THE MEASUREMENT OF LEAF AREA IN PASTURE PLANTS

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THE significance of leaf area in pasture growth, and its importance as a determinant of herbage yield, has been described and discussed in the preceding article. Workers who have attempted to use the concept of leaf area index in studies of pasture production have, however, experienced considerable difficulty in measuring leaf area in pasture communities. This is largely because of the fact, that even in a relatively small sample of herbage (e.g., herbage from a ½ sq. ft. of ground) thousands of leaves are involved, and a direct estimate involving every single leaf cannot easily be made. Consequently, it has been customary to use a sub-sample of representative leaves, measure their leaf area, and then relate the weight per unit area of the sub-sample to the dry weight of the sample, to determine total leaf area. Very often in pasture communities, the problem is complicated further by the fact that different species grow in association, and the process of sub-sampling for estimation of leaf area has to be repeated for each individual component of the pasture. This involves among other things hand separation of samples of herbage from a mixed sward into their component species. Finally, an estimate of weight per unit area of leaf has to be obtained for each sampling date, using a separate sub-sample each time, since this co-efficient shows marked variations through the growing season. Table 1 shows a comparison of the mean weights per unit area of grass and clover leaves, taken at random at different times of the season on a pasture of perennial rye grass and white clover. (Appadurai 1961). The weights per unit area of both grass and clover leaves showed marked seasonal variations. Further, the mean weight per unit area of grass leaf was significantly higher than that of the clover leaf.

TABLE I

Comparison of the Weights per Unit Area of Grass and Clover Leaf at different times of the Season

	5. 8.60	8. 9.60	26. 5.61	3. 6.61	11. 6.61	23. 6.61	*Mean*
Grass :							
Leaf area (sq. cm.) ..	82·4	85·1	41·1	64·7	58·7	62·3	65·7
Leaf weight (g) ..	0·321	0·249	0·127	0·223	0·222	0·239	0·230
Wt/area (g/sq. cm.) ..	0·0038	0·0029	0·0030	0·0034	0·0037	0·0038	0·0034
Clover :							
Leaf area (sq. cm.) ..	42·8	34·8	37·8	34·3	31·1	44·2	37·5
Leaf weight (g) ..	0·128	0·084	0·092	0·094	0·093	0·145	0·106
Wt/area (g/sq. cm.) ..	0·0029	0·0024	0·0024	0·0027	0·0029	0·0032	0·0027

These observations emphasize the need for regular sub-sampling in order to get a fresh estimate of weight per unit area of leaf at each sampling date, and confirm the observation made earlier, that one of the main factors contributing to the difficulties of leaf area measurement in pasture communities, is the necessity for regular and detailed sub-sampling.

TECHNIQUE OF LEAF AREA MEASUREMENT

SEVERAL methods of estimating leaf area both in crops and in pastures have been reported in recent years, most of which are indirect estimates made from certain morphological attributes of leaves. A few of these methods that have been used by workers in various parts of the world are listed below. Brougham (1956) estimated the leaf area of a rye grass/clover pasture subjected to three heights of defoliation, from samples of herbage taken from 1 sq. ft. quadrats at 4 day intervals during a recovery period of 32 days. He measured the mean width of central 100 m.m. sections of forty rye grass leaves, oven-dried the sections, and then calculated the weight per unit area. From the dry weight of the bulk sample and the weight per unit area of the sub-sample, he estimated total leaf area. He determined the area of clover leaf similarly using disks of known diameter taken from clover leaves. Neales (1956) described a method of measurement of leaf area in barley leaves in which he calculated leaf area from measurements of leaf length and breadth, using a correction factor leaf index (k) based on the ratio :

$$\frac{\text{Computed area } (l \times b)}{\text{Actual area } (A)}$$

Langar (1956) and Kemp (1960), both described methods of estimating leaf area in grasses based on measurements of length and

breadth of leaves. Even in these methods, a technique of correlating the leaf area of a known sub-sample to that of the main sample is implicit, owing to the average size of herbage samples.

In recent years several devices which could deal with slightly larger samples, and which could at the same time simplify the actual measurements have been developed. Maggs (1956) described an instrument which estimated photo-electrically the area of 100 — 400 sq. cm. of detached leaves. More recently Jenkins (1959) described an air flow planimeter which measured the areas of detached leaves quickly and reasonably accurately. Both these devices are improvements on the methods described earlier, but are still limited by the fact that they involve sub-sampling, and further individual handling of every single leaf of the sub-sample, similar to the other methods.

THE USE OF THE PLANIMETER IN MEASURING LEAF AREA

APPADURAI (1961) observed that the use of the planimeter was an effective method of measuring leaf area in pasture plants. The error involved is of the order of 2 per cent (which is lower than most other methods), and the method itself is the simplest, so long as methods which eliminate the need to sub-sample are not available. In experiments conducted at Wye in England, on a pasture of perennial rye grass and white clover, the following procedure for sampling and measuring leaf area was adopted.

METHOD OF SAMPLING

LEAF area determinations were made from samples of herbage taken from a ½ sq. ft. of ground. At regular intervals herbage from a ½ sq. ft. of ground was cut to ground level and removed to the laboratory for leaf area determinations. In order to obtain suitable samples a grid, divided into ½ sq. ft. areas was constructed. At each sampling date, the grid was placed over the sward and the appropriate predetermined area was harvested. No area was sampled more than once.

METHOD OF ESTIMATING LEAF AREA

IN the laboratory the samples of herbage from the ½ sq. ft. quadrats were first separated into grass and clover. The individual components were again separated into leaf and stem. About 40 grass leaves and 10 clover leaves were then picked at random and laid out with their flat surface on a photosensitive dyaline paper, held firmly in a

frame, and covered with a sheet of glass. The paper was then exposed either to sunlight or strong artificial light which desensitized the uncovered portions of the paper. The covered portions on mopping with a sponge dipped in Unax developing solution, yielded well defined black line prints of the grass and clover leaves. The sub-samples of grass and clover leaves were then oven dried in separate containers at 90°C for 24 hours, while their areas were determined from the prints by the use of a planimeter. Thus the weights per unit area of grass leaf and clover leaf were obtained. The remainder of the grass and clover leaves from the quadrat were oven dried separately to determine their individual dry weights. From these values it was possible to calculate the total leaf area of grass and clover in the sample, and also the leaf area index of the mixed herbage.

The above method of estimating leaf area, developed for use in a mixed sward of grass and clover, would be considerably simplified if applied to a pure grass sward. The method eliminates the use of expensive equipment, is relatively simple, and reasonably accurate.

LIST OF REFERENCES

1. APPADURAI, R. R. (1961). Studies in pasture growth. Ph.D. thesis Univ., Lond.

2. BROUGHAM, R. W. (1956). Effect of intensity of defoliation on regrowth of pasture. *Aust. J. Agric. Res. 1.* p. 377-87.

3. JENKINS, H. V. (1959). An air flow planimeter for measuring the area of detached leaves. *Plant physiol.* 34. p. 532-36.

4. KEMP, C. D. (1960). Methods of estimating the leaf area of grasses from linear measurements. *Ann. Bot.* 24. p. 491-99.

5. LANGAR, R. H. M. (1956). Measurement of leaf growth in grasses. *" Growth of leaves "*, Ed. F. L. Milthorpe. Butterworth, Lond. p. 197-8.

6. MAGGS, D. H. (1956). A photometer for estimating the area of samples of detached leaves. *East Malling Res. St. Annl. Rpt.* p. 107.

7. NEALES, T. F. (1956). The magnesium nutrition of certain herbage plants. Ph.D. thesis. Univ. Lond.