A review of the use of chicory, plantain, red clover and white clover in a sward mix for increased sheep and beef production

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Abstract
Many farmers are sowing mixed swards containing chicory (*Cichorium intybus*), plantain (*Plantago lanceolata*), red clover (*Trifolium pratense*) and white clover (*T. repens*) (hereafter termed herb and clover mix). This herb and clover mix has comparable annual dry matter (DM) production to perennial ryegrass white clover pasture (rye/wc), however, it has a different pattern of growth, producing more DM during summer and autumn. The herb and clover mix also has a higher nutritive value and is able to support greater rates of animal production, especially over summer, than rye/wc in both sheep and cattle. The herb and clover mix is most suited to a rotational grazing interval of 3–4 weeks to an 8 cm residual height, with no winter grazing. When managed appropriately the herb and clover mix is able to persist for at least 2 years and up to 5 years under both sheep and cattle grazing.

Keywords: *Cichorium intybus, Plantago lanceolata, Trifolium pratense, Trifolium repens,* legume, perennial, nutritive value.

Introduction
New Zealand pastoral systems have traditionally been based on perennial ryegrass (*Lolium perenne) with a component of white clover (Trifolium repens)* (Kemp *et al.* 2002). However, throughout the summer and autumn months production of perennial ryegrass and white clover pasture (rye/wc) can be limited in both nutritive value and production, which can lead to reduced animal intakes and performance (Burke *et al.* 2002; Moorhead *et al.* 2002). Therefore, during these periods alternate forage species are of interest, particularly under dryland systems. Chicory and plantain are both high yielding, summer active perennial herbs which can maintain high nutritive values during warm summer conditions (Lee *et al.* 2015; Minneé *et al.* 2013; Powell *et al.* 2007). However, the persistence of both chicory and plantain are reduced markedly when they are grazed during winter (Ayala *et al.* 2011; Li *et al.* 1997), and therefore they are not particularly compatible with winter active grass species.

Sheep and beef farmers are using varying combinations of chicory (*Cichorium intybus*), plantain (*Plantago lanceolata*), red clover (*Trifolium pratense*) and white clover in mixes as specialist summer-active perennial swards, for enhanced animal production. A common sward mix being used contains chicory, plantain, red clover and white clover (hereafter termed herb and clover mix). This herb and clover mix has been developed to maximise herbage production and nutritive value throughout summer, primarily for use under dryland conditions and therefore does not include a grass species. The herb and clover mix differs from other diverse pasture mixes which contain a major proportion of grass and minor proportions of other species including herbs and legumes (Daly *et al.* 1996; Goh & Bruce 2005; Ruz-Jerez *et al.* 1991). Furthermore, compared to a pure sward of chicory the herb and clover mix is likely to have a greater herbage yield, a longer growing season and greater persistence due to the addition of plantain. The purpose of this review is to examine current research on this herb and clover mix including herbage production and composition, nutritive value, animal performance and grazing management.

Herbage production and composition
In the Manawatu region, the herb and clover mix can produce 9–15 t dry matter (DM)/ha/year, when comprised of 40–60% plantain, 20–40% chicory, 5–20% red clover and 0–10% white clover (Cranston *et al.* 2015; Somasiri 2014; DairyNZ unpublished report). This is a similar DM production to that commonly achieved on rye/wc in the same region (Kerr *et al.* 2012), although the herb and clover mix has greater herbage production over the summer and autumn period (Somasiri 2014). To date, research on the herb and clover mix has been focused in the Manawatu region, however under dryland conditions pure swards of chicory and plantain have been shown to yield 7–16 t DM/ha/year in Canterbury (Brown *et al.* 2005; Hunter *et al.* 1994; Stewart 1996) and 8–19 t DM/ha/year in Waikato (Lee *et al.* 2015; Minneé *et al.* 2013). This suggests the herb and clover mix would also be suitable in other regions of New Zealand. The production of the herb and clover mix can be especially evident during dry summers, due to the herbs having

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greater drought tolerance than rye/wc (Nie *et al.* 2008). The herb and clover mix can have negligible winter growth (Cranston *et al.* 2015; Somasiri 2014). Within the herb and clover mix the growth of the individual species varies, plantain beginning its growth earlier in spring and continuing later into autumn than the other species (Kemp *et al.* 2010), but chicory and red clover are more productive than plantain and white clover during summer (Kemp *et al.* 2002; Li & Kemp 2005). These seasonal variations result in changes in botanical composition between seasons.

Nutritive value

The clear advantage of the herb and clover mix is that it has a higher nutritive value during summer, compared to rye/wc. The herb and clover mix generally has a lower fibre content, similar crude protein content and higher organic matter digestibility percentage and metabolisable energy content than rye/wc (Table 1). When sown as a pure sward, the crude protein content of plantain can be low (<15%) (Lee *et al.* 2015; Pain *et al.* 2015), potentially limiting animal production. However, the clover content in a herb and clover mix is likely to ameliorate this potential problem (Sinhadipathige *et al.* 2012). Therefore, the herb and clover mix is more suitable as a specialist summer-active perennial forage for lamb/cattle finishing than a pure plantain sward.

Animal performance

The herb and clover mix can support greater lamb liveweight gains in spring, summer and autumn than rye/wc, with average daily gains of approximately 250 g/day (Table 2). This result is particularly notable in summer when lambs grazing rye/wc typically have growth rates of 80–150 g/day (Fraser & Rowarth 1996; Kerr 2000). Furthermore, the herb and clover mix can support greater total lamb carcass weight production per hectare per year than rye/wc (average over 2 years of 676 vs. 440 kg/ha/yr) (Somasiri 2014). Similarly, dairy heifer calves grazing the herb and clover mix during summer display greater liveweight gains than those grazing rye/wc (0.75 vs. 0.53 kg/head/day) (Handcock *et al.* 2015).

Ewes grazing the herb and clover mix during late pregnancy and lactation have increased liveweight gain and body condition score (Table 3) and have been shown to produce 17–25 % more milk than those grazing rye/wc (Hutton *et al.* 2011). Furthermore, their lambs mostly displayed improved liveweight gain to weaning (Table 3), with the exception of Kenyon *et al.* (2010) where lamb liveweight was improved at 20 days after the midpoint of the lambing period but not at 75 days. Similarly, lamb survival to weaning from mature ewes grazing the herb and clover mix was 14–24% higher than those grazing rye/wc (Hutton *et al.* 2011; Kenyon *et al.* 2010), while Corner-Thomas *et al.*

Table 1 Crude protein (CP), neutral detergent fibre (NDF), organic matter digestibility (OMD), and metabolisable energy content (ME) of the herb and clover mix (herb mix); containing chicory, plantain, red clover and white clover compared to perennial ryegrass and white clover pasture (rye/wc) across the seasons; early spring (September/October), late spring (Nov/Dec), summer (Jan/Feb), early autumn (Mar/Apr), late autumn (Apr/May) in the Manawatu region, New Zealand.

Season and study	CP (% DM)		NDF (% DM)		OMD (% DM)		ME (MJ/kg DM)	
	rye/wc	herb mix	rye/wc	herb mix	rye/wc	herb mix	rye/wc	herb mix
Early spring								
Kenyon *et al.* (2010)	13	13	54	38			9.2	10.5
Hutton *et al.* (2011)	12	15	36	28	72	74	10.6	10.8
Somasiri (2014)	25	20	42	27	71	78	10.4	11.4
Late spring								
Somasiri *et al.* (2015a)	16	23	48	28	69	78	10.2	11.2
Summer								
Kenyon *et al.* (2010)	9	9	62	49			8.9	9.8
Hutton *et al.* (2011)	9	12	50	38	64	68	9.5	9.9
Cranston (2014)	21	25	40	24	74	81	10.6	11.6
Somasiri *et al.* (2015b)	15	18	50	30	67	76	9.8	10.9
Early autumn								
Golding *et al.* (2011)	20	16	48	28	64	83	9.0	11.4
Late autumn								
Somasiri (2014)	24	23	45	25	71	80	10.4	11.3

Values from Somasiri (2014) and Somasiri *et al.* (2015a; 2015b) are averages of two years.

Table 2 Live weight gain (g/day) of weaned lambs grazing the herb and clover mix (herb mix); containing chicory, plantain, red clover and white clover in comparison with perennial ryegrass and white clover pasture (rye/wc) across the seasons; early spring (September/October), late spring (Nov/Dec), summer (Jan/Feb), early autumn (Mar/Apr), late autumn (Apr/May) in the Manawatu region, New Zealand. Means within rows with different superscripts are significantly different at $P < 0.05$ level.

Season and study	Year	Live weight gain (g/day)	
		rye/wc	herb mix
Early spring			
Somasiri (2014)	2011	322[a]	360[b]
	2012	321a	367[b]
Late spring			
Somasiri *et al.* (2015a)	2011	190[a]	262[b]
	2012	244[a]	329[b]
Summer			
Somasiri *et al.* (2015b)	2012	169[a]	214[b]
	2013	120[a]	221[b]
Early autumn			
Golding *et al.* (2011)	2007	119[a]	247[b]
	2008	56[a]	246[b]
Parker *et al.* (2008)	2008	93[a]	192[b]
Late autumn			
Somasiri (2014)	2012	160[a]	255[b]
	2013	170[a]	208[b]

(2014) observed greater lamb survival of the progeny born to ewe lambs only during the second year of the study (Table 3). The grazing preference for species within the herb and clover mix differs between seasons due to changes in species availability, vertical access and palatability (Cave *et al.* 2015; Somasiri 2014). Consequently sward mixes containing herbs and clover can persist as multi species mixes over at least a 3-year period (Fraser *et al.* 1998; R. Corner-Thomas, unpub. data). There is also evidence to suggest that grazing chicory and plantain can potentially reduce the reliance on anthelmintics and dagging levels in sheep (Marley *et al.* 2003; Niezen *et al.* 1998).

Grazing management

Within pure swards it is well established that grazing chicory or plantain during late autumn and winter has substantial negative effects on yield, plant density and crop persistence (Ayala *et al.* 2011; Li *et al.* 1997). Chicory responds poorly to defoliation below 5 cm (Li *et al.* 1997). These findings are also relevant for the herb and clover mix. Cranston *et al.* (2015) compared the herb and clover mix under sheep grazing with 4 and 8 cm residuals using a 3–4 week grazing interval and no winter grazing. The 8 cm grazing treatment better supported the maintenance of all four species in the herb and clover mix over 2 years. Navarrete *et al.* (2013) found the net herbage accumulation of the herb and clover mix over one growing season under cattle grazing was greater under a 4-week grazing frequency than a 2-week grazing frequency, when grazing to an

Table 3 Effect of grazing ewes on the herb and clover mix (herb mix); containing chicory, plantain, red clover and white clover in comparison with perennial ryegrass and white clover pasture (rye/wc) during late pregnancy and lactation on ewe liveweight and body condition score (BCS) change to weaning and their lambs liveweight gain (g/day) and survival.

Study	Year		Ewe liveweight change to weaning (kg)	Ewe BCS change to weaning	Lamb live-weight gain to weaning (g/day)	Lamb survival to weaning (%)
Kenyon *et al.* (2010)	2007	rye/wc	-9.31	-0.1	242	75.0
		herb mix	-4.02	0.3	238	93.0
Hutton *et al.* (2011)	2008	rye/wc	-16.1	-0.3	205	76.0
		herb mix	-9.9	0.1	253	86.3
Corner-Thomas *et al.* (2014)	2012	rye/wc	5.5	-0.27	333	84.7
		herb mix	21.8	0.67	376	81.3
	2013	rye/wc	1.8	-0.07	248	64.3
		herb mix	12.5	0.81	301	82.0

Liveweight and body condition score change values were calculated for each study
Weaning was defined as the end of the study period (66–75 days after midpoint of lambing period)
The Corner-Thomas study used ewe lambs and not mature ewes

8 cm residual. It is well established that both chicory and red clover yield more and persist better under lax grazing (Brock *et al.* 2003; Li *et al.* 1997) and so the previous results are unsurprising. When managed appropriately sward mixes containing herbs and clover can persist for at least 3 years and up to 5 years under grazing (Fraser *et al.* 1998; R. Corner-Thomas, unpub. data).

Conclusion

The high nutritive value and dry matter production of the herb and clover mix during summer and autumn complements traditional rye/wc that often has poor nutritive value and low production during this time of the year. Furthermore when compared to rye/wc, the herb and clover mix can support greater rates of animal performance particularly during summer and autumn. The herb and clover mix prefers lax grazing (≥8 cm residual) with intervals of 3–4 weeks. Late autumn and winter grazing should be avoided. In conclusion, the herb and clover mix is being used successfully as a high quality perennial pasture option under both sheep and cattle grazing.

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