AN EVALUATION OF THE PERFORMANCE OF THE CAPACITANCE METER FOR ESTIMATING THE YIELD OF DAIRY PASTURES

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Summary

An electronic capacitance meter was used to estimate pasture yield in a grazing experiment of two years' duration. One day each month a yield measurement and meter reading were made at ten sites within each of four paddocks. The regression of pasture dry weight on meter reading was calculated for each of 84 paddocks and only about half were found significant at the 5% level. Significant differences in regression coefficients or intercepts existed between individual paddock regressions for 19 of the 21 months. Prediction of yield was least reliable in autumn. It is concluded that factors causing variations in yield-meter reading relationships need identification and their effects reduced before the meter can be used widely in grazing trials.

INTRODUCTION

THE most important criteria for evaluating grazing management systems are those based on animal output. Even so, a complete evaluation cannot be made unless effects of management systems on the pasture are also assessed. Definition of the causal factors responsible for differences in animal production is sometimes impossible without this information.

Most techniques of pasture measurement have disadvantages which either preclude or severely limit their use in whole-farm experiments. However, estimation of pasture yield using the electronic capacitance meter developed by Campbell *et al.* (1962) is one technique of great potential value. It is a technique that has been extensively used at the Ruakura Nutrition Centre during the last two years in an experiment aimed at assessing the effects of grazing interval on butterfat production at high stocking rates. This paper is based on some of the data obtained during that experiment; it presents an evaluation of the meter when used to estimate the yield of intensively grazed dairy pastures.

EXPERIMENTAL

Details of the experiment from which the data are derived together with a description of the pastures have been presented by Bryant and Parker (1970, 1971). The main features were as follows:

Comparisons were made of production from four farmlets in which a 12- and a 24-day grazing interval were contrasted at each of two stocking rates, 1⅔ and 2 cows per acre. Each farm had 24 paddocks and carried 24 cows. The experiment was of 24 months' duration commencing July 1969, the contrasting rotations being applied from early September to late April.

Estimates of pasture yield were made with the aid of a meter similar to that described by Campbell et al. (1962) . On one day each month a meter reading and a corresponding dry weight of pasture were obtained at ten random sites on one paddock from each of the four grazing treatments. The selection of the four paddocks was made by quartering the 96 paddocks making up the trial area into four categories depending on visual assessment of the amount of pasture present on each and selecting one paddock from each category.

Pasture dry weight for a desired site was obtained by placing a frame enclosing an area of 461 sq. in. over the meter's measuring head on to the pasture and cutting the enclosed herbage to ground level using a shearing hand-piece. The entire sample was freed from adhering soil by washing and its weight determined after oven drying.

The field measurements were usually made between 8 a.m. and noon, requiring for each paddock 5 to 10 minutes to obtain the meter readings and mark the areas to be cut and 30 to 45 minutes for the actual cutting.

Linear regressions of pasture dry weight per frame on meter reading were calculated from the ten paired observations for each of 84 paddocks representing 21 months. Data for the remaining 4 months of the two-year period were derived by procedures different from those described here and hence were. excluded from the present analysis. For each month, the homogeneity of the four within-paddock regressions were tested using regression procedures.

RESULTS

Of the 84 within-paddock regressions, 52 were significant at the 10% level of significance, 44 at the 5% level and 24 at the 1% level.

In attempting to define the factors contributing to the non-significance of the regressions, the square of the correlation coefficient (r^2), representing the proportion of the total variation in pasture yield accounted for by the regression, was used to indicate the efficiency of the regression. The magnitude of this coefficient was not obviously related to the number of days elapsed since grazing the paddock or to the amount of dry matter present (Table 1). Small correlation coefficients were more frequent for measurements made in the autumn than in other seasons and for paddocks subjected to a 12- compared with a 24-day grazing interval.

To indicate the variation in pasture yield between sites within a paddock, the distribution of within-paddock coefficients of

TABLE 1: PADDOCK DATA CLASSIFIED ON THE BASIS OF THE CORRELATION BETWEEN PASTURE YIELD AND METER READING

		Square of Correlation Coefficient (%)			
Season	Item	0-25	25-50	50-75	75-100
Winter (Jun.-Aug.)	*n*	9	9	8	2
	d	36	55	53	31
	y	42.1	53.7	52.6	45.0
	n (12)	5	6	2	1
Spring (Sep.-Nov.)	*n*	2	5	8	1
	d	8	9	17	8
	y	39.6	66.9	65.5	48.5
	n (12)	0 3	4	5	0
Summer (Dec.-Feb.)	*n*	8 10	6	1	103
	d				
	y	51.5	65.1	64.3	78.5
	n (12)	2	2	2	2
Autumn (Mar.-May)	*n*	11	11	2	
	d	10	21	26	
	y	48.1	50.3	36.8	
	n (12)	8	6	0	
Total	*n*	25	31	22	6
	d	15	24	26	16
	y				
	n (12)	45.3 15	59.0 18	54.89	57.72

n = number of paddocks.

d = days since grazed.

y = pasture yield (g DM/frame).

n (12) = number of paddocks subjected to a 12-day grazing interval.

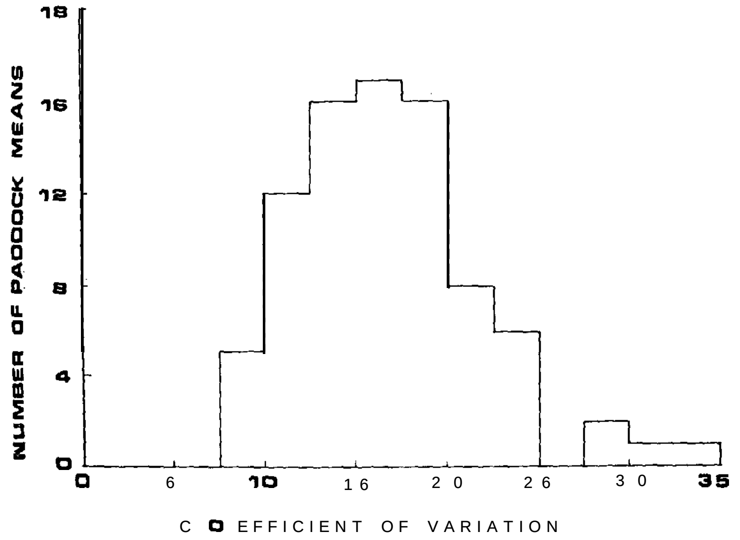

FIG. 1: *of within-paddock coefficients of variation of pasture dry matter per frame.*

variation of pasture dry weight per frame is shown in Fig. 1. The mean of these 84 coefficients was 16.8%, 60% of them being 15% or lower. That this uniformity of pasture yield within a paddock was not the sole cause of the non-significance of the regressions is shown by Fig. 2. It indicates that a high correlation between pasture dry weight and meter reading was not necessarily dependent on a high variance of actual dry matter yield.

The homogeneity of the four paddock regressions for each month were tested irrespective of the level of significance of the individual regressions. The data are summarized in Table 2.

TABLE 2: SUM-MARY OF DIFFERENCES BETWEEN REGRESSIONS WITHIN EACH MONTH

Significance of Differences between ***Regression** Coefficien ts (b) and Intercepts (c)* b	c	*No.of* Regressions	*Level of Significance and No. at Each Level* b	c
NS	*NS*	2	$P > 0.10$ (2)	$P > 0.10$ (2)
NS	S	16	$P > 0.10$ (16)	($P < 0.01$ (15) ($P < 0.10$ (16)
S	NS	1	$P < 0.01$	$P > 0.10$
S	S	2	($P < 0.01$ (1) ($P < 0.05$ (2)	$P < 0.01$ (2)

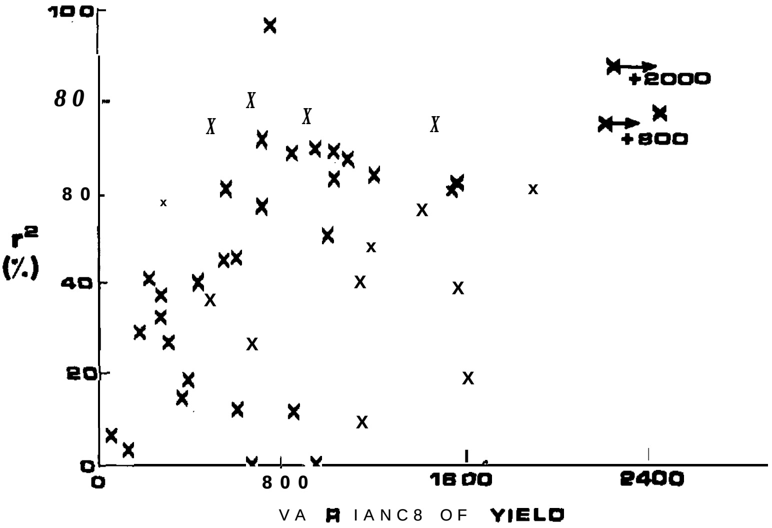

FIG. 2: *Variance of within-paddock yield.*

Heterogeneity was established for 19 of the 21 months. On 16 occasions, significant differences were found in the adjusted means but not regression coefficients.

Overall regressions for each month were also established by pooling the data from each of the four paddocks.

Except in March and April of both years when the pooled regressions were not significant, highly significant linear relationships existed for each month. Even so, in only 14 of the 21 months was the proportion of total variation in yield accounted for by meter reading greater than 50%. As is illustrated by the first 12 months' data in Table 3, this tended to be the highest in winter and spring and the least in March and April.

DISCUSSION

Previous reports evaluating the capacitance meter describe good relationships between pasture yield and meter reading within pasture types or series at any one time. For example, Campbell *et al.* (1962), Johns and Watkin (1965) and Jones and Haydock (1970) found that about 90% of the variation in yield was accounted for by meter reading.

The generally poor and at times almost non-existent within-paddock relationship described here is ,in marked contrast to these reports.

TABLE 3: SUMMARY OF REGRESSIONS FOR TWELVE CONSECUTIVE MONTHS

	Y	$SD(y)$	b	S_b	r	RSD
Jul. 1969	47.4s	13.09	**2.89**	**0.39**	0.77	8.43
Aug.	52.92	16.47	1.90	0.30	0.72	11.56
Sep.	55.85	22.47	2.43	0.13	0.95	6.91
Oct.	60.62	14.72	2.11	0.20	0.86	?.62
Nov.	83.34	15.31	4.37	0.59	0.77	9.91
Dec.	71.74	18.08	2.74	0.29	0.84	10.04
Jan. 1970	68.12	17.89	5.06	0.72	0.75	11.94
Feb.	63.73	18.00	18.10	3.05	0.69	13.13
Mar.	62.70	13.94	−0.38	5.63	−0.01	14.12
Apr.	51.21	12.34	0.96	0.52	0.29	11.97
May	33.79	9.27	2.37	0.23	0.86	4.76
Jun.	47.71	10.53	1.66	0.21	0.79	6.60

y = average pasture yield (g DM/frame)
SD(y) = standard deviation of y
b = regression coeffkient
S_b = standard error of b
r = correlation coefficient
RSD = residual standard deviation

The causes of this poor relationship were not established. That variations between operators werc responsible is discounted since these were not changed within a paddock and generally not within a day. Neither were variations in environmental conditions likely to be important because of the brief time required to complete the measurements for any one paddock.

Campbell *et al.* (1962) found that the coefficients of residual variation for the regression of pasture dry weight on meter reading was of the order of 10%. Back et *al.* (1969) reported averages of 9.7 to 18.6%. In the work described here, many of the coefficients of variation associated with the pasture yield measurements made within a paddock were of this magnitude (Fig. 1). It is therefore to be expected that significant regressions of pasture yield on meter reading could be established. If this lack of variability within a paddock was important in determining significance, then it is not clear why a better relationship was not apparent between r^2 and the variance of pasture yield measurement.

The failure to obtain consistently significant within-paddock relationships between meter reading and pasture yield invalidates the use of the meter to obtain estimates of the amount of pasture present on a given paddock. This is particularly regrettable since the use of the meter in the manner proposed by Jones and Haydock (1970) offers the possibility of readily obtaining estimates of the amount of pasture present on a paddock immediately before and after grazing. These are essential measurements in the direct assessment of pasture performance in a grazing experiment since, from them, pasture growth and allied estimates are derived.

The poor within-paddock relationships do not necessarily invalidate use of the meter for obtaining estimates of the average amount of pasture present at any one time on a whole farm or grazing treatment. This requires a relationship between meter reading and pasture yield applicable to all paddocks of that farm or treament. It involves the prediction of yield on paddocks other than those used to establish that relationship. The heterogeneity of individual paddock regressions within months suggests that such a procedure is invalid. However, it may be that the heterogeneity arose from the small variation of yield within a paddock and the non-significance of a large proportion of the individual regressions. The data of each of the four paddocks may, in fact, represent separate portions of a single regression line. Irrespective of these considerations, the high errors of prediction associated with the pooled regressions, and the absence of a significant,' relationship between meter reading and pasture yield in autumn, indicate that use of the meter in this way is limited.

On the basis of the data presented here, extensive use of the meter in grazing trials is not justified. It will not be justified until the factors responsible for its poor performance are identified. and their effects reduced. Until then, or until new techniques are developed, those engaged in farm-scale experiments must rely on conventional pasture measurement techniques. The limitations of these need no emphasis.

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JOINT DISCUSSION

Round-Turner (Invermay) asked if any consideration had been given to using a rectangular plate and cutting a sample from under it or a circular quadrat which could be placed over the circular plate. Phillips replied that in the original development a circular quadrat had been made to fit over the instrument. However, Clarke had found in a measurement trial that valid comparisons could be made between meter readings and mower cuts. He also pointed out that twenty meter measurements were made on the strips. Clarke added that he had made measurements under square foot quadrats but that these had not yet been computed. Cullen (Invermay) inquired how effective the weighted disc technique would be on sloping ground. Clarke stated that the ground had to be fairly level to allow the stem tc pass through the smooth bearing. Phillips said that obviously the effective weight on pasture would be less on sloping ground. They were examining the possibility of having a compensatory system. Pugged ground would preclude the use of the instrument and good sense and judgement would be necessary if it were to be used under farming conditions. In very short pastures, stubble could affect readings. Lynch (Ruakura) thought the observer variation in the capacitance meter readings was incredible and asked how it occurred. Stephen replied that he did not find it surprising when it was considered that the readings were made in a paddock 1 ha in area and the meter covered only a very small part. How did the observer decide how many clumped areas should be measured relative to non-clumped? It would be easy for one observer to over-emphasize the clumpiness — in fact it was all a matter of human. psychology. Systematic placement was laid down precisely on paper before going out to measure the paddock. In practice, in the random technique, the observer placed the meter at random. If he were untrained this would in fact be so, but the trained observer, as already mentioned, would subconsciously try to make an assessment of clumped and non-clumped areas and so bias could come in. Campbell (Ruakura), commenting on Table 1 in Stephen's paper, said that if variations in readings were discrepancies between observers in reading the instrument, and if the observers made the same ± errors in reading the dial at the mean reading sites selected for cutting, these samples might still be cut at the appropriate sites and give a true mean DM yield for the paddock. The observers might only have required training. Table 2 combined data collected on a day following that for Table 1. Here three observers, including 2 from the previous table, obtained excellent agreement in mean "Charlie" readings. Perhaps they were more experienced. Was the sudden increase in mean reading from 60 readings due to "Charlie's" unreliability or could it be due to some change in the environment? Then in a comparison of yield estimates from cattle and sheep pastures the actual yield of the cattle pasture was less than that of the sheep, but "Charlie" gave the opposite result. These pastures were 9 in. and 6 in. The actual yield and cage cuts were made at 25.4 mm. "Charlie" could take into account pasture growing below 25.4 mm, a most high producing region. Stephen said there was no bias as none of the observers had had any experience with the meter. Data had been combined for simplicity. In smaller areas differences between observers were not significant, but they were in larger areas. It was much easier to make a better estimate of variability in a small area, but extremely difficult in a large one. The observers were consistent in their readings. There had been no difference in climatic conditions.