

Integrating novel forage management into sheep farm systems

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Abstract

Sheep have a higher intake of nutrients when offered continuous free access to ryegrass and white clover growing separately than when offered the same species growing as a mixture. To determine if this greater nutrient intake would translate to higher animal performance, three experiments of 3-6 weeks duration measured liveweight gain by ewes+twin lambs in early spring, weaned lambs in mid-late spring and hoggets during late winter to identify the class of sheep most responsive to this form of forage presentation. Offering pasture comprised of ryegrass and clover growing separately resulted in higher average daily gains for weaned lambs (330 vs 185 g/day, $P < 0.01$) and hoggets (240 vs 190 g/day, $P < 0.05$), compared with ryegrass-only pasture. The farm simulation model STOCKPOL and the experimental results reported above were then used to examine four scenarios for implementing this form of pasture arrangement on-farm. This analysis predicted that using pastures comprised of ryegrass and clover growing separately on 15-20% of the area of a typical sheep breeding/finishing farm is feasible and could increase lamb carcass output and net farm income. A higher proportion of area than this shifts the distribution of feed supply towards summer and would be appropriate for systems having higher feed demand in summer, such as specialist lamb-finishing or highly prolific breeding flocks.

Keywords: average daily gain, forage presentation, grazing behaviour, ryegrass, STOCKPOL, white clover

Introduction

White clover (*Trifolium repens* L) has a higher nutrient density than grasses (Ulyatt 1981), animals prefer to eat it (Parsons *et al.* 1994), and they perform best when their diet contains a high proportion of it (e.g. Gibb & Treacher 1984; Harris *et al.* 1997). However, the generally low proportion of white clover in mixed pastures, and the annual and seasonal variability in its production (Hoglund *et al.* 1979), makes it difficult to capture those attributes in higher animal production.

There are alternative ways of presenting grass and clover that overcome some of those difficulties and

better meet the needs of animals and pastures. Growing ryegrass (*Lolium perenne* L) and clover separately within the same paddock instead of together in a mixture avoids inter-species plant competition and overcomes this constraint to sustaining a higher proportion of clover in mixed pasture. It also makes it easier for sheep and cattle to eat grass and clover in the proportions they want, and to satisfy nutritional requirements with a high intake of clover.

The benefits of this alternative method of presentation of pasture are most likely to be realised when used for feeding animals during periods of the year when they have high nutrient demand. However, in assessing the on-farm implications of this practice it is important that the consequences for whole-farm feed supply and demand, and flow-on effects on non-target classes of livestock, be carefully considered. For example, the feasibility of applying it to a lamb breeding/finishing system might be affected by the low growth rate of clover during winter.

This paper summarises recent experiments comparing liveweight gain responses by three different classes of sheep, and evaluates four scenarios for strategically implementing this method of forage presentation, using a farm simulation model.

Materials and methods

Experimental procedures

In three separate experiments, ewes with new-born twin lambs (conducted at the AgResearch, Aorangi Research area, Manawatu), newly weaned lambs (also at Aorangi) and 1-year-old hoggets (at the Poukawa Research area, central Hawke's Bay) were offered three pasture treatments: ryegrass only, white clover only and continuous, free access to ryegrass and clover growing separately, side-by-side. For the latter treatment each plot contained equal areas of each species. In the experiment using weaned lambs, a fourth treatment consisted of ryegrass and white clover growing as a mixture, containing 90% ryegrass and 10% white clover when the experiment started. The 3-year old swards of 'Yatsyn' perennial ryegrass used at Aorangi contained a nominally high level of infection with wild-type endophyte (*Neotyphodium lolii*). The 6-month old, autumn-sown 'Meridian'

Figure 1 Annual distribution of dry matter (DM) production and energy density of ryegrass and white clover growing separately (DM production redrawn from Harris & Hoglund 1977).

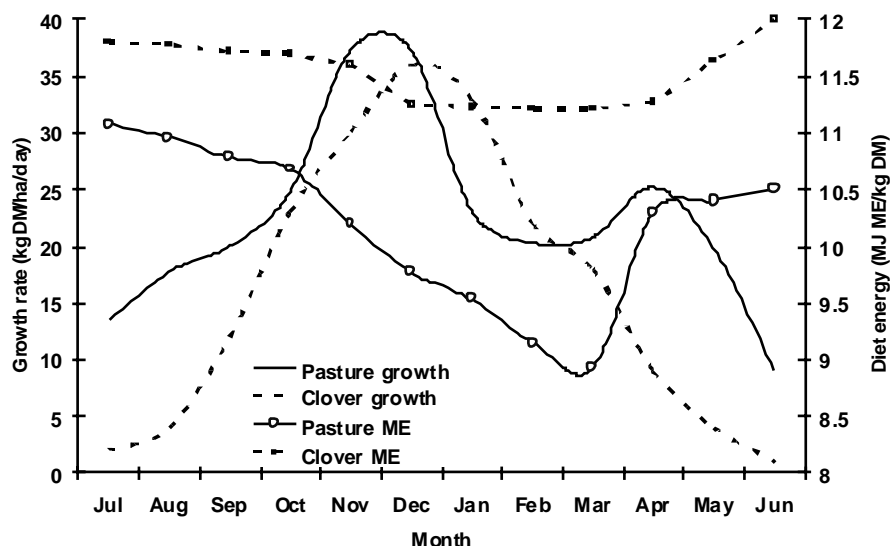


Table 1 Description of the base farm constructed in STOCKPOL, and the assumptions used for the base farm (C0) and the 4 scenarios comprised of ryegrass and white clover growing separately side-by-side (grass + clover) on 5% (C5), 10% (C10), 15% (C15) and 20% (C20) proportions of farm area.

Descriptor	Assumptions
Farm	Pasture cover at lambing (1440 kg DM/ha) and at the start (1 July) and end (June 30) of each year were the same for each scenario.
Pasture	Annual dry matter (DM) production was 8200 kg DM/ha, and average energy density was 10.2 MJME/kg DM.
Forage crops	This farm has 20 ha of Pasja. Ram lambs born on the farm were finished on Pasja during January-February. Pasja was replaced by annual ryegrass, producing 10400 kg DM/ha and used to finish ram hoggets during May-August.
Clover	Annual DM production was 5900 kg DM/ha, and average energy density was 11.5 MJME/kg DM. Clover was not available for grazing during May to October. The proportion of sheep allocated to the clover+grass was calculated using feed requirements of 3.6 kg DM/ewe with twin lambs, and 1.3 to 1.5 kg DM/lamb depending on lamb LW. The additional LWG relative to base farm was adjusted pro-rata for proportion of stock fed on the grass + clover.
Ewes	1440 ewes, 135% lambing, mean lambing date 31 August with weaning date 23 November, 278 g/d LWG from birth to weaning. Increasing proportions of twin ewes were allocated to clover (from 40% twins for C5 to all ewes in C20) and this increased weaning weights from 56.1 kg to 60 kg and lambs from 31.6 kg to 34 kg for C0-C20. Ewes achieved the same mating weight (61 kg with fleece) and were the same weight at the beginning and end of the year (ewe + preweaned lamb intake 1692-1788 kg annual DM/ha/ewe for C0-C20).
Ewe lambs	155 of the heaviest ewe lambs were sold at weaning. When average weight of ewe lambs was 38 kg (16 March-16 December for C0-C20) replacements were selected and 366 lambs sold (lightest in C0, random selection in C5-C20) and 530 retained. Ewe lamb carcass weights increased with proportion of clover (15 to 16.2 CW for C0-C20). Post weaning feed use 413-361 kgDM/ha for C0-C20.
Ewe hoggets	Ewe hoggets were heavier at mating (fleece free 42.7- 44.6 kg) but no increase in lambing % was included in the analysis.
Ram lambs	All ram lambs above 34 kg were sold at weaning (189-715 C0-C20) and then progressively drafted at 48 kg LW with all lambs being sold by April. As proportion of clover increased lambs are finished at the same weight (CW 20.1 kg), but used less feed (348-196 kgDM/ha post weaning for C0-C20). Additional ram lambs were purchased (2400-3000 for C0-C20) during summer and autumn to use surplus feed (617 to 852 kg DM/ha for C0 to C20) and were drafted at >48 kg and lambs sold in May to bring numbers down to 1191 for finishing May-August (22 kg CWT).

perennial ryegrass swards used at Poukawa contained AR1, a selected endophyte strain. At both sites the white clover swards ('Grasslands Pitau') were sown at the same time as the ryegrass swards. Average daily gain (ADG) was determined by weighing sheep before and after the period grazing on the respective treatments.

Experiment 1

Twenty-four Coopworth ewes (62.7 ± 9.4 kg; mean liveweight, standard deviation) and twin lambs (individual birthweight 5.8 ± 1.3 kg), were allocated to plots in groups of three ewes plus six lambs with a mean age of 3.5 days (range 1-7 days). Ewes and lambs were continuously stocked for 31 days from July 3, 2001. The limited number of twin-bearing ewes available restricted the scope for balancing according to ewe liveweight, lamb birth weight or lamb gender, and there were sufficient ewes for only two replications of the ryegrass only and clover only treatments, and four replications of the treatment comprised of ryegrass and clover growing separately.

Experiment 2

Sixty-four Coopworth mixed-sex lambs (30 ± 3.2 kg LW) were allocated in groups ($n=4$) balanced for LW to four replicates of four treatments and continuously stocked for 29 days, commencing from October 17, 2001. The lambs had been weaned approximately one week prior to this, and grazed together as a group on mixed ryegrass-white clover pasture during this period of adjustment. The ryegrass only, clover only, and ryegrass and clover growing side-by-side treatments used the same plots as for experiment 1. Lambs were treated with an oral anthelmintic at the start of the trial.

Experiment 3

Ninety, Romney ewe hoggets (37 ± 3.9 kg LW) were randomly allocated in groups ($n=10$) balanced for liveweight, to three replicates of three treatments for 35 days starting on September 24, 2001. Hoggets were strip-grazed and moved at weekly intervals to a new break. Hoggets were treated with oral anthelmintic 21 days before going on the trial, at the start of the trial, and 21 days after the trial started.

In experiments 1 and 2, plot size and sward surface height (minimum of 6 cm) were adequate to ensure that each species offered alone or together was available *ad libitum* for the duration of the experiment. In experiment 3, the size of each weekly strip was set to ensure a high, *ad libitum* allowance for each treatment.

Experimental design and analyses

The experimental unit was the group of sheep allocated to each plot. Each experiment was analysed

as a randomised complete block design, in which treatment effect was tested against the replicate x treatment interaction.

Scenario development and model assumptions

The whole-farm simulation model, STOCKPOL 6.0 (see Marshall *et al.* 1991) was used to simulate a mixed sheep breeding-finishing farm, this type being chosen because of the flexibility to adopt this alternative pasture arrangement. Five whole-farm system scenarios, base farm (C0), and 5% (C5), 10% (C10), 15% (C15) and 20% (C20) of the farm area allocated to this novel method of pasture presentation, were developed. The proportion in each scenario was made up of equal areas of ryegrass and white clover. The base farm simulated the Manawatu/Rangitikei Intensive 2002 Farm Monitoring farm (MAF, 2002). The 393 ha farm is flat to rolling with good quality forages and is stocked at 11.1 SU/ha (550 kg DM/SU) with a sheep:cattle ratio of 60:40. It operates breeding ewe and lamb and cattle finishing enterprises. MAF collates budgetary and some production data each year from 20 farms representative of this farm type into a representative model farm. The base farm was created in STOCKPOL 6.0 and the financial outputs generated using the production data and carcass and store stock values for 2001/02. The monthly average carcass (courtesy of Agri-Fax) and store stock (courtesy of Market Update Ltd) values from 2001 to 2003 were then superimposed on to this farm.

The growth rates of ryegrass and white clover (Figure 1) and annual DM production (Table 1) were based on pure swards of ryegrass and white clover growing in the Manawatu, a summer moist area (Harris & Hoglund 1977).

Results

Liveweight gain

Differences among treatments in ADG of ewes and lambs (experiment 1) were not significant (Table 2). For weaned lambs (experiment 2), ADG was greater ($P < 0.01$) on clover alone and the ryegrass-clover choice (345 and 330 g/day, respectively) than on ryegrass alone or the ryegrass clover mixture (185 and 205 g/day, respectively). Hoggets (experiment 3) gained weight faster ($P < 0.05$) on clover alone and ryegrass and clover growing side-by-side (275 and 240 g/day, respectively) than on ryegrass alone (190 g/day).

Scenario evaluation

Forage production

The annual DM production of clover is 72% of that of pasture but the lower DM production is partially

Table 2 Average daily liveweight gain by sheep in three experiments, each with three pasture treatments comprised of ryegrass only, white clover only, and ryegrass and clover growing side-by-side within the same paddock. Experiment 2 included a fourth treatment of a mixture of ryegrass and clover.

Experiment	Class of sheep	Pasture treatment				Significance	
		Ryegrass only	Clover only	Grass + clover side-by-side	Grass/clover mixture	P-value	LSD
—ADG (g/hd/day)—							
1	Ewes	-100	50	75	-	NS ¹	563
	Twin lambs	245	315	320	-	NS	98
2	Weaned lambs	185	345	330	205	P<0.01	61
3	Hoggets	190	275	240	-	P<0.05	39

¹ NS = not significant.

compensated by the greater energy density of clover and the total annual energy produced (MJ ME/yr) is 81 % of that of pasture. The farm grew less DM in total as the proportion of farm area having pastures comprised of ryegrass and clover growing side-by-side increased from 0 to 20% (Table 3). However, the utilisation of feed grown increased from 74 to 76% as the proportion of clover increased. This increase in utilisation may occur in reality because clover is easier to control and dead material does not accumulate in clover as much as it does in grass pastures.

Lamb and ewe growth rates

The ADG of lambs pre-weaning was 80 g/day higher on ryegrass and clover growing separately than on pasture, and the ADG by ewes was 150 g/day higher, although this latter difference was sustained only for the first month of lactation. The improvements in ADG of lambs after weaning over and above the ADG of those on the base farm are shown in Table 4.

Whole farm performance

Lambs born on the property grew faster and were sold earlier (more ram lambs sold at weaning) [Table 5]. The average carcass weight (CW) was reduced from 18.7 for C0 to 17.8 kg for C20, but carcass value of the lambs was increased from \$4.12 to 4.29/kg CW due to earlier selling. This resulted in a similar lamb value of \$77/hd for each scenario. The financial return from the breeding enterprise was 17 c/kg DM eaten, irrespective of the proportion of clover. The breeding system achieved similar return per unit of feed eaten because 2-6% less feed was required for C5-C20.

For the C20 scenario there were insufficient ewes and lambs available during late lactation to consume all of the clover grown. This surplus was allocated to less productive stock but their ADG was constrained in the model to the levels of the base farm. In reality

this may not be possible on clover because feeding ewes at maintenance would require very restricted feeding. As the proportion of clover increased more lambs were purchased and finished to a similar carcass weight on the clover systems, returning 19 to 21 c/kg DM eaten (Table 5). This increased the net income from lambs (gross income-purchase cost) by 3%, 16%, 27% and 40% for C5, C10, C15 and C20, respectively, relative to the base farm. Compared with the base farm net farm income was increased by \$2400, \$10000, \$17800, \$23400 for C5, C10, C15 and C20, respectively.

Discussion

Animal performance

Lambs post-weaning and hoggets gained weight faster when offered continuous free access to pastures comprised of ryegrass and clover growing separately, compared with ryegrass pastures. This higher ADG is consistent with the higher daily intake by sheep offered ryegrass and clover growing separately in short-term experiments (Champion *et al.* 1998; Cosgrove *et al.* 1999; Marotti *et al.* 2002) and with the 30% higher milksolids production by cows offered a similar arrangement of ryegrass and white clover in mid-lactation (Marotti *et al.* 2001). For the experiment with ewes and lambs, greater variability in ewe liveweights compared with the lambs and hoggets used in experiments 2 and 3 (see methods) and fewer replications limited the statistical power, and the differences among treatments in ADG were not significant. However, the differences among treatments were comparable with experiments 2 and 3, which with four and three replications, respectively, were significant, and support the generalisation of higher ADG by sheep offered grass and clover compared with ryegrass only. White clover is often considered the benchmark forage in terms of high animal performance (Ulyatt 1981). However, sheep want to eat both ryegrass and clover (c.f. eating just

Table 3 Feed grown, feed eaten and feed utilisation, and ewes and lambs stocked on the base farm (0%) and four farms with differing proportions (5%, 10%, 15% and 20%) of farm area in pastures comprised of ryegrass and white clover growing separately side-by-side (grass + clover).

	Proportion of farm in clover + grass				
	0%	5%	10%	15%	20%
Feed grown (kgDM/ha)	8260	8204	8147	8090	8034
Feed eaten (kgDM/ha)	6143	6133	6159	6177	6185
Utilisation (%)	74	75	76	76	77
Ewe + lambs born on farm	2797	2743	2687	2664	2617
Lambs purchased	806	861	945	983	1030
Total sheep	3603	3604	3632	3647	3647

Table 4 Increase in average daily liveweight gain (g/day) during November–April for ram lambs and ewes lambs stocked on pastures comprised of ryegrass and white clover growing separately, side-by-side (grass + clover), compared with those stocked on the base farm.

	Additional ADG ¹ on grass + clover					
	Nov	Dec	Jan	Feb	Mar	Apr
Ram lambs	106	145	40 ²	20 ²	170	114
Ewe lambs	166	130	140	160	180	160

¹ ADG increases calculated using Q-Graze functions relating diet ME to LWG (Woodward *et al* 2000).

² Lambs on Pasja in January and February so improvement in LWG compared with base farm is lower.

Table 5 Animal production and financial returns from ewes and lambs bred on farm and purchased lambs for the base farm (0%) and four farms with differing proportions (5%, 10%, 15% and 20%) of farm area in pastures comprised of ryegrass and white clover growing separately side-by-side (grass + clover).

	Proportion of farm in clover + grass				
	0%	5%	10%	15%	20%
Breeding ewes and lambs					
Ewe lamb weight at mating (kg)	42.7	43.2	44.5	44.6	44.6
Carcass weight lambs finished (kg)	18.7	18.7	18.4	18.4	17.8
Carcass value (\$/kg)	4.12	4.13	4.19	4.21	4.29
Carcass value (\$/lamb)	77	77	77	78	76
Total net income (\$000)	179	179	179	180	178
c/kg DM eaten	16	17	17	17	17
Purchased lambs					
Number purchased	2400	2550	2750	2800	3000
Carcass weight (kg)	21.6	21.6	21.8	22.4	21.9
Carcass value (\$/kg CW)	4.20	4.20	4.20	4.20	4.18
Total net income (\$000)	62	64	72	79	86
c/kg DM eaten	19	19	19	20	21

one of these species), and the ADG of sheep offered ryegrass and clover growing separately was as high as that of sheep offered clover only. Using both species reduces the proportional area of clover required and increases the proportional area that can be retained in ryegrass, while still achieving the high ADG possible from clover. As a result the affect on seasonal distribution of feed supply is minimised making it easier to integrate on-farm.

Feed supply and demand patterns

Ryegrass and white clover have different seasonal patterns of feed supply, and growing ryegrass and clover separately to ensure more clover is available to animals may affect total feed flows. However, the overall pattern of feed supply is affected by the proportion of each species, not the spatial separation *per se* (see Harris & Hoglund 1977). For example, sowing 20% of a given area in white clover and 80% in ryegrass does not alter the combined feed supply profile compared to a conventional mixture with a similar ratio of the two species. The difference between the two forms of presentation lies in the ability to sustain the high proportion of clover that the various classes of sheep require for high ADG (e.g. 55%, 65% and 80% of daily DM intake for ewes, hoggets and weaned lambs respectively, Cosgrove *et al.* 2002) compared with the low, variable proportion in mixed pasture. As the

proportion of clover increases (for either method of presentation) the distribution of forage production shifts towards summer (Figure 1), and at a whole-farm scale this may reduce carrying capacity in winter relative to that in summer.

Model scenarios

STOCKPOL outputs indicate that up to 15-20% of farm area allocated to this alternative forage arrangement could generate higher net farm income (Table 5). Improved animal performance during summer offsets the difficulties that were anticipated to arise from low growth rate of clover during winter. The amount of feed available on 1 April in each scenario farm was approximately 100 kg DM/ha greater than on the base farm, partially offsetting the lower growth rates during winter. Replacement ewe lambs grew faster during summer and reached their target winter LW earlier and did not need to grow during winter. This reduced the feed requirements during winter. Similarly, ewes were heavier at weaning and did not need to regain as much LW prior to mating, reducing the feed requirements during autumn.

The estimates of the advantages accruing from growing ryegrass and clover separately on a proportion of the farm are likely to be conservative. The efficiency of use of metabolisable energy (ME) intake for maintenance was 12% greater and for ADG was 4% greater than on the base farm. However, these benefits have not been captured in this analysis because STOCKPOL 6.0 is based on ME not on net energy and does not account for the higher efficiency of use of ME for maintenance or production from forages having high ME. No benefit was attributed to the higher LW of ewe hoggets at mating resulting from their higher ADG as ewe lambs, or to the heavier ewes at each subsequent mating. Heavier ewes produce more lambs (e.g. 15-20% more ewes producing twins for every 10 kg additional LW; Kelly & Knight, 1979). No additional animal health costs were incurred as a result of the greater number of lambs finished, because they grew faster and were finished more quickly.

The primary purpose of this analysis was to test feasibility and no other costs of implementation were allowed for. It is assumed that pastures comprised of ryegrass and clover growing separately could be established during normal pasture renewal operations, without incurring additional direct costs.

The results from this analysis are sensitive to the assumptions used (see methods), and a single analysis cannot demonstrate conclusively that this alternative method of forage presentation improves whole farm system performance in every situation. However, the

results suggest that growing grass and clover separately as a method of providing animals with pastures having a high proportion of clover increases animal performance and financial returns. This analysis also indicates that this form of forage management is most appropriate when implemented on a small proportion of farm area for feeding to a responsive class of stock such as lambs.

Conclusions

Growing ryegrass and clover separately within the same paddock is feasible and economically viable on a breeding/finishing farm when integrated at a low proportion of total farm area (15%-20%) and used to boost the growth rate of weaned lambs prior to slaughter. This class of sheep was the most responsive in converting the higher nutrient intake to additional LWG, and those benefits can be directly realised at slaughter. Gains in whole-system financial performance will be influenced by relativity in prices for different classes of stock e.g. the margin for finished lambs compared with store lambs. In regions where the relative growth rates of ryegrass and white clover or their seasonality of growth differs from the assumptions used in this analysis, the optimum proportion of farm area to allocate to this form of management may change.

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