Tropical Agricultural Research Vol. 27 (3): 217 - 228 (2016)

Is Plantain (*Plantago lanceolate* L.), Chicory (*Cichorium intybus* L.) and Clover Mixtures Effective on Weaned Lamb Growth?

S.C. Somasiri[1*], P.R. Kenyon[1], P.D. Kemp[1], P.C.H. Morel[1] and S.T. Morris[1]

Agronomy Division
Coconut Research Institute
Bandirippuwa Estate
Lunuwila, Sri Lanka

ABSTRACT: *The research was undertaken to assess the lamb production performance over two consecutive years (2011/2012 and 2012/2013) on three sward mixtures; Pasture mixture, Plantain mixture and Chicory mixture in early spring, late spring, summer and autumn. The Pasture mixture consisted of perennial ryegrass (Lolium perenne L.) and white clover (Trifolium repens L.) whereas the Plantain mixture was included with plantain (Plantago lanceolata L.), white clover and red clover (Trifolium pratense L.). The Chicory mixture contained plantain, chicory (Cichorium intybus L.), white- and red-clover. It was hypothesised that the highest lamb live weight gain (LWG) and carcass weights would be obtained by feeding Plantain and Chicory mixtures in all four periods. In each period weaned lambs were reared on the three herbage treatments for a maximum of two months. The lambs were weighed fortnightly throughout the experimental period and slaughtered at the end. Both Plantain and Chicory mixtures produced higher ($P<0.05$) LWG and carcass weights compared to the Pasture mixture in all periods. Both Plantain and Chicory mixtures had lower ($P<0.05$) feed conversion ratios (FCR) and higher ($P<0.05$) herbage utilization efficiencies compared to the Pasture mixture. This research has shown that sheep farmers in New Zealand can finish lambs at a faster rate for heavier carcasses from spring to autumn using herb-clover mixtures than using ryegrass/white clover pastures.*

Keywords: *Carcass weight, Cichorium intybus L., lamb growth, Plantago lanceolate L.*

1. INTRODUCTION

A mixture of ryegrass (*Lolium perenne* L.)/white clover (*Trifolium repens* L.) is the main feed available for grazing livestock in New Zealand (Hodgson *et al.*, 2005). However, the quality and production of this herbage mixture is seasonal. Ryegrass/white clover production is limited due to the low soil moisture levels during summer (McKenzie *et al.*, 1999) and the quality can be low due to high fibre content (Hodgson and Brookes, 1999). Hence, farmers adjust the stocking rates to accommodate the poor herbage production and quality by

[1] International Sheep Research Centre, Institute of Veterinary, Animal and Biomedical Sciences, Massey University, Private Bag 11-222, Palmerston North, New Zealand 4442
* Corresponding author: sharinisc@yahoo.com

slaughtering the lambs in summer and autumn, more than in other periods of the year (Webby and Bywater, 2007; Beef+Lamb New Zealand, 2014). These factors contribute to low lamb growth rates and hence, low carcass weights during summer and autumn (Fraser *et al.*, 1999; Powell *et al.*, 2007).

Thus, finding alternative pastures or herbage species that are of high quality and produce significant quantity from early spring to late autumn, would be of benefit to the New Zealand lamb meat production system. Earlier research showed that herbages such as plantain (*Plantago lanceolata* L.), chicory (*Cichorium intybus* L.), white clover and red clover (*Trifolium pratense* L.) have a higher nutritive and feeding value than the ryegrass (Barry, 1998; Hodgson and Brookes, 1999; Waghorn *et al.*, 2007; Hayes *et al.*, 2010). Thus this paper discusses lamb production performance on three herbage treatments (Pasture mixture vs Plantain mixture vs Chicory mixture) over two consecutive years. It was hypothesised that the Plantain and Chicory mixtures (herb-clover mixtures) would produce higher lamb live weight gains and carcass weights on a per animal basis compared to the Pasture mixture.

2. METHODOLOGY

2.1 Experimental site and treatments

A research was undertaken at the Moginie Pasture and Crop Research Unit, Massey University, Palmerston North, New Zealand ($40^0$21' S, $175^0$37' E, and altitude of 30 m). Ten experiments were undertaken in two consecutive years (Year one: 2011/2012 and Year two: 2012/2013) in five different periods; winter, early spring, late spring, summer and autumn in each year. The experimental design was nested linear model. The experiments consisted of three herbage treatments; (i) 'Pasture mixture' with perennial ryegrass (One50 cultivar) and white clover (Bounty cultivar); (ii) 'Plantain mixture' with plantain (Ceres Tonic cultivar), white clover and red clover (Sensation cultivar); and (iii) 'Chicory mixture' with plantain, chicory (Puna II cultivar), white- and red-clover. These experiments received the Massey University Animal Ethics Committee approval.

There were three mobs of lambs per each herbage treatment serving as replicates. Total grazing area per herbage treatment was 2.25 ha consisting of three replicates (0.75 ha × 3). Each replicate had three 0.25 ha paddocks for rotational grazing.

2.2 Animal management

Lambs were given a five days adaptation period before commencing each experiment. Crossbred weaned lambs (cryptorchids) were stratified by live weight and allocated in herbage treatments at the start of each experiment. Every 28 days lambs were drenched with Ancare 'Matrix' triple combination drench (1 ml per 5 kg body weight); active ingredients 1 g/l Abamectin; 40 g/l Levamisole HCL; 22.7 g/l Oxfendazole (Merial Ancare, Manukau City, New Zealand). The stocking rates used in each experimental period were given in Table 1. Adult ewes were introduced to the experiments after first year late spring at a rate of six ewes per herbage treatment to maintain a refugia population of gastrointestinal nematodes at the farmlets (Waller, 1999) as the ewes were not routinely drenched with anthelmintic drugs. Different ewes were used for different experiments.

Table 1. The stocking rates in ten experimental periods in two consecutive years

Period	Stocking rate (lambs/ha)		
	Pasture mixture	Plantain mixture	Chicory mixture
Year one (2011/2012)			
Winter	20	*	*
Early spring	30	30	25
Late spring[1]	40	40	40
Summer	24	40	40
Autumn	28	32	32
Total no. of lambs[2]	309	309	297
Year two (2012/2013)			
Winter	16	*	*
Early spring	32	32	32
Late spring[1]	40	40	40
Summer	24	24	32
Autumn	28	19	28
Total no. of lambs[2]	297	240	279

Note: Stocking rates in summer and autumn in year one and all the five periods in year two include the adult ewes (6 ewes/treatment/period) present to ensure parasitic contamination of pasture treatments.
[1]Late spring 2nd November to 19th December in 2011 (Year one) and 31st October to 17th December 2012 (Year two) and stocking rates were excluding the adult ewes.
[2]Total number of lambs reared in each treatment each year
*No lambs present

Lambs were reared only in the Pasture mixture during the winter period. The Plantain and Chicory mixtures were not grazed during the winter period as plantain, chicory and red clover were partially dormant during the winter (Valentine and Kemp, 2007; Kemp *et al.*, 2010). The Pasture mixture was grazed hard using ewes whenever necessary to maintain the pasture quality in late spring and summer. At the end of the first rotation during summer Plantain mixture and the Chicory mixture paddocks were mowed to a height of 10 -12 cm to remove the seed heads and other reproductive structures (Labreveux *et al.*, 2006) and two to three weeks' rest period was maintained to allow the pasture and herbage to re-grow to the prescribed herbage mass and heights before commencement of the next experiment. *Ad-lib* feeding was practised during experiments allowing three times predicted intake (Kenyon and Webby, 2007). Lambs were rotated when the post-grazing sward surface height reached 5 cm in the Pasture mixture or 7 cm in the Plantain and Chicory mixtures.

Table 2. Initial mean live weight (mean ± SE) of lambs

Period	Initial live weight (kg)		
	Pasture mixture	Plantain mixture	Chicory mixture
Year one (2011/2012)			
Winter	36.0±0.48	*	*
Early spring	41.4±0.07	41.2±0.07	41.3±0.08
Late spring[1]	32.4±0.06	32.5±0.06	32.5±0.06
Summer	32.8±0.08	32.8±0.06	32.9±0.06
Autumn	34.3±0.08	34.2±0.07	34.3±0.07
Year two (2012/2013)			
Winter	36.6±0.62	*	*
Early spring	34.6±0.09	34.8±0.09	34.9±0.09
Late spring[1]	32.6±0.08	32.5±0.08	32.6±0.08
Summer	35.9±0.11	35.8±0.11	35.9±0.09
Autumn	34.1±0.10	34.2±0.12	34.1±0.10

[1]Late spring and early summer 2nd November to 19th December in 2011 (Year one) and 31st October to 17th December 2012 (Year two).
* No lambs present.

Lambs were weighed (un-fasted) fortnightly. Each experiment was conducted until either the lambs gained 10 kg body weight or for maximum 56 days or the herbage/pasture growth was not sufficient to meet lamb *ad-lib* feeding requirements. The initial live weights of the lambs were given in Table 2. At the end of each experiment lambs were trucked in the late afternoon and slaughtered at Alliance Meat Works (Dannevirke, New Zealand) in the early morning of the following day.

2.3 Herbage quality measurement

Two samples of herbage were plucked at each post-grazing from the enclosed cages placed in each paddock and frozen at -20 ^{0}C for herbage quality analysis. Herbage was analysed for crude protein (AOAC 968.06 and Leco Total Combustion Method [LECO Corporation, St. Joseph, MI, USA]), neutral detergent fibre (NDF) and acid detergent fibre (ADF) according to Robertson and Van Soest, (1981), *In vitro* organic matter digestibility (OMD) and digestible organic matter digestibility (DOMD) according to Roughan and Holland (1977). Metabolizable energy (ME) was calculated by multiplying DOMD% by 0.163 (Geenty and Rattray, 1987).

2.4 Other calculations

Feed Conversion Ratio (FCR) and efficiency of herbage utilization (EHU) were calculated on dry matter (DM) basis using the equations (Eq I and Eq II). The assumptions given in Nicol and Brookes (2007) were used in the calculation of FCR and EHU.

$$FCR = \frac{\text{Total feed required for maintenance + growth (kg DM per ha)}}{\text{Total live weight gain per ha (kg per ha)}} \text{----------Eq I}$$

The assumptions;
The requirement of metabolisable energy (ME) for maintenance;
eg. 40 kg lamb = 8.0 MJ ME/day and 50 kg lamb = 9.5 MJ ME/day

The requirement of ME for growth;
eg. 35 kg lamb = 3.0 MJ ME/100 g LWG and 45 kg lamb = 3.5 MJ ME/100 g LWG

The total dry matter (DM) requirement for maintenance and growth;
= ME requirement for maintenance/lamb + ME requirement for growth/lamb × SR
ME content of the herbage treatment
SR = stocking rate and,

Total live weight gain/ha/mob (replicate);
= (mean end live weight - mean initial live weight) × SR

EHU = Total feed required for maintenance + growth (kg DM per ha) × 100 --------Eq II
Apparent herbage utilization (AHU) (kg DM per ha)

where, AHU for lambs for each experiment was calculated by;

AHU = Apparent herbage disappearance (kg DM per ha) × total herbage growth (kg DM per ha)

where, apparent herbage disappearance was calculated by;
= pre-grazing herbage DM mass – Post-grazing herbage DM mass

and total herbage growth was calculated by;
Total herbage growth = herbage growth per day × duration of the grazing period

2.5 Statistical analysis

Data were analysed using General Linear Model (GLM) procedure in SAS version 9.2 (SAS, 2008). The model included herbage treatment, period and their interaction as fixed effects and the mob of lambs (replicate) effect nested within the herbage treatment x period interaction as a random effect. Winter data were analysed separately using ANOVA with mob as a fixed effect using GLM procedure for each experiment. Feed conversion ratio (FCR) and EHU data were analysed using a randomized block design model with herbage treatment as a fixed effect and mob as a random effect using GLM. The means were separated using least significant difference procedure (LSD).

3 RESULTS AND DISCUSSION

3.1 Annual nutrient quality of herbage treatments

There were significant differences ($P < 0.05$) in all herbage quality measurements of the sward mixtures except for CP (Table 3). Crude protein percentage was comparable ($P > 0.05$) in the Pasture and Chicory mixtures during the year 2011/2012 and in all three sward mixtures in the year 2012/2013.

The present study shows that plantain and chicory based herb-clover mixtures had higher nutritive value in terms of OMD and ME compared to the Pasture mixture supporting the findings of Cave *et al.* (2015) and Pain *et al.* (2014). This difference was also reported by Golding *et al*. (2011) in late summer/early autumn period.

Table 3. *In vitro* organic matter digestibility (OMD), metabolizable energy (ME), neutral detergent fibre (NDF), crude protein (CP) and ash contents of herbage treatments on DM basis (mean ± SE)

Year one (2011/2012)	Pasture mixture[1]	Plantain mixture	Chicory mixture
OMD (%)	$69.1^{a} \pm 0.47$	$75.2^{b} \pm 0.47$	$77.4^{c} \pm 0.47$
ME (MJ/DM kg)	$10.1^{a} \pm 0.06$	$10.9^{b} \pm 0.06$	$11.1^{c} \pm 0.06$
NDF (%)	$46.5^{c} \pm 0.68$	$32.7^{b} \pm 0.68$	$28.8^{a} \pm 0.68$
CP (%)	$19.7^{a} \pm 0.57$	$22.0^{b} \pm 0.57$	$19.9^{a} \pm 0.57$
Ash (%)	$10.1^{a} \pm 0.31$	$12.1^{b} \pm 0.31$	$13.2^{c} \pm 0.31$
Year two (2012/2013)	Pasture mixture[1]	Plantain mixture	Chicory mixture
OMD (%)	$68.7^{a} \pm 0.89$	$74.9^{b} \pm 0.89$	$77.5^{b} \pm 0.89$
ME (MJ/DM kg)	$10.1^{a} \pm 0.13$	$10.9^{b} \pm 0.13$	$11.1^{b} \pm 0.13$
NDF (%)	$47.6^{c} \pm 1.63$	$36.1^{b} \pm 1.63$	$28.6^{a} \pm 1.63$
CP (%)	18.2 ± 1.37	22.5 ± 1.37	21.5 ± 1.37
Ash (%)	$9.4^{a} \pm 0.53$	$11.4^{b} \pm 0.53$	$12.9^{b} \pm 0.53$

Differing superscripts (a,b,c) within rows and years indicate means that were significantly different ($P < 0.05$).
[1] Excluding winter data.

3.2 Live weight gain (LWG) and dressing out percentage (DO%) of lambs between different periods

The effect of feeding herb-clover mixtures on the weaned lamb growth are shown in Table 4. During late spring, summer and autumn lambs fed with Plantain and Chicory mixtures had higher LWG than the lambs fed with the Pasture mixture. During year one early spring lambs in the Plantain mixture had similar LWG as the lambs in the Pasture and Chicory mixtures. However, in year two early spring Plantain mixture lambs had the highest ($P < 0.05$) LWG than the lambs in the other two sward mixtures.

Golding *et al*. (2011) reported a greater LWG in a herb-clover mixture similar to the Chicory mixture during late summer/early autumn period. The faster lamb growth rates may have attributed by the higher quality in the herb-clover mixtures throughout early spring to autumn period. With higher nutrient digestibility and energy content combined with the higher rate of feed passage (Hodgson and Brookes, 1999; Litherland *et al.*, 2010) may have resulted such faster growth rates in lambs on herb-clover mixtures. The higher fibre percentage could limit feed intake and negatively affect lamb growth in the Pasture mixture (Burke *et al.*, 2002; Waghorn *et al.*, 2007).

Table4. Effect of herbage treatment on LWG of lambs within each of the five study periods (winter, early spring, late spring, summer and autumn) (mean ± SE)

Period	LWG (g/day)		
	Pasture mixture	Plantain mixture	Chicory mixture
Year one (2011/2012)			
Winter	151.6±5.48	*	*
Early spring	$321.8^{a, y} \pm 11.24$	$336.0^{ab, z} \pm 11.24$	$360.0^{b, z} \pm 12.37$
Late spring[1]	$190.3^{a, x} \pm 9.90$	$304.5^{c, y} \pm 9.84$	$262.2^{b, y} \pm 9.84$
Summer	$169.0^{a, x} \pm 13.62$	$226.0^{b, x} \pm 10.25$	$213.5^{b, x} \pm 10.32$
Autumn	$159.7^{a, x} \pm 12.48$	$294.9^{c, y} \pm 11.58$	$254.8^{b, y} \pm 11.58$
Year two (2012/2013)			
Winter	222.0 ± 5.44	*	*
Early spring	$320.7^{a, z} \pm 9.24$	$397.3^{c, z} \pm 9.24$	$366.5^{b, z} \pm 9.24$
Late spring[1]	$243.9^{a, y} \pm 7.85$	$315.9^{b, y} \pm 7.85$	$329.2^{b, y} \pm 7.90$
Summer	$120.4^{a, w} \pm 11.00$	$231.1^{b, w} \pm 10.87$	$221.1^{b, x} \pm 9.46$
Autumn	$169.7^{a, x} \pm 9.87$	$252.3^{c, x} \pm 12.42$	$207.7^{b, w} \pm 9.87$

Note: the negative LWG values were excluded from analysis.
[1]Late spring and early summer 2nd November to 19th December in 2011 (Year one) and 31st October to 17th December 2012 (Year two).
Means followed by different superscripts (a,b,c) within a row and year were significantly different ($P < 0.05$).
Means followed by different superscripts (w,x,y,z) within a column and year were significantly different ($P < 0.05$).
* No lambs present.

Dressing out percentage (DO%) is expressed as a carcass in proportion of final live weight (Kirton *et al.*, 1984). Greater carcass weights (Table 5) obtained from both Plantain and Chicory mixtures compared to those of the Pasture mixture in the present study resulted higher DO% (DO% data were not shown in the present paper). Similarly, Golding *et al*. (2011) also obtained a higher carcass weight (16 kg) in the lambs on herb-clover mixture. Fraser and Rowarth (1996) obtained greater carcass weights by feeding pure swards of plantain, chicory and white clover and Speijers *et al.* (2004) by feeding red clover. Therefore, the present results in this experiment and that of Golding *et al.* (2011) indicate that farmers can utilize herb-clover mixtures to increase carcass weights.

Table 5. Effect of herbage treatment (Pasture mix vs Plantain mix vs Chicory mix) on carcass weight within each of the five study periods (early spring, late spring and early summer, summer and autumn) (mean ± s.e.).

Period	Carcass weight (kg)		
	Pasture mix	Plantain mix	Chicory mix
Year one 2011/2012			
Winter	17.8±0.52	*	*
Early spring	$21.1^{a, z}$±0.16	$21.8^{b, y}$±0.17	$22.3^{c, z}$±0.18
Late spring[1]	$15.7^{a, y}$±0.14	$18.3^{c, x}$±0.15	$17.8^{b, x}$±0.14
Summer	$15.7^{a, y}$±0.20	$18.7^{b, x}$±0.15	$18.4^{b, y}$±0.15
Autumn	$15.2^{a, x}$±0.18	$18.6^{b, x}$±0.17	$18.7^{b, y}$±0.17
Year two 2012/2013			
Winter	19.9±0.34	*	*
Early spring	$18.1^{a, z}$±0.21	$20.3^{b, z}$±0.21	$19.7^{b, z}$±0.21
Late spring[1]	$17.1^{a, y}$±0.18	$19.3^{b, y}$±0.18	$19.6^{b, z}$±0.18
Summer	$14.5^{a, x}$±0.25	$16.8^{b, x}$±0.25	$16.5^{b, x}$±0.21
Autumn	$16.7^{a, y}$±0.22	$18.6^{b, y}$±0.28	$18.2^{b, y}$±0.22

[1]Late spring and early summer 2nd November to 19th December in 2011 (Year one) and 31st October to 17th December 2012 (Year two).
Means followed by different superscripts (a,b,c) within a row and year were significantly different ($P < 0.05$).
Means followed by different superscripts (x,y,z) within a column and year were significantly different ($P < 0.05$).
* No lambs present.

New Zealand lamb prices are determined using both GR tissue depth measurements and carcass weights (Kirton *et al.*, 1984; Litherland *et al.*, 2010). Mean GR tissue depth measurements in the lambs on the Pasture mixture were 5.2 mm and 5.8 mm in the year one and year two respectively. In contrast, lambs on both Plantain and Chicory mixtures had approximately 8.0 mm GR tissue depths in both years obtaining higher prices compared to the lambs on the Pasture mixture. Hence there is a higher potential for higher income from the lambs reared on herb-clover mixtures.

3.3 Variation of apparent carcass weight production per ha

Apparent carcass weight production per ha for each herbage treatment was calculated by taking the difference between total carcass weight production per ha per treatment at slaughter and estimated carcass weight production at day one (D_1) per ha per treatment.

Estimated carcass weight production at D_1 was assumed to be 40% of D_1 live weight (Kirton *et al.*, 1984) for all lambs. Overall in year one, Plantain mixture had the highest total apparent carcass weight production per ha than the Chicory mixture (Table 6). However, during year two the Chicory mixture had the highest total carcass weight production per ha. During both years, Pasture mixture had the lowest total carcass weight production per ha. According to Table 6 herb-clover mixtures of plantain, chicory, white- and red-clover produce more lamb meat per ha than the ryegrass/white clover Pasture mixture from early spring to autumn period.

Table 6. Effect of herbage treatment on apparent carcass weight production per ha within each of the five study periods (winter, early spring, late spring and early summer, summer and autumn) (mean ± SE)

Period	Apparent carcass weight production per ha (kg/ha)		
	Pasture mixture	Plantain mixture	Chicory mixture
Year one 2011/2012			
Winter	68.9±6.56	*	*
Early spring	138.0^{z}±8.59	158.9^{x}±8.59	143.7^{x}±8.59
Late spring[1]	$107.2^{a, y}$±8.59	$215.3^{c, y}$±8.59	$190.5^{b, y}$±8.59
Summer	$58.7^{a, x}$±8.59	$225.1^{b, y}$±8.59	$217.1^{b, z}$±8.59
Autumn	$34.3^{a, w}$±8.59	$148.5^{b, x}$±8.59	$157.7^{b, x}$±8.59
Total[2]	407.1[3]	747.8	709.0
Year two 2012/2013			
Winter	84.3±6.56	*	*
Early spring	$136.5^{a, y}$±8.59	$202.3^{b, y}$±8.59	$182.2^{b, y}$±8.59
Late spring[1]	$162.9^{a, z}$±8.59	$250.9^{b, z}$±8.59	$264.3^{b, z}$±8.59
Summer	$4.8^{a, w}$±8.59	$59.5^{b, w}$±8.59	$67.2^{b, w}$±8.59
Autumn	$85.3^{a, x}$±8.59	$94.1^{a, x}$±8.59	$128.2^{b, x}$±8.59
Total[2]	473.8[3]	606.8	641.9

[1]Late spring and early summer 2nd November to 19th December in 2011 (Year one) and 31st October to 17th December 2012 (Year two).
[2]Statistically could not test.
Means followed by different superscripts (a,b,c) within a row and year were significantly different ($P < 0.05$).
Means followed by different superscripts (w,x,y,z) within a column and year were significantly different ($P < 0.05$).
[3]Included winter data.
* No lambs present.

3.4 Annual Feed Conversion Ratio (FCR) and Efficiency of Herbage Utilization (EHU) of herbage treatments

Both Plantain and Chicory mixtures had lower ($P < 0.05$) FCR than Pasture mixture during both years (Table 7). Meyer and Garrett, (1967) explained Efficiency of Herbage Utilization (EHU) as the measurement of an animal's growth and maintenance in proportion to feed intake. Lambs on the Plantain and Chicory mixtures expressed greater performances utilising herbage more efficiently than the lambs on the Pasture mixture. This is also supported by the lower FCR values and higher herbage quality values in the herb-clover mixtures.

During the year two (2012/2013) summer and autumn periods there was a drought prevailed across the study area directly affecting herbage growth (Beef+Lamb New Zealand, 2014). In the year two summer and autumn periods, EHU in the Chicory mixture was greater than the

Plantain mixture. This indicates that during dry summer and autumn periods, Chicory mixture is more efficient than the Plantain mixture. Even though the botanical composition data was not discussed in the present paper, it was observed that the plantain and white clover species composition drastically decreased after late spring in the Plantain mixture due to the effect of drought prevailed in the area in the year two. As a result Plantain mixture had a lower stocking rate than the Chicory mixture.

Overall lambs in the Plantain and Chicory mixtures had similar yet, greater live weight gains and carcass weights during most of the periods compared to the Pasture mixture. Hence, the herb-clover mixtures can be used by farmers to increase lamb growth rates over the early spring to autumn period.

Table 7. Annual Feed Conversion Ratio (FCR) and Efficiency of Herbage Utilization (EHU) of herbage treatments on DM basis (mean ± SE)

	Pasture mixture[1]	Plantain mixture	Chicory mixture
Year one (2011/2012)			
Feed Conversion Ratio (kg dry matter intake/kg growth)	7.6^{b}±0.08	5.9^{a}±0.08	6.0^{a}±0.08
Efficiency of herbage utilization (%)	59.5^{a}±0.86	66.6^{c}±0.86	62.4^{b}±0.86
Year two (2012/2013)			
Feed Conversion Ratio (kg dry matter intake/kg growth)	8.1^{b}±0.08	6.1^{a}±0.08	6.2^{a}±0.08
Efficiency of herbage utilization (%)	41.3±0.47	40.0±0.47	41.2±0.47

Means followed by different superscripts (a,b,c) within rows and years indicate means that were significantly different ($P < 0.05$).
[1] Excluding winter data.

4 CONCLUSION

Both Plantain and Chicory mixtures produced greater carcass weights and a higher LWG compared to the Pasture mixture. Therefore, herb-clover mixtures can be used to improve lamb production compared to the ryegrass/white clover sward mixture over the early spring to autumn period in the Manawatu area, New Zealand and also in other areas having similar weather conditions.

5 ACKNOWLEDGEMENT

The authors acknowledge the International Sheep Research Centre, Massey University and the National Research Centre for Growth and Development, New Zealand for funding this research.

6 REFERENCES

Barry, T.N. (1998). The feeding value of chicory (*Cichorium intybus*) for ruminant livestock. J. Agric. Sci. *131*, 251-257.

Beef+Lamb New Zealand. (2014). New Season outpook 2013-14. Beef+Lamb New Zealand Economic Service. Beef+Lamb New Zealand limited Economic Service, P.O.Box 121, Wellinton.

Burke, J.L., Waghorn, G.C. and Chaves, A.V. (2002). Improving animal performance using forage-based diets. Proceedings of the New Zealand Society of Animal Production. pp. 267-272.

Cave, L.M., Kenyon, P.R., Morris, S.T., Lopez-Villalobos, N. and Kemp, P.D. (2015). Ewe lamb diet selection on plantain (*Plantago lanceolata*) and on a herb and legume mix, including plantain, chicory (*Cichorium intybus*), red clover (*Trifolium pratense*) and white clover (*Trifolium repens*). Anim. Prod. Sci. *55*, 515-525. doi: 10.1071/AN13379

Fraser, T.J., Moss, R.A., Daly, M.J. and Knight, T.L. (1999). The effect of pasture species on lamb performance in dryland systems. Proceedings of the New Zealand Grassland Association. pp. 23-29.

Fraser, T.S., Rowarth, J.S., (1996). Legumes, herbs or grass for lamb growth. Proceedings of the New Zealand Grassland Association. pp. 49-52.

Geenty, K.G., Rattray, P.V., (1987). The energy requirements of grazing sheep and cattle, pp. 39-53. In: Nicol, A.M. (Ed.), Livestock Feeding on Pastures. New Zealand Society of Animal Production. Occasional Publication, No.10, Hamilton.

Golding, K.P., Wilson, E.D., Kemp, P.D., Pain, S.J., Kenyon, P.R., Morris, S.T. and Hutton, P.G. (2011). Mixed herb and legume pasture improves the growth of lambs post weaning. Anim. Prod. Sci. *51*, 717-723.

Hayes, R.C., Dear, B.S., Li, G.D., Virgona, J.M., Conyers, M.K., Hackney, B.F. and Tidd, J. (2010). Perennial pastures for recharge control in temperate drought-prone environments. Part 1: productivity, persistence and herbage quality of key species. New Zeal. J. Agr. Res. *53*, 283-302.

Hodgson, J. and Brookes, I.M. (1999). Nutrition of grazing animals, pp. 117-132. In: White, J., Hodgson, J. (Eds.), New Zealand Pasture and Crop Science. Oxford University press, Auckland, New Zealand.

Hodgson, J., Cameron, K., Clark, D., Condron, L., Fraser, T., Hedley, M., Holmes, C., Kemp, P., Lucas, R., Moot, D., Morris, S., Nicholas, P., Shadbolt, N., Sheath, G., Valentine, I. and Waghorn, G., D., W. (2005). New Zealand's pastoral industries: efficient use of grassland resources, pp. 181-205. In: Reynolds, S.A., Frame, J. (Eds.), Grasslands: Developments, Opportunities, Perspectives. Science Publishers, Inc., Enfield (NH), USA.

Kemp, P.D., Kenyon, P.R. and Morris, S.T. (2010). The use of legume and herb forage species to create high performance pastures for sheep and cattle grazing systems. Sociedade Brasileira de Zootecnia. *39*, 169 -174.

Kenyon, P.R. and Webby, R.W. (2007). Pastures and supplements in sheep production systems, pp. 255-273. In: Rattray, P.V., Brookes, I.M., Nicol, A.M. (Eds.), Pasture and Supplements for Grazing Animals. New Zealand Society of Animal Production. Occasional Publication No.14, Hamilton.

Kirton, A.H., Carter, A.H., Clarke, J.N. and Duganzich, D.M. (1984). Dressing percentages of lambs. Proceedings of the New Zealand Society of Animal Production. pp. 231-233.

Labreveux, M., Sanderson, M.A. and Hall, M.H. (2006). Forage Chicory and Plantain: Nutritive value of herbage at variable grazing frequencies and intensities. Agron. J. *98*, 231-237.

Litherland, A.J., Dynes, R.A. and Moss, R.A. (2010). Factors affecting dressing-out percentage of lambs. Proceedings of the New Zealand Society of Animal Production. pp. 121-126.

McKenzie, B.A., Kemp, P.D., Moot, D.J., Matthew, C. and Lucas, R.J. (1999). Environmental effects on plant growth and development, pp. 29-44. In: White, J., Hodgson, J. (Eds.). New Zealand Pasture and Crop Science. Oxford University Press. Auckland, New Zealand.

Meyer, J.H. and Garrett, W.N. (1967). Efficiency of feed utilization. Anim. Sci. *26*, 638-646.

Nicol, A.M. and Brookes, I.M. (2007). The metabolisable energy requirements of grazing livestock, pp. 156-157. In: Rattray, P.V., Brookes, I.M., Nicol, A.M. (Eds.), Pasture and Supplements for Grazing Animals. New Zealand Society of Animal Production. Occasional Publication No. 14.

Pain, S., Corkran, J., Kenyon, P.R., Morris, S.T. and Kemp, P.D. (2014). The influence of season on lambs. Anim. Prod. Sci. *55*, 1241-1249.

Powell, A.M., Kemp, P.D., Jaya, I.K.D. and Osborne, M.A. (2007). Establishment, growth and development of plantain and chicory under grazing. Proceedings of the New Zealand Grassland Association. pp. 41-45.

Robertson, J. and Van Soest, P. (1981). The detergent system of analysis and its application to human foods, pp. 123-158. In: James, W.P.T., Theander, O. (Eds.), The Analysis of Dietary Fibre in Food Volume 3. Marcel Dekker Inc. USA, New York.

Roughan, P.G. and Holland, R. (1977). Predicting in - vivo digestibility of herbages by exhaustive enzymic hydrolysis of cell walls. J. Sci. Food Agr. *28*, 1057-1064.

SAS. (2008). SAS 9.2. SAS Institute Inc., Cary, NC.

Speijers, M.H.M., Fraser, M.D., Theobald, V.J. and Haresign, W. (2004). The effect of grazing forage legumes on the performance of finishing lambs. J. Agric. Sci. *142*, 483 - 493.

Valentine, I. and Kemp, P.D. (2007). Pasture and supplement resources, pp. 3-12. In: Rattray, P.V., Brookes, I.M., Nicol, A.M. (Eds.), Pasture and Supplements for Grazing Animals. New Zealand Society of Animal Production. Occasional Publication No. 14, Hamilton.

Waghorn, G.C., Burke, J.L. and Kolver, E.S. (2007). Principles of feeding value, pp. 35-60. In: Rattray, P.V., Brookes, I.M., Nicol, A.M. (Eds.). Pasture and Supplements for Grazing Animals. New Zealand Society of Animal Production. Occasional Publication No. 14, Hamilton.

Waller, P.J. (1999). International approaches to the concept of integrated control of nematode parasites of livestock. Int. J. Parasitol. *29*, 155 - 164.

Webby, R.W. and Bywater, A.C. (2007). Principles of feed planning and management, pp. 189-220. In: Rattray, P.V., Brookes, I.M., Nicol, A.M. (Eds.), Pasture and Supplements for Grazing Animals New Zealand Society of Animal Production. Occasional Publication No. 14, Hamilton.