A COMPARISON OF THREE PASTURE MEASUREMENT TECHNIQUES

R. C. STEPHEN
Invermay Agricultural Research Centre, Mosgiel
K. J. A. REVFEIM
Biometrics Section, Department of Agriculture, Wellington

Summary

Pasture yield estimations using a capacitance meter were compared with data obtained from the random quadrat and cage techniques and with the actual yields. The cage technique gave the most accurate and consistent estimations of the yield whereas the random quadrat method underestimated the yield and the capacitance meter gave inconsistent results.

INTRODUCTION

THE USE of a reliable and accurate technique in the measurement of pasture productivity is a basic necessity in research work. However, present techniques in experiments involving grazing animals suffer from a number of disadvantages. The development of a non-destructive method for estimating pasture yield is therefore of considerable significance.

Fletcher and Robinson (1956) were the first to employ an electronic capacitance measuring unit for the estimation of forage yields. Campbell *et al.* (1962), using a modified unit, examined the relationship between pasture yield and meter reading under a variety of conditions and concluded that, *within* trials, the instrument accounted for over 90% of the variation in pasture sample yield. However, significant differences existed *between* trials.

Other workers (Alcock, 1964; Alcock and Lovett, 1967; Johns *et al.*, 1965; Lovett and Bofinger, 1970) have studied this problem extensively but finally Back (1968) and Jones and Haydock (1970) agreed with the conclusion made by Campbell *et al.* (1962) that a general prediction equation, derived from pooled data, was not attainable.

Jones and Haydock (1970) suggested an alternative method of using the capacitance meter which depended on the very strong linear relation between yield and meter reading that existed within any one pasture at any one time. The method consisted of establishing a mean meter reading for any pasture from a number of randomly-placed meter readings; three samples of pasture having this mean reading were cut and the average of these represented the yield for that paddock. The technique gave acceptable results with lower standard deviations compared with other methods when tested in an area of oats.

This paper reports the results of preliminary work on pastures using the Jones and Haydock (1970) method and compares these with data obtained by using two other techniques.

EXPERIMENTAL

The Jones and Haydock (1970) method depends essentially on obtaining a representative mean meter reading as this determines the pasture samples to be cut for yield estimation. The first two trials were concerned with the ability of an observer to provide a reliable mean reading.

Both trials were carried out in a rectangular paddock approximately 0.9 ha in size with a rolling topography. The pasture height was 7 to 10 cm. Three areas of 0.2, 0.4 and 0.8 ha were marked out, the smaller being symmetrically arranged within the larger areas. Before use, the capacitance meter was "zeroed" whilst standing on a tin metal sheet and after each set of observations the zero point was rechecked; no fluctuation was observed.

In the first trial carried out in an afternoon after rain in the morning, five observers took a series of randomly-selected meter readings such that each area was covered in as representative a manner as possible. The number of readings made was equivalent to 75/ha as recommended by Jones and Haydock (1970). The results are shown in Table 1.

There were significant differences between the mean readings obtained by the observers and the relatively large spread of the means from 0.67 to 0.86 might represent substantial differences in dry matter yields of the pasture. There was no difference between the average readings of the five observers when the area of pasture was increased from 0.2 to 0.4 ha but a further increase in the area to 0.8 ha resulted in a rise in the average reading. The existence of these differences between mean readings impliea that none could be accepted as being representative of the area concerned. Presumably the recommended number of readings (i.e., 75/ha) was insufficient to give adequate coverage of the

TABLE 1: MEAN METER READINGS OBTAINED BY FIVE OBSERVERS IN THREE AREAS OF VARYING SIZE

	Area in ha and (No. of Readings)			
	0.2 (15)	0.4 (30)	0.8 (60)	*Mean*
1	0.67	0.64	0.69	0.67 cB
2	0.68	0.64	0.82	0.71 bB
3	0.71	0.74	0.86	0.77 bAB
4	0.75	0.69	0.79	0.74 bB
5	0.81	0.86	0.91	0.86 aA
Mean	0.72 B	0.71 B	0.81 A	0.75

pasture. One other feature of this trial was the generally high degree of variability (pooled CV = 38%) that existed.

A second trial was carried out on the 0.2 ha area to determine the effect of increasing the number of readings taken. Three observers took 15, 30, 45 and 60 meter readings and on this occasion the grass was mainly dry though there was a tendency for dampness to occur in the taller grass. The results are given in Table 2.

TABLE 2: THE EFFECT OF INCREASING THE NUMBER OF METER READINGS ON THE MEAN VALUE

	No. of Readings					
Observer	*15*	30	45	60	*Mean*	*cv %*
1	0.59	0.57	0.57	0.67	0.60 bA	39
2	0.59	0.59	0.59	0.66	0.61 bA	38
3	0.61	0.64	0.62	0.67	0.64 aA	37
Mean	0.60 bB	0.60 bB	0.59 bB	0.67 aA	0.62	38
CV %	38	38	37	40	38	

An increase in the number of readings from 15 to 30 and from 30 to 45 had no effect on the mean values. When the number of readings was increased to 60, however, the mean reading was higher than those obtained from fewer readings. An increase in the number of readings had no effect on the level of variability which was of the same order as in the first trial. Differences between observers again appeared though these were of a lower order than in Trial 1.

A third trial was carried out to compare three methods of estimating pasture yields:

(1) The Jones and Haydock (1970) method — three 0.56 m^2 samples with the mean meter reading.

(2) Random quadrat method — three 0.56 m^2 samples.

(3) Cage technique — three randomly-selected 1.22 $\times$ 3.32 m samples.

The trial was carried out on two sites, the first on a cattle pasture where the foliage was approximately 24 cm tall and the second in a sheep pasture, the height of which was about 16 cm. Each experimental site was divided into four replicate blocks measuring 9 m^2 on the cattle pasture and 18 m^2 on the sheep pasture.

Two methods of selecting the meter reading locations were adopted. In the first instance 36 sites were selected at random and, in the other, each replicate block was divided into 36 equal-sized squares and one reading was made in the same position in each square. Thirty-six readings per 9 m^2 or 18 m^2 were selected so as to be comparable with the results reported by Jones and Haydock (1970) who used 40 readings/0.325 ha in a crop of oats; it should be noted that this number of readings was considerably in excess of the 75/ha recommended by those authors.

The size of the samples, namely 0.56 m^2, was such that it included the pasture enclosed by the 16 probes of the capacitance meter (0.42 m^2) and an area 7 cm outside the periphery of the probes. A similar sample size was used for the random quadrat method. The pasture samples from both of these methods were cut to a height of 2.54 cm above ground level using motorized shears. The cage technique samples, consisting of two strips 0.61 m x 3.32 m, were cut to the same height with a Dennis mower. After all the samples had been taken, the whole of the pasture remaining in each replicate block was similarly cut with the Dennis mower to provide data on the actual yield/replicate.

All pasture samples were dried at 80° C for 15.5 hr to determine dry matter yields.

The results of the trial are shown in Table 3.

Systematic placement of the capacitance meter gave lower estimates of pasture yield compared with random placement though the difference was significant in the cattle pasture only. The meter estimates were lower than those obtained using the cage technique in the sheep pasture but were similar in the cattle pasture. The random quadrat method gave lower yields compared with the

TABLE 3: ESTIMATES OF DRY MATTER PRODUCTION USING THREE TECHNIQUES TOGETHER WITH THE ACTUAL YIELD

Technique	Mean Estimated and Actual Yields (kg/ha) Cattle Pasture	Sheep Pasture
Meter-random	1,918 aA	1,361 bBC
Meter-systematic	1,354 bBC	1,142 bC
Random quadrats	943 cc	1,306 bC
Kandom cages	1,600 abAB	1,668 aAB
Actual yield	1,571 abAB	1,745 aA

cage technique in both pastures and with the meter estimates in the cattle pasture.

Compared with the actual yields, the cage technique gave closer and more consistent approximations of the yield compared with the other two techniques. The random meter estimates were the most inconsistent because of a considerable overestimate in the cattle pasture compared with a marked underestimate in the sheep pasture. Systematic placement of the meter and the random quadrat methods both gave estimates that were lower than the actual yields though the difference between the yield from systematic placement of the meter and the actual yield in the cattle pasture failed to reach significance.

With the exception of the random quadrat method in. the cattle pasture, in which the amount of variability was higher, the coefficients of variability were relatively low and of an acceptable level.

DISCUSSION

Pasture yield estimation using the capacitance meter, according to the alternative method propounded by Jones and Haydock (1970), was less satisfactory compared with the cage technique which gave more consistent and closer approximations to the actual yield. The more favournble results obtained by Jones and Haydock (1970) in a standing oat crop might have been due to the greater uniformity that prevailed in such a crop compared with the variability inherent in pastures, but other reasons can be suggested to account for the poorer' performance of the capacitance meter in the present study.

Differences were found between the mean meter readings obtained by a number of observers which suggested that the determination of a single mean meter reading by one observer might not be representative of the area. Since the Jones and Haydock (1970) method depends essentially on obtaining a reliable mean reading, part of the inaccuracy and inconsistency found in the present study might have been due to this.

Increase in the number of meter readings failed to reduce the level of variability and hence it seemed that the inability to obtain a reliable mean reading might have been associated with the size of the pasture sample rather than. with the number of readings. The lower estimates of yield obtained using the random quadrat method compared with the values from the cage technique tended to support this, since the main difference between the two was the size of the pasture sample, although differences in the cutting technique probably accounted for some of the discrepancy observed.

Since the yield- estimates derived from the cage technique closely approximated the actual yield, it would appear that the smaller size of the pasture sample used in the random quadrat method failed to overcome the natural variability of pasture. The same-sized pasture sample was taken in the random quadrat and capacitance meter methods and the yield estimates derived from systematic placement of the meter were also lower than the actual yields for the same reason,

One major source of variability in pasture grazed by animals is the close aggregation or greater growth of plants in "clumps" scattered over the paddock but occupying less than about 10% of the total area. These "clump" areas tend to yield more highly than the surrounding regions. Thus the smaller the size of a pasture. sample the less is the likelihood that such samples will take sufficient account of these areas and therefore the yield estimate is likely to be lower than the actual yield. If the capacitance meter is placed truly at random, according to some prearranged random system, a similar situation is likely to prevail. In practice, however, no prearranged random svstem is employed to locate the meter-reading sites and so placement decisions are forced on an observer in the light of the need to cover the area in as representative a manner as possible. The mean meter reading obtained will therefore be a reflection of the observer's ability to take an accurate account of this "clumping" effect. The more completely detached his placement decisions are, the greater will be the likelihood of lower yield estimates, whereas overemphasis with regard to the "clump" areas will give rise to estimates higher than the actual yield. Such a situation tends to produce inconsistent results which were a feature of the data concerned with random placement of the capacitance meter. Clearly further work is required before use of the meter can be recommended.

REFERENCES

Alcock, M. B., 1964: Nature, Lund., 203: 1,309-10.
Alcock, M. B.; Lovett, J. V., 1967: *J. agric. Sci., Camb., 68: 27-38.*
Back, H. L., 1968: *J. Br. Grassld Soc., 23:* 216-22.
Campbell, A. G.; Phillips, D. S. M.; O'Reilly, E. D., 1962: *J. Br. Grassld Soc., 17:* 89-100.
Fletcher, J. E.; Robinson, M. E., 1956: *J.* Range *Mgmt, 9: 96-7.*
Johns, G. G.; Nicol, G. L.; Watkin, B. R., 1965: *J. Br. Grassld Soc., 20:* 212-26.
Jones, R. J.; Haydock, K. P., *1970: J. agric. Sci., Camb., 75: 27-36.*
Lovett, J. V.; Bofinger, V. J., *1970: J. Br. Grassld Soc., 25: 119-24.*