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The efficiency of utilization of fresh grass*

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Grass is a major crop in this country and grassland a cheap source of feed. But unless the produce is effectively utilized it is an unprofitable way of using land, particularly where conditions suit the growing of other crops. Grass is of course the only way of utilizing land which by reason of topography or rainfall is unsuitable for other crops. Moreover, in arable areas a grass ley is considered to confer some benefits on succeeding crops. Nevertheless grassland and especially grazing is probably one of the farming resources which in general is least well exploited. This is not difficult to explain in view of the technical complexities of grassland management, and it should be appreciated that improving grazing efficiency is not necessarily the best thing a farmer can do with his available time and resources. However, grass efficiently used can compete in economic terms with many other

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forms of agricultural production, and the purpose of this paper is to examine and if possible define the sources of inefficiency in the use of fresh grass, where possible to indicate ways in which it might be improved and in some respects to point out the need for yet more research.

The efficiency of grazing over a whole grazing season depends on the total yield of herbage, its distribution over the year, the proportion of the herbage actually consumed by the animal and the efficiency of the consuming animal. Production and distribution of herbage over the season hardly come into this discussion, but clearly the fluctuation in rate of growth from 0 to 150 lb dry matter per acre per day (Holmes, 1962) increases the problems of management since some grass will undoubtedly be surplus to immediate animal needs and must be conserved for winter. Despite the fluctuating supply, the feed available for animals should be kept in close relation to requirements.

The effectiveness of removal of herbage over the year is difficult to define objectively, particularly since removal at one time may influence regrowth for a later time and since, in some systems of grazing, removal is continuous over the season. Reference to some factual estimates is made below.

Attainable levels of energetic efficiency

As for other feeding-stuffs, the efficiency with which grass is used depends on the efficiency of the consuming animals. As Tables 1 and 2 show, the gross efficiency is liable to be low unless animals are highly productive and is nil when animals merely maintain their weight. Livestock in Britain are rarely grazed throughout the year, but clearly the calculated levels of energetic efficiency (Table 2) are very low for animals such as breeding ewes or breeding cows whose sole product is a single lamb (plus wool) or a calf.

Table 1. *Calculated gross efficiencies of animal production from grass*

Animal	Weight (lb)	Daily production: Milk (lb)	Daily production: Weight gain (lb)	Daily intake of DOM (lb)	Mcal: Feed*	Mcal: Product†	Efficiency of use of metabolizable energy (%)
Dairy cow‡	1100	—	2	16·6	27·40	—	0
	1100	30	1	22·2	36·60	10·2	27·9
	1100	60	—	27·8	45·80	20·4	44·6
Fattening steer§	800	—	—	8·90	14·68	—	0
	800	—	1	11·40	18·80	1·43	7·6
	800	—	2	13·92	22·95	3·33	14·5
	800	—	3	16·44	27·10	6·00	22·2
Fat lamb ‖	80	—	0·3	2·15	3·55	0·69	19·4
	80	—	0·6	2·90	4·78	1·40	29·3

For meaning of abbreviations, see p. 93.

*1650 kcal/lb DOM.

†Calorific value of milk or meat available for human consumption: 340 kcal/lb FCM, 700 kcal/lb for calf, 700 kcal/lb for lamb, 1700 kcal/lb for steer gain.

‡DOMI = 0·27 FCM + 0·07 $W^{0·73}$ + 2·5 LWG (Holmes & Jones, 1963, unpublished).

§DOMI = 0·068 $W^{0·73}$ + 2·52 LWG (Holmes, Jones & Drake-Brockman, 1961).

‖DOMI = Maintenance 1·4, gain 2·5 lb/lb (G. Hadjipieris, 1963, unpublished.)

Table 2. *Calculated gross efficiencies of production from grass, annual cycle*

Animal	Weight (lb)	Milk (lb)	Weight gain (lb)	DOM intake lb	DOM intake Mcal	Product* (Mcal)	Efficiency of use of metabolizable energy (%)
Dairy cow, March-calved, grass-fed	1100	9000	50†	6900	11380	3060	26·9
Beef cow, February-calved, grass-fed, suckled calf	900	—	50† calf 500	5800	9560	350	3·7
Low-ground ewe, grass-fed, single lamb	140	—	10† lamb 80	1400	2310	56	2·4
Low-ground ewe, grass-fed, twin lambs	140	—	10† lambs 160	1630	2690	112	4·2
Beef steer, fattened on grass, 665–935 lb in 180 days	—	—	270	2320	3830	459	12·0

For meaning of abbreviations see p. 93.

*Calorific value of milk or meat available for human consumption: 340 kcal/lb FCM, 700 kcal/lb for calf, 700 kcal/lb for lamb, 1700 kcal/lb for steer gain.

†Gain not included in efficiency.

Unless fertility can be increased or the price of product relative to milk greatly improved, therefore, the breeding meat animals should be relegated to cheap land and only rapidly growing fat stock or high-yielding milk stock carried on good land. The grassland ewe flock poses a particular problem since about 90% of the total feed consumed is for maintenance (cf. 60% for the dairy cow). Although over the whole growing season grassland is one of the most efficient crops in using light energy (capturing up to 6% of the available radiation (Alberda, 1962)), Table 2 shows that only a very small proportion of this energy is converted into a form suitable for human consumption.

The relationship of animals to feed available

There is reason to believe that herbage may be wastefully used under grazing conditions owing to excessive consumption leading to only small responses in animal production for a large increase in intake. Mott (1961) set out a theoretical consideration of the problem and demonstrated how output per acre can be improved by the attainment of correct grazing pressure. The attainment of the optimum position on the graph (Fig. 1) day by day is the problem facing the efficient grassland farmer.

The direct measurement of feed intake on pasture

A field of study which promises to lead to a better understanding of grazing efficiency is the measurement of individual feed intakes of cattle by the use of the

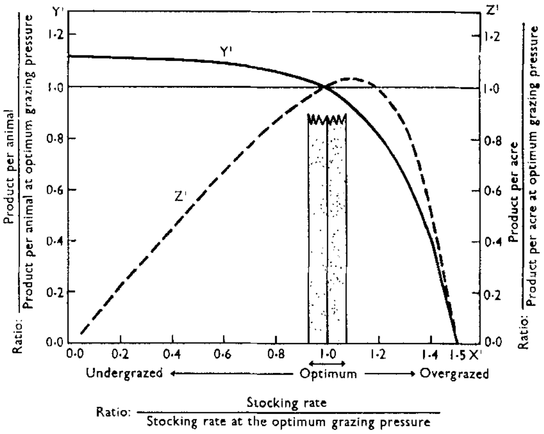

Fig. 1. The relationship of product per animal and product per acre to stocking rate (after Mott, 1961). (Reproduced from Holmes (1962) by permission of the Editor of the *Journal of the British Grassland Society*.)

chromic oxide–faecal nitrogen techniques. This procedure has now been carried out by several groups of workers, in particular at Ruakura, Cornell, the Grassland Research Institute, the National Institute for Research in Dairying, the Rowett Research Institute and Wye College. Such studies suffer from several sources of error including those connected with the efficiency of recovery of chromic oxide and the accuracy of estimation of digestibility. The latter is particularly important with high-quality pastures where an error of 1 percentage unit in digestibility may cause an error of 5% in the estimate of digestible organic matter consumed. This matter has been studied by Greenhalgh, Corbett & McDonald (1960).

In some of the studies intake has been related to weight, milk yield and live-weight gain of the animals. In many instances these three factors account for over 90% of the variability in intake although it is not always so. However, even then in some instances the equations may introduce a bias giving too much weight to the portion associated with maintenance and too little to weight change, or vice versa. However, some of the recent equations have been contrasted with other published data. Data for cattle are given in Table 3. These data indicate that under conditions in which feed supply was unrestricted, high intakes which agreed closely with the estimates based on equation (2) (p. 93) were recorded. Where, however, feed quality, the method of offering feed or the quantity available were such as to restrict intake (e.g. in close strip grazing), then lower quantities of feed were consumed and estimates based on equation (4) (p. 93) agreed more closely with the measured intakes. Though there were differences between the equations in the partial regression coefficients for fat-corrected milk yield and live-weight gain, the major difference between them was in the coefficients for $W^{0 \cdot 73}$. This need not necessarily imply that the maintenance requirement *per se* differed but that maintenance, plus effort of grazing, climatic stress and possibly luxury consumption on grazing combined to give a higher total feed consumption per unit body-weight when feed was not restricted.

Table 3. *Feed intakes of cattle measured by various authors and compared with intakes estimated by two regression equations**

Reference	DOMI (lb/day) Measured	Estimated from equation:* (2)	(4)	Conditions
Holmes & Osman (1960)				
Strip grazing	17·8	23·3	17·6	Cocksfoot pasture
Free grazing	18·8	23·3	17·6	Cocksfoot pasture
Corbett *et al.* (1963)				
Period 2	20·4	19·9	17·1	Liberal strip grazing
Period 6	16·4	17·5	14·3	
Waite *et al.* (1959)	22·6†	22·8	20·0	*Ad lib.* spring grass indoors
Waite *et al.* (1952)	18·2†	21·8	16·7	Close strip grazing
	21·7†	22·2	16·9	Liberal rotational grazing
Holmes Arnold & Provan (1961)	26·0	26·6	20·7	Winter feed, high concentrates
	17·1	22·7	18·4	Winter feed, low concentrates
Holmes *et al.* (1962)	23·8	28·0	23·2	Winter feed, high concentrates
	19·4	25·3	20·5	Winter feed, medium concentrates

For meaning of abbreviations, see p. 93.
*Equations:
(2) from Holmes & Jones (1963, unpublished),
$$\text{DOMI} = 0{\cdot}23\ \text{FCM} + 0{\cdot}164\ W^{0{\cdot}73} + 1{\cdot}25\ \text{LWG} - 12{\cdot}5$$ (see p. 93).
(4) from Corbett *et al.* (1962),
$$\text{DOMI} = 0{\cdot}30\ \text{FCM} + 0{\cdot}046\ W^{0{\cdot}73} + 0{\cdot}56\ \text{LWG}$$ (see p. 93).
†DOM estimated as 70% of DM.

This observation is in accordance with an interpretation of Mott's (1961) diagram (Fig. 1), in which on the left-hand side it can be considered that the animal is consuming excess feed and that, at the margin, food conversion efficiency is low, whereas on the right-hand side when feed available per animal is restricted the efficiency of utilization is higher although maximum animal production may not be obtained. Experimental support for these conclusions may be derived from several sources. Blaser, Hammes, Bryant, Hardison, Fontenot & Engel (1961) showed that the amount of food consumed was restricted by the quality of the diet. Waite, Holmes & Boyd (1952) found in early experiments on strip grazing that food intake could be reduced at little cost in animal production and Line (1961) also found low intakes associated with higher stocking rates. Whereas a few years ago it was suggested that intakes on grass did not differ much from estimates based on indoor standards (Holmes, 1959), recent experience indicates that excess consumption probably does occur under many more liberal forms of cattle feeding.

This view is supported in experiments reported by Hutton (1962) when cattle were fed on cut grass under conditions in which there was little chance of error occurring in the estimate of feed intake. In these conditions an equation of the form:

$$\text{DOMI} = 0{\cdot}21\ \text{FCM} + 0{\cdot}095\ \text{W}^{0{\cdot}73} + 1{\cdot}64\ \text{LWG}, \qquad (1)$$

where DOMI = digestible organic matter intake (lb/day), FCM = fat-corrected milk yield (lb/day), W = live weight (lb) and LWG = live-weight gain (lb/day), fitted the data from milking cows.

These results agree with a series of equations which have been derived at Wye College on liberal strip grazing. Typical equations are:

$$\text{DOMI} = 0{\cdot}23\ \text{FCM} + 0{\cdot}164\ \text{W}^{0{\cdot}73} + 1{\cdot}25\ \text{LWG} - 12{\cdot}5\ \text{(residual standard error} \pm 1{\cdot}96), \qquad (2)$$

or when the constant term is eliminated

$$\text{DOMI} = 0{\cdot}20\ \text{FCM} + 0{\cdot}098\ \text{W}^{0{\cdot}73} + 0{\cdot}76\ \text{LWG}\ (\text{RSE} \pm 2{\cdot}15). \qquad (3)$$

The equation with the constant term is preferred and has been used in subsequent calculations. These equations give predicted intakes over the normal range almost identical to that obtained with Hutton's equation. They also agree with recorded values for intakes and animal production quoted by Waite, Castle & Watson (1959) for cows fed *ad lib.* on early spring grass indoors, with results quoted by Corbett, Langlands & Reid (1963) under liberal strip grazing, by Waite *et al.* (1952) on rotational grazing and with intakes of cows liberally fed on concentrates and high-quality silage in winter (Holmes, Arnold & Provan, 1961).

On the other hand, an equation of Corbett, Langlands & Boyne (1962),

$$\text{DOMI} = 0{\cdot}30\ \text{FCM} + 0{\cdot}046\ \text{W}^{0{\cdot}73} + 0{\cdot}56\ \text{LWG}\ (\text{RSE} \pm 1{\cdot}8) \qquad (4)$$

which implies a much lower maintenance requirement gives predicted intakes in close agreement with those found by Holmes & Osman (1960) with strip and free grazing on cocksfoot pasture, by Greenhalgh & Runcie (1962) under strip grazing and zero grazing (feeding with cut forage), by Line (1961) on intensive grazing at high stocking rates and by Holmes, Jones, Drake-Brockman & White (1962) with winter-fed cows receiving concentrates with medium-quality ensilage rations, all circumstances in which some restriction in intake was imposed, either by rationing or by the quality of the feed.

Measurements of feed intake of sheep

Several studies have also been made of the feed consumed by grazing sheep (Coop, 1961; Langlands, Corbett, McDonald & Reid, 1963; G. Hadjipieris, 1963, unpublished). Typical computed intakes for 100 lb dry and 140 lb lactating ewes are shown in Table 4, contrasted with some observations made on sheep under indoor conditions. Again the partition equations suffer from the risk of distortion, and in some instances, as with cows, the portions allotted to live-weight change appear to be low. Both with dry and lactating sheep, however, there is evidence that feed consumed at pasture substantially exceeds that in indoor conditions. Coop & Drew (1963) indicate that the loss of the wool coat by itself resulted in an increased maintenance requirement. Graham (1962) from calorimetric trials has suggested that the effort

Table 4. *Comparison of estimates of intake of digestible organic matter of sheep fed indoors and on grazing*

Reference	lb/100 lb live weight	lb/lb weight gain	Conditions
	Dry sheep		
Coop (1961)	0·92	2·27	Pen-feeding
	1·36–1·63	0·90–1·98	Outdoor grazing
Langlands *et al.* (1963)	0·94	3·0	Pen-fed (by regression)
	1·10	3·2	Outdoor grazing (by regression)
	0·82	3·7	Pen-fed (functional analysis)
	1·02	4·2	Outdoor (functional analysis)
Coop & Drew (1963)	1·78		Short grazing
	1·34		Long grass for a short time
	1·01		Penned indoors
	1·10		Penned outdoors
	Lactating ewes Estimated intakes for 140 lb ewe yielding 5 lb milk/day		
		lb/ewe	
Coop & Drew (1963)		4·89	Outdoor grazing
G. Hadjipieris (1963, unpublished)		5·0	Outdoor grazing
		3·12	Indoor feeding
Wallace (1948)		3·46*	Indoor feeding

*Gross digestible energy.

of grazing resulted in a 12–18% increase in energy output of the sheep. The most recent work of Coop & Drew (1963) tends to confirm the suggestion of Lambourne (1961) that the DOM intake per 100 lb live weight is appreciably higher where the grazing is short and sparse than where it is readily available. These results are in apparent contradiction to those reported for cattle. However, it is possible that, under the widely varying conditions which occur on grazing, luxury consumption on liberal feeding on the one hand and elevated maintenance requirement under harsh conditions on the other may both occur in different grazing situations.

It will be recalled that Sjollema (1950) considered that the energy cost associated with grazing was very high. Recent work seems to be returning to this view, although careful calorimetric work (Blaxter, 1962) has shown that locomotion associated with grazing is itself unlikely to result in more than a 15% increase in feed consumption.

Practical measures that may be taken to improve grazing efficiency

These theoretical considerations suggest methods whereby grazing efficiency may be increased, but before discussing them three practical matters must be mentioned.

The first is that the attainment of a high level of grazing efficiency for all except the intensive grassland dairy herd makes such demands on management skills and leaves such low returns that it may not be worth while. In the economist's terms, the marginal productivity of effort put into this enterprise may be far lower than from similar effort put into crop or pig production.

The second, which largely explains the first, is that the farmer is faced with a continuously variable supply of feed and his system of utilization must be able to deal with this. It is probable that to cope with this situation and attain maximum efficiency of grass use would demand conservation of all produce and its subsequent use under conditions of rationing.

Thirdly, brief reference should be made to the percentage of available herbage that is utilized. Measurement of net consumption is possible only under rotational or strip grazing methods. Such estimates have shown that at one grazing 55–95% of the available herbage may be consumed, the higher the proportion the more strictly the grass was rationed. McMeekan (1958), taking a very intensive system of grazing as 100% effective, indicated that in other systems only 62–66% were utilized. In a series of experiments in 1951–3 in which strip grazing was carefully practised, Holmes (1954) claimed that the pasture had been fully utilized since the calculated production from grazing days agreed with that expected from fertilizer plot experiments. On a more general basis it may be calculated that since the average amount of starch equivalent (SE) utilized from grassland in the UK is 15–20 cwt/acre (Great Britain: Parliament, 1958), the probable output of dry matter is at least 40–50 cwt/acre and its probable SE 50, from 60–80% of the grass produced is apparently utilized.

Stocking rate and grazing pressure

All recent studies have stressed that the attainment of a high grazing pressure is the first essential. Reasonable standards for stocking rate for the year allowing for conservation and assuming only modest use of supplementary concentrates are 1·5 acres per dairy cow, 1·25 acres per beef cow (on low ground), 1 acre per young cattle beast and 0·3 acre per ewe.

Rotational strip grazing. There is no doubt that, for practical management on the intensive grass farm, for dairy cows strip grazing within rotational paddocks or the use of daily paddocks, and for ewes and lambs rotational creep grazing, are the best methods to enable the farmer to maintain the correct grazing pressure. These methods achieve efficient removal of the herbage, possibly stimulate tillering in the early season because of the close defoliation achieved and enable a reliable forecast of future supplies to be made.

The efficient conduct of experiments to detect the benefit of such a system is of course fraught with difficulty (Holmes, 1962) but it is unfortunate that, in the reaction from unequal stocking rates, experiments should often have swung to equal stocking rates which cannot reveal differences in terms of animal production unless grazing pressure is very high, although many such experiments demonstrated that increased stocking rate itself could greatly increase the utilization of pasture. The experiments of McMeekan (1961) and Lambourne (1956) have, however, shown that even under experimental conditions increased performance per acre at high stocking rates results from a rotational system of management.

Mechanical grazing. Increased herd sizes, the increasing trend to arable farming with few fences and the improvement of forage harvesting machinery all make mechanical grazing more attractive. The difficulty of effective experimental comparisons has again hampered its evaluation. So far none of the comparisons have shown a financial advantage in favour of mechanical grazing (Moore & Williams, 1961; Smith & Keyes, 1959), although Hull, Meyer & Kroman (1961) claimed that utilization was about 30% higher under mechanical grazing than under rotational grazing at a comparable stocking rate on irrigated lucerne–cocksfoot pastures. In general mechanical grazing is more effective with coarse types of pasture.

Restriction of time. Of more immediate practical interest might be the restriction of time available for grazing. In Africa, studies (Joblin, 1960) have shown that cattle do better if they graze by night as well as by day and Vik (1956) showed that day grazing reduced intake. However, with our high-quality temperate pastures restriction of grazing to the day only (or night only if the fences were sound) might achieve the degree of restriction desired. A preliminary investigation with beef cattle at Wye College yielded the results in Table 5. The combination of a restriction in

Table 5. *Influence of restriction on pasture output as determined at Wye College on beef cattle*

	Restricted grazing, day only, 0·45 acre/head	Unrestricted grazing, day and night, 0·9 acre/head
Estimated pasture output DOM/acre (lb)	3650	2240
Average gain/day (lb)	1·00	1·72

DOM, digestible organic matter.

area and restriction in time resulted in an increase in utilization of DOM from pasture of over 50%, but it was accompanied by a reduction in gain per animal from an average of 1·72 lb to 1·00 lb/day. Obviously further work is needed.

The use of herbage at a more advanced stage of maturity. Less frequent defoliation of herbage gives higher yields of feed energy and imposes a restriction on appetite. But, as Bosch (1950) found, utilization of long material is inefficient under grazing conditions. However, time control, mechanical grazing or conservation and refeeding all offer scope for this economy.

The use of supplementary feed. Supplementary concentrate feeds are widely given to grazing cattle although there is a massive volume of evidence showing that their net effect on animal production is small (cf. Corbett & Boyne, 1958; Holmes & Sykes, 1961). From a survey of published data we have calculated that when concentrates were added to a roughage diet:

$$I = 2{\cdot}8 - 0{\cdot}034D,$$

where I = lb increase in total feed intake per lb concentrates consumed and D = the digestibility of the organic matter of the roughage to which the concentrate was added.

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Since grazed pasture generally falls within the range 70–80% digestibility, the expected increase per lb concentrates OM is therefore only 0·1–0·4 lb, which largely explains the small response in animal production.

With milking cows recent experiments at Bridget's (National Agricultural Advisory Service, 1962) have confirmed that the return from supplementary concentrate feeding is negligible so long as an adequate supply of grazing is available, and Laird & Walker-Love (1962) showed that even careful rationing according to yield (which was not always apparent in some of the earlier experiments) did not give a worth-while response.

Similarly Alder, Head & Berting (1956) and Dodsworth & Ball (1962) have shown that the provision of supplementary feeds to beef cattle is rarely of value.

Restriction of pasture with concentrate feeding. However, in all these studies no deliberate restriction of pasture has taken place and the effect of supplementary feeding was merely to provide more total feed and reduce the grazing pressure, pushing the situation back into the left-hand area of Mott's curve (Fig. 1). Since home-grown concentrate feeds such as barley need cost the farmer no more than 2d/lb SE at growing price and 3d/lb at selling price there may be a case for deliberate restriction of pasture intake and supplementation with cheap grain, particularly in the east of Britain and other areas where cereal production is more reliable than grassland production and may be at least as productive per acre (Holmes, 1964).

In a trial at Wye College in which restricted grazing for beef store cattle was supplemented with barley the results shown in Table 6 were obtained (R. S. Musangi, 1963, unpublished).

Table 6. *The influence of supplementary feed on total output per acre from beef cattle as determined at Wye College*

	Restricted grazing		Unrestricted grazing	
Barley (lb/head day)	10	—	10	—
Gain/head (lb/day)	1·26	0·77	1·85	1·59
Mean DOM utilized/acre, allowing for barley at 35 cwt/acre (lb)	3350	3650	2640	2240
Gain/acre including barley (lb)	360	240	350	270

DOM, digestible organic matter.

The indications are that the improved performance per head resulting from barley feeding gave the highest level of gain per acre, account being taken also of the acres used for barley. Gain is of course the least satisfactory measure of performance, but it may also be calculated that, although grass intensively used gave the highest average DOM production, performance with intensive use of grass plus barley exceeded that with less intensive use of grass by nearly 50%. In this experiment the overall levels of animal performance and of utilization of grass were low. Barley supplementation might not be so effective in terms of output per acre if the level of grass production were higher, but if it could result in a marginal increase in production per animal and improve 'finish' it might be economically justifiable when used with severely restricted pasture. Further work on beef cattle and milking cows is needed.

Summary

This is intended to be a speculative review considering the many facets of grass utilization. Efficiency of pasture use in part depends on the productivity of the animals, but attainment of a stocking rate which ensures a high grazing pressure is essential.

There is evidence from intake studies that the feed consumed on grazing may exceed that on indoor rations not only because of the extra cost of locomotion but because of additional climatic stress, energy expenditure in grazing and, probably, in some circumstances, luxury consumption of readily available feed. These may add up to 100% above the theoretical maintenance requirement.

Some practical standards of grazing efficiency are suggested and methods of attaining restriction in intake are outlined. Though the use of supplementary feed is usually wasteful, there are some indications that it might be worth while in terms of animal production per acre when combined with severely restricted pasture.

We are indebted to G. Hadjipieris and R. S. Musangi of Wye College for agreeing to quotation from their unpublished results.

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Some factors affecting the efficient utilization of conserved grass*

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The efficient utilization of conserved grass is dependent on several factors, and these include the nutritive value of the product and its intake by the animals to which it is given, both of these factors being influenced by the crop which is conserved and the efficiency of preservation. The method of conservation (i.e. by ensilage or haymaking) also has an effect on utilization, as have supplementary foods given with the conserved product. The loss of nutrients associated with the conservation process must also be considered, since the extent of this loss determines the quantity of nutrients that will be available in the final product.

The most important methods of conservation in Britain are ensilage and haymaking, and discussion will be limited to these two methods.

The loss of nutrients associated with the conservation process

Losses in making silage. The sources of nutrient loss in ensilage are surface waste, plant respiration, bacterial fermentation and effluent from the silage. The losses associated with plant respiration and the subsequent fermentation are often referred to as being unavoidable, but though it may be true when applied to conditions in any one mass of silage, the term is incorrect in general application. It has been shown clearly that the type of fermentation in silage has a marked effect in determining nutrient losses (Murdoch & Holdsworth, 1958), the losses being higher when the volatile fatty acid content of the silage is high relative to that of the lactic acid. Many factors influence the fermentation in silage, and the most important appear to be the sugar and the dry-matter content of the herbage being ensiled (Murdoch, 1961).

There can be an appreciable loss of nutrients in the effluent from the silage, the loss being determined to some extent by pressure on the silage and the additives used

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