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Alternative method to measure herbage dry matter mass in plantain and chicory mixed swards grazed by lambs

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Abstract

Calibration equations are available to determine the dry matter (DM) mass of pasture using either sward height or plate meter readings. Currently there are no methods available for determining DM in a herb-clover mix other than using quadrat cuts. The objective of this research was to determine the relationships between herbage DM mass as measured by quadrat cuts vs sward height and plate meter readings for herb-clover mixes during four seasons from early spring to autumn. Pre- and post-grazing herbage DM masses (kg/ha) in the plantain mix (plantain (*Plantago lanceolata*), white clover (*Trifolium repens*) and red clover (*T. pratense*)) and in the chicory mix (plantain, chicory (*Cichorium intybus*), white clover and red clover) were estimated by collecting quadrat cuts. For each quadrat cut, a plate meter reading and five sward height measurements were also recorded. Separate regression equations were then developed for quadrat herbage DM mass vs sward height and plate meter readings. In addition, data from the plantain and Chicory mixes were pooled to obtain a data set for a combined herb-clover mix. The individual R^2 values were significant for all three relationships and ranged from 0.49 to 0.86. The concordance correlation coefficient (CCC) for all three relationships fell between 0.56 and 0.94. The relative prediction error (RPE) for all three relationships varied between 18 and 29%. The regression equations developed by these non destructive methods, would enable farmers to obtain a reliable estimate of the herbage DM mass, with a level of precision sufficient for making day-to-day grazing management decisions on farm. The data do suggest different regression equations need to be utilised for different seasons of the year.

Keywords: herbage DM mass; sward height; plantain mix; chicory mix; herb-clover mix

Introduction

The increased use of pastures based on plantain and chicory has created a demand for a simple and objective method to estimate the herbage dry matter (DM) mass of these pastures. Subjective visual estimations of herbage DM mass or sward height are less precise than objective measures (Frame 1981) and can lead to either an over or under estimation of the true value (Hodgson et al. 1999). The standard objective method used to determine DM mass is quadrat cuts (Hodgson et al. 1999; Sanderson et al. 2001). The method involves cutting pasture, washing, oven drying and weighing of the samples. This method is destructive, time consuming and expensive from a farmer perspective and thus not used on farm (Webby & Pengelly 1986). Therefore, there are clear benefits from alternative non-destructive, objective measures of pasture. Alternative methods for determining herbage DM mass or sward height of ryegrass/white clover swards include the sward stick or the rising plate meter (JENQUIP, Fielding, New Zealand) (Hodgson et al. 1999). The rising plate meter provides an estimate (kg DM/ha) based on the pasture height, density and the species present in the sward (Fulkerson & Slack 1993; Hodgson et al. 1999). The automated sward stick measures the height (cm) of the sward (Frame 1981; Stewart et al. 2001). The calibration equations for both the plate meter and sward stick in ryegrass/white clover pastures are well established (Hodgson et al. 1999). Herb-clover mixes are becoming more common in New Zealand pastures (Kemp et al. 2010). The standard method for measuring herbage DM mass on herb-clover mixes is via the quadrat cuts with no calibration equations existing for either using the plate meter or sward stick for herb-clover mixes.

Therefore, this research has four objectives in respect to the herb-clover mixes;

1. Determine the relationship between herbage DM mass measured by the quadrat cut method and sward surface height measurements using the sward stick.
2. Determine the relationship between herbage DM mass measured by quadrat cut method and plate meter readings.
3. Determine the relationship between sward surface height measurements and plate meter readings.
4. Determine if the above relationships are consistent across four seasons (early spring, late spring & early summer (late spring), summer and autumn).

Materials and methods

This research was carried out in the plantain and the chicory mixes from September 2012 to June 2013 over the seasons of early spring, late spring, summer and autumn. Within each herbage type (plantain mix and Chicory mix) there were three paddocks serving as replicates. Each mob of lambs was rotated among the same three paddocks, when the post-grazing sward surface height reached 7 cm in the plantain and chicory mixes.

Pre- and post-grazing herbage DM masses in the herb-clover mixes were taken using a direct measurement by collecting four quadrat cuts (0.1 m^2) per paddock in each grazing rotation (Brown et al. 2005). The samples were then washed and oven dried in a draught oven at 70^0 C for a minimum of 24 hours. The dry weights were then used to calculate the herbage mass on a DM basis.

Before each quadrat was cut, five sward height readings were recorded using the sward stick (JENQUIP, Fielding, New Zealand). Prior to start, the initial sward stick meter reading was noted and, at the end of the five sward height measurements, the final meter reading was recorded. Then, using these two values, the average sward height of each quadrat was determined. In addition, a single plate meter reading (JENQUIP, Fielding, New Zealand) was recorded for each quadrat cut (Hodgson et al. 1999). Therefore, for each pre- and post-grazing quadrat cut, there were a plate meter reading and a sward height measurement. Hence, at each pre- or post-grazing measurement, 12 plate meter readings (1 plate meter reading x 4 quadrat cuts x 3 paddocks) and 12 sward height measurements (1 sward height measurement x 4 quadrat cuts x 3 paddocks) were obtained for each treatment at each grazing rotation. The total number of plate meter readings and sward height measurements obtained per treatment per grazing season varied by season (early spring, late spring, summer and autumn) depending on the length of the grazing season. The total measurements recorded were 168, 192, 72 and 144 for early spring, late spring, summer and autumn grazing seasons, respectively.

Statistical analysis

The relationships between herbage DM mass and sward height, herbage DM mass and plate meter readings, as well as between sward height and plate meter readings were analyzed within seasons and across seasons for each herbage mix individually, and when both herbage mixes were combined via proc GLM in SAS 9.2 (SAS 2008). Individual prediction equations were developed for the different seasons (early spring, late spring, summer and autumn), assuming that the seasonal effect was greater than the treatment effect. To determine if one ‘combined herb’ equation was suitable for herbage DM mass vs sward height and the plate meter readings, measurements in both plantain and chicory mixes were ‘pooled’.

Concordance correlation coefficient (CCC), relative prediction error (RPE) and coefficient of variation (CV) were used to evaluate the level of prediction of herbage DM mass for a given sward height or plate meter reading. CCC and RPE were calculated as follows.

$$\mathrm{RPE} = (\mathrm{MPE}/\bar{\mathrm{A}}) \times 100$$

$$\mathrm{CCC} = 2\mathrm{S_{AP}}/(\mathrm{S^2{}_A} + \mathrm{S^2{}_P} + (\bar{\mathrm{A}} - \bar{\mathrm{P}})^2$$

where,

$$\mathrm{MPE\ (Mean\ Prediction\ Error)} = \sqrt{\frac{1}{n}\sum_{i=1}^{n} (\mathrm{Ai} - \mathrm{Pi})^2}$$

Ai is the i^{th} observed quadrat cut herbage DM mass value and Pi is the i^{th} predicted herbage DM mass value predicted by using either sward height or plate meter readings. Means are the $\bar{\mathrm{A}}$ and $\bar{\mathrm{P}}$. $S^2{}_A$ and $S^2{}_P$ are the variances and S_{AP} is the covariance of Ai and Pi.

Results

Relationship between quadrat cuts and sward height and plate meter readings

Plantain sward mix

All models tested for herbage DM mass vs sward height across all seasons were significant ($P<0.05$) with R^2 values ranging from 0.49 to 0.74 (Table 1). All models tested for herbage DM mass vs the plate meter readings across all seasons were significant ($P<0.05$) with R^2 values ranging from 0.54 to 0.68. Similarly, all models tested for the relationship between sward height vs the plate meter readings across all seasons were significant ($P<0.05$) with R^2 values ranging from 0.51 to 0.86.

The regression equations for herbage DM mass vs sward height were different ($P<0.05$) for other seasons, except between early spring and late spring. The regression equations for herbage DM mass vs the plate meter readings for early spring and late spring were different ($P<0.05$) from summer and autumn.

Concordance correlation coefficients (CCC) and relative prediction error (RPE) for herbage DM mass vs sward height across all seasons ranged from 0.66 to 0.84 and 20 to 26% respectively. Concordance correlation coefficients (CCC) and RPE for herbage DM mass vs the plate meter readings across all seasons ranged from 0.71 to 0.81 and 18 to 27% respectively. Concordance correlation coefficients (CCC) and RPE for the relationship between sward height vs the plate meter readings across all seasons ranged from 0.84 to 0.94 and 19 to 27% respectively.

Chicory sward mix

All models tested for herbage DM mass vs sward height across all seasons were significant ($P<0.05$) with R^2 values ranging from 0.54 to 0.62 (Table 2). All models tested for herbage DM mass vs the plate meter readings across all seasons were significant ($P<0.05$) with R^2 values ranging from 0.52 to 0.66. Similarly, all models tested for the relationship between sward height vs the plate meter readings across all seasons were significant ($P<0.05$) with R^2 values ranging from 0.57 to 0.81.

Table 1 The relationships between quadrat cut herbage DM mass and sward height and plate meter measurements for the plantain sward mix during four seasons (early spring, late spring, summer and autumn) of the year.

	Early spring	Late spring	Summer	Autumn	Mean
Number of samples (n)	n=168	n=192	n=72	n=144	n=576
Sward height					
[1] Regression (kgDM/ha)	1647.8+124.4x[c]	1609.5+152.6x[c]	1188.1+161.1x[b]	834.3+109.9x[a]	1418.5+129.4x
R^2	0.66	0.49	0.74	0.59	0.50
[2]SE of slope (kgDM/ha)	6.93	11.26	11.54	7.75	5.44
[3] CCC	0.80	0.66	0.84	0.74	0.66
[4]RPE (%)	21	26	23	20	29
Mean (kgDM/ha)	3296.0±54.28	3016.6±57.45	3163.6±86.65	2110.2±36.04	2889.9±35.11
Plate meter					
[5] Regression (kgDM/ha)	1884.7+86.3x[b]	1753.6+107.4x[b]	1204.4+129.9x [a]	843.0+100.3x[a]	1511.1+100.4x
R^2	0.63	0.54	0.61	0.68	0.54
[2]SE of slope (kgDM/ha)	5.09	7.12	12.34	5.78	3.86
[3] CCC	0.78	0.71	0.74	0.81	0.70
[4]RPE (%)	22	25	27	18	28
Mean (kgDM/ha)	3296.0±56.06	3016.6±54.36	3163.6±105.13	2110.2±31.71	2889.9±33.51
Sward height vs Plate meter					
[6] Regression (cm)	2.5+0.66x	2.4+0.58x	2.7+0.63x	2.2+0.74x	2.5+0.65x
R^2	0.86	0.76	0.51	0.77	0.76
[2]SE of slope (cm)	0.02	0.02	0.07	0.03	0.02
[3] CCC	0.87	0.86	0.84	0.94	0.87
[4]RPE (%)	22	27	27	19	28
Mean (cm)	13.2±0.23	9.2±0.18	12.3±0.63	11.6±0.19	11.4±0.13

[1] kgDM/ha = dry matter + slope X average sward height (x)
[2] SE of slope, standard error of slope
[3] CCC = concordance correlation coefficient
[4] RPE = relative prediction error = mean prediction error/mean of the observed values X 100
[5] kgDM/ha = dry matter + slope X average plate meter reading (x)
[6] sward height (cm) = sward height + slope X average plate meter reading (x)
Differing superscripts (a,b) within rows indicate means that were significantly different ($P<0.05$)

The regression equations during early spring, late spring and summer for herbage DM mass vs sward height and also for herbage DM mass vs the plate meter readings were different ($P<0.05$) from the autumn values. The regression equations for the relationship between sward height vs the plate meter readings during early spring, late spring and autumn were different ($P<0.05$) from the summer values.

Concordance correlation coefficients (CCC) and relative prediction error (RPE) for herbage DM mass vs sward height across all seasons ranged from 0.56 to 0.76 and 25 to 27% respectively. Concordance correlation coefficients (CCC) and RPE for herbage DM mass vs the plate meter readings across all seasons ranged from 0.67 to 0.79 and 21 to 26% respectively. Concordance correlation coefficients (CCC) and RPE for the relationship between sward height vs the plate meter readings across all seasons ranged from 0.73 to 0.89 and 24 to 27% respectively.

Combined plantain and chicory mix relationship

All models tested for herbage DM mass vs sward height across all seasons were significant ($P<0.05$) with R^2 values ranging from 0.51 to 0.64 (Table 3). All models tested for herbage DM mass vs the plate meter readings across all seasons were significant ($P<0.05$) with R^2 values ranging from 0.52 to 0.63. Similarly, all models tested for the relationship between sward height vs the plate meter readings across all seasons were significant ($P<0.05$) with R^2 values ranging from 0.55 to 0.83.

The regression equations during early spring, late spring and summer for herbage DM mass vs sward height and also for herbage DM mass vs the plate meter readings were different ($P<0.05$) from the autumn values. The regression equations for the relationship between sward height vs the plate meter readings during early spring and late spring were different ($P<0.05$) from summer, and late spring was different ($P<0.05$) from autumn season.

Concordance correlation coefficients (CCC) and relative prediction error (RPE) for herbage DM mass vs sward height across all seasons ranged from 0.67 to 0.79 and 24 to 27% respectively. Concordance correlation coefficients (CCC) and RPE for herbage DM mass vs the plate meter readings across all seasons ranged from 0.69 to 0.77 and 24 to 29% respectively. Concordance correlation coefficients (CCC) and RPE for the relationship between sward height vs the plate meter readings across all seasons ranged from 0.71 to 0.91 and 23 to 25% respectively.

Table 2 The relationships between quadrat cut herbage DM mass and sward height and plate meter measurements for the chicory sward mix during four seasons (early spring, late spring, summer and autumn) of the year.

	Early spring	Late spring	Summer	Autumn	Mean
Number of samples (n)	n=168	n=192	n=72	n=144	n=576
Sward height					
[1] Regression (kgDM/ha)	1553.3+118.5x [b]	1465.8+142.6x [b]	1534.8+119.1x [b]	814.2+104.6x [a]	1453.8+112.5x
R^2	0.54	0.54	0.56	0.62	0.46
[2]SE of slope (kgDM/ha)	8.53	9.48	12.50	6.89	5.05
[3] CCC	0.70	0.56	0.72	0.76	0.63
[4]RPE (%)	25	25	26	27	30
Mean (kgDM/ha)	3198.9±63.10	2993.5±54.77	3388.7±103.90	2299.8±51.99	2929.4±36.81
Plate meter					
[5] Regression (kgDM/ha)	1677.6+84.2x [b]	1660.2+91.3x [b]	1768.6+72.9x [b]	869.4+76.3x [a]	1561.3+77.7x
R^2	0.52	0.55	0.57	0.66	0.48
[2]SE of slope (kgDM/ha)	6.28	6.04	7.50	4.61	3.36
[3] CCC	0.67	0.71	0.73	0.79	0.65
[4]RPE (%)	21	25	25	26	30
Mean (kgDM/ha)	3198.9±64.32	2993.5±54.65	3388.7±102.68	2299.8±49.16	2929.4±36.16
Sward height vs Plate meter					
[6] Regression (cm)	2.3+0.64x [a]	2.3+0.57x [a]	5.4+0.46x [b]	2.8+0.61x [a]	2.8+0.58x
R^2	0.79	0.81	0.57	0.75	0.75
[2]SE of slope (cm)	0.03	0.02	0.05	0.03	0.01
[3] CCC	0.88	0.89	0.73	0.85	0.85
[4]RPE (%)	24	24	25	27	28
Mean (cm)	13.9±0.26	10.7±0.18	15.6±0.65	14.2±0.32	13.1±0.15

[1]kgDM/ha = dry matter + slope X average sward height (x)
[2]SE of slope, standard error of slope
[3]CCC = concordance correlation coefficient
[4]RPE = relative prediction error = mean prediction error/mean of the observed values X 100
[5]kgDM/ha = dry matter + slope X average plate meter reading (x)
[6]sward height (cm) = sward height + slope X average plate meter reading (x)
Differing superscripts (a,b) within rows indicate means that were significantly different (P<0.05)

Discussion

The aims of this research were to determine the regression relationships between quadrat cut herbage DM mass vs sward height and plate meter readings for the plantain mix and chicory mix and to determine whether the relationships were consistent across seasons.

Across the individual plantain and chicory mixes, and when both were combined, the R^2 for all three relationships; herbage DM mass vs sward height and plate meter readings and the relationship between sward height and plate meter readings were positive (P<0.05) for all four seasons, ranging from 0.49 to 0.86. Webby and Pengelly (1986), using ryegrass/white clover based pastures, obtained R^2 values of 0.23, 0.61 and 0.76 for pre-grazed, post-grazed and pooled data for the relationship between sward height and herbage DM mass, and R^2 values ranging from 0.56-0.76 from winter to autumn. Sanderson et al. (2001) observed an R^2 of 0.31 between herbage DM mass vs plate meter for grass/legume pastures. Piggot (1986) obtained R^2 values of 0.82-0.88 for the relationship between either total or grazeable DM mass vs both sward height and plate meter for ryegrass/white clover pastures. Litherland et al.(2008), with ryegrass-based pastures obtained an R^2 of 0.44 for an annual linear regression equation between herbage DM mass vs sward height and an R^2 of 0.43 for December-January period, 0.41 for March-May period, 0.55 for June-August period and 0.42 for the September-November period. Litherland et al. (2008) also obtained an R^2 of 0.52 for annual linear regression equation between herbage DM mass vs rising plate meter and R^2 values of 0.56, 0.61, and 0.50 for summer, spring and winter for ryegrass-based pastures. The R^2 for all three relationships in the present research was higher than the values obtained by Litherland et al. (2008) but, like Litherland et al. (2008), the values were different for different seasons. For sward height, higher R^2 values were observed during the summer and, for plate meter readings, higher R^2 values were observed during the autumn for all three sward types. The intercept of all regression equations were above 1000 kgDM/ha. The relationships developed by Webby and Pengelly (1986) for the ryegrass/white clover based pastures also started with an intercept of approximately 1000 kgDM/ha. Thus, it is evident that an intercept of zero is impractical due to the errors during measurements and the variations in the field conditions (Sanderson et al. 2001). The presence of multiple species and dead matter in the plantain and chicory mixes may have caused a variation in the DM content and sward height measurements and hence, contribute to the

Table 3 The common relationships between quadrat cut herbage DM mass and sward height and plate meter measurements for herb-clover mix during four seasons (early spring, late spring, summer and autumn) of the year.

	Early spring	Late spring	Summer	Autumn	Mean
Number of samples (n)	n=336	n=384	n=144	n=288	n=1152
Sward height					
[1] Regression (kgDM/ha)	1603.9+121.1x [b]	1569.8+144.0x [b]	1396.7+135.1x [b]	854.0+104.7x [a]	1460.1+118.4x
R^2	0.59	0.51	0.64	0.61	0.47
[2]SE of slope (kgDM/ha)	5.48	7.29	8.56	4.94	3.69
[3] CCC	0.75	0.67	0.79	0.76	0.64
[4]RPE (%)	27	26	25	24	30
Mean (kgDM/ha)	3247.5±41.79	3005.1±40.08	3276.1±69.23	2205.0±31.63	2909.6±25.59
Plate meter					
[5] Regression (kgDM/ha)	1794.6+84.4x [b]	1752.4+95.0x [b]	1716.1+83.7x [b]	1019.8+75.50x [a]	1596.7+83.8x
R^2	0.57	0.52	0.53	0.63	0.49
[2]SE of slope (kgDM/ha)	4.03	4.63	6.59	3.41	2.53
[3] CCC	0.72	0.69	0.69	0.77	0.66
[4]RPE (%)	24	26	29	24	27
Mean (kgDM/ha)	3247.5±43.13	3005.1±39.33	3276.1±78.63	2205.0±30.77	2909.6±25.20
Sward height vs Plate meter					
[6] Regression (cm)	2.4+0.65x [ab]	2.4+0.58x [a]	4.5+0.50x [c]	3.3+0.61x [bc]	2.8+0.60x
R^2	0.83	0.79	0.55	0.75	0.75
[2]SE of slope (cm)	0.02	0.02	0.04	0.02	0.01
[3] CCC	0.91	0.88	0.71	0.86	0.86
[4]RPE (%)	23	25	25	25	25
Mean (cm)	13.6±0.17	10.0±0.13	13.9±0.45	12.9±0.19	12.2±0.10

[1]kgDM/ha = dry matter + slope X average sward height (x)
[2]SE of slope, standard error of slope
[3]CCC = concordance correlation coefficient
[4]RPE = relative prediction error = mean prediction error/mean of the observed values X 100
[5]kgDM/ha = dry matter + slope X average plate meter reading (x)
[6]sward height (cm) = sward height + slope X average plate meter reading (x)
Differing superscripts (a,b) within rows indicate means that were significantly different ($P<0.05$)

variation in the linear regression intercepts and R^2 values across seasons. The percent of dead matter in the plantain and chicory mixes varied from 6-16% from spring to autumn with higher proportions in the summer in the present research.

The concordance correlation coefficient (CCC) (Lin 1989) for all three relationships fell between 0.56 and 0.94 in the present research. If CCC is equal to '1', that means the prediction is a perfect positive agreement. Any CCC value above 0.60 has been considered as a substantial prediction (Fuentes-Pila et al. 1996; Visser et al. 2012). The relative prediction error (RPE) is the variation in the mean prediction error as a percentage of the herbage DM mass. The coefficient of variation (CV) is a measure of the variation in the error rates as a percentage of mean herbage DM mass. Both RPE and CV ranged from 18% and 29%. Any RPE value above 20% has been considered as a poor prediction (Fuentes-Pila et al, 1996). A generally acceptable CV range for pastures is 15-20% (Fulkerson & Slack 1993; Hodgson et al. 1999; Sanderson et al. 2001). The relatively high error rates in the present research indicate variability in the data set used (Gabriels & Berg 1993). Piggot (1986) obtained CVs in the range of 15-19% for total or grazeable DM mass vs sward height and plate meter for ryegrass/white clover pastures. Murphy et al. (1995) obtained CV of 27% and 28% for the relationship between bluegrass (*Poa pratensis* L.)/white clover pastures pre-grazing herbage DM mass vs sward height and plate meter respectively. Sanderson et al. (2001) observed 26% RPE and CV for grass/legume pasture herbage DM mass vs plate meter equations. The plate meter was designed for ryegrass/white clover pastures (Sanderson et al. 2001) which might explain the higher CV in the herb-clover DM mass estimations as the actual weight of the plate meter may not be appropriate (Murphy et al, 1995). The relatively high RPE and CV in the regression equations for sward height could be due to the presence of seed head, stem materials and the variable heights of the multiple species within each sward type in this research (Webby & Pengelly 1986). The presence of dead matter, uneven ground, seasonal variation, treading damage and human error are known to contribute to the variation in equations such as these (Hodgson et al. 1999; Murphy et al. 1995; Sanderson et al. 2001). The overall strength of regression equations are also dependant on the number of readings recorded with increased measurements increasing precision (Fulkerson & Slack 1993). The data set used in the present research consisted of both pre- and post grazing measurements with 288 pre- and 288 post-grazing measurements for each sward type. Therefore, the present herbage DM mass predictions using either sward heights or plate meter readings could be reasonable with a level of precision adequate to make satisfactory day-to-day grazing management decisions related to herb-clover mixes on farm. If this data set is combined with that of future studies, further precision in the regression equations should occur.

The regression equations developed for herbage DM mass vs sward height in the plantain mix were similar between early and late spring, but different from both summer and autumn which also differed from each other. While the regression equations for herbage DM mass vs plate meter in the plantain mix were similar during early and late spring, and during summer and autumn. However, the regression equations for summer and autumn differed from early and late springs. In contrast, in both the chicory and the combined herb-clover mixes, the regression equations for the above relationships during early and late springs and summer did not differ but all were different from the autumn season. This variation indicates that farmers should consider utilising different equations for different seasons of the year for accurate estimates of herbage DM mass in herb-clover mixes, with the proviso that they can readily judge the appropriate time to change equations.

Conclusion

The results of this research indicate that herbage DM mass of plantain and chicory mixes can be estimated using either the sward height or plate meter readings. The regression equations developed in the present research by these non-destructive methods would enable farmers to obtain a reliable estimate of the herbage DM mass, with a level of precision sufficient for making daily decisions related to grazing management on farm. The data suggest different regression equations need to be utilised for different seasons of the year. Hence, farmers need be able to judge the appropriate time to change equations.

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Utilising a plantain, red clover and white clover mix - A farmer's perspective

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Cheltenham Downs – brief background and farm description

Cheltenham Downs is located in the Manawatu district of the North Island of New Zealand. The farm was purchased by Landcorp in early 2011. It has a total area of 1427 ha, of which 1237 ha are effective. The farm is primarily utilised as a lamb-finishing enterprise. The property is located in a relatively summer safe area, with a mix of soil types (Rangitikei Sandy Loam and Milton, Te Arakure, Halcombe, Kiwitea, Ohakea, Milson and Manawatu Silt Loams) and has a flat to easy contour. The average rainfall is 1150mm per annum, evenly spread throughout the year. The majority of the farm is in ryegrass-white clover-based pastures. Each year, on average, 100 ha of Hunter brassica and 40 ha of kale are planted. Currently, the farm has 144 ha of the plantain, red clover and white clover mix.

The current management policy includes; finishing lambs (approximately 37,000 lambs in 2014); a ewe breeding flock (of approximately 2000 ewes); growing 3000 ewe lambs for replacements and for sale; trading cattle (approximately 800); dairy heifer grazing (1200 calves from December to May, and then retaining 800 through to the following May).

Lambs are purchased in at an average live weight of 26-27 kg, with a range of 24 to 30 kg. The aim is to slaughter winter lambs at an average carcass weights of 20kg and new season lambs at 18 kg. The aim is to achieve an average 120 g/d live weight gain in the winter lambs and 250 g/d in the new season lambs. Cheltenham Downs has a flexible slaughter schedule and will kill down to lighter live weights in a bad season, or will increase numbers if the opportunity arises in a good season.

Why switch from finishing lambs on ryegrass white clover to a plantain-clover mix?

There were a number of reasons considered for changing from a system based on ryegrass- white clover to a herb based option; these included:

i) to achieve faster individual carcass weight gains
ii) to allow for a higher stocking rate and thus greater carcass gains per hectare
iii) to allow for a faster turnover of lambs.

However, the aim was not to increase individual carcass weights of lambs at slaughter. To achieve the above three goals, a plantain-clover mix was suggested by the Landcorp agronomist. The farmer had heard of this option as a potential mix to increase lamb performance by others in the industry although the manager had no experience with it himself. He had in the past tried a ryegrass, white clover and plantain mix with little success.

Once convinced to try the plantain-clover mix, the decision was made to plant enough area (50 ha) to allow for a significant number of lambs to remain on the mix until slaughter. This would allow for a true comparison of performance of lambs on a plantain-clover mix with those on ryegrass white clover mix. Subsequently, it was found that on average lamb growth rates are 100 – 150 g/d higher on the plantain-clover mix than on the ryegrass-white clover sward. In addition, dressing-out percentages are generally higher with the plantain-clover mix, allowing for a greater carcass weight for a given live weight. A further advantage observed is that the plantain-clover mix results in consistent and predictable animal performance, improving the planning for stock buying and selling.

Management of the plantain-clover mix

The plantain-clover mix used consists of 8 kg of plantain (Tonic), 5 kg of red clover (Sensation) and 3 kg of white clover (Tribute). It is sown in the October/November period following a full cultivation and is planted with a roller drill. Currently, the farm has a mix of one- and two-year old swards, with a total area of 144 ha. The plantain-clover mix is grazed year-round. Once a year, the sward mix is mechanically topped in October, as this has been found to be a period of prolific seed heading. Although seeding still occurs year-round, it has been observed that the lambs struggle to control and consume the seed head in late spring.

Management of the plantain-clover mix to ensure high performance

The stocking rate of finishing lambs varies throughout the year with an average of 35 lambs per ha. The stocking rate is lowest in winter, at 16 to 20 lambs per ha and peaks in late spring/summer at 40 lambs per ha. Through experience, the manager has found that it is better to have a slightly lower stocking rate than what could be possible, allowing for greater per animal performance. While many guidelines suggest post grazing heights can be to 'a squashed beer

Table 1 Herbage quality test results for the plantain, red clover and white clover mix.

	September 2013	November 2013	January 2014
Neutral detergent fibre (% DM)	22.3	32.0	34.5
Digestibility of Organic Matter in Dry Matter (%)	76.0	68.0	65.7
Crude protein (% DM)	20.0	21.0	20.1
Metabolisable energy (ME/kg DM)	12.1	11.0	10.5

Average value for each given month. Data from Hill Laboratories, Hamilton, New Zealand.

can height' it is actually better to have slightly higher post grazing height. The manager utilises a post-grazing height rule of 'coffee mug height'. He feels that this higher post grazing height ensures lamb intake is not limited. Further, he believes grazing too low is bad from a plant perspective, in terms of both persistence and herbage regrowth. Pre-grazing heights are between 15 and 30 cm. The plantain-clover mix is rotationally grazed. The aim for this plantain-clover mix is to achieve a persistency of five years before renewal. He believes that maintaining suitable post grazing heights is the key to this.

When lambs arrive on the farm, they are given appropriate animal remedies (i.e. drench) and then are placed straight onto the plantain-clover mix where they remain until slaughter. They have noticed no ill-health effects in lambs from grazing the plantain-clover mix. It is important that urea is applied twice a year at a rate of 80 kg per ha in spring and in autumn. A maintenance level of fertiliser is also applied once a year.

Monitoring lambs on the plantain-clover mix is an important management tool

A sub-set of lambs are electronically tagged and their performance is monitored. The monitoring is linked with FarmIQ. Three to four times a year, herbage samples are sent for laboratory quality assessment (Table 1). It is felt that this is important management practice, as it helps with the understanding of animal performance. In addition, herbage exclusion cages are used to estimate monthly herbage production (Figure 1) which assists in the planning of rotation lengths and for the buying and selling of lambs. The aim is for the plantain-clover mix to yield 12 – 17t DM per year.

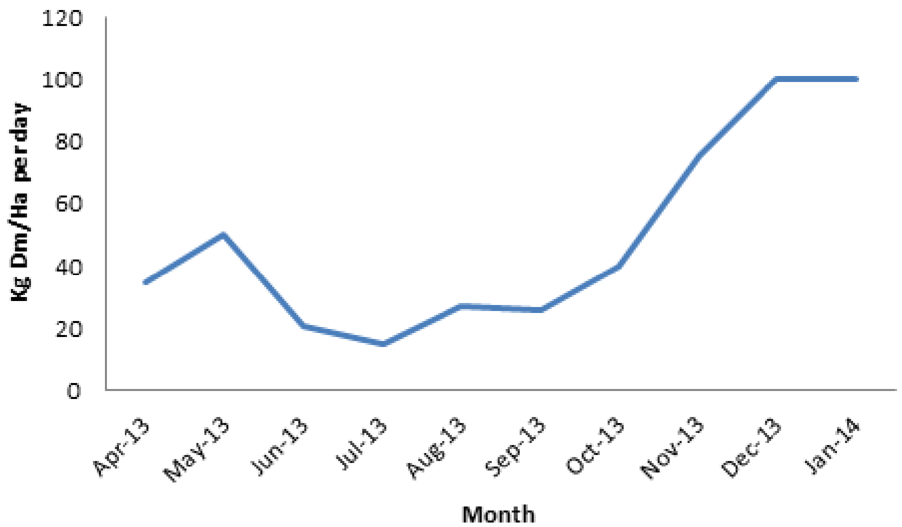
Other uses for the plantain-clover mix

The tail-end dairy heifers are grazed on the plantain-clover mix to increase daily live weight gains allowing them to catch up to target live weights. Ewes are not set stocked on the plantain-clover mix, but twin- and triplet-rearing mobs will be introduced as soon as lambing is finished and rotated through the mix. The aim is to improve weaning weights of lambs and ewes.

Disadvantages of the plantain-clover mix

The main issue that has been encountered is the control of weed species including grasses. This has generally been controlled by spraying with 'Dictate' (bentazone) in spring to control weed species, and 'Sequence' (clethodim) to control grasses, although the later

Figure 1 Average monthly herbage production (kg DM/ha) for the plantain, red clover and white clover mix (Plantain mix). Data collected via exclusion cages.



does have a withholding period which requires careful management. They have found that some paddocks have had a high pennyroyal infestation, and these have required control using ‘Kamba’ (dicamba). However, a side- effect of this spray is that it has killed the clover in the plantain-clover mix, and has resulted in paddocks that are plantain only. These paddocks display lower animal performance than those which have clover. It is planned that clover will be re-introduced into these paddocks at a later date.

Future planning

At this stage, it is intended to keep the plantain-clover area at about the same size. This is due to the risk of removing more area for cultivation in the summer period resulting in areas being taken out of production and thus requiring de-stocking. A risk of increasing the area in plantain-clover is the requirement to procure more lambs in the peak lamb finishing season, to meet the extra herbage production, at a period when schedule prices are not favourable. It is believed that 10% of the total farm area in the plantain-clover mix fits the system best.

Conclusion

On Cheltenham Downs, the use of a plantain, red clover and white clover mix has been found to be a successful herbage mix for finishing lambs. The farm has only been utilising this mix for two years, and during that time has developed its own management guidelines to ensure high performance. While the mix has been very successful, it does have its own challenges, such as weed infestation which requires precise management. Given the appropriate grazing and weed control management, results to date suggest that the plantain, red clover and white clover mix has the potential to persist for at least five years.