occurred in late spring, there were a greater number of tillers and a lower proportion of reproductive tillers in swards maintained at 30 mm and 60 mm than in swards maintained at 90 and 120 mm height. Elsewhere, it has been argued that harder grazing to promote increased tiller density would be the preferred strategy in spring grazing management. However in practice lower grazing heights and associated lower values of LAI are needed to produce tiller density increases of this type, meaning that productivity is likely to be decreased, despite tiller density increase. Consequences for sward persistence of grazing regimes favouring tiller size or conversely tiller density have yet to be experimentally determined.

The size/density compensation response is a very general response to change in grazing height in grass swards (Matthew *et al.,* 2000). The stimulation of tillering following laxer late-spring or early-summer grazing and reported here, is a distinctly separate phenomenon, with current evidence pointing to reallocation of reserves not used in reproductive growth as the cause. To distinguish the two types of response, it is necessary to consider tiller density and tiller size together, as co-ordinates which jointly determine sward status, when comparing the effects of different grazing regimes (Matthew *et al.,* 2000). This can be done as a two-dimensional plot, and plots of this type did indicate a theoretical advantage to SR and LR swards compared with EC (Hernández Garay *et al.*, 1999).

Industry interest will focus particularly on the December – March phase of the response. The pre-December response to laxer spring grazing occurs at a time of feed surplus. This is associated with increased seed-head production and some quality loss. These negative effects have proved less pronounced than expected and did not seem to undermine the overall animal production response to laxer spring grazing because the extra herbage production was associated with increased milk production in dairy cows grazing the experimental swards (da Silva, 1994).

In terms of New Zealand farming practice on hill country, harder spring grazing is a key to dealing with the summer feed surplus. For this reason it is hard to see how laxer spring grazing could be adopted in a farm system context. On lowland farms, particularly dairy farms, the industry has moved independently of this research to adopt recommendations for greater spring pasture cover than was prevalent when the research commenced. Therefore, there seems to be an industry perception that close grazing in spring is not conducive to optimum pasture performance. We suggest the late control research reported here gives some insight to the reasons why.

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