Pasture growth and quality, and lamb growth rates in high stocking rate dryland sheep farming systems

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ABSTRACT

Pasture growth and quality, and lamb growth rates were measured on a conventional grass based trial unit of 87.8 ha and a high legume unit of 85.1 ha, established to investigate climate-risk management strategies within high stocking rate dryland sheep farming systems. There was no difference between the units in total pasture production with a pasture utilization of 71.7% and 74.3% on the grass and legume units, respectively. Metabolisable energy values remained close to, or above, the target values throughout the growing season. Pre-weaning lamb growth rates averaged 304 g/day on both units. There were significant differences between singles (342 g/day), twins (300 g/day) and triplets (254 g/day) and between lambs from first cycle (294 g/day) and main mob ewes (315 g/day). There were some differences in lamb growth rates between different pastures types but these were not consistent between years. Post-weaning growth rates averaged 137 g/day with significant differences attributable to litter size, mob and year. Growth from birth to sale averaged 295 g/day, slightly less than the target of 300 g/day. Thus high lamb growth rates are possible on a range of pasture types on dryland at low pasture covers of high quality.

Keywords: dryland sheep systems; pasture growth rates; pasture quality; lamb growth rates.

INTRODUCTION

Dryland sheep farming systems are subject to significant risk associated with variability in pasture production over the late spring:summer period because of uncertain rainfall (Avery *et al.*, 2008). Pasture growth may cease at any time during this period due to a lack of moisture which may quickly lead to a feed deficit. If this happens, lamb growth rates may be depressed, drafting date extended and the possibility that lambs will compete with ewes for the best feed at the time of flushing is increased (Bywater *et al.*, 2011).

Key variables in managing this risk are lamb growth rate and the flexibility to change feed demand or supply quickly when conditions become dry (Bywater *et al.*, 2011). Lamb growth rate is important because the risk of dry conditions increases as the season progresses (Avery *et al.*, 2008) and the faster a lamb grows, the sooner it will be drafted and the lower the chance it will still be on the farm if and when conditions become dry.

Pasture quality has been shown to be important in determining lamb growth rates (Waghorn & Clark, 2004). Key factors in keeping pasture quality high are a high proportion of green grass leaf with little reproductive development and low dead matter accumulation (Litherland & Lambert, 2007) and high clover content (Hyslop *et al.*, 2000).

Flexibility to change feed demand and supply quickly and without major financial loss is important to minimise fluctuations in income often associated with a variable climate (Avery *et al.*, 2008).

Following discussions with a local farmer group, who wanted to see research on a farm scale that "pushed the boundaries of dryland farming", a trial was established in March 2007 to investigate management strategies that would increase production and profitability, and reduce the risks, of dryland sheep farming systems. The aims of the trial were to maintain high pasture quality and utilisation, leading to high lamb growth rates and increased production and profitability, without increasing variability in the latter two. Two different approaches to maintain high pasture quality and utilisation were used: an intensively grazed conventional grass-based system, and a high legume-content system.

Targets were to maintain pasture quality values at 11.5 MJ metabolisable energy (ME)/kg dry matter (DM) or better throughout the growth period and to average 300 g/day or better for lamb growth rates from birth to sale. The philosophy for both systems was to carry higher than average livestock numbers for the district to enable sufficient grazing pressure to maintain pastures in an actively growing state, reduce reproductive stem development and accumulation of dead matter, and then to reduce this stocking rate to best financial advantage when soil conditions became dry. This required building flexibility into the livestock policies enabling stock numbers to be reduced quickly. The production and profitability of these systems in comparison with the Canterbury Marlborough breeding and finishing sheep and beef monitor farm (Ministry of Agriculture and Forestry, 2010) are described in

Bywater *et al*. (2011). This paper describes pasture growth and quality, and lamb growth rates attained in the trial.

MATERIALS AND METHODS

In 2007 two non-replicated farm-scale trial units were established at Hororata, mid-Canterbury: a conventional grass-based unit of 87.8 ha (G) and a high legume-content unit of 85.1 ha (L). Each unit had 16 paddocks, stocked at a target of 14 stock units per hectare (SU/ha), 5 SU/ha higher than the regional monitor farm (Ministry of Agriculture and Forestry, 2010). The first year of the trial in 2007/08 was used to bring data collection procedures, and pasture and stock management into line with the trial protocol. Data collection was then carried out for two years over 2008/09 and 2009/10.

The Grass unit included 13 paddocks of predominantly grass-based pasture or approximately 81% of the unit; one paddock of lucerne (8% of the unit); and two paddocks in a pasture-renewal rotation (11% of the unit) including winter kale, followed by barley for silage and then a perennial grass mix in one paddock, and leaf turnips under-sown with a perennial grass mix in the other. Eight of the grass pastures were established ryegrass:clover pastures, two of which also contained cocksfoot and two tall fescue. Two older, brown top dominant pastures were renewed as above in 2007/08 and two out of three Bareno brome pastures were renewed in 2008/09, all going into Alto ryegrass with white and red clover.

On the Legume unit there were four paddocks of predominantly grass-based pasture (30% of the unit), five paddocks of ‘switch’ pastures (30% of the unit) which are annual and perennial clovers over-sown with annual ryegrass each autumn (Nicol *et al*., 2010); five paddocks of lucerne (29% of the unit); and two paddocks in a similar pasture-renewal sequence to the grass unit (11% of the unit), except that forage rape was used instead of leaf turnips. The grass pastures included two established ryegrass:clover pastures and two of Bareno:clover which were renewed in 2007/08 and 2008/09 respectively, also going into the Alto ryegrass:clover mix. The five switch pastures were established at the start of the trial in 2007. In 2009/10, pastures on this unit were changed to five paddocks of grass-based pasture and four paddocks of lucerne.

Stock included a mixed age flock and 18 month-old trading cattle (23% of total stock units (SU)) on the grass unit and a mixed aged flock with additional older ewes on the legume unit. The main sheep breed used were Coopworths from the Ashley Dene breeding flock (Nsoso *et al*., 1999), mated to terminal sires. Cattle were purchased in May and sold any time after October according to feed conditions. Older ewes were lambed either three (Grass) or four (Legume) weeks before the main mob, allowing early weaning, sale of lambs and culling of ewes if required (first cycle ewes, 7% and 20% of SU on the grass and legume units, respectively). Main mob ewes were lambed on 6 September on both units and lambs were weaned at 25 kg, or earlier if conditions dried out. Ewes were set stocked on individual lambing paddocks one week before the start of lambing until weaning except for ewes on switch pastures. Pasture mass had diminished quickly following set stocking of these pastures in 2007/08 so they were subsequently rotationally grazed from before lambing to weaning. Store lambs were sold at weaning based on projected feed availability at the time.

Pasture cover was assessed on all paddocks at weekly intervals from August to December and at fortnightly intervals for the rest of the year, using a plate meter that was calibrated to the different pasture types every three months. Four grazing exclusion cages were placed in each of 12 paddocks, two each of different pasture types. Two cages in each of these paddocks were cut every two weeks to 2 cm to estimate pasture growth rates, giving a 28 day cutting interval for each cage. Measurement of growth rate for Bareno and tall fescue paddocks ceased in autumn 2009 as these paddocks were renewed. The first paddock of Alto ryegrass was sown in autumn 2008 and measurement began shortly thereafter; data are from one paddock in the first season and three paddocks in the second season. Otherwise growth rate data represent two sub-samples from two cages in each of two paddocks.

Pasture samples were taken at random from the same paddocks at six weekly intervals, cut to 2 cm, bulked for each paddock, and duplicate sub-samples taken for herbage quality analysis using near infrared spectroscopy (Fosse Feed and Forage Analyser 5000 at Lincoln University) and dissection into botanical species components.

Five groups of either 30 or 40 ewes on the Grass unit and three groups on the Legume unit were weighed monthly from weaning through to one month before lambing and fortnightly with their lambs from six weeks after lambing to weaning. Remaining lambs from these groups were weighed every two weeks from weaning to sale. This resulted in estimates of pre-weaning growth rates on 658 lambs over the two years of the trial, of which 120 also had measurements of post-weaning growth rate. These groups of ewes and lambs were lambed on pastures on which growth rate was measured and samples taken for quality and composition analysis, providing replicated comparison of lamb growth rate on four pasture types within the two units.

TABLE 1: Average seasonal and total pasture production (kg DM/ha) for the Grass and Legume unit and for the different pasture types.

Unit/Species	Seasonal pasture production				Total pasture production
	Autumn	Winter	Spring	Summer	
	Mar, Apr, May	Jun, Jul, Aug	Sep, Oct, Nov	Dec, Jan, Feb	
Unit					
Grass unit	2,054	1,246	4,659	2,455	10,414
Legume unit	1,731	1,536	4,551	2,519	10,336
Pasture type					
Ryegrass Bronsyn	2,488	713	4,618	1,851	9,670
Ryegrass Alto	2,208	1,215	4,977	2,529	10,930
Cocksfoot	2,233	579	4,428	2,626	9,866
Tall fescue	2,920	822	6,675	2,137	12,553
Brome Bareno	3,551	1,177	4,331	2,370	11,428
'Switch'	2,093	1,377	5,001	1,663	10,133
Lucerne	2,394	153	4,999	4,026	11,571

Pasture quality and lamb growth rate data were analysed using a restricted maximum likelihood (REML) variance component analysis routine in Genstat (Gilmour *et al.,* 2009). For pre-weaning growth, fixed effects were Unit, Litter size, Mob, Pasture Type, Year, and first order interactions. Initial analyses showed the Mob by Pasture Type interaction, and the Mob by Year interaction to be highly non-significant. To simplify presentation of tables of means, these terms were discarded from the analysis.

With the post-weaning data, there were a number of missing values and the analyses were run without interaction terms. Fixed effects were Litter size, Mob and Year.

RESULTS

Average seasonal growth rates for the different pasture types from July 2007 to March 2010 are shown in Table 1 based on a three period, rolling average daily growth rate for each type. Grass unit pastures include Bronsyn ryegrass, cocksfoot, tall fescue, and Bareno brome; legume unit pastures include lucerne and switch pastures; and data on the Alto ryegrass pastures are from the Legume unit in 2008/09 and from paddocks on both units in 2009/10. As noted above, all grass pastures contained clovers and the cocksfoot and tall fescue pastures were a mix containing ryegrass as well. Patterns of growth of all pasture types were typical for dry land with low growth in winter, variable growth between September and December with a peak sometime around November and a sharp decline thereafter, low and variable growth over summer, rising slightly in autumn before dropping again in winter. Within this general pattern, data for Bronsyn, Alto and switch pastures showed a lower peak and earlier decline in 2008/09 than for the other two years. Soil moisture levels dropped to less than 10% by volume in early November 2008/09 whereas in 2009/10 they remained above 20% throughout the season (Bywater et al., 2011). This difference was not evident with the cocksfoot mix and there were insufficient data for the tall fescue mix and Bareno pastures to compare years. Based on the average pasture growth rates in Table 1 and the proportion of each pasture type on each unit, there was no difference in the estimated total annual average pasture production on the two units with 10,414 kg dry matter (DM)/ha grown on the Grass unit and 10,336 kg DM/ha on the Legume unit.

One of the main aims of the trials was to maintain high pasture quality and utilisation and to demonstrate the effects on animal performance. Estimated average pasture utilisation was 71.7% on the Grass unit and 74.3% on the Legume unit (Bywater *et al.*, 2011) which was slightly lower than expected given the relatively low and even cover profile on both units. In 2009/10 for example, average cover on the grass unit was 1,135 ± 210 (standard deviation) kg DM/ha and on the legume unit was 1,300 ± 252 kg DM/ha.

Measures of pasture quality are shown in Table 2. For 2008/09, quality for all pasture types on both units remained high up to the reading at the end of October and then dropped as conditions became dry in early November. Dry matter digestibility was in excess of 75% for most measurements during this period and over 80% on occasion, crude protein content started to decline a little earlier but was higher than 20% for most of the season, and ME values were close to or above the target value of 11.5 MJ ME/kg DM for most measurements through to the end of October.

As noted above, in 2009/10, soil moisture levels remained high throughout the season and so

TABLE 2: Pasture dry matter digestibility (DMD)(%), crude protein (CP)(%) and metabolisable energy (ME)(MJ ME/kg DM) of pasture samples harvested from the Grass and Legume units in 2008/09 and 2009/10. Bronsyn = Ryegrass Bronsyn; T. fescue = Tall fescue; Alto = Ryegrass Alto.

Year/Species		Date								
2008/09		17/04/08	12/05/08	17/06/08	7/07/08	4/08/08	16/09/08	31/10/08	8/12/08	19/01/09
Grass Unit										
Bronsyn	DMD	78.3	81.6	83.2	79.0	78.2	77.4	74.1		68.9
	CP	22.3	24.8	22.5	25.8	27.4	24.7	15.5		15.8
	ME	11.5	12.0	12.4	11.5	11.6	11.3	11.2		10.3
T Fescue	DMD	76.2			77.9	77.3	74.6	73.9	62.4	63.9
	CP	27.9			25.9	29.4	28.7	17.3	9.1	15.3
	ME	10.9			11.6	11.4	10.8	11.2	9.8	9.8
Cocksfoot	DMD	79.3	79.8	82.4	76.7	78.5	76.2	74.2	64.2	
	CP	29.7	26.4	30.0	29.3	27.9	26.6	15.2	9.6	
	ME	11.8	11.7	12.2	11.2	11.6	11.3	11.3	10.0	
Legume Unit										
Alto	DMD					79.6	80.4	76.0		69.2
	CP					26.7	17.8	18.7		18.2
	ME					11.6	12.0	11.5		10.4
Switch	DMD	76.2	77.0	80.9	77.8	79.2	78.7	75.7	59.7	
	CP	29.0	26.3	23.4	24.2	22.0	21.0	22.7	11.4	
	ME	11.1	11.4	12.1	11.4	11.8	11.6	11.3	9.3	
2009/10		3/03/09	14/04/09	11/06/09	7/07/09	4/08/09	28/09/09	31/10/09	18/11/09	26/01/10
Grass Unit										
Bronsyn	DMD	71.5	77.6	82.8	78.9	78.7	76.7	75.2	74.5	74.0
	CP	32.9	18.4	21.0	24.1	25.5	25.5	15.0	12.4	23.1
	ME	10.1	11.7	12.5	11.3	11.7	11.4	11.4	11.6	11.1
Alto	DMD	76.9	80.2		80.0		77.3	79.0	77.4	73.7
	CP	27.5	21.7		25.8		16.2	16.3	18.1	21.6
	ME	11.2	12.0		11.6		11.6	11.8	11.8	11.0
T Fescue	DMD	68.5	78.4		76.3	78.3		75.2		
	CP	32.8	23.4		26.4	25.7		17.9		
	ME	9.6	11.8		11.2	11.7		11.4		
Cocksfoot	DMD	74.4	76.5	81.6	75.5	79.1	74.2	75.4	73.9	74.3
	CP	31.2	23.4	27.8	25.5	25.9	22.7	14.5	14.9	22.3
	ME	10.5	11.5	12.2	10.6	11.8	11.0	11.5	11.4	11.2
Legume Unit										
Alto	DMD	74.0	76.9		78.9	80.0	78.6	76.9	76.5	73.1
	CP	32.1	13.2		23.4	24.8	17.1	18.7	9.3	17.9
	ME	10.7	11.7		11.1	11.8	11.8	11.6	11.8	10.9
Switch	DMD		79.9	80.6	79.3	80.0	75.6	76.7	80.4	
	CP		23.7	21.7	20.3	20.0	24.0	21.0	23.2	
	ME		12.0	12.1	11.8	12.0	11.3	12.0	12.1	

did pasture quality. Dry matter digestibility was close to or in excess of 75% throughout although dropped a little towards the final reading in late January. Metabolisable energy values for the most part were close to or above the target of 11.5 MJ ME/kg DM. The main exception is the cocksfoot mix which dropped marginally below 11.0 MJ ME/kg DM during spring. Crude protein content remained above 20% in most pastures through the season until October.

Analysis of variance of the data on pasture DM digestibility and ME content showed significant differences with time of season ($P < 0.001$), some small differences between pastures types ($P < 0.05$) but no difference between the two units in average digestibility or ME values. The overall mean ± standard error for all pasture types at all measurements were 75.59% ± 0.31% for digestibility and 11.24 ± 0.063 MJ ME/kg DM for

ME. The results were similar for crude protein content although there was a small difference between the units (P <0.05) with means of 21.93% ± 0.55 for the Grass unit and 23.28% ± 1.06% for the Legume unit.

Results of the analysis of pre-weaning lamb growth rates are shown in Table 3. There was no difference in growth rates between the Grass and Legume units. As expected there were significant differences between growth rates of lambs from first cycle ewes and those from the main mob (P <0.05) and between lambs raised as singles, twins or triplets (P <0.001). There is also a significant effect of year (P <0.01). July and August were cold and wet in 2008/09 which resulted in a high death rate of both ewes and lambs, especially on the legume unit (Bywater *et al.*, 2011). Conditions then dried out very quickly in early November. In contrast, 2009/10 had a much milder winter but soil moisture levels remained much higher throughout the season. This resulted in higher lamb survival in 2009/10 and therefore higher stocking rates. Table 3 shows that pre-weaning growth rates were higher in 2008/09 despite the more difficult climate conditions and this is likely due to the lower number of animals present.

TABLE 3: Predicted mean ± standard error of the mean for fixed effects of Grazing unit (Grass or legume), Mob (1st cycle or Main mob), Litter size (Single, Twin, Triplet), Year and Pasture type on the pre-weaning growth rate (g/day) of the lambs.

Effect	Factor			
Unit	Grass	Legume		
	304 ± 11	304 ± 11		
Mob*	1st cycle	Main		
	294 ± 13	315 ± 12		
Litter size***	Single	Twin	Triplet	
	342 ± 4	300 ± 5	254 ± 8	
Year**	2008/09	2009/10		
	312 ± 12	297 ± 12		
Pasture type**	Alto	Bronsyn	Cocksfoot	Switch
	319 ± 13[a]	305 ± 13[ab]	306 ± 14[ab]	288 ± 12[b]
Pasture type by Year[1]***	Alto	Bronsyn	Cocksfoot	Switch
2008/09	322 ± 16[a]	313 ± 13[b]	284 ± 14	324 ± 14
2009/10	317 ± 13[a]	296 ± 14[b]	324 ±17	250 ± 13

*P <0.05, ** P <0.01, *** P <0.001.
Means in the same row with different superscript letters are significantly different (P <0.05).
[1]Comparisons are between Years within Pasture types

TABLE 4: Predicted mean ± standard error of the mean for fixed effects of Mob (1st cycle or Main mob), Litter size (Single, Twin, Triplet) and Year on the post-weaning growth rate (g/day) of the lambs.

Effect	Factor		
Mob***	1st cycle	Main	
	174 ± 25	103 ± 23	
Litter size**	Single	Twin	Triplet
	163 ± 27	128 ± 11	144 ± 19
Year***	2008/09	2009/10	
	174 ± 23	103 ± 26	

** P <0.01, *** P <0.001

Table 3 also includes growth rates on the different pastures types on the units. There is no significant difference between lamb growth rates on Alto ryegrass, Bronsyn ryegrass and the cocksfoot mix or between the cocksfoot mix, Bronsyn and switch pastures. However there were some significant pasture type by year effects. In 2008/09 there was a significant difference between growth rates on the cocksfoot mix and those on switch, with growth rates for switch being the highest of all pastures types in that year. In 2009/10, this was reversed with growth rates on switch being the lowest and those on the cocksfoot mix the highest. As noted above, there was a higher lamb survival in 2009/10, meaning a higher stocking rate of lambs, and there was also a lower clover percentage on the switch pastures than in the previous year (Bywater *et al*., 2010) which may be part of the reason for the lower lamb growth rates. Mean and standard error of pre-weaning lamb growth rate overall was 304 ± 12 g/day.

Lamb growth rates post weaning are shown in Table 4. With a much lower numbers of observations and many missing values, these data are a little more difficult to interpret and should be treated with some caution. In line with the trial policies, these are lambs that were not sold at weaning either to the works or as store lambs. In effect the fastest and slowest growing lambs have been removed from the group represented in Table 4. The analysis shows that there are significant differences between growth rates due to litter size (P <0.01), mob and year (P <0.001). The differences due to litter size show that triplets grew faster than twins post-weaning. Whether this is an effect of compensatory growth as the triplets grew more slowly before weaning, is not possible to say. Also lambs from the first cycle ewes grew faster post-weaning than those from the main mob ewes. Again this may be a compensatory growth effect or it may reflect differences in feed quality at different stages of growth since the first cycle lambs were slightly older at weaning but weaning occurred earlier than for the main mob lambs. Overall, post weaning growth rates averaged 139 ± 32 g/day.

Combining the data for pre- and post- weaning growth rates results in an overall mean growth rate of 295 ± 3 g/day from birth to sale. This is slightly below the target level of 300 g/day.

DISCUSSION

The main objectives of this trial were to confirm that on a farm scale, pasture quality could be maintained at a high level through high grazing pressure, keeping pastures in an actively growing state with high clover percentages, low seed head development and little build up of dead material; and that this would lead to high lamb growth rates. High lamb growth rates allow farmers to draft stock earlier, and with the addition of flexible stock policies which facilitate rapid destocking when required of trading cattle and older ewes that lambed early, will not only increase production and profitability but reduce their variability. Overall production and profitability have been discussed by Bywater *et al.* (2011). Data presented in this paper shows that pasture quality and lamb growth rates were maintained at above, or close to, target levels with the management policies used.

Total pasture production was the same on the two units with different combinations of pasture types. Pasture quality remained high throughout the growing season on both units with ME levels at or above the target of 11.5 MJ ME/kg DM as long as there was sufficient soil moisture to keep the pastures growing. This was up to early November in 2008/09 and through to January in 2009/10. This lead to high pre-weaning lamb growth rates despite the fact that pasture mass remained lower than most farmers would expect or perhaps would be comfortable with.

Lamb growth rates overall were close to the target value of 300 g/day averaged over all litter sizes, pastures types, mob type and years. Within litter sizes, singles and twins averaged in excess of 300 g/day pre-weaning, confirming on a farm scale the results of previous studies that growth rates of single and twin lambs of greater than 300 g/day are possible on dryland at high stocking rates (Ates *et al.*, 2006; 2008). There are differences between years in lamb growth rates and between lambs of first cycle ewes and main mob ewes. Although there are also differences between pastures types, most of these are not significant, emphasising the fact that high growth rates are possible on a range of pastures if they are kept in an actively growing state and ME levels are high. Growth rates on the cocksfoot mix and switch pastures were significantly different in both years of the trial but switch pastures delivered the highest growth rates in one year, and cocksfoot in the next.

The key message for farmers is that a high stocking rate can maintain pastures in active growth and that high lamb growth rates are possible on low pasture masses of good quality. At the same time, a high stocking rate increases the risk and consequences associated with the severity and timing of the dry period which emphasises the importance of fast lamb growth and flexibility to reduce stock numbers rapidly as discussed by Bywater *et al.* (2011).

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