

# PROCEEDINGS OF THE NUTRITION SOCIETY

ONE HUNDRED AND THIRD SCIENTIFIC MEETING  
ZOOLOGY LECTURE THEATRE, UNIVERSITY OF READING, BERKS

20 JULY 1956

## GRASSLAND AND THE FEEDING OF LIVESTOCK

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### **The grassland environment**

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I want to lay particular stress on the dynamic nature of the grassland sward. Floristically, grassland is in a state of flux, ever changing in response to micro-environment. In the normal grassy sward the bulk of the constituents is perennial, but consists of an aggregation of shoots (or tillers) which are annual or 'near annual' in nature, so that the sward as a whole consists of units that are themselves in a state of flux. These dynamic features provide for a very marked instability in that sward. Such instability provides, however, an important weapon which the grazier can use to improve the quality of and output from his grassland. So marked is this instability that any change in treatment of grassland is likely to promote botanical changes as well as changes in the rate of growth and total output from grassland. The balance of species and botanical composition of grassland has, of course, a direct bearing upon growth and overall production.

Many features of the environment can be controlled by the grazier, and even the influence of soil and weather can be modified by agronomic treatment. The level of soil fertility, for example, can be appreciably modified by changes in farming technique, including cultural operations, systems of crop rotation, as well as the direct application of nutrients. The system of grazing and the method of use of grassland is controlled by the farmer. The unstable and dynamic character of the mixed sward makes that control more absolute but, perhaps, more difficult to achieve at any desired point of maintenance. The grazier aims to produce a predominantly leafy sward and one which will make active growth over the longest possible grazing season, this in order to satisfy the needs of his animals and to maintain high production of animal products.

Grassland that is in a leafy condition and of reasonable vigour is itself providing herbage that is seldom uniform either in proportion of leaf to stem or in chemical composition and nutritional value. Furthermore, grazing animals are selective and it will be appreciated that herbage actually eaten by the animal will seldom approach uniformity from day to day. All this adds much to the interest of grassland studies both in relation to the nutrition of the animal and in regard to the amount of grass ingested.

Grassland has an important part to play in the farming economy of most countries. This theme is now widely recognized and yet we are a long way from making the best use of our resources. Modern techniques of management together with more effective use of fertilizer on grassland are still only practised on a proportion of our farms, usually by the more progressive and forward-thinking type of farmer. At some time in history, the British Isles were largely under forest and woodland, and a depopulated Britain would return to forest in due time. The grasslands of this country, therefore, are in a very real sense man-made, for it is man and his grazing animals which maintain grassland and retard the spread of agriculturally undesirable scrub and woodland.

If we include hill grazings as well as lowland pastures we find that of the total of the agricultural area of just over 48,000,000 acres in the United Kingdom, about three-fourths is under grass and the remainder in arable crops. These figures have varied considerably over the past century. There was a high proportion of arable land during the period 1850–75, followed by a rapid decline from 1880 to 1900, and the trend continued to 1939 when it was reversed by wartime needs. Periods when land goes from arable to grass in this country are associated with depressed conditions in agriculture.

The production per acre from grassland is likely to have decreased appreciably between 1875 and 1939 in both the lowlands and hills of this country. In the lowlands understocking of land put to grass without adequate seed and fertilizer was associated with deterioration in botanical features of grassland. Most of this land by 1939 was in permanent pasture or rough grazing and had attained some sort of stability in relation to treatment. Most of it was in the relatively low category of *Agrostis*—white clover pasture in our lowlands. Similarly the hill and marginal pastures had deteriorated and there was much invasion by bracken and heather. The intake fields of the 19th century crofts in Scotland and in Wales had deteriorated, and even today are frequently under rushes, bracken and other typical moorland vegetation. To prevent this sort of deterioration, it is necessary to keep a balance of livestock to grass and of grass to arable so that adequate numbers of livestock can be maintained.

I want now to consider a few of the major grassland types found in this country, and to indicate how they form a connected series. This series has a relationship with practical farming, because the various grassland types, based on botanical composition, correlate with agricultural value. Beginning with the agriculturally most useful, we can define the series as follows:

- |   |   |                                 |
|---|---|---------------------------------|
| (a) rye-grass—white clover pastures                         | } | leguminous                      |
| (b) rye-grass—meadow grasses— <i>Agrostis</i> —white clover |   |                                 |
| (c) <i>Agrostis</i> —mixed grasses—white clover             |   |                                 |
| (d) fescue— <i>Agrostis</i>                                 | } | largely<br>devoid of<br>legumes |
| (e) <i>Nardus</i> —fescue                                   |   |                                 |
| (f) <i>Molinia</i> — <i>Nardus</i>                          |   |                                 |
|   |   |                                 |

Each one of these groups is important in Britain because of the large aggregate area it occupies, and together they account for the bulk of our grassland. The best

rye-grass—white clover pastures, for example those of the Kent marshes, carry a restricted flora, and sometimes little else than the two dominant species. The remaining types in the series often carry very mixed swards, sometimes without any clear dominant. The nomenclature I have suggested for these pasture types offers an oversimplification, and indeed is in no way intended to be fully descriptive. I would, however, suggest that a 'treatment' connexion exists between the groups. These various groups represent the 'natural' pasture types of Britain and as such show a close relationship to soil and other features of the environment. If, however, the level of soil fertility is changed, or if the grassland management is altered, then the pasture will change floristically in response to the change in treatment. Such a change will take place more rapidly if the grazing management or other treatment is modified in such a way as to encourage 'invading' species.

Thus the *Agrostis*—white clover pasture, which is perhaps the commonest type in the lowlands of Britain, occupies soils that are at a low level of fertility, usually deficient in phosphate and tending to be acid. Application of lime and phosphates promotes the spread of clover and in due course encourages the better grasses. If manuring is accompanied by more intensive grazing, then the change towards the rye-grass—white clover dominance is usually accelerated. Milton (1940, 1947) has shown that application of fertilizer together with rotational grazing has been instrumental in replacing a fescue—*Agrostis* pasture by one in which meadow grass and white clover were at first conspicuous and ultimately dominant (Tables 1 and 2). This has been done on typical open moorland without ploughing or other cultivation. The process, however, is slow and could be greatly hastened by ploughing and

Table 1. *Influence of fertilizers on botanical composition and yield of grasses of the Molinia community*

(After Milton, 1940, 1947)

(A) Percentage cover of major constituents

Species	Before treatment	After treatment	
	1930	1946 With fertilizer*	1946 Without fertilizer
<i>Molinia</i>	71	—	3
<i>Nardus</i>	6	—	15
Fine-leaved fescue	17	20	40
<i>Agrostis</i>	1	10	35
Yorkshire fog	—	28	—
Rough-stalked meadow grass	—	25	—
White clover	—	12	—
Other species	5	5	7
Total	100	100	100

(B) Yield (air-dry weight, lb./acre/year)

Treatment	Year	
	1930-3	1944
Without fertilizer	990	2300
With fertilizer*	2570	9696

\*Calcium, nitrogen, phosphorus, potassium.

Table 2. *Influence of fertilizers on yield and botanical composition of grasses of the fine-leaved fescue community*  
(After Milton, 1940, 1947)

## (A) Percentage cover of constituents

Species	Before treatment		After treatment	
	1930	1946	1946	1946
		With fertilizer*	Without fertilizer	
Fine-leaved fescue	65	Trace	37	
<i>Agrostis</i>	20	Trace	50	
Yorkshire fog	—	Trace	—	
Smooth-stalked meadow grass	—	15	—	
Rough-stalked meadow grass	—	32	—	
White clover	—	38	—	
Other species	15†	15‡	13	
Total	100	100	100	
Grassland type	Fescue— <i>Agrostis</i>	Meadow grass— white clover	<i>Agrostis</i> —fescue	

## (B) Yield (air-dry weight, lb./acre/year)

Treatment	Year	
	1930-3	1944
Without fertilizer	2030	4179
With fertilizer*	3210	9080

\* Calcium, nitrogen, phosphorus, potassium.

† Chiefly *Molinia* and *Nardus*.

‡ Chiefly lowland grasses including rye-grass, cocksfoot, timothy, tall fescue (*Molinia* absent and only a trace of *Nardus*).

reseeding. The changes brought about by Milton (1940, 1947) show an orderly sequence commencing at first with the increase and spread of white clover followed by an invasion and later spread of *Poa* and other grasses. Perennial rye-grass has already gained entrance into these swards and the end-phase could be an increase in and ultimate dominance by the rye-grass component.

*The influence of concentrated grazing*

Concentration of grazing by livestock implies at once that the fertility level of the soil is being raised by virtue of the droppings (dung and urine). Where grassland is close-grazed the animals are offered a rich, leafy diet, and the excreta are correspondingly rich in nutrients (Raymond, 1949; Sears, 1942; Wolton, 1955). Close grazing and an increase in the supply of nutrients promote the floral changes to which I have already referred, and result in greater pasture output.

Striking botanical changes due to animal influence occur on the penguin rookeries of the Falklands (Davies, 1938). The vegetation of the coastal strip has been changed from typical moorland (akin to British moorlands) to close-grazed grassy swards among the most productive in the Falklands. These grassy swards, under the influence of the penguin are usually dominated by *Poa annua*. In this condition they are grazed hard at all seasons of the year and owe their present stability to the heavy dunging and urination which follows concentrated grazing by sheep and by

wild geese. Therefore, owing to the combined influence of penguin which by complete destruction of the original moorland vegetation set the first changes in motion, and the following close grazing with sheep and wild geese, there is a complete transformation in sward type. Agriculturally, this change has produced swards of high productivity compared with the original herbage and a new grassland type is produced by the combined influences of improved soil conditions and concentrated grazing.

This example of change of vegetation on the Falkland penguin grounds finds its counterpart in the holding pens throughout our sheep country in Britain. The sward type developed on many homestead fields in this country and also on the night paddock of New Zealand is basically due to the combined influences of heavy grazing and the concentration of animal excrement. This observation indicates that the type of sward, and indeed the potential output from grassland, need not show the wide range found in practice. There is in fact general agreement that pasture output can be much increased simply by botanical substitution, however induced. If this method is coupled with a balanced fertilizer programme and a more knowledgeable use of pasture, then the botanical changes as well as relative level of output are improved. This procedure indeed is the basic feature of British agriculture, for with the better use of the potential offered by the grasslands, this country can become ever more competitive with the rest of the world in the production of meat and other animal products. We have the potential for growing far more grass per acre than we now do, and there is the vast potential concerned with extending the grazing season to cover the whole 52 weeks of the year. The last 20 years have witnessed a considerable extension of the grazing season in Britain, which has substantially lessened costs of production. Grass from ordinary pastures has a grazing period of anything up to 16 weeks in the summer, say from mid-May to mid-September with a blank period during the dry weather after mid-summer. The British farmer now looks for a grazing period from early April to early October and should know how to fill the summer gap. He therefore has a grazing period 50% higher than the traditional level. There are pioneer farms in Britain on which in most years the pastures are grazed from March to December, a grazing season of 40 weeks, but to do so grass has to be farmed properly. There is evidence to suggest that the gap can be further reduced. As technicians we should aim high and see what we can do about the whole 52 weeks.

#### *Fertilizer influence on composition and grassland yield*

Yield is not a simple phenomenon, but is a feature of the whole ecological environment. An increase in the amount of available nutrients, as brought about by the application of fertilizer, influences the whole environment, and there is an abundance of evidence to show that increased yields of herbage follow application of fertilizer. Responses are frequently, though not invariably, greater where swards of good botanical composition are concerned. Table 3 shows the average yearly yield of dry matter per acre over three seasons on an old pasture of the fescue—

*Agrostis* type. The whole area received a uniform dressing of about 70 lb. nitrogen/acre in each of 3 years. The responses shown in the table are for superphosphate and for muriate of potash each applied at 1 cwt./acre/year.

Table 3. *Influence of nitrogenous fertilizer on botanical composition of sheep pasture ; percentage cover after 4 years' treatment, 1952-5 inclusive*

(Unpublished results from Grassland Research Institute, Hurley. cf. Grassland Research Institute, 1953, 1954-5)

Species	In each year	
	No fertilizer	Nitro-Chalk (4 cwt./acre)
Perennial rye-grass	10	28
Cocksfoot	11	26
Rough-stalked meadow grass	10	18
Red fescue	12	7
<i>Agrostis</i>	4	7
White clover	21	5
Other species (chiefly forbs)	32	9
	100	100

Table 4. *Influence of nitrogen, phosphorus and potassium on yields of grassland*

Fertilizer	None	P*	K†	N‡	N,P,K
Dry-matter yield (lb./acre)	4285	4890	4655	7013	6820

\* 2 cwt. superphosphate/acre.

† 1 cwt. sulphate of potash/acre.

‡ 4 cwt. Nitro-Chalk/acre.

Table 5. *Effect upon dry-matter yield of low level (annual) dressings of phosphates and potash (mean for 3 years)*

Treatment	Dry-matter yield (100 lb./acre)	Relative yield
No phosphate or potash	67.7	100
Phosphate only	77.8	115
Potash only	75.6	112
Phosphate and potash	90.4	134

Responses of the order of 15-30% to phosphates and potash are fairly common (Tables 4 and 5); the precise increase in yield will depend upon a number of factors including the nutrient status of the soil. Response also depends upon the rapidity of sward change. Both phosphates and potash normally benefit the legume more than the grass component and in this way provide the trigger action which culminates in a complete change of sward type. In the grasses demanding high fertility this change is associated with a reduction in the population of those plants that can normally tolerate lower levels of soil fertility. The spread of clover and of many forbs as well

as of the low-fertility grasses is checked by the vigorous growth of invading grasses, typically those demanding better soil conditions.

The influence of N on grassland production is very marked, especially where aeration and water relationships are good. N, air and water all show a high degree of mobility in the soil, indeed responses to N and water have many features in common and the response by grass is often spectacular, particularly in early spring. The overall response to N over the year and from season to season is less spectacular on the mixed grass—clover sward, because soluble inorganic N, when applied to the mixed sward, tends to depress clover. Hence, in normal pasture maintenance, it seems necessary to have an adequate clover base or otherwise to provide the greater part of the N requirements of that sward by means of fertilizer application. In New Zealand and the United States, the tendency is to rely mainly on the clover component to provide the sward with its N requirements. The Dutch take a converse view, and tend to rely upon fertilizer N. The New Zealand system provides high yields of herbage and animal products, but so also does the Dutch system.

A good grass—clover sward in Britain will provide some 6,000–10,000 lb. dry matter/acre during the growing season with an average crude-protein (C.P.,  $N \times 6.25$ ) content of 15%. If we assume a dry-matter yield of 8000 lb./acre with an N content of  $2\frac{1}{2}\%$  (equal approximately to 15.6% C.P.) it would contain some 200 lb. N/acre. If this yield be from a field used wholly for grazing and a cattle beast is assumed to eat an average of 30 lb. dry matter daily for 180 days (i.e. a 1000 lb. beast to the acre for the period 15 April–15 October), then some 5400 lb. dry matter/acre is actually consumed. This amount would contain about 135 lb. N, of which one-third might be retained by the grazing animal and say two-thirds excreted. Some 90 lb. N/acre are thus returned in the excreta and some 65 lb. N/acre retained in the uneaten herbage. If we assume that this latter ultimately finds its way back to the soil it seems that  $90 + 65 \text{ lb.} = 155 \text{ lb. N/acre}$  will be returned either in the form of animal excreta or through uneaten 'stubble'. No doubt some of this N will be lost by normal process of oxidation, some may be leached in drainage water and some may be locked up in plant tissues. It can be assumed that two-thirds of this N is out of circulation either permanently or temporarily, leaving a net amount of some 50 lb./acre in circulation, whereas the needs of the crop at full vigour are at least 200 lb./acre/year. To retain the sward in full vigour this deficit of 150 lb. N must be made up in one way or another, partly by such 'natural' processes as clover 'root', soil micro-activity and N-containing rain. Whether these figures are exact or not does not really affect the argument. What seems clear is that we need to apply bag nitrogen if we are to achieve high levels of production on our grassland. The very striking response to N in spring, indicates that the grasslands of Britain are not at full vigour and that there is an appreciable N deficiency. The practical lesson is that whereas a good clover 'root' under British conditions makes available some 150 lb. N/acre/year (Cowling & Green, 1956) and there is a further gain from microbial activity in the soil, there is still a deficit which can only be made up by the use of nitrogenous fertilizers, unless we can do as New Zealand, namely provide for very

heavy density of stocking per acre on highly leguminous pastures which, as Sears (1942) has shown, provides an annual total as high as 600 lb. N/acre/year.

For normal purposes in Britain, fertilizer N has its greatest effect and overall production when used sensibly on the grass—clover pastures, and used with some knowledge of its effects on the floristic composition of the grassland. It is in spring and later summer when the clovers are not at maximum production that we not only get the greatest benefit from fertilizer N but also get the least adverse effect upon the clover itself. The 'high-fertility' grasses start growth early in the season and go on growing late into the autumn, and it is at these times of the year that the greatest benefit accrues in production from the use of N fertilizers.

There are, therefore, two alternative methods as regards the use of fertilizer N on pasture. The first is to use bag N only in spring and autumn to ensure the maximum 'collection' of rhizobial N. The second is to rely wholly on bag N and forget about the clover. This latter alternative would seem to me to be best used as a method to increase yields on short-term leys based on Italian rye-grass. Here is an important field of work, but it is already clear that heavy dressings of N, if frequently applied to good rye-grass pastures, can promote very high levels of yield. Any intensive fertilizer programme, however enlightened, must essentially be associated with skilful pasture management. One might here pose the question 'What is good pasture management?' I like to think of good pasture management as that which produces feed of adequate quality for the grazing animal throughout the grazing season and beyond into the autumn and spring. To do that the farmer must use all his available resources, and must also be skilful in exploiting the crop on the one side and in compensating on the other for any misuse of it in the process of exploitation. Personally, I like the concept of exploitation—compensation. It goes rather deeper than 'resting and grazing', such as we have with rotational grazing. The stockman must feed his animals adequately. To do that he must exploit his grass, but in exploiting, he must be fully aware of any adverse effect imposed upon the various components of the sward, and he must know how to compensate for his misdeeds.

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