SUMMARY

The productivity of grassland is largely determined by the availability of soil nutrients within a particular environment; these can be regulated by fertilizer application but nitrogen has much the most potent influence on grass production.

Given appropriate grassland and livestock management, the output of utilized feed per acre of grassland can be increased by nitrogen-fertilizer application on commercial dairy farms at an almost linear rate up to over 100 lb. nitrogen/acre.

Grass is the cheapest food for grazing livestock and is generally the most economical basis for increasing the stock-carrying capacity of the farm and thereby expanding output per acre. With the dairy herd, increasing the stocking density is likely to increase output more effectively than increasing the degree of reliance on grass in feeding.

On these farms each £10 rise in the value of gross output, mainly derived from milk, was associated with a rise in profit of £3/acre. With each successive increment of 25 gal. milk/acre, the profit per acre increased by from £1 to £2—this profit increase being greatest at the higher levels of milk output per acre.

There are many other aspects of the effects on milk production of fertilizer application to grassland which cannot be discussed within the confines of this paper. For example, there is the crucial problem of whether it is more advantageous to increase output by purchasing feed or by enhancing yield per acre on the farm itself. On this group of farms over the past 2 years the comparison shows that both gross output and profit per acre have been increased much more by greater outlay on fertilizer applied to grassland than by a similar increased expenditure on purchased food. In other words, £1 spent on fertilizer applied to grass gave a better return in milk production than £1 spent on purchased food. This finding has special topical significance in view of the national problem of cheapening agricultural production without at the same time contracting its scale or profit while if possible reducing the present degree of reliance on imported foods for grass-eating livestock. In existing circumstances there appears to be a clear case for improved efficiency in those forms of livestock production that are based on the use of grass and little doubt that its more intensive exploitation on dairy farms offers financial advantage to the producer.

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The measurement of pasture output

By W. F. RAYMOND, *The Grassland Research Institute, Hurley, Berks*

Pasture output a function of management

Most systems of pasture evaluation take little account of two of the main characteristics of pasture output, namely that it is made up of a number of harvests in any one year, and that management in one year affects yields and persistence in subsequent years. On a national or a farm scale it is possible to talk of yields from 'grassland' in terms of live-weight increase, milk production, or utilized starch equivalent per acre, these being measures of the output actually obtained under conditions of practical grassland management. These same measures are, however, very generally used to assess pasture output under experimental conditions and I hope to indicate that they are quite inadequate for the critical type of evaluation now being made.

This approach implies that one can consider pasture output in the same terms as arable output, and derives from the early evaluation of grassland in terms of hay yields. However, in the 1920's Woodman, Blunt & Stewart (1927) showed the profound effect that frequency of cutting has on total annual yield of dry matter from grassland. These experiments showed clearly that an acre of grassland cannot be considered to have a predictable output potential comparable to that of an acre under an arable crop, annual yield from pasture depending very much on the management system imposed, as well as on soil fertility and climate which largely determine arable yields. This finding has been further illustrated by the results of grazing experiments recently reported by Eyles, Williams & Green (1956). Three similar areas of pasture were grazed by groups of sheep under three systems of management which differed particularly in their rates of spring stocking. The average live-weight increase per acre over three grazing seasons ranged from 384 lb. under a system where maximum utilization was made of the spring grazing down to 290 lb. where an attempt was made, by lenient spring grazing, to conserve some herbage *in situ* for midsummer keep. Thus output from the pasture, measured in terms of live-weight gain, varied by as much as one-third, solely as a result of the management employed.

It appears therefore that comparison of different pastures in terms of dry-matter yield or live-weight gain produced per year is quite inadequate, because differences found are as likely to reflect the effects of the managements imposed as true differences in output potential between pastures. This difficulty cannot be overcome by imposing the same system of management on all pastures, for it is almost axiomatic that if there are true differences between pastures their optimum management systems will differ.

It is also becoming recognized that the total annual yield from a pasture is of relatively less importance than the distribution of that yield between different months of the year. Total annual yield is always dominated by May—June production, much of which is conserved as being in excess of stock requirements, but in terms of practical grazing management herbage production during other months is of greater importance. Despite this fact, comparisons such as of species, seeds mixtures, commercial and pedigree strains are still far too frequently reported in terms of annual yields. In fact the important difference between strain A and strain B is likely to be, not that one yielded 8500 lb. and the other 9000 lb. of dry matter during the year, but that strain A yielded 800 lb. in April, before strain B was ready for grazing. Studies of early bite, midsummer keep, winter foggage all emphasize that seasonal distribution of yield is a most important attribute of a herbage species, and, together with such characters as persistence, palatability and wintergreenness, is of more significance than total annual yield.

Thus pasture investigation increasingly requires ability to measure output from a pasture over a relatively short period, perhaps from one plot on a rotation, or a day's move under strip-grazing, and some of the techniques that were apparently valid for assessing output over a whole grazing season have been found inadequate when applied to such short grazing periods.

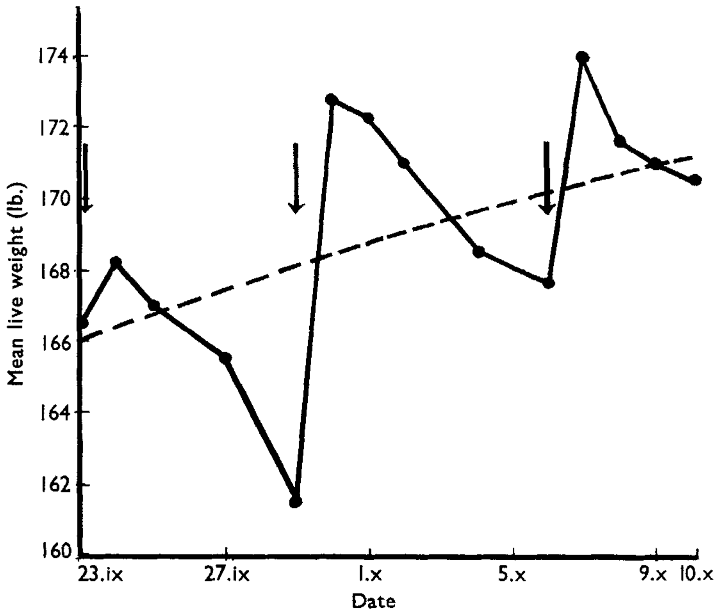

Fig. 1. Daily variation in mean live weight of a group of thirteen sheep on rotational grazing. Move to fresh paddock after weighing at 10 a.m. of days ↓. — — — —, approximate mean live-weight curve.

Measurement in terms of animal production

The most commonly used technique has been measurement of the live-weight increase of grazing stock. It has been accepted that live weight will to some extent depend on 'fill', but the magnitude of this effect over short grazing periods is not always realized. Fig. 1 shows the average live weight of a group of thirteen sheep which were weighed daily while under a system of rotational grazing. Though a general trend of increasing live weight is evident, it is obviously not possible to determine the true live-weight gain during any particular grazing period. This effect is most marked when indoor-fed stock are put out to pasture in spring, when the measured drop in live weight is certainly not all body substance. Overnight fasting of stock does reduce the fluctuation in live weight due to 'fill', but not to the extent required to allow accurate estimates of gain over short grazing periods. However, even if live-weight gain can be determined accurately, it suffers, as a measure of pasture output, from the previously noted defect that it is largely a reflection of skill in grazing management: a pasture stocked lightly will allow animals to gain weight when the same pasture more heavily stocked would only maintain them. A better measure of output is obtained by converting the number of grazing days as well as live-weight gain to feeding units such as starch equivalent. It must be accepted, however, that such units can only be approximate with our present knowledge of energy metabolism in ruminants.

Milk production provides a more sensitive reflection of pasture output than does live-weight gain, and milk output can certainly be allocated more accurately to production from a particular pasture than can live-weight production. However, milk production is probably even more dependent on management than is live-weight gain, and the technical problems of using the dairy cow for pasture evaluation, when only small areas are available, have still to be investigated. Cox, Foot, Hosking, Line & Rowland (1956) have recently described an experiment in which cows were grazed individually on plots, but considerable replication is required before valid between-pasture comparisons can be made, because of the effects of animal variation, stage of lactation and so on.

Animal production data, besides being frequently a reflection more of skill in management than of true differences between pastures, can also seldom provide information on the reasons for any differences found. For an understanding of the effects of management on animal production, production data need to be supported by information on the amounts and quality of herbage consumed. It is only when animal production can be related to intake of nutrients that a reasonable understanding of pasture production will be possible.

Indirect methods of estimating output

Cutting methods. Two main methods of assessing pasture intake are being investigated. The first involves some system of sampling the amount of pasture available to the grazing animals and the amount left after grazing, the difference being regarded as the amount of herbage consumed. It is only recently that the main requirements of a valid cutting technique have been recognized, including allowance for growth of the pasture during the period of grazing, the cutting of samples below the level at which stock graze, and the taking of adequate numbers of samples. Allowance for growth has generally been made by protecting areas of the sward and sampling at the end of the grazing period for 'herbage available', but this procedure generally leads to an overestimate, as the protected herbage grows more rapidly than the herbage being grazed on the sward: this difference is particularly marked during the period of most rapid growth in the spring, when very high consumption figures are obtained. Conversely, when little keep is available, stock may obtain much of their intake below the level at which herbage samples are cut with many types of equipment, and at these times very low intakes are recorded. Unfortunately in many experiments these effects have been concealed because herbage consumption has been measured over the season as a cumulative figure, the overestimates of spring and underestimates of midsummer averaging out to give a reasonable intake over the whole season. At present it is likely that valid estimates of herbage consumption can only be obtained under intensive systems of grazing, where herbage growth is very small compared with herbage consumption. Holmes, Waite, Fergusson & MacLusky (1952) have used a cutting technique with animals under strip grazing conditions; recently van der Kley (1956) has shown that, under a system of heavy rotational grazing, a move to a new paddock should be made at least every 10 days if the coefficient of variation of daily estimate of intake, by a cutting technique, is not to exceed 20. As long as adequate numbers of samples are taken, such cutting techniques should allow the day-to-day intake of grazing stock to be assessed. The errors in pasture sampling increase, however, as a pasture is grazed down and becomes less uniform, and impracticably large numbers of samples may be required to estimate intake during the last few days of grazing on a paddock.

Estimation from faecal production of grazing stock. Thus it appears that, with present information, cutting techniques for estimating herbage intake are likely to be valid only under a very restricted range of grazing conditions. Because of this, alternative evaluation techniques are being investigated, of which those depending on the faecal production of grazing stock show promise (Raymond, 1956). Faecal production/lb. herbage intake depends on the digestibility of that herbage, so that if the quantity of faeces voided and the digestibility of the herbage grazed can be measured, herbage intake can be calculated. Faecal production can be measured either by total collection or by the feeding to stock of known amounts of an indigestible tracer such as chromic oxide followed by the analysis of a sample of faeces for its content of this tracer. The important point here is that the sample taken should be representative of the total voided. In practice it is impossible to mix the tracer uniformly with the herbage eaten by grazing stock, so that the tracer concentration in the faeces varies considerably at different times of day, and a single random sample of faeces is inadequate. Raymond & Minson (1955) have described a method of obtaining a representative sample of faeces directly from the grazing sward; it has the advantage that any required degree of accuracy can be obtained by taking a sufficiently large sample. From the concentration of tracer in this sample the total excretion of faeces during the day is calculated as that weight of faeces that would contain the total weight of indigestible tracer fed.

The determination of the digestibility of the herbage consumed by grazing stock can be studied by two methods, both of which attempt to take account of the most important factor of the selective grazing habit of ruminants. By measuring the concentrations in faeces and in 'herbage as grazed' of a natural component, e.g. lignin, which is indigestible, an estimate of digestibility can be obtained. Alternatively, in the 'faecal index' method, herbage digestibility is estimated directly from the composition of the resulting faeces, by means of relationships based on digestibility experiments indoors. Of these two methods the second appears preferable, as it does not require subjective sampling of the sward for 'herbage as grazed', nor does it require any assumptions as to the indigestibility of any plant component. However, the accuracy of prediction of digestibility by the faecal-index method is not adequate for many pasture studies, and improved relationships must still be looked for.

Briefly then, it appears that we now require techniques for measuring and comparing pasture outputs over relatively short periods, rather than over the whole season, as has generally been done. The measurement of animal production over short periods is liable to considerable errors, and as a measure of output is very sensitive to skill in pasture management. For a more complete measure of pasture output information on herbage consumption is also required. Two main methods of estimating herbage intake are at present being studied, involving herbage cutting or faecal measurements, and improvements in the precision of these techniques are urgently needed in further studies of pasture evaluation.

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Some effects of spring grass on rumen digestion and the metabolism of the dairy cow

By M. J. Head and J. A. F. Rook, *National Institute for Research in Dairying, Shinfield, near Reading*

During the last two decades, there has been a marked increase in the productivity of our grasslands. It has been achieved, in part, by the application of heavier dressings of fertilizer, especially nitrogenous fertilizer, which tends to produce an early spring growth of succulent herbage of high crude-protein content. This type of herbage, often containing 25–35% crude protein on a dry-matter basis, provides the grazing cow with an unbalanced ration when judged by accepted feeding standards, an excess of protein (N $\times$ 6·25) being consumed in relation to both the cow's protein requirements and to the starch equivalent consumed.

In the ruminant, the preliminary fermentation within the rumen has a profound effect on the subsequent digestion and metabolism of the feed constituents. With nitrogenous substances, the end-product of the katabolic microbial processes is ammonia which is, however, concurrently elaborated by other micro-organisms into the constituents of their bodies. The study of the fermentation in vivo is complicated by this resynthesis of breakdown products and by the continuous absorption of substances from the rumen by the blood and the passage of digesta to the omasum.