Project AS10796 Calibration of pasture meters to estimate the top leafy stratum on offer for ryegrass pastures

Final report

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Summary

The first aim of this project was to develop calibration equations for ryegrass to estimate the top leafy stratum (TLS) and the bottom stemmy stratum (BSS) on offer for three pasture meters on-farm: raising plate meter (RPM), ruler and PUP (proportion of un-grazed pasture) grazing ruler. The calibration equations can then be used to estimate TLS, BSS and total pasture on offer from pasture height measured with any of the pasture meters. This was done by taking 15 pasture samples per month in two farms located in southeast Queensland during June, August and October 2018. A total of 90 samples provided the data for the calibration equations. Each pasture meter was used to measure pasture height or plant part length before the TLS and the BSS were cut from each pasture sample to calculate the TLS and BSS on offer. Regression analysis was used to establish the relationship between pasture height or plant part length and the TLS and BSS on offer. The results indicated that calculated calibration equations were not significantly different between farms but there were significant differences between months. Therefore, equations were calculated for individual months, which provided accurate estimates of pasture on offer for all pasture meters. Accuracy of the predictions was higher for the TLS than for the BSS and total pasture on offer. The average error for the estimation of the TLS, BSS and total pasture on offer was 17.0 and 21.1 respectively across all pasture meters. The second aim of the project was to calculate the number of observations required to obtain representative averages of pasture on offer on-farm. This was done by measuring the variability of pasture height across transects in grazing strips of approximately 1 ha. Power analysis was used to calculate the required number of observations. The results indicated that the number of observations to obtain the same level of confidence varied between pasture meters, the level of variability of pasture height and the required level of accuracy of the estimates. For example, the average coefficient of variability found in this project for pasture surface height measured with a ruler, pasture height using RPM, leaf extended length using the PUP ruler and stem length using the PUP ruler was 21.3, 23.2, 25.1 and 48.3%. This means that the number of observations required to have 95% confidence of the average height/length being within 10% of the true mean was 20, 31, 23 and 93 observations within pasture strips of approximately 1 ha. The third aim of this project was to establish the relationship between pasture height and the nutritive value of the plant material in the TLS and BSS. This was not only done for the ryegrass samples collected through this project but also for kikuyu samples collected during the summer 2017-2018 as part of the initial project AS10796. There was a significant interaction between pasture height, farm and month for the nutritive value of both strata and both species. This indicates that the nutritive value of the plant material was driven by complex interaction between all factors. The direction of the change in nutritive value of both species as a result of pasture height was not consistent within farm, month or strata. However, nutritive value was consistently higher for the TLS in comparison with the BSS for both species particularly for kikuyu.

Protocols for the use of each pasture meter were developed based on the results of this project. Additionally, conclusions on the grazing management of ryegrass pastures were drawn based on the observed changes in pasture structure with increased pasture height.

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1 Introduction

The DAF dairy team have recently demonstrated that dairy cows can achieve high levels of pasture intake only when grazing the top leafy stratum of pastures (Ison *et al.*, 2019). Pasture intake and milk production decreased when cows were forced to graze the bottom stemmy stratum of pastures. These results indicate that high levels of pasture intake can be achieved if pasture allocations are calculated based on the top leafy stratum on offer rather than from the total pasture on offer, as the lower stratum is of low quality, ultimately reducing milk production.

The pasture meters currently used by industry such as the raising plate meter are calibrated to provide an estimate of the total pasture on offer rather than the top leafy stratum on offer. Therefore, there is a need to develop calibration equations to estimate the top leafy stratum on offer for ryegrass. Preliminary data collected at Gatton Research Dairy indicates that there is a significant relationship between total pasture height or the depth of the top leafy stratum and the top leafy stratum on offer. Therefore, it is highly likely that robust calibration equations can be developed under farm conditions.

The project will deliver calibration equations for different pasture meters for ryegrass under farm conditions. This will allow the farmers to calculate pasture allocations that result in higher levels of pasture intake and milk production from ryegrass pastures.

2 Objectives

The objectives of this project were to:

- Develop calibration equations for ryegrass pastures to estimate top leafy stratum and bottom stemmy stratum on offer for pasture meters. Farmers can then use these equations to estimate pasture on offer using the average pasture height within grazing strips measured with any of the pasture meters.
- Calculate the number of observations required to obtain representative averages of the pasture height and pasture on offer within grazing strips. This was done by quantifying the variability in pasture height within grazing strips of ryegrass.
- Put together protocols for the use of each pasture meters based on the results of this project.
- Draw conclusions on the grazing management of ryegrass pastures based on the changes observed in plant structure with increasing pasture heights.
- Determine the relationship between pasture height and the nutritive value of both strata. This was done for ryegrass using the samples of this project but also for kikuyu using the samples from the initial project AS10796.

3 Methodology

3.1 Location, pasture management and sampling dates

The project was conducted during the 2018 ryegrass season in two dairy farms located in southeast Queensland. Farm A and B were located in Glenore Grove (Latitude 27° 30′ 59.66″ S and Longitude 152° 26′ 0.57″ E) and Wilsons Plains (Latitude 27° 50′ 22.12″ S and Longitude 152° 38′ 36.44″ E). In both farms the ryegrass pastures were regularly irrigated, fertilized and grazed following industry standards. These pastures were well established ryegrass pastures that were over sown over kikuyu in April 2018. The ryegrass varieties used in farms A and B were Tetila (diploid) and Speedy (tetraploid).

The pastures were sampled three times during the ryegrass season: 26 June, 14 August and 9 October 2018 for Farm A and 29 June, 20 August and 23 October 2018. All samples were collected from pasture strips of about 1 ha that were about to be grazed. Fifteen samples of a range of pasture heights were taken per farm per month. Therefore, a total of 90 pasture samples (2 farms x 3 months x 15 samples per month) were collected and the data used for the calibration equations of the pasture meters.

In order to assess the variability of the data pasture height was measured along two transects of 100 m within the grazing strips per farm per month. Therefore, the data from a total of 12 transects (2 farms x 3 months x 2 transects per month) were collected and used to calculate the number of observations required to obtain representative averages of pasture heights and pasture on offer on-farm.

The same pasture sampling procedure was used to collect the kikuyu samples in the initial project AS10796. Samples were collected on 9 January, 14 February and 20 March 2018 from Farm A and on 11 January, 12 February and 22 March 2018 from farm B. See details in the final report at http://dairyinfo.biz/technical-information/feedbase-nutrition/grazing-management/

3.2 Pasture sampling procedure

The pasture sampling procedure for each pasture sample consisted of six steps:

3.2.1 Step 1: Pasture height measurements using a ruler

A 50 x 50 cm quadrant was used to sample the pastures. A ruler was used to measure eight tillers within the quadrant. The tillers were carefully chosen so that four of them represented tall tillers within the quadrants (exceptionally tall and rare tillers were avoided). The second group of tillers represented the average height of all tillers present within the quadrant (medium height tillers).

Each of the tillers were measured for non-extended tiller height, extended tiller height and stem height. Stem height was defined as the height above ground to the base of the lamina (ligula) of the top fully expanded leaf (Image 1). These measurements were used to calculate:

-Pasture surface height (cm) as the average of the 4 tall tillers

-Stem height (cm) as the average stem height of all tillers (4 medium height tillers and 4 tall tillers)

-Extended leaf length (cm) as the difference between extended tiller height and stem height of each tiller

-Non-extended leaf length (cm) as the difference between non-extended tiller height and stem height of each tiller

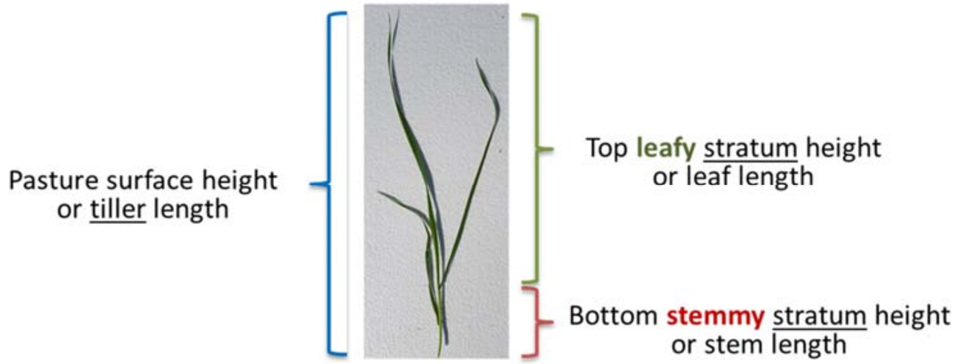
-Extended leaf length (cm) as the average of the extended leaf length of the four tall tillers only

-Non-extended leaf length (cm) as the average of the non-extended leaf length of the four tall tillers only

-Top leafy stratum height (cm) as the average of the non-extended leaf length of the four tall tillers only

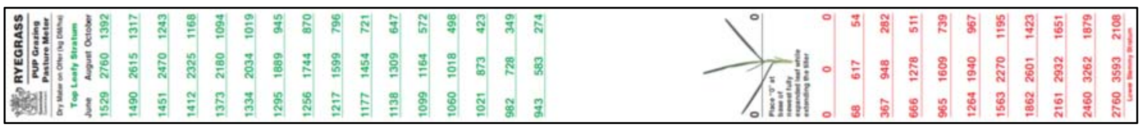
-Bottom stemmy stratum height (cm) as the average stem height of the four tall tillers only

Image 1 –Tiller, strata and pasture height or length.



This data was then used to develop calibration equations for both a common ruler based on pasture surface height, as well as the PUP grazing ruler based on length of plant parts (Image 2).

Image 2 –PUP grazing ruler built using the results from this project.



3.2.2 Step 2: Pasture height measurements using raising plate meters

Both the traditional square raising plate meter (RPM) and the Farmworks F300 RPM were used to measure pasture height inside the 50 x 50 cm quadrant. The dimensions of the plate of the square RPM were 31.5 x 31.5 cm. The diameter of the plate of the Farmworks F300 RPM was 36 cm. The weight of the plate was 400 and 700 g for the square and the Farmworks F300 RPMs respectively.

3.2.3 Step 3: Top leaf stratum cut

The top leafy stratum was cut within the 50 x 50 cm quadrant at the average stem height calculated in step 1 (Image 3). This was the average stem height of the medium and tall tillers within the quadrant. This stem height was chosen because previous data collected at the Gatton Research Dairy from the animal demonstration trial conducted in early 2016 showed that cows grazed at this height irrespective of pre-grazing pasture height (Figure 1 and Image 4). Samples were then dried at 60º C to calculate:

-<u>Top leafy stratum on offer</u> (kg DM/ha)

This data was then used to develop calibration equations for all pasture meters. Samples were sent to the DairyOne lab for analysis.

Image 3 –Top and bottom strata partially cut within the 50 x 50 cm quadrant used for pasture cuts. The top leafy stratum was cut at the average stem height of the medium and tall tillers within the quadrant. This is the height cows selectively graze the top leafy stratum (see Figure 1 and Image 4 below).

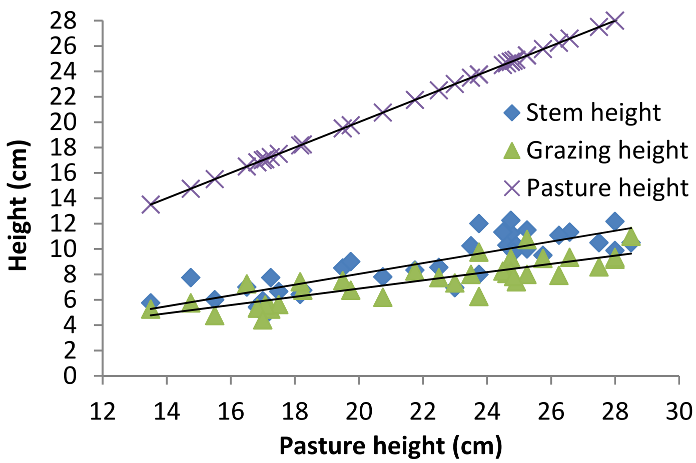


Figure 1 – Kikuyu pastures grazed at Gatton Research Dairy in March 2016. Stem height was calculated as the average of medium and tall tillers.

Image 4 –Grazing of the top leafy stratum (left) and bottom stemmy stratum (right). High levels of pasture intake are achieved when grazing the top leafy stratum because of the large bites and thus high intake rates. Pasture intake is low when grazing the bottom stemmy stratum because of the small bites and thus low intake rate.

3.2.4 Step 4: Bottom stemmy stratum cut

The bottom stemmy stratum was cut at 5 cm within the same 50 x 50 cm quadrant used to cut the top leafy stratum (Image 3). Samples were then dried at 60◦C to calculate:

-<u>Bottom stemmy stratum</u> on offer (kg DM/ha)

These data were then used to develop calibration equations for all pasture meters. Samples were sent to the DairyOne lab for analysis.

3.2.5 Step 5: Tiller samples

A 10 x 15 cm quadrant was used to cut all tillers within this quadrant at the ground level. This quadrant was located next to the 50 x 50 cm quadrant used in steps 1 to 4. All tillers were taken to the lab and counted. Also, a subset of 36 tillers were measured for non-extended tiller height, extended tiller height, stem height and number of fully expanded leaves (Image 1).

Tillers were then separated in 11 extended tiller height categories with increments of 5 cm between categories and heights ranging from 5 to 60 cm (Image 5). The tillers were then dried at 60º C to calculate the average dry mater weight per tiller for each height category.

Image 5 –Tillers separated in extended tiller height categories from left to right: 10 to 15, 15 to 20, 20 to 25, 25 to 30, 30 to 35, 35 to 40, 40 to 45, 45 to 50, 50 to 55 and 55 to 60 cm.

3.2.6 Step 6: Light interception

A photosynthetic active radiation (PAR) meter (Apogee Quantum Flux, Model MQ-301) was used at 12 pm to measure PAR at 5 cm above ground inside the canopy in a representative area next to the 50 x 50 cm cuts done in steps 3 and 4. PAR was also measured above the canopy in full sun to calculate:

- Light interception (% of PAR above the canopy) at 5 cm above ground, as the difference in the PAR above the canopy minus the PAR inside the canopy divided by the PAR above the canopy times 100.

3.3 Transect sampling procedure

Pasture measurements were recorded every second step in two diagonal 100 m transects in strips ready to be grazed in both farms for each of the three months. Pasture measurements included non-extended tiller height, extended tiller height and stem height of tall tillers and RPM height.

3.4 Statistical analysis

All variables were analysed in GenStat (2016). Regression analysis was used to develop the calibration equations for the pasture meters. For each equation the form of the regression model was chosen by considering both the degree of fit and the biological expectation. Exponential, asymptotic and lineal models were assessed.

Power analysis was used to calculate the number of pasture height measurements required to obtain representative averages of the pasture strips using transect data. The number of observations were calculated to have 95% confidence of the estimated mean being within the 10, 5, 2 and 1% of the true mean.

4 Results and discussion

4.1 Pasture structure and light interception

The height of both the top leafy stratum and the bottom stemmy stratum increased with pasture height (Figure 2). However, while this increase was exponential for the bottom stemmy stratum, it was asymptotic for the top leafy stratum. This means that there was a similar increase in height of both strata for pasture heights ranging from 8 to 30 cm. However, for pastures taller than 30 cm the rate of increase in the height of the stemmy stratum was much greater than the leafy stratum reaching heights of up to 38 and 25 cm respectively (Figure 2). This rapid increase in stem elongation in pastures taller than 30 cm seemed to be triggered by canopy closure as shown in Figure 2. Figure 2 shows that light interception at 5 cm in pastures taller than 30 cm was closed to 100% indicating full canopy closure.

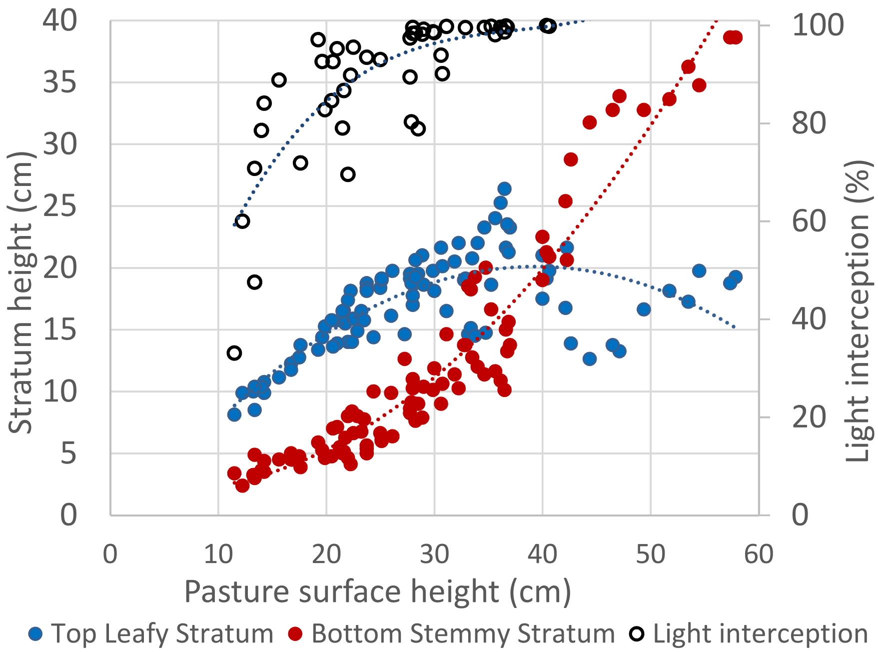


Figure 2 –The relationship between stratum height and pasture surface height measured with a ruler. N = 90 including both farms, 3 months and 15 observations per month.

4.2 Calibration equations for pasture meters

The calibration equations to estimate top leaf stratum and bottom stemmy stratum on offer for all pasture meters are included in Table 1. The equations were not significantly different between farms but there were significant differences between months ($P < 0.001$). Therefore, individual equations for each month (including both farms) are shown in Table 1.

There were significant lineal relationships ($P < 0.001$) between pasture height, measured with the ruler or RPM, and top leaf stratum, bottom stemmy stratum and total pasture on offer for all months (Table 1).

The average difference in pasture height between the square RPM and the Jenquip RPM was insignificant (0.4 cm difference). Therefore, the calibration equations are applicable to either RPM. However, the average difference in pasture height between the RPM and the Farmworks F300 RPM was 1.2 cm. Therefore, a separate equations was developed for this RPM (Table 1).

The calibration equations for the ruler and the PUP grazing ruler included in Table 1 are based on the dimensions of tall tillers. This is because tall tillers are easy to find in the sward and provided accurate estimates of pasture on offer with R^2 greater than 0.86 for the top leafy stratum ($P < 0.001$) (Table 1). Short and medium height tillers provided similar levels of accuracy but they are harder to sample as they are found deeper into the sward.

The extended leaf length provided greater accuracy than the non-extended leaf length for the estimation of the top leafy stratum on offer (R^2 0.86 vs 0.68) (Table 1). Therefore, the extended leaf length was used to develop the PUP ruler (see section 5.2 below).

Table 1 –Calibration equations for individual months for the ruler (X1), raising plate meters (X2 and X3), and PUP grazing ruler (X5, X6, X7) to estimate top leafy stratum (Y1) and bottom stemmy stratum (Y2). N = 30 including both farms and 15 samples per month. Y = A + B x X.

X	Y	Month	Coefficients		Error (%)	R^2	P
			A	B			
X1	Y1	June	499	32.24	18	0.94	<0.001
		August	-646	91.52			
		October	56	17.03			
X1	Y2	June	-911	48.6	24	0.88	<0.001
		August	-2184	130.7			
		October	-2413	104.6			
X2	Y1	June	686	50.81	17	0.84	<0.001
		August	-48	129.91			
		October	123	34.91			
X2	Y2	June	-587	73.3	24	0.86	<0.001
		August	-1369	188.7			
		October	-846	115.7			
X3	Y1	June	643	52.8	17	0.84	<0.001
		August	-64	115.1			
		October	305	17.77			
X3	Y2	June	-626	74.6	21	0.88	<0.001
		August	-1381	166.4			
		October	-984	114			
X5	Y1	June	358	53.5	28	0.68	<0.001
		August	-1030	167.7			
		October	411	16.2			
X6	Y1	June	356	34.96	16	0.86	<0.001
		August	-510	72.33			
		October	88	21.58			
X7	Y2	June	-522	113.2	15	0.95	<0.001
		August	-1021	230.3			
		October	-690	107.1			

X1 Pasture surface height using ruler on tall tillers (cm)
X2 Pasture height using the Farmwork F300 RPM (cm)
X3 Pasture height using the traditional square RPM or Jenquip RPM (cm)
X5 Leaf non-extended length of tall tillers (cm)
X6 Leaf extended length of tall tillers (cm)
X7 Stem length of tall tillers (cm)
Y1 Top leafy stratum on offer (kgDM/ha)
Y2 Bottom stemmy stratum on offer (kgDM/ha)

4.3 Number of pasture height observations for representative estimates of pasture on offer

The number of observations to obtain representative estimates of the pasture on offer (for leaves or stems) depends on the variability of pasture height data and the desired level of representability of estimates (Figure 3).

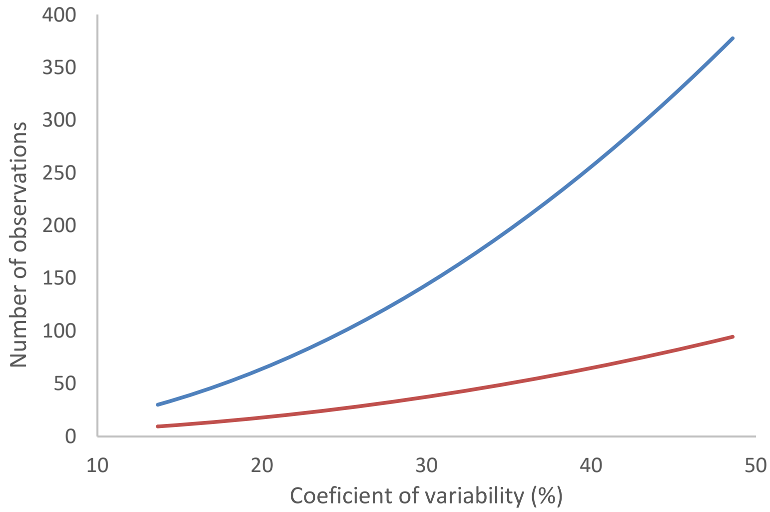


Figure 3 –The relationship between the level of variability and the number of observations required to have 95% confidence of the average pasture height to be within 5 or 10% of the true mean (blue and red lines respectively).

Table 2 shows the average variability found for pasture height measurements along two transects of 100 m in strips ready to be grazed in both farms and the three months. The average coefficient of variability for pasture surface height measured with a ruler, pasture height using RPM, leaf extended length using the PUP ruler and stem length using the PUP ruler was 21.3, 27.3, 21.3 and 48.3% respectively (Table 2). This means that the number of observations required to have 95% confidence of the average height/length being within 10% of the true mean was 20, 31, 20 and 93 observations within pasture strips of approximately 1 ha.

Table 2 –Number of observations required to have 95% confidence of the average height/length being within the nominated percentages of the true mean for pasture strips of approximately 1 ha. This is indicated for the average pasture variability observed in this project for individual transects.

	Average (cm)	CV (%)	Number of observation to be within 10%	5%	2%	1%
Pasture surface height using ruler	26.7	21.3	20	73	453	1813
Pasture height using RPM	14.3	27.3	31	119	744	2976
Leaf extended length using PUP ruler	28.6	21.3	20	72	452	1809
Leaf non-extended length using PUP ruler	15.7	25.1	26	101	632	2530
Stem height using PUP ruler	11.0	48.3	93	373	2334	9337

5 Protocols for the use of pasture meters

The differences observed between months for the relationship between pasture height and pasture on offer indicates that a single calibration equation should not be used for all months if accurate estimates of pasture on offer are required. This applies to all pasture meters. It is also recommended that these calibration equations should be validated in other regions and across years. For maximum accuracy, each farmer should validate these equations on their own farms.

The following protocols were developed using the data collected from this project:

5.1 RPM protocol

Walk a transect of 100 m for strips ready to be grazed.

Take a minimum of 30 height measurements along the transect. Depending on the level of pasture height variability a larger number of observations may be necessary if greater accuracy of the estimates are required.

Calculate the average pasture height for the strip.

Use the average pasture height to estimate leaf and stem on offer from values shown in Table 3 or from the equations for individual months shown in Table 1.

Table 3 –Pasture on offer for ryegrass pastures of different heights measured with raising plate meters (RPMs).

RPM height (cm)	Top leafy stratum on offer (kg DM/ha)			Bottom stemmy stratum on offer (kg DM/ha)		
	Jun	Aug	Oct	Jun	Aug	Oct
Farmworks F300 RPM						
5	940	602	298	0	0	0
10	1194	1251	472	146	518	311
15	1448	1901	647	513	1462	890
20	1702	2550	821	879	2405	1468
25	1956	3200	996	1246	3349	2047
30		3849	1170		4292	2625
35			1345			3204
40						3782
Square RPM or Jenquip RPM						
5	907	512	394	0	0	0
10	1171	1087	483	120	283	156
15	1435	1663	572	493	1115	726
20	1699	2238	660	866	1947	1296
25	1963	2814	749	1239	2779	1866
30		3389	838		3611	2436
35			927		4443	3006
40			1016			3576

5.2 Ruler protocol

Walk a transect of 100 m for strips ready to be grazed.

Take a minimum of 20 height measurements along the transect. Measure the non-extended height of the tall tillers avoiding the exceptionally tall and rare tillers as shown in image 6. Depending on the level of pasture height variability a larger number of observations may be necessary if greater accuracy of the estimates are required.

Calculate the average pasture height for the strip.

Use the average pasture height to estimate leaf and stem pasture on offer from values shown in Table 4 or from the equations for individual months shown in Table 1.

Image 6 –When using a ruler or the PUP grazing ruler measure tall tillers like the one being selected in this image.

Table 4 –Pasture on offer for ryegrass pastures of different surface heights measured with a ruler.

Pasture surface height (cm)	Top leafy stratum on offer (kg DM/ha)			Bottom stemmy stratum on offer (kg DM/ha)		
	Jun	Aug	Oct	Jun	Aug	Oct
10	821	269	226	0	0	0
15	983	727	311	0	0	0
20	1144	1184	397	61	430	0
25	1305	1642	482	304	1084	202
30	1466	2100	567	547	1737	725
35	1627	2557	652	790	2391	1248
40	1789	3015	737	1033	3044	1771
45	1950	3472	822	1276	3698	2294
50			908		4351	2817
55			993			3340
60			1078			3863

5.3 PUP grazing ruler protocol

Using the data from Table 5 or the equations for individual months from Table 1 you can construct your own PUP grazing ruler. Otherwise, contact the DAF dairy team and get a PUP grazing ruler.

Walk a transect of 100 m for strips ready to be grazed.

Measure a minimum of 20 tillers along the transect using the PUP grazing ruler (Image 7) and calculate the average pasture on offer for the strip. Measure the extended length of leaves and stems of the tall tillers as shown in Image 6. Make sure you place the base of the top fully extended leaf on the 0 cm mark on the ruler as shown in Image 7. Depending on the level of leaf and stem length variability a larger number of observations may be necessary if greater accuracy of the estimates is required. Collecting this large number of observations can be time consuming. Therefore, it is recommended that the PUP grazing ruler should be used:

- for farmers to train their visual estimations of the amount of pasture on offer. Trained farmers can then use only visual estimations of the amount of pasture on offer to calculate pasture allocations as long as they also use the second PUP grazing strategy as indicated below. This strategy will help farmers to allocate the right amount of pasture to achieve the target post-grazing residues and thus achieve maximum pasture intake and milk from pastures.

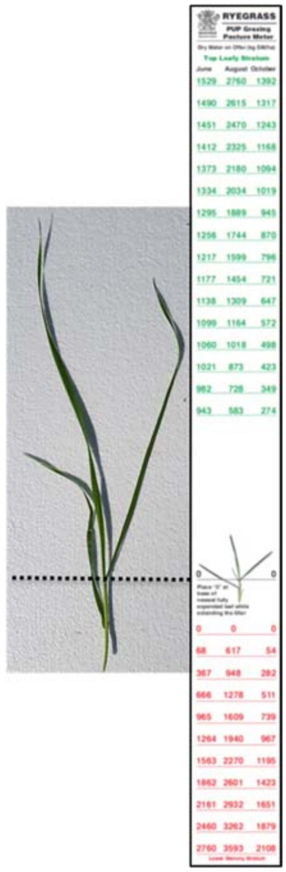
- with the second key strategy of PUP grazing to achieve the target post-grazing residues. This second strategy consist of visual observations of pasture residues. For more information on these two PUP grazing strategies visit:

http://dairyinfo.biz/wp-ontent/uploads/2018/01/Northern_Horizons_Dec2017.pdf

Table 5 – Pasture on offer for ryegrass pastures of different extended plant part lengths measured with the PUP grazing ruler

Extended leaf length (cm)	Top leafy stratum on offer (kg DM/ha)			Stem length (cm)	Bottom stemmy stratum on offer (kg DM/ha)		
	Jun	Aug	Oct		Jun	Aug	Oct
10	706	213	304	10	610	1282	381
15	880	575	412	15	1176	2434	917
20	1055	937	520	20	1742	3585	1452
25	1230	1298	628	25		4737	1988
30	1405	1660	735	30			2523
35	1580	2022	843	35			3059
40	1754	2383	951	40			3594
45	1929	2745	1059	45			4130
50		3107	1167	50			
55			1275	55			

Image 7 – When using the PUP grazing ruler make sure you place the base (ligula) of the top fully extended leaf on the 0 cm mark on the ruler as shown in this image.



6 Nutritive value of ryegrass and kikuyu pastures

The nutritive value of ryegrass was greater than kikuyu (Figure 4). The protein and energy content of ryegrass was greater than kikuyu for both strata and farms. Also, the fibre content of ryegrass was much lower than kikuyu for both strata and farms.

There was a significant interaction between pasture height, strata, month and farm for all forage quality parameters in both pasture species ($P < 0.05$) (Figure 4). This indicates that the nutritive value was determined by a complex interaction between all these factors in both species. Despite these complex interactions, the factor with the most consistent effect on nutritive value was the <u>strata</u> in both species as indicated by its high F-value (Table 6). In fact, the nutritive value of the top stratum was consistently higher than the bottom stratum in both species and farms (Figure 4).

The nutritive value was also affected by <u>farm</u> particularly in kikuyu (Table 6 and Figure 4). The nutritive value of pastures in Farm A was greater than Farm B for both strata particularly in kikuyu. The <u>month</u> of the year had a low level of influence on the nutritive value of both species particularly in ryegrass (Table 6).

The direction of the change in nutritive value due to <u>pasture height</u> was not consistent between months and farms for both species. For example, the crude protein (CP) content of the top leafy stratum of ryegrass decreased with pasture height in June ($P < 0.001$) but increased in October ($P < 0.001$) in Farm A. Therefore, each line/relationship shown in Figure 4 includes the data from all three months within each farm.

The nutritive value of pastures typically decrease with increasing pasture height (Reeves *et al.*, 1996) as the plant matures. However, since the samples used for this project were collected within the same grazing strips the stage of maturity for all samples were similar despite large differences in pasture height. Therefore, pasture height was not associated with stage of maturity but probably with other factors such as soil fertility or previous defoliation intensity. Consequently the direction of the change in nutritive value was probably influenced by the soil nitrogen content which affected the protein content of the pasture. Since the nutrient content is expressed as a proportion of the dry mater, then an increase in protein may have resulted in a decrease in the proportion of other components such as neutral detergent fibre (NDF) or non-fibre carbohydrates (NFC). For example, an increase in CP resulted in a significant decrease in NDF for kikuyu and NFC for ryegrass (Figure 5). Also, energy was strongly associated with protein content (Figure 5). This then explains, for example, the increase in nutritive value with increasing pasture height observed in kikuyu in Farm B (Figure 4). In this case the samples of the taller pasture were probably collected from patches of higher soil nitrogen content. This probably resulted in the observed increase in CP and ME and decrease in NDF with increased pasture height (Figure 4).

Table 6 – F-values from the analysis of variance for the effect of stratum, farm, month and pasture height on the nutritive value of the top leafy stratum of kikuyu and ryegrass.

	Stratum	Farm	Month	Pasture height
Kikuyu				
CP	424.8	256.7	20.6	8.1
NDF	248.1	159.7	17.6	3.6
NFC	1.6	2.3	15.3	0.0
ME	403.3	249.4	19.1	6.7
ADF	301.7	17.0	3.9	22.2
Average	**275.9**	**137.0**	**15.3**	**8.1**
Ryegrass				
CP	107.5	38.7	5.4	0.0
NDF	169.1	0.4	48.5	265.1
NFC	9.0	35.4	3.1	86.2
ME	178.3	30.4	20.5	35.3
ADF	16.9	9.4	7.0	40.6
Average	**96.2**	**22.9**	**16.9**	**85.4**

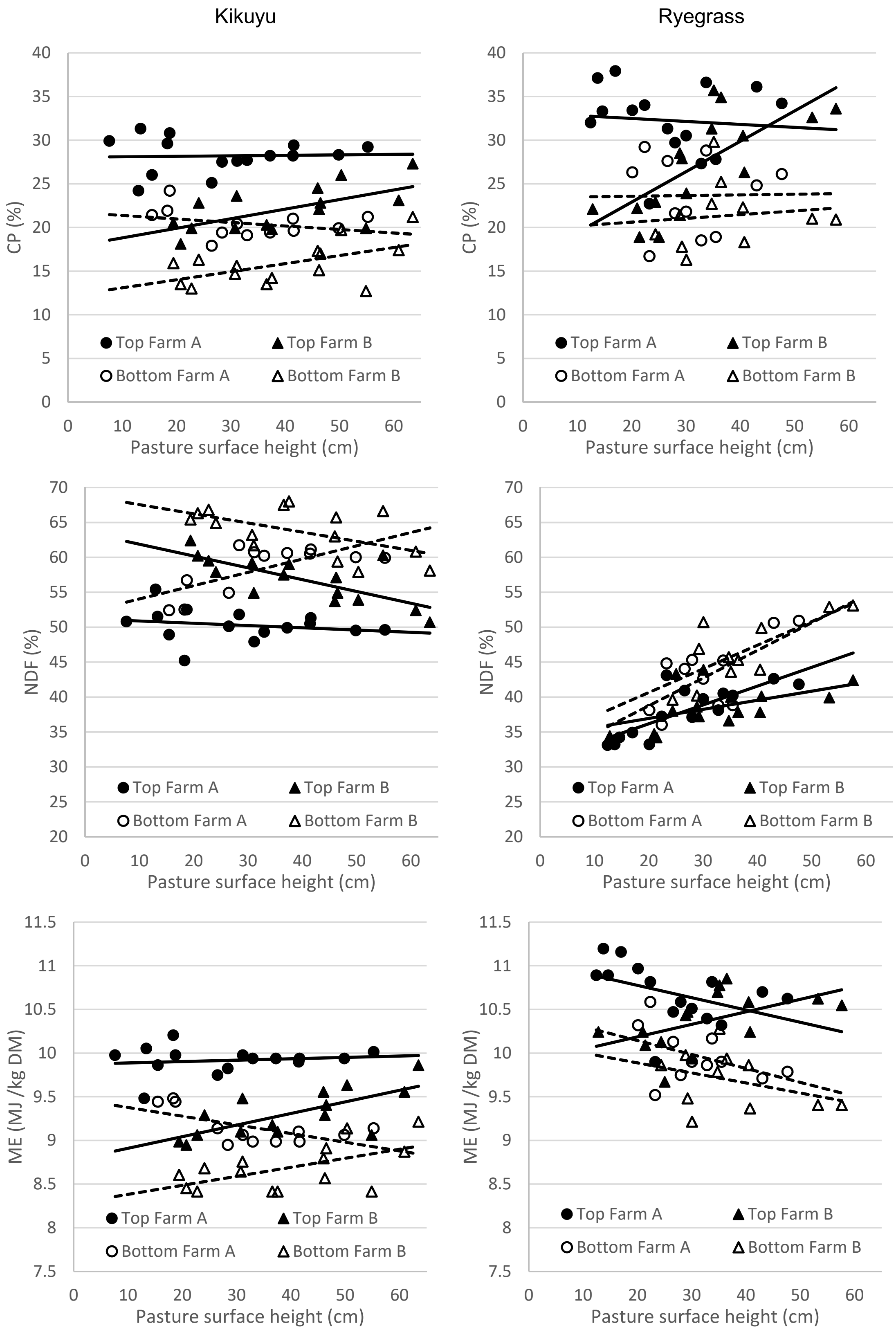


Figure 4 –Nutritive value of the top (solid lines) and bottom (dashed lines) strata.

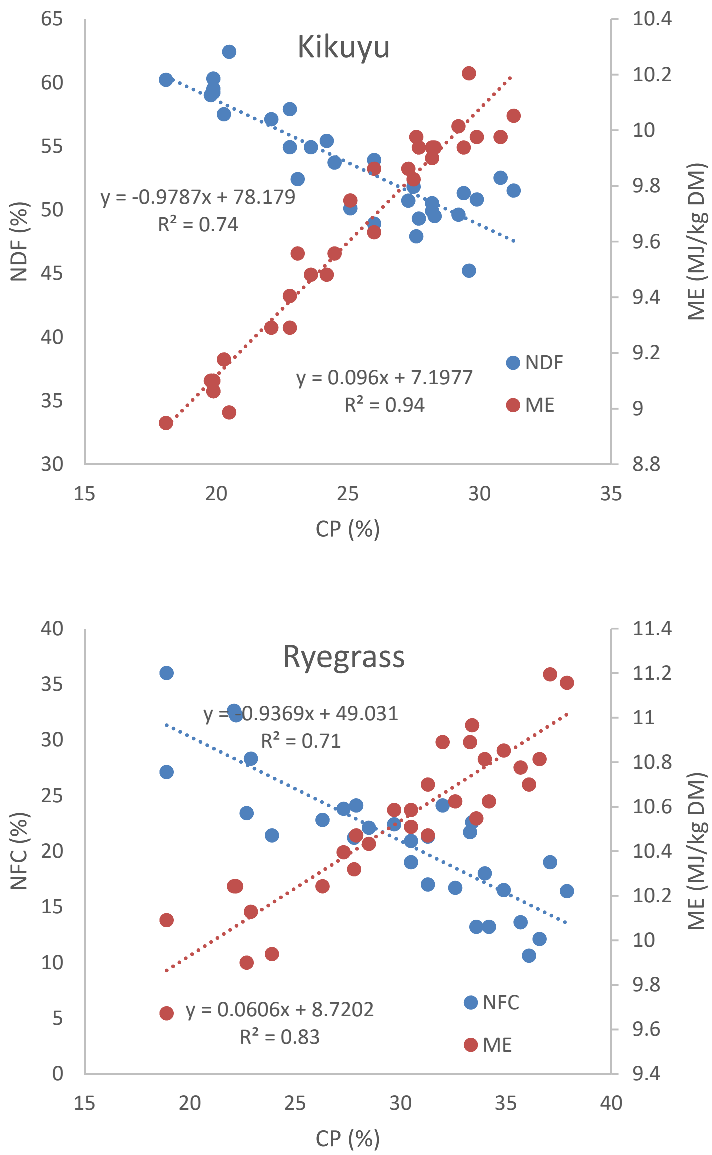


Figure 5 –The relationship between crude protein (CP) and metabolizable energy (ME), NDF and non-fibre carbohydrates (NFC)

7 Implications for the grazing management of ryegrass pastures

This project has not only allowed us to collect the data for the calibration of pasture meters on-farm but also to have a better understanding of the structural changes that occur in the ryegrass sward with increasing pasture height. We can now draw some conclusions from this understanding with significant implication for the grazing management of ryegrass pastures as well as for the identification of knowledge gaps.

The results seemed to indicate that there is no benefit in letting the pasture grow beyond 30 cm. Beyond that pasture height, there are three potentially negative consequences for the pasture and animal productivity:

1- A large proportion of the pasture growth consists of an accumulation of the stem.
2- There may be a decrease in tiller density. This may result in a decline of growing points in the pasture which may reduce the regrowth rate of the pasture after grazing.
3- Grazing only the top leafy stratum allows the cows to achieve high pasture intake but would leave large pasture residues of at least 10 cm. These large residues are recommended to be reduced which may increase the cost of the system if done mechanically by slashing or mulching.

Grazing short pastures of less than 20 cm may also have negative consequences for the pasture and the animals:

1- It is well documented for other pasture species that bite size and intake rate is low in short pastures which may result in low daily pasture intakes.
2- Also, grazing short pastures may compromise the growth rate of the pasture. As shown in Figure 2 canopy closure has not occurred indicating that the pasture has not reached maximum growth rate.

The ideal pasture height for grazing ryegrass seems to be between 20 and 30 cm for the following reasons:

1- Reasonable pasture residues of less than 10 cm are likely to be achieved after grazing the top leafy stratum Figure 2.
2- The pastures may be close to achieving maximum growth rate as their canopy is nearly fully closed Figure 2.
3- The pastures are tall enough so that bite size, intake rate and thus daily pasture intake may not be compromised as found for other grass species.

8 Acknowledgments

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9 References

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