THE IMPLEMENTATION AND LIMITATIONS OF USING A FALLING PLATE METER TO ESTIMATE PASTURE YIELD

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Abstract

The heights above ground level of a circular falling plate meter (FPM) were calibrated against pasture dry weight from quadrat cuts at many different stages of pasture growth and decomposition for four pasture types, *i.e*. i) a perennial pasture of phalaris, cocksfoot, lucerne and subterranean clover; ii) a perennial pasture in a crop rotation of perennial ryegrass, lucerne and subterranean clover; iii) an annual pasture of annual ryegrass and subterranean clover; and iv) a subterranean clover pasture in a one year clover, one year wheat rotation. The change in the regression relationships with time and hence the phenological development stage of the pasture, were studied. The main factors that affected the disc height were the amount of pasture dry matter per unit area, the steminess and stage of maturity of grass pastures during stem elongation and the degree of lodging of the dry, mature pasture sward.

Key words Pasture yield, falling plate meter, model, phalaris, ryegrass, subterranean clover

Introduction

Quadrat cutting is frequently used to estimate pasture yield because it is objective, but sample numbers required for accurate estimates of mean yields often require substantial labour. Cutting itself may also become a significant treatment on the area if many samples are cut (1). Non-destructive techniques for the estimation of pasture yield have been widely used in practice due to their efficiency and reasonable accuracy. The most commonly used non-destructive techniques to estimate pasture yield are visual estimations (7), the simple plate meters (rising plate meter/falling plate meter) based on pasture heights (1,8) and the electrical capacitance type of meter, pasture probe (5,9). Generally speaking, the simple plate meters have performed better than the pasture probes (6,9), whereas visual estimates have been poor, especially when assessing post-grazing yield (7).

A falling plate meter (FPM) was chosen to estimate pre- and post-grazing herbage mass in the MASTER (Managing Acid Soils through Efficient Rotations) project during 1993-1997. The most important characteristic of the falling plate meter is its higher downward pressure (30 kg/m^2) compared with rising plate meters (4 - 7 kg/m^2) (1,2,6). The extra pressure may give a more accurate estimate of pasture yield where resistance to compression is greater. The aim of this project was to establish a standard calibration of the falling plate meter on the four pasture types used in the experiment so that the amount of pasture dry matter present could be estimated from disc heights.

Materials and methods

The calibration studies were conducted on the four pasture types established on the 80, 45 m ? 30 m plots, in the MASTER experiment. The pasture types were: i) a perennial pasture (PP) of phalaris, cocksfoot, lucerne, subterranean clover; ii) a perennial pasture in a crop rotation (PP/C) - perennial ryegrass, lucerne, subterranean clover (3 years) followed by 3 years' crops; iii) an annual pasture (AP) - annual ryegrass and subterranean clover, and iv) a subterranean clover pasture (1 year) rotated with wheat (1 year) (AP/C).

All pastures and the plots in pasture phases in PP/C and AP/C treatments were rotationally grazed by Merino hoggets. The rotation periods were 7.5 weeks for the three plot rotation system (PP, PP/C and AP) and 5 weeks for the two plot rotation system (AP/C) throughout the year except in spring (September/October) and during the establishment of annual pastures in autumn (March - May) when short rotation periods (3 or 2 weeks) were used for three and two plot rotation systems. A FPM was used to estimate the pre- and post-grazed pasture yield, with 20 measurements on each plot.

The falling plate meter, is a 3 kg steel disc, 0.1 m^2 in area that exerts a downward pressure of 30 kg/m^2. The disc slides freely on a central rod with a scale (mm) on one side. A mirror allows readings to be made from above the instrument to the nearest 2 mm. The foot of the central rod is circular with an area of 346 mm^2 to prevent the penetration of the rod into to the ground. The meter was supplied by Arborline, Hamilton, Victoria.

The FPM heights were calibrated against the dry matter yield from the quadrat cuts (0.1 m^2) for each type of pasture at each grazing period in 1994 and at many different stages of pasture growth and decomposition in 1995 - 1997. In December/January, 1996/1997, a large number of quadrats were cut to check the regression equations for different pasture conditions in the dry pasture period (*eg*. lodging vs standing, vulpia dominant vs ryegrass dominant). A curvilinear model, $y = bx + cx^2$, relating pasture yield and FPM readings was developed for different phenological periods of each pasture type from all measurements over 4 years). Linear model, $y = bx$, was regarded as a particular case of the curvilinear model. Because of space limitations only the calibrations of perennial pastures (PP) are fully discussed in this paper.

Results and discussion

Regression relationships have been developed to represent three main periods of the year - a) the leafy green period from the break of season to mid-August; b) the period from mid-August to mid-October when the annual and perennial grasses undergo stem elongation; and c) the maturation and dry feed period from mid- October to the following break of season. The standardised calibration curves for PP treatment are shown in solid line on Figure 1. These curves can be used as a reasonable basis for estimating pasture dry matter on farms or in research studies in association with further calibration checks. During the leafy green period and the section of the dry feed period from mid-January to season break, the calibration coefficients were relatively constant. A single model for each pasture type was adopted for each of these periods. During the stem elongation and post maturity/dry feed periods, however, the calibration equations varied with time and certain pasture characteristics (Table 1 and Fig. 1b) so the coefficients were modelled as functions of time.

The leafy green period (break of season to mid-August)

In this period individual regression relationships were reasonably consistent from time to time (Table 1 and Fig. 1a). The curvilinear relationship defined in August 1995 was used in the model because the wide range of heights enabled good definition of the curvilinear effect, the slope was not greatly different to the 1994 regressions. The August 1994 relationship was considered an outlier because the high grazing pressure in the drought year resulted in a low range in heights and a bias in the results because a high proportion of the dry matter was in stem bases. This effect probably also caused the other 1994 curves to have steeper slopes than the 1995 regression and is likely to have been influential in the stem elongation period as well. Michell (1982) also found that the regressions, using data pooled over a period, for heavily grazed paddocks had a significantly higher slope than for ungrazed or regrowth paddocks (*eg*. 416 vs 253 (kg/ha)/cm disc height). In this experiment significantly higher regression slopes after grazing occurred occasionally, but more frequently during periods of high grazing pressure in droughts. Therefore, individual calibration equations should be used for the pre- and post-grazed pastures when heavy grazing pressure is applied.

The stem elongation period (mid-August to mid- October)

During this period of fast growth that is coincident with stem elongation of the grasses, the slopes of the equations decreased with time for pastures containing grasses (Table 1 and Fig. 2a). The models used to represent this period have coefficients that vary linearly through time from mid-August to mid-October based on interpolation between the August, 1995 and October, 1995 regressions. For the pure clover pasture (data not shown) the slope of the linear section of the regression was not affected by stem elongation, seed set and maturation but the linear section continued to higher disc heights with time during the maturation period before the slope began to decrease. This probably reflects an increase in pasture density, caused by the thickening of the horizontal stems plus the production of seed pods, providing support to the disc to greater heights as maturation proceeds.

The maturity and dry-feed period (mid-October to break of the next season)

During this period the slopes of the regression equations generally increased with time (Table 1 and Fig. 1b). The main factor involved was the increase in lodging of the dry, mature pasture over time due to the effects of wind and rain, and trampling by stock. Increased lodging resulted in more herbage dry weight per unit FPM height, reflecting the reduction over time of the effect of stem strength in supporting the disc (Fig. 1b, curves 1 to 5 are in order of increased degree of lodging). This is similar to the observations of Gonzalez *et al.* (2). It is recognised that the lodging status within a plot is often not uniform. More accurate estimates of pasture dry weight would require input of the degree of lodging at each sampling point as well as the height. As a result Stockdale and Kelly (9) suggested that cutting quadrats was the best way to estimate herbage mass in circumstances in which pastures were severely lodged by trampling. Murphy *et al* (6) argued that it was very unlikely that farmers would cut quadrats for their day-to-day management decision. It is suggested that the time dependent regressions illustrated on Figure 1 for use in the maturity and dry feed period, based on the general increase in lodging between maturity and mid-January, are good enough for the grazing management decisions by farmers, but provide only an approximation of the amount of pasture present for research studies.

Botanical composition is another factor that influences the slopes of regression equations during this period. On some of the plots in the PP treatment, some areas were dominated by vulpia and others by annual ryegrass. In December 1996, separate calibrations were conducted on these pasture patches, that were at a similar lodging status, to check the standardised model (Table 1). Vulpia dominant patches had steeper regression than ryegrass dominant patches (curve 6 vs curve 2; Fig. 1b) which reflect the finer stems of vulpia with less strength to support the FPM. Pooled regressions for plots with variation in botanical composition in different parts of the plot therefore also contribute to errors in estimation of the pasture yield. Earle and McGowan (1) also suggested that the Ellinbank Pasture Meter would probably be less suitable for the treatments with marked differences in botanical composition or sward structure than mowing techniques.

Conclusions

Standard calibration curves for the falling plate meter can be used to monitor pasture yield with reasonably accuracy provided different calibrations are used on different types of pastures at different growth stages. The calibration curves were constant before the period of stem elongation for the grasses, but subsequently changed with time. During stem elongation the slopes decreased with time before a period of increase after maturation in association with lodging of the mature pasture. During the stem elongation period consistent changes of the regression coefficients with time occurred, however in the maturity/dry feed period, the estimation of pasture yield by using FPM was less reliable because pasture lodging occurred irregularly in space and time. Quadrat cutting is a more reliable way to estimate the pasture yield where the pattern of lodging is not consistent in time or space or where botanical differences are important.

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Table 1 Calibration curves ($y = bx + cx^2$) relating pasture yield (*y,* kg DW/ha) and falling plate meter reading (*x,* cm) over season for perennial pastures

?	N†	b	c	r^2	P	FPM range	Comments
Leafy green period	?	?	?	?	?	?	?
May 94	24	585.31	-	0.71	<0.001	1.1 - 7.7	Most points at 1-4 cm, one point at 7.7
Jun 94	16	770.15	-	0.64	<0.001	0.9 - 4.0	High grazing pressure
Jul 94	31	642.96	-	0.64	<0.001	0.8 - 8.0	Most points at 1-4.5 cm, one point at 6.1 and one at 8.0
Aug 94	73	1157.07	-	0.45	<0.001	0.2 - 3.0	High grazing pressure, low *x* range, slope affected by stem bases; not accepted for general model
Aug 95	**15**	**625.09**	**-16.43**	**0.88**	**<0.001**	**1.6 - 16.2**	**Sampled carefully for the full *x* range resulting in significant quadratic term; used in general model**
				Stem elongation period			
Sep 94	20	723.27	-	0.46	<0.001	0.2 - 2.0	High grazing pressure, very low *x*

							range
Oct 94	15	965.15	-	0.51	<0.01	0.3 - 1.3	High grazing pressure, very low *x* range
Oct 95	**10**	**441.02**	**-5.52**	**0.90**	**<0.001**	**6.2 - 17.8**	**Sampled carefully for the *x* full range, used as general model**
				Maturity/dry feed period			
Dec 94 (1)[‡]	10	470.91	-	0.55	<0.05	0.2 - 3.4	High grazing pressure, not enough herbage accumulated to lodge, lack range in *x*
Dec 96 (2)	7	723.11	-35.19	0.99	<0.001	2.1 - 10.7	Ryegrass dominant, very little phalaris, lodged, but not totally trampled flat
Dec 96 (3)	9	1146.70	-	0.76	<0.01	1.4 - 6.0	Long ryegrass and some phalaris, lodged, but not totally trampled flat
Jan 97 (4)	59	1645.51	-33.57	0.37	<0.001	1.6 - 4.8	An example of maximum lodging in January
Dec 96 (5)	10	1941.89	-125.71	0.65	<0.05	1.3 - 5.8	Long ryegrass and some phalaris, totally lodged, trampled flat on the ground
Dec 96 (6)	5	1223.59	-40.82	0.96	<0.05	2.9 - 9.1	Vulpia dominant, very little phalaris, lodged, but not totally trampled flat
Dec 95 (7)	15	1524.41	-183.24	0.37	=0.05	1.4 - 4.4	No observation on lodging status
Jan 95	5	659.23	-	0.79	<0.05	0.4 - 1.4	High grazing pressure, lack in *x* range
Feb 95	5	-	-	-	-	0.3 - 1.7	No relationship, high grazing pressure, insufficient range in *x*
Mar 94	16	1274.86	-80.17	0.69	<0.001	1.6 - 6.8	Dry feed from previous year
Apr 94	38	1171.17	-95.58	0.53	<0.001	1.4 - 6.7	Dry feed from previous year, transition to green period

† N: number of calibration points; b and c: calibration coefficients; P: significant level.
‡ Number in brackets is the curve number, curves 1 to 5 are in order of increased degree of lodging.

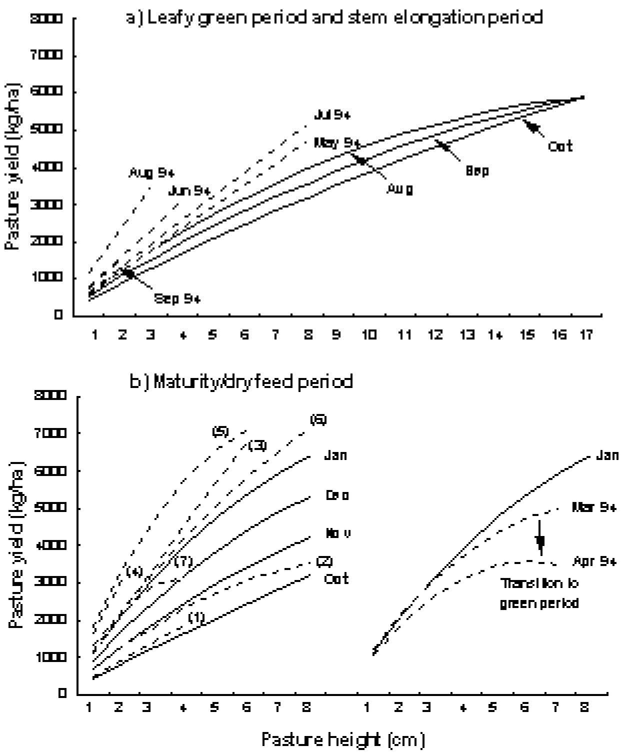

Figure 1 Regression models for perennial pastures over years. The solid lines show the standardised models used in MASTER project, the light broken lines show the models on particular situations.