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SYMPOSIUM ON 'GRASS AND GRASS PRODUCTS IN THE EIGHTIES'

Grass and fresh grass products

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Grass is capable of producing greater quantities of food nutrients for ruminant livestock than most other crops grown within the United Kingdom. Rook (1978) observed that kale was the only crop which produced similar yields of both digestible organic matter and crude protein/ha to that achieved from a moderate yield of grass of 9000 kg DM/ha. However, the potential for grass growth is considerably greater than this, with Wright (1978) suggesting a potential yield of 30 000 kg DM/ha. While this may seem high, it is not greatly in excess of some herbage yields recorded in the literature. For example, Cooper & Breese (1971) presented the results from four trials which showed production levels above 21 000 kg DM/ha with a maximum of 29 000 kg DM/ha. However, these outputs are considerably above those which are recorded on the farm. Table 1 gives the yields obtained in differing situations. This information demonstrates the relatively low yields of grazed grass obtained nationally when compared both to potential yields and those which have been reported under experimental grazing situations.

Table 1. *Potential and actual grass yields*

Harvested mechanically	Yield (kg DM/ha)
Potential yield (Wright, 1978)	30 000
Maximum recorded (Cooper & Breese, 1971)	29 000
Experimental plots (Wright, 1978)	24 000
Good farm swards	14 000
Harvested by grazing animals	
Grazing experiments (Gordon, 1978)	12 750
Estimated national average (Greenhalgh, 1978)	4 500

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Given that certain yields of grass DM/ha can be produced, estimates of the potential animal outputs from grass can be calculated. When consumed at the grazing stage, grass has a high protein:energy value and it is therefore generally assumed that energy will be the major nutrient limiting the output of both milk and meat from grassland. However, animal responses to protein supplementation at pasture have been reported under certain circumstances (Gordon & Merron, 1978) although it is not clear whether this is a direct effect of protein or an indirect effect through an increase in grass intake. Nevertheless, if a grass DM yield of 13 000 kg/ha under grazing is assumed, and using an ME value of grazed grass of 11·5 MJ/kg DM, this represents a total ME output of 150 GJ/ha. If this was converted into milk by cows averaging 15 kg milk/d, assuming no live-weight change, the potential output would be approximately 16 600 kg milk/ha. Similarly, with growing animals of 200 kg live weight the output of live-weight gain should be 2300 kg/ha and with 500 kg animals the theoretical potential is 1320 kg/ha (assuming a live-weight gain in both instances of 0·75 kg/d). These values set the theoretical targets for the production of both milk and meat from grazed grass, but at national level the production achieved is well below these targets. For example, Greenhalgh (1978) estimated that on a national scale, milk production was only approximately 2000 kg/ha, after allowance was made for concentrate supplementation, which is less than 12% of the theoretical potential figure. It is therefore of interest to examine some of the factors which may affect the production obtained per unit area.

Animal production from grassland

While the theoretical targets for the production of both meat and milk from grassland have been given, that achieved in practice will depend upon a large number of factors including the quantity of grass grown and the efficiency with which the grass is both harvested and converted into animal products by the animal. Although these factors will be interrelated within animal production systems, for simplicity they are dealt with separately in this discussion.

Quantity of herbage produced

It has been appreciated for many years that there is considerable variation in the grass producing potential of different sites and this is amply demonstrated by the results presented by Morrison *et al.* (1980) which show more than a twofold difference in grass yields, for the same levels of inputs, at different sites within the United Kingdom. It would seem likely that the major part of this difference between sites is due to the environment, which includes both climatic and soil effects and their interaction. In Britain the primary climatic limit to grass production is set by the solar energy input although in many situations the use of this energy may be greatly affected by low winter temperatures or by summer drought. Water is essential for plant growth and, if there is a large deficit, a depression in grass yield will be obtained. Garwood (1979) has estimated that 30% of grassland in England and Wales would on average require at least 150 mm of

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additional water to maintain a deficit of less than 25 mm and it has been calculated that this deficit would depress yield by approximately 2·1 t DM/ha.

In practice, apart from water, the major limitation to the total production from grassland is the amount of soil nutrients, particularly nitrogen which is available to the plant. Nitrogen comes from a number of sources, including the soil, legumes, recycled N from animals and fertilizer N. The N available from the first three of these sources is extremely variable depending upon the soil and sward type, climate and stocking rate as well as the over-all management of the sward. Because of this the use of fertilizer N continues to be the major method available to the farmer for increasing grass production. Most experiments have shown a linear response in grass DM yield with N inputs up to at least 350 kg/ha, although there is a marked difference between sites in optimum N inputs (Morrison *et al.* 1980). Most experiments have, however, measured the response to N in terms of grass DM production by cutting and relatively few have involved the grazing animal which thus would allow interactions between the animal and the sward to occur. Holmes (1974) and Gordon (1974) have reviewed the responses obtained with grazing beef and dairy cattle respectively, and have concluded that there was little difference between responses to N measured in terms of grass DM production or through the grazing animal except at high N rates. On the farm the optimum economic level of nitrogen input will vary depending upon the circumstances obtaining on the farm and the ratio of the cost of nitrogen relative to the price obtained for the animal product. Bearing these points in mind Holmes (1974) and Gordon (1974) both show that in most circumstances high levels of N fertilizer can still be justified on an economic basis.

In the national context, the economic optimum may not always be the factor which determines optimum N inputs and this is particularly true in the context of limited energy resources. Laidlaw & Wright (1979) have examined the energy input–output relationship for high N grass swards and grass–clover swards. These results have been used to compare the output from a grass sward receiving around the maximum economic level of N (450 kg/ha) with that of a grass–clover sward receiving only 60 kg N in the spring (Table 2). This demonstrates that, while the level of production from the grass–clover sward is lower than that of the grass + N sward, the energy cost of producing 1 MJ ME is four times higher with the grass +

Table 2. *Comparison of energy inputs and outputs for a grass plus nitrogen sward and a grass–clover sward**

	Grass + 450 kg N†	Grass + clover‡
Total energy input (MJ)	37 940	6 814
Output (kg DM/ha)	13 200	9 700
ME output (MJ)	145 200	106 700
ME output/MJ input	3·8	15·7

*Adapted from Laidlaw & Wright (1979).
†Given five applications/year; (kg) N, 450; P_2O_5, 90; K_2O, 190.
‡Given one application/year; (kg) N, 60; P_2O_5, 60; K_2O, 140.

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N sward. However, there are considerable limitations to the use of clover in practice. These centre around the lower levels of DM produced/ha, its unpredictability between years and the marked seasonality of its growth pattern.

Efficiency of harvesting grass

The quantity of herbage harvested per unit area by grazing is a function of the intake of the individual animal and grazing intensity. When grazing intensity is low, the intake of the animal is related to its physiological condition and the quality of herbage available. The effects of both these factors have been reviewed by Hodgson (1977) and will not be discussed here. However, as grazing intensity is increased the quantity of herbage available becomes the major factor limiting intake. This has been demonstrated by Marsh (1979) who offered steers herbage allowances ranging from 3·0 to 12·5 kg DM/100 kg live weight. He reported that maximum intake was not achieved until herbage allowance reached 10 kg DM/100 kg live weight. Nevertheless, Mott (1960) demonstrated that maximum intake, and hence maximum performance/animal, does not coincide with maximum output/unit area. McMeekan & Walshe (1963), using dairy cows, estimated that maximum output/hectare coincided with a depression in yield/cow of 10–12% while Le Du *et al.* (1979) have suggested that the depression is likely to be of the order of 20–25%. This conflict between maintaining the performance of the individual animal while striving to maximize output/unit area continues to be a major problem in grass utilization and becomes more important when emphasis is placed on individual animal performance.

Various systems of grazing management are adopted on the farm. Rotational grazing systems, in which the pasture is defoliated at intervals, have only been adopted widely within the past 25–30 years. The major impetus for rotational growing was due to cutting experiments, which showed that the yield of both ME and digestible crude protein (DCP)/ha increased with increasing interval between defoliations. It was therefore argued that rotational grazing systems should produce considerably greater levels of animal output than set stocking or continuous grazing systems. However, the experimental evidence for this has not been convincing. Marsh (1975) in a review of comparisons between rotational and continuous grazing systems for beef cattle concluded that rotational grazing only produced 5% more live-weight gain than continuous grazing and, similarly, Campling (1975) when reviewing the information available for dairy cows also concluded that there was little experimental evidence to show a marked advantage for rotational grazing systems. Nevertheless, there is evidence that when very high stocking rates have been used rotational grazing systems are superior (McMeekan & Walshe, 1963; Marsh, 1975). While the possible reasons for the relatively poor response in animal production experiments from lengthening the interval between defoliations cannot be discussed at length here, there is evidence, that with grazing, the response in grass DM production to increasing the interval between defoliations is considerably lower than that obtained when the grass has been harvested by mechanical means.

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'Zero grazing', in which the herbage is harvested mechanically and brought indoors to stock, is a possible approach to circumvent some of the problems arising from the interaction of the animal and the sward. Marsh (1975) concluded from a review of studies using beef cattle that 'zero grazing' could increase output of live-weight gain/ha by around 20%. However, this increase in performance relates to live-weight gain and Collins *et al.* (1977) have shown that, even when cattle that were given cut herbage have produced similar live-weight gains to those grazing pasture, their killing out percentage was considerably lower. These latter workers have concluded, that even with 1·8 kg of a barley supplement/d cattle on 'zero grazing' did not produce as high carcass gains as those grazing conventionally.

Conversion of grass into animal products

The nutritive value of the grass available affects animal performance both through the effect on pasture intake (Hodgson, 1977) and the efficiency with which grass will be converted into the animal product. Whereas with the dairy cow the efficiency with which ME is utilized is unlikely to vary greatly, in the growing animal it may vary between 30–55% (Greenhalgh, 1978). In addition, season of the year may also have a considerable effect on efficiency. Blaxter *et al.* (1971) recorded very low efficiencies for meat production with autumn herbage even though it was of relatively high digestibility.

In milk production, the efficiency of utilization is mainly affected by the potential of the animal. For example, a 590 kg cow producing 25 kg milk/d can convert metabolizable energy intake into milk energy output with an efficiency of 39%, while a similar cow in late lactation and producing only 5 kg milk would have an efficiency of only 17% (based on MAFF, DAFS & DANI, 1975). In practice the differences in efficiencies are much greater than those illustrated here, due to the fact that feed intake at pasture is not controlled and hence the lower yielding animal is likely to be partitioning feed toward tissue gain and hence, further decreasing the efficiency of energy conversion into milk. The conclusion is that efficient systems require animals of high potential and, in dairying, this implies not only animals of good dairy merit, but also that they are at a stage in their lactation when they are producing high milk yields. For this reason mid- or late-winter calving offers the best opportunity for efficiently converting grass into milk. For example, a January–February-calving herd at Hillsborough has produced a mean milk yield of 16 450 kg/ha over a 6-year period, while a similarly managed autumn-calving herd has produced 12 500 kg/ha.

A great deal of research has shown that the feeding management of growing cattle during the winter period can affect their performance during the subsequent pasture period. Gleeson (1972) overwintered animals at growth rates of 0·07, 0·39 and 0·52 kg/d and reported corresponding live-weight gains at pasture of 0·75, 0·68, and 0·61 kg/d respectively. Collins *et al.* (1977) have also reported similar effects. However, these latter authors have concluded that the degree of compensation was much less for small (140 kg) than for larger animals. There is, however, less evidence available on the effect of winter plane of nutrition with the

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dairy cow on performance at pasture, but recent experiments have shown considerable effects. For example, in a series of experiments carried out at Hillsborough using January–February calving cows, (Gordon, 1976; Steen & Gordon, 1980*a,b*) milk yield/cow and /ha was increased by increasing the plane of nutrition indoors when the basal level of nutrition was low. On the other hand, high planes of nutrition indoors reduced output/cow and /ha during the grazing period. A similar but more marked effect has been reported by Chalmers & Leaver (1980) when higher supplementation levels have been used during the indoor period. It is unclear at present whether these differences in performance at pasture reflect a difference in the efficiency of converting the grass consumed into milk or an effect on herbage intake.

The responses in animal production to supplementation of pasture with cereal-based concentrates are generally low and almost always uneconomic (Leaver *et al.* 1968; Collins *et al.* 1977). However, it is common practice to give dairy cows supplementary concentrates during the pasture period and this has a considerable effect on the output, which cannot be attributed to grassland. For example, it has been calculated (Gordon, 1980) that a concentrate supplement (2 kg/d) given to a herd of cows with a mean yield of 20 kg, even though it may produce a yield response of 0·6 kg, would reduce the contribution which grass makes towards production by 26%. Indeed, Greenhalgh (1978) has pointed out that the major reasons for low milk yields attributable to pasture is the use of supplementary feeds, accentuated by the fact that a large proportion of cows in the United Kingdom calve in the autumn and thus produce low milk yields at pasture.

Present production levels

While the targets for animal production from grassland have been given and the major limitations to output discussed, it is interesting to examine the yields which have been achieved under experimental conditions. There are numerous reports in the literature of high milk outputs, in excess of 14 000 kg/ha, being achieved (Gordon, 1973, 1978; Steen & Gordon, 1980*a*; Le Du *et al.* 1979). For example, Gordon (1978) reported a mean production of 16 462 kg milk and 156 kg live-weight gain/ha over a 6-year period. If this performance is calculated in terms of utilized ME/ha, it corresponds to an output of 141·3 GJ which is 94% of the theoretical target given earlier in this paper. However, this calculation assumes that the live weight changes recorded at pasture are a true reflection of the changes in tissue energy.

With regard to meat production, recent reports indicate that live-weight gains of around 1600 kg/ha are being obtained (Marsh, 1977; Collins & Conway, 1972) although with relatively small animals. However, McFetridge (1973) over a 3-year period has reported a mean gain of 1237 kg/ha for heavier animals. In calculations of utilized ME with growing cattle, animal size and rate of gain have considerable bearing on the utilized ME required/kg gain. Using the results of Marsh (1977) and Collins & Conway (1972) the best estimates of utilized ME would be 111 and 126 GJ/ha respectively, while Horton & Holmes (1974) have recorded utilized ME values as high as 116 GJ/ha. While these values are not as high as those recorded with dairy cows, they indicate that there is considerable potential for utilizing grass through growing cattle by grazing *in situ*.

Fresh grass products

Grass fractionation is not a new technique, but there has been an increased interest in it during the past decade. In theory, it allows the protein in grass which is surplus to the requirements of ruminants to be extracted and fed separately to either humans or monogastric farm animals. It is not intended to discuss the subject in detail here since this has been adequately covered at a recent symposium (Wilkins, 1977) as well as in reviews by Connell & Foxell (1976) and Connell (1978). However, evidence indicates that extracted juice can supply a substantial amount of the protein required by growing pigs and leaf protein concentrate has produced good results when used in both poultry and pig feeding trials (Morris, 1977). The ME content of the processed grass is reduced by approximately 0·2 MJ/kg DM and crude protein content by about 4% with the result that ruminant production is slightly lower with the processed, than with unextracted forage (Connell, 1978).

While the technology exists to allow the efficient use of grass through fractionation, it is likely that, due to energy and economic considerations, it will continue to be more effective to convert unprocessed grass through ruminants into animal products.

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