Dairy pasture yield and growth responses to summer and spring grazing

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Abstract

A three-year Summer and Spring Experiment estimated grazing effects on dry matter (DM) consumed and seasonal growth patterns of dairy pasture. The Summer Experiment had treatments applied annually from December to March inclusive. These comprised grazing frequency (HF, MF and LF = pre grazing mass 2000, 2300, 2800 kg DM/ha) and intensity (HI, MI and LI = post grazing height 3.0-3.5, 4.0-4.5, 5.0-5.5 cm respectively). A rapid grazing (RG) treatment maintained pasture between 1500 and 1800 kg DM/ha (grazing every 2-3 weeks). The Spring Experiment had treatments applied annually from September to November inclusive. Grazing frequency was based on perennial ryegrass leaf stage (HF, MF and LF = 2, 3 and 4 leaves per tiller respectively) and intensity on post grazing height (HI, MI and LI = 3, 5 and 8 cm respectively). Additional treatments included RG with pasture maintained between 1500 and 1800 kg DM/ha (grazing weekly), early cut silage (6-7 week lock-up) (SIL) and late cut hay (11-12 week lock-up) (HAY).

Over three years, high summer grazing frequencies (e.g. RG, HFHI and HFLI produced 9.2, 8.4 and 7.8 t DM/ha/yr) resulted in higher DM consumed than low to medium summer grazing frequencies (e.g. MFMI, LFLI and LFHI produced 6.9, 7.1 and 7.5 t DM/ha/yr). In Years 1 and 2, RG resulted in a higher ($P<0.05$) spring growth (65 and 52 kg DM/ha/d in October 1999 and 2000 respectively) than all other treatments. At the end of the experiment, LFLI resulted in a higher ($P<0.05$) spring growth (63 kg DM/ha/d in October 2001) than all other treatments, while prior to this LFLI only produced a relatively moderate to low growth pattern.

LFLI and LFHI spring grazing resulted in a greater ($P<0.05$) decline in DM consumed over time than RG, HFHI, HFLI and MFMI spring grazing, while the SIL and HAY treatments resulted in a greater ($P<0.05$) decline in DM consumed over time than all other treatments. In Years 1, 2 and 3 DM consumed ranged from 9.7 (HAY) to 16.3 (RG), 4.2 (HAY) to 10.1 (HFHI) and 7.3 (SIL) to 10.9 t DM/ha/yr (HAY) respectively. On average, pasture growth ranged from <5 (February / March) to 100-110 kg DM/ha/d (September / October). Overall, the SIL treatment resulted in a lower ($P<0.05$) pattern of growth than all other treatments.

***Additional key words*:** Grazing frequency, leaf stage, post-grazing height

Introduction

Perennial ryegrass is the most important perennial species used for dairying in south west Victoria (Doyle *et al.* 2000). These pastures generally produce a feed of high nutritive value for a greater period of the year than annual pastures and serve to provide a protective ground cover all year thus helping prevent soil damage and loss. Perennial ryegrass is agronomically one of the most suitable species for more than 80 % of the dairying area and has the greatest acceptance within the farming community (Ward and Quigley, 1992). However, when rotationally grazed with dairy cattle, perennial ryegrass declines in density with time (McKenzie *et al.*, 2002). A poor understanding of grazing management may contribute to poor persistence.

Summer grazing (December to April) may be particularly important because of relatively high temperatures and dry conditions in south west Victoria which place pastures under stress at these times. Spring (September to November) also presents a challenge with respect to grazing management as 60-70 % of the total annual dry matter (DM) production occurs from September to November (Jacobs *et al.*, 1999). Grazing management is critical as pasture growth exceeds herd requirements. During spring there are issues concerning not only the management of surplus pasture, but also how to maintain pasture quality and species density to ensure productive and persistent pastures in subsequent seasons.

A Summer experiment tested the hypothesis that decreased grazing frequency and intensity during summer will increase persistence and optimise the density of perennial ryegrass and white clover. A Spring Experiment tested the hypothesis that increased grazing frequency and intensity during spring will increase persistence and optimise the density of ryegrass and white clover. Specific objectives for this study were to quantify the effect of different grazing management regimes in summer and spring on pasture dry matter (DM) consumed and the seasonal pattern of growth.

Materials and Methods

Both experiments were located near Koroit (142°22'E, 38°18'S) in south west Victoria. The area has a mean annual precipitation of 780 mm. The soil, derived from volcanic sediment, is a well-drained clay loam. Mean maximum and minimum temperatures are 25.2 and 11.6 °C for the hottest (February) and 12.3 and 4.1°C for the coldest (July) month, respectively. Light frosts occur infrequently (< 5 days) during winter.

The paddock used for the Summer Experiment was sown to perennial ryegrass (Lincoln @ 6 kg/ha, Banks @ 6 kg/ha and Aries @ 6 kg/ha), subterranean clover (Leura @ 2 kg/ha) and white clover (Kopu @ 2 kg/ha, Challenge @ 2 kg/ha, Wavely @ 1 kg/ha and Tahora @ 1 kg/ha) on 15 April 1998. Initial (spring 1998) soil fertility levels were: 41 mg/kg P (Olsen method), 470 mg/kg K (available estimate), 34 mg/kg S (CPC) and $pH_{(water)}$ 5.5. Maintenance applications of N (150 kg/ha), P (40 kg/ha), K (70 kg/ha) and S (30 kg/ha) were applied annually with N being applied as 3 equal dressings during the growth season (April to November).

Prior to sowing for the Spring experiment, soil tests established that soil fertility levels were: 25 mg/kg P (Olsen method), 430 mg/kg K (available estimate), 30 mg/kg S (CPC) and $pH_{(water)}$ 5.4. The paddock was sown down to perennial ryegrass (Lincoln @ 20 kg/ha), subterranean clover (Leura @ 5 kg/ha) and white clover (Kopu @ 5 kg/ha) on 3 May 1999. At sowing, fertiliser was applied (P @ 45 kg/ha, K @ 27kg/ha and S @ 18 kg.ha). Following germination (11 June) the paddock was sprayed with Tigrex (800 ml/ha) to remove germinated wild radish and turnips. Due to a poor kill this was repeated on 24 June with Le Mat (100 ml/ha) also being applied for control of red legged earth mite and lucerne flea. A maintenance application of fertiliser was applied on 28 July (P @ 35 kg/ha, K @ 68 kg/ha, S @ 44 kg.ha and N @ 40 kg/ha. In Years 2 and 3, maintenance applications of N (150 kg/ha), P (40 kg/ha), K (70 kg/ha) and S (30 kg/ha) were applied annually with N being applied as 3 equal dressings during the growth season (April to November).

Monthly summer rainfall for Year 1 ranged from 7 (January 1999) to 46 mm (February 1999) and from 13 (January 2000) to 46 mm (December 1999) and 11 (January 2001) to 65 mm (December 2000) during Years 2 and 3. Average air temperatures peaked during February 1999 (24.5 °C), 2000 (25.5 °C) and 2001 (24.0 °C).

For the Summer Experiment, treatments were based on pre-grazing mass as the grazing criteria (HF, MF and LF = 2000, 2300, 2800 kg DM/ha) and intensity (post grazing height cm) (HI, MI and LI = 3.0-3.5, 4.0-4.5, 5.0-5.5cm respectively) as the criteria to cease grazing. Five combinations of pre-grazing mass and intensity were used: HFHI, LFHI, MFMI, HFLI, and LFLI (Table 1). A sixth treatment, named rapid grazing (RG), was imposed to maintain pasture between 1500 and 1800 kg DM/ha by grazing approximately every 2 weeks during summer. For the remainder of the year all treatment plots were grazed when the perennial ryegrass component reached a 3-leaf stage of development. A residual grazing height of 4-5 cm during these periods was set. Treatments were allocated to plots (25m x 25m) and replicated 4 times within a randomised block design.

With the Spring Experiment, treatments were based on ryegrass leaf development stage (H, M and L = 2, 3 and 4 leaf stage respectively) as the grazing frequency and post grazing height as the grazing intensity (HI, MI and LI = 3, 5 and 8cm respectively). Five combinations of pre-grazing leaf stage and post grazing intensity were used: HFHI, LFHI, MFMI, HFLI and LFLI. Additional treatments included rapid grazing (RG) with pasture maintained between 1500 and 1800 kg DM/ha by grazing weekly during spring, early cut silage (6-7 week lock-up) (SIL) and late cut hay (11-12 week lock-up) (HAY). Treatments were allocated to plots (20m x 30m) and replicated 3 times within a randomised block design. Each year, grazing treatments were imposed from September to November. Thereafter, all plots were grazed at the 3 leaf stage of growth of the ryegrass component of the sward or when pasture mass had reached 2800 kg DM/ha and grazed to a residual height of 5 cm during these periods.

Pasture DM consumed (yield) was measured as the difference between pasture DM yield before and after grazing using a calibrated rising plate meter (Earle and McGowan, 1979). Pasture growth rates to establish the seasonal pattern of growth were calculated from post- to pre -grazing herbage mass. For pasture DM consumed and the pattern of seasonal growth, a linear mixed model including a cubic spline of time (Verbyla *et al.*, 1999) was fitted to test for the effects of grazing management, and allowing for random plot effects. All statistical analyses were performed using Genstat 5.42 (GenStat Committee 2000).

Results

Summer ExperimentThe effect of grazing on the seasonal pattern of pasture growth was plotted with fitted trend lines (Figure 1). Treatment and day linear effects were significant ($P<0.05$) (Table 1). There was also a significant curvature trend ($P<0.05$) for treatments over time, indicated by the spline effect. In Years 1 and 2, RG resulted in a higher overall growth rate (65 and 52 kg DM/ha.day in October 1999 and 2000 respectively) compared to all other treatments. Towards the end of the three-year trial LFLI resulted in a higher growth rate (63 kg DM/ha.day in October 2001) than all other treatments, while prior to this treatment LFLI only produced a moderate to low growth rate.

Table 1. A summary of the fixed and random spline terms of the model fitted to the pattern of pasture growth The Wald statistic is an approximate *F*-test (Verbyla *et al.*, 1999)

Parameter	Wald statistic	d.f.[A]	*P-value*
Fixed terms			
Treatment	22.2	5	<0.001
Day	3.9	1	<0.05
Treatment x day	9.0	5	>0.05
Random spline terms	Change in REML log likelihood		
Spline (day)	27.0		<0.001
Treatment x spline (day)	3.3		<0.05

[A]degrees of freedom

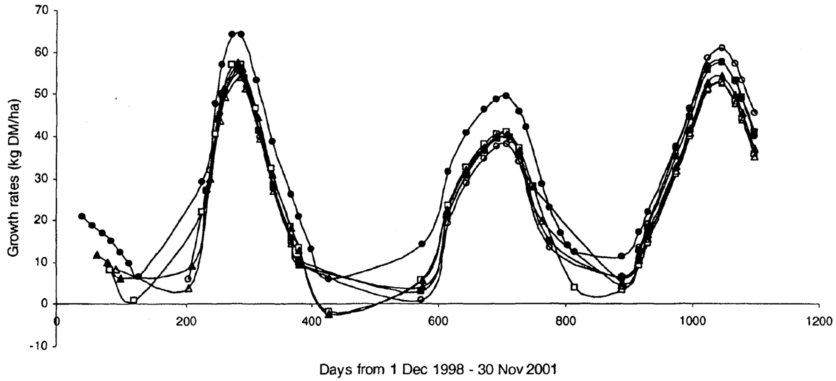

Figure 1. Fitted trend lines representing the whole sward seasonal pattern of pasture growth in response to summer grazing from December 1998 to November 2001. Treatments were HFHI (□), LFHI (■), MFMI (Δ), HFLI (▲), LFLI (o) and RG (•).

The effect of grazing on DM consumed was also plotted with fitted trend lines (Figure 2). Treatment and treatment by day linear effects were significant (P<0.05) (Table 2). There was also a significant curvature trend (P<0.05) for treatments over time, indicated by the spline effect. RG resulted in higher levels of DM consumed over time while LFHI and LFLI resulted in decreased DM consumed levels over time.

Annual DM consumed ranged from 6.6 (LFHI) to 10.1 (HFHI), 5.0 (LFLI) to 7.3 (RG) and 8.2 (MFMI) to 10.6 t DM/ha (RG) in Years 1, 2 and 3 respectively.

Table 2. A summary of the fixed and random spline terms of the model fitted to pasture dry matter consumed.

Parameter	Wald statistic	d.f.[A]	P-value
Fixed terms			
Treatment	18.5	5	<0.01
Day	0.3	1	>0.05
Treatment x day	20.5	5	<0.01
Random spline terms	Change in REML log likelihood		
Spline (day)	3.5		<0.05
Treatment x spline (day)	39.5		<0.001

[A]degrees of freedom

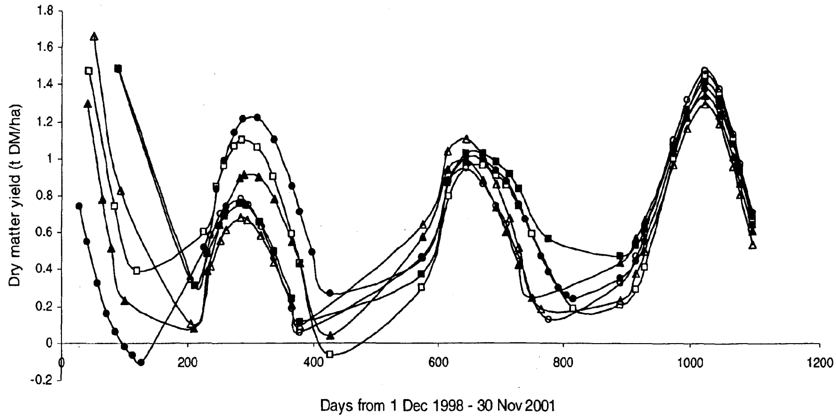

Figure 2. Fitted trend lines representing estimated pasture dry matter consumed in response to summer grazing from December 1998 to November 2001. Treatments were HFHI (□), LFHI (■), MFMI (Δ), HFLI (▲), LFLI (o) and RG (●).

Spring Experiment

Spring grazing effects on the seasonal pattern of pasture growth was plotted with fitted trend lines (Figure 3). There was a significant ($P<0.05$) curvature trend (random effect) due to treatment; hence, the departure from the linear trend was unique to each treatment. Also, treatment linear effects were significant (P<0.001) (Table 3). Overall, the SIL treatment resulted in a lower growth rate than all other treatments. On average, pasture growth rates ranged from <5 (February / March) to 100-110 kg DM/ha.day (September / October).

Table 3. A summary of the fixed and random spline terms of the model fitted to the pattern of pasture growth.

Parameter	Wald statistic	d.f.	P-value
Fixed terms			
Treatment	72.0	7	<0.001
Days	140.2	1	<0.001
Treatment x days	9.0	7	>0.05
Random spline terms	Change in REML log likelihood		
Spline (days)	728.0		<0.001
Treatment x spline (days)	3.8		<0.05

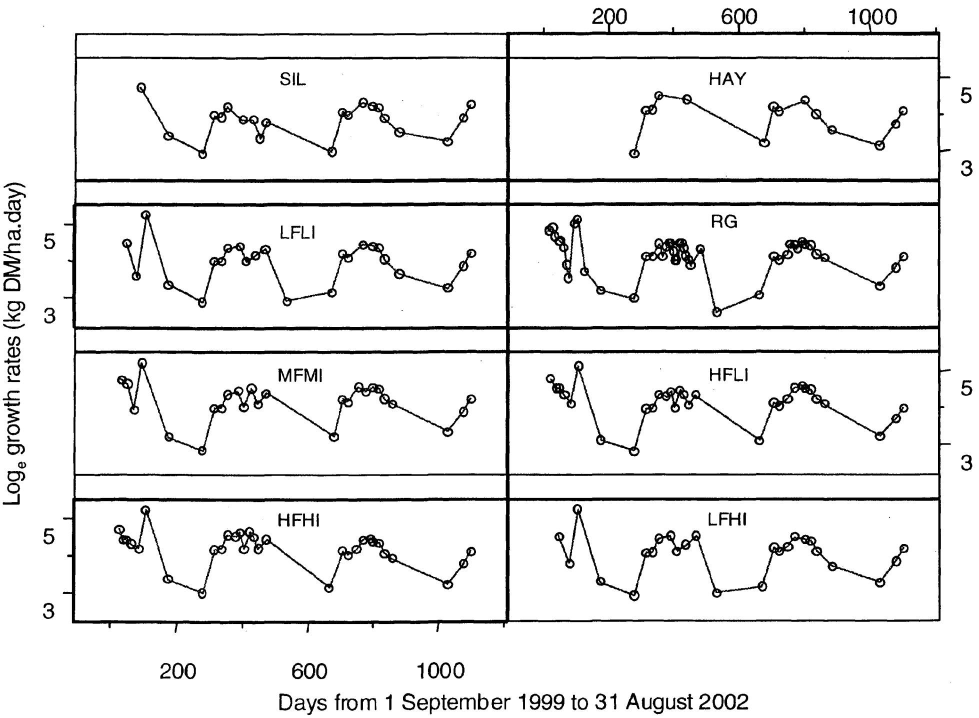

Figure 3. Fitted trend lines representing the whole sward seasonal pattern of pasture growth (log$_e$ transformed) in response to spring grazing: SIL = silage; LFLI = low frequency, low intensity; MFMI = medium frequency, medium intensity; HFHI = high frequency, high intensity; HAY = hay; RG = rapid grazing; HFLI = high frequency, low intensity; and LFHI = low frequency, high intensity.

Spring grazing effects on pasture DM consumed were plotted with fitted trend lines (Figure 4). There was a significant (*P*<0.001) curvature trend (random effect) due to treatment; hence, the departure from the linear trend was unique to each treatment. Also, treatment x day effects were significant (P<0.001) (Table 4). LFLI and LFHI spring grazing resulted in a greater decline in DM consumed over time than RG, HFHI, HFLI and MFMI spring grazing, while the SIL and HAY treatments resulted in a greater decline in DM consumed over time than all other treatments.

In Years 1, 2 and 3 DM consumed ranged from 9.7 (HAY) to 16.3 (RG), 4.2 (HAY) to 10.1 (HFHI) and 7.3 (SIL) to 10.9 t DM/ha.annum (HAY) respectively

Table 4. A summary of the fixed and random spline terms of the model fitted to pasture dry matter consumed

The Wald statistic is an approximate *F*-test (Verbyla *et al.* 1999)

Parameter	Wald statistic	d.f.	P-value
Fixed terms			
Treatment	149.4	7	<0.001
Days	175.4	1	>0.001
Treatment x days	65.8	7	<0.001
Random spline terms	Change in REML log likelihood		
Spline (days)	229.0		<0.001
Treatment x spline (days)	613.0		<0.001

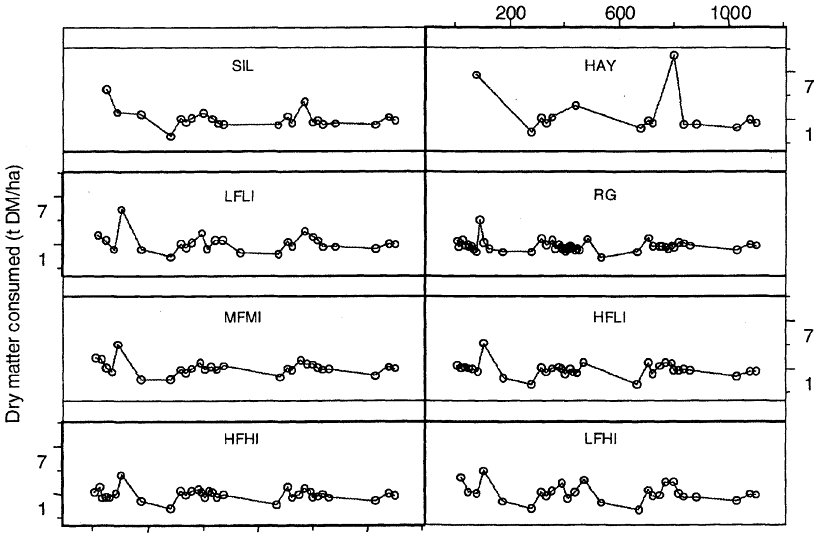

Figure 4. Fitted trend lines representing estimated pasture dry matter consumed in response to spring grazing: SIL = silage; LFLI = low frequency, low intensity; MFMI = medium frequency, medium intensity; HFHI = high frequency, high intensity; HAY = hay; RG = rapid grazing; HFLI = high frequency, low intensity; and LFHI = low frequency, high intensity.

Discussion and Conclusions

Perennial ryegrass / white clover pastures, when rotationally grazed with dairy cattle often show a decline in density with time (McKenzie *et al.,* 2002). Potential constraints to the persistence and productivity of dairy pastures may include: climate (soil moisture and temperature; Barker *et al.*, 1985), soil physical properties (e.g. compaction; Passioura, 1991), soil fertility (Lambert *et al.*, 1986), weed competition (McKenzie, 1997a), invertebrate pests (Cunningham *et al.* 1994) and grazing management (McKenzie 1997b; 1997c). Two separate experiments focused on summer and spring grazing management, having ensured that constraints such as soil fertility, soil compaction, and weed and pest management were not likely to have limited the persistence and productivity of perennial ryegrass / white clover pastures. The relatively dry hot summers (1998/99, 1999/00 and 2000/01) appear to have been an impediment to perennial ryegrass and white clover persistence and productivity. This was reflected in relatively low total DM yield estimates for the summer trial, particularly during Year 2 (Figure 1). Both perennial ryegrass and white clover are sensitive to soil moisture stress (Barker *et al.,* 1985). Soil moisture stress reduces DM yields, and when severe, dormancy or even death may occur (Barker *et al.*, 1985). The optimal ambient temperatures for perennial ryegrass growth are 17 to 21 °C, while growth ceases above 30 to 35 °C (Mitchell, 1956). For white clover, optimal temperatures for growth are 22 to 24 °C (Mitchell and Lucanus, 1962).

Treatments that were frequently grazed during summer (e.g. RG and HFHI) yielded more pasture DM than treatments infrequently grazed (e.g. LFLI and LFHI). This observation was due, in part, to frequently grazed treatments meeting their grazing criteria sooner than infrequently grazed treatments during periods of limited summer growth following occasional rain. It is questionable, however, if frequent summer grazing will sustain high DM yields and persistence in the long term. Other studies have shown that over time, frequent summer defoliation results in decline in the pattern of growth, and in pasture DM yields (Fulkerson *et al.*, 1993; McKenzie, 1996a). In support of this, the Summer Experiment demonstrated that by the end of 3 years, infrequent summer grazing (LFLI) resulted in higher pattern of spring growth than all other treatments, while initially (Years 1 and 2) LFLI resulted in only low to moderate growth in all seasons compared to all other treatments.

On the basis of three years of data, it would be reasonable to conclude that frequent summer grazing may be a preferred option to infrequent summer grazing, or even zero summer grazing. This is borne out by the fact that frequent summer grazing (RG, HFHI and HFLI) constantly out-yielded infrequent summer grazing for most of the experiment. Summer is a time of the year when pasture DM is in short supply in south west Victoria and any mechanism resulting in higher DM yields is likely to be perceived as valuable by dairy farmers. Despite this, however, it is cautioned that frequent summer grazing is likely to be detrimental to the longer-term persistence of a pasture (Fulkerson *et al.*, 1993; McKenzie 1996a). This is further reinforced by a previous study that showed that the vigour of infrequently grazed perennial ryegrass, particularly during summer, is greater than frequently grazed perennial ryegrass (McKenzie 1996b). Alternatively, regardless of grazing management, the productive life-span of all treatments in the current trial was likely to have been curtailed by severe summer conditions. If one accepts that one of the main constraints to pasture productivity in south west Victoria are hot and dry summers, and that perennial ryegrass-based pasture are therefore not likely to persist beyond 3-5 years, then frequent summer grazing may be the best option to extract the highest DM yield possible from the pasture.

The Spring Experiment set out to quantify the effects of different spring grazing management regimes on pasture growth pattern and DM consumed. Spring pasture growth and DM production accounts for 60-70 % of the total annual pasture grown from September to November in south west Victoria (Jacobs *et al.*, 1999). This was supported by the findings of the current trial where the highest pasture growth rates of 100-110 kg DM/ha/d occurred during September and October, and the lowest growth rates (<5 kg DM/ha/d) occurred during summer (January / February). This growth pattern is consistent with other literature findings for dryland temperate dairy pastures in south east Australia (Jacobs *et al.,* 1999; Doyle *et al.*, 2000). Given the relatively high spring growth, scope should exist to manipulate pasture growth and DM yield by altering grazing management at this time.

In the Spring Experiment, all treatments resulted in a decline in DM yield over time. Regardless of treatment, a decline in pasture DM yield over time has been noted for perennial ryegrass-based pastures in south west Victoria (McKenzie *et al.,* 2003), and is most likely related to hot summer temperatures coupled with low soil moisture during summer. As with the Summer Experiment, this was reflected in relatively low total DM yield estimates, particularly during the summer of Year 2.

Despite the decline in pasture DM yield over time, the Spring Experiment demonstrated that spring grazing management can be employed to alter the magnitude of decline. LFLI and LFHI spring grazing resulted in a greater decline in DM consumed over time than RG, HFHI, HFLI and MFMI spring grazing, while the SIL and HAY treatments resulted in a greater decline in DM consumed over time than all other treatments. Overall, frequent and intense spring grazing (e.g. RG and HFHI) out-yielded infrequent spring grazing (e.g. LFLI and HAY; with the exception of HAY in Year 3). Such a result indicates that frequent and intense grazing management during spring is important in helping maintain high annual pasture DM yields. Conversely, frequent and intense grazing during other seasons may actually be detrimental to high pasture DM yields in the long run as evidenced by the Summer Experiment and other studies (Fulkerson *et al.*, 1993; McKenzie, 1996).

Pasture DM consumed estimated in the Spring Experiment (i.e. a treatment average of 12.7, 7.8 and 8.8 t DM/ha/yr in Years 1, 2 and 3 respectively) are, apart from Year 1, consistent with other estimates for intensively managed dryland dairy pastures in south west Victoria (Jacobs *et al.*, 1999, McKenzie *et al.,*, 2003). The high Year 1 yield estimates may be due to a newly renovated pasture and a particularly favourable spring and early summer in terms of soil moisture, while depressed yield in Year 2 may be related to a lack of summer rain.

These results have demonstrated that frequent and intense grazing management (e.g. HFHI and RG) during spring is important in maintaining high pasture DM consumed and growth rates.

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