BALANCED MANURING AND BALANCED STOCK FEEDING.

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Those of us who are working on grassland problems fully realise that manuring is only one factor in production. Sir John Russell said when he was in New Zealand that in considering the manurial scheme for any farm one'has first to decide what manure should be used, and then when it should be used. I disagree with this view. I first want to look at the farmer and then at his farm. In other words,a great deal of money can be wasted by inefficient management.

In this short paper, I am 'going to assume that we are considering the manuring scheme on farms whose management is such that the grass is kept under close control and always fed at the right stage of growth.

Further, I propose to deal with the question of feeding almost entirely from the wholly grass farm point of view.

It is quite impossible in a short paper to deal fully with the whole subject of "balanced manuring and balanced stock feeding". One could write a book on this subject.

We, in this country, are faced with&e fact that during the spring period we have. a great flush of growth. During the summer and during the winter we get far less growth. In some autumns we also get plentiful feed. The problem we have to solve is the distribution of the amount of growth more evenly throughout the year. The difficulty is being combated to some extent by conserving excess feed produced in the flush periods as ensilage and hay.

Quite apart, however, from the quantity of feed, we have to consider particularly its quality. In this respect there are a number of considerations.

(1) Is it likely that such a highly nitrogenous diet as young grass is likely to have any ill effect on the health of the animal.

Many loose statements have been made to the effect that stock troubles,,e.g. kidney trouble s, have arisen as a result of feeding highly manured short grass. The evidexice to this effect is very slight. On my own farm where feeding of short intensively treated grass is pushed to the limit, no ouch ill effects have been observed. The stock carried include ewes and lambs, as-11 as cows, etc. In the case of milking animals, the act of milk secretion provides a means of eliminating some of the nitrogen which is not available to fattening stock.

Cases 'have been reported where animals have behaved abnormally on pastures treated with nitrogen. In one case, at Castle Douglas, cattle appeared to be passing blood and red water was suspected. Investigation, however, showed no parasites, and the presence of complete blood corpuscles with particles of cell wall detritus. This phenomenon occurred fairly regularly about five hours after grazing had commenced. Chemical investigation of the grass showed a very high content of non-protein nitrogen. amounting to 50 per cent: and the trouble was undoubtedly due to this. This led to an investigation being initiated on the nitrogen content in young grass. Normally, nitrogen-treated grass at three to five week's growth contains about 88 per cent. of its nitrogen in the protein form. This investigation is taking place at Jealott's Hill but sufficient data are not available to come to definite conclusions. It would appear, however, that a certain time is necessary for the nitrogen of the manure to become elaborated into protein., This period seems to vary with the time taken to achieve a certain growth, and it would appear that the more rapid the growth the higher is the soluble or new protein nitrogen. Thus, from the practical side, due care should be taken not to stock immediately after a rspid period of growth. Two other cases of supposed nitrate poisoning with sheep were reported following an application of nitrochalk. To test this a lamb wasfed with 10 oz. of nitrochalk in nine days and its health was in no way impared.

The urine contained large quantities of nitrate nitrogen but there were no traces of blood. Part of the nitrochalk was fed in one dose of 3 oz. with no disturbance of health. Another lamb was fed with ¼ oz. of nitrochalk daily for 14 days. It ate its ration containing this and showed no signs of ill-health. It would appear from this that nitrochalk is in no way harmful to sheep.

(2) The extent to which topdressing may influence the quality of our product. Thus: there are frequent references by practical men which indicate that troubles in cheese making have increased by topdressing. There are two points which occur to me in this connection:

(a) Increase of manuring has led to more intensive stocking and probably, therefore, to an increase in mastitis. There can be no doubt regarding the deleterious effect on quality of cheese of the use of milk from infected quarters.

(b) The large development in the use of phosphatic manures has certainly encouraged clover development. This is a case of unbalanced manuring. I have made preliminary observations of the effect of clover on milk but so far no one has seen fit to make an exhaustive study of the enzyme content of our pasture plants with the particular object of tracing the effect of such enzymes on the quality of the milk. I would like to see large scale experiments in which cows are fed wholly on rye grass; also it would be easy to feed large quantities of ferments such as lipase or rennet.

(3) The Mineral composition of the pasture.

High per acre production is the solution of our economic ills in New Zealand. There can be no question that because of our high production it is of prime importance that we pay particular attention to the mineral requirements of our cattle in New Zealand.

We have cases in New Zealand of diseases due to phosphate deficiency (e.g. Waihi disease). Fortunately, the value of phosphatic manures is pretty generally realised. However, much of our land is near the border line as regards its lime content. There is a body of opinion which holds that because application of lime gives no visible effect in a certain area that it is not necessary. This is a dangerous assumption, and it is more than likely that an increase of stock troubles is occurring on land which are on the border line for lime requirement, and yet give no visible response to lime.

New Zealand offers a splendid field for the worker in mineral deficiency diseases, and fortunately Mr. Aston and his co-workers as well as Messrs. Rigg and Askew, have been doing excellent work in this connection for many years past.

Regarding the question of the importance of minerals in animal feeding this has been well summarised by Orr in his book "Minerals in Pastures". Much work on the mineral composition of pastures has recently been published both in England and in New Zealand. T.B. Wood, in reviewing Orr's book in Nature raises the question as to whether the failure of animals to thrive on mineral deficient pastoral areas might not sometimes be due as much to the energy-deficient character of the herbage as to its deficiency in minerals. The starch value of such herbage may be so low that animals even when consuming it to the limit of their appetite may not be able to secure sufficient net energy to allow of normal development.

The further question also arises as to the method whereby mineral deficiencies cause the sumptoms of malnutrition. These may arise conceivably from four causes:

(1) The digestibility of the organic constituents of the herbage may be depressed in the absence of any adequate supply of minerals.

(2) The lack of sufficient mineral matter of proper quality may confer an unpalatable character on the herbage, a circumstance which might react adversely on the appetite of animals subsisting on such herbage;

(3) The physiological utilisation of the digested nutrients may not proceed normally if the amount of minerals in the herbage is deficient;

(4) The mineral deficiency may prevent the normal development of the "skeletal structure. Of this, there can, of course, be no doubt, the question at issue being solely the extent to which the first three factors may also operate in the prddudtion of physiological disturbances in animals subsisting on mineral-deficient herbage.

Woodman carried out, a series of investigation in order to obtain information on these points. His main conclusion was as follows:-

The results led to the belief that the failure of stock to thrive in mineral-deficient pastoral areas cannot be explained by assuming that the low mineral content is responsible for a lack of palatability in the herbage and a consequent depression of appetite in the grazing animals.. Neither is there any evidence that the shortage of minerals cause's the herbage to be digested any less efficiently than "normal" cultivated herbage of similar maturity and organic composition. The amount of net energy which ruminant animals are able to derive from any form of herbage seems to be independent of the mineral content and to depend solely on the amount and character of the organic constituents.

, Malnutrition on padturage of subnormal mineral content is due directly to the failure of the diet to supply the necessary inorganic materials for constructional purposes, and for maintaining the normal balance, of minerals in the blood and tissues and is not, even in part, to be ascribed to an indirect effect such as is embodied in the suggestidn that the mineral deficiency leads to under-nutrition of the animal by causing a depression of its appetite and its capacity to digest the organic constituents of the herbage.'

Greenhill and Page at Jealott's Hi&have recently published some interesting work on mineral content of pastures. They confirmed the fact noted by other workers that in periods of drought the phosphate content of pastures diminishes. They established, however, the very interesting fact also recorded by other workers, that in intensively treated pasture there is a definite positive correlation between the nitrogen and phosphate content. The correlation is much less and perhaps absent in new pasture. It would seem that these results provide some basis for the view that it is better to supply nitrogen and phosphate, together, rather than at different timeshof the year., ,

The experiments in Northumberland, at Cockle Park, provide interesting data on the effect of phosphatic manuring with slag on the mineral composition of the pasture produced, and incidentally, also, on thk protein content of the herbage.

The unmanured pasture only contains from a third to half as much lime and phosphoric acid as the pasture regularly receiving slag and would rank as a mineral deficient pasture.

With these preliminaries let me take a few statements from various authorities on animal nutrition.

A 12 cwt. cow will require for maintenance about

7 lb. of starch equivalent
and 0.75 lb. of digestible protein.

For each gallon of milk produced she will further require

$2\frac{1}{2}$ lb. of starch equivalent,
and 0.6 " of digestible protein.

Larsen and Putney (Dairy Cattle Feeding and Management) state that the best pasture will only maintain a cow and produce two gallons of milk. Their statement applies only to American conditions where pasture as a rule is poor, T.B.Wood in "Rations for Livestock" - (Ministry of Agriculture Publication No.32) states that the ration of a cow on average grass will contain approximately 27 lb. of dry matter containing 9 lb. of starch equivalent and 2¼ lb. of digestible protein. Subtracting the requirements for maintenance (7 lb. of starch equivalent and 0.75 lb. of digestible protein) leaves sufficient protein for three gallons of milk, but only sufficient starch. equivalent for about one gallon. A four gallon cow would thus require an extra 7 lb. of starch equivalent and about 0.75 of digestible protein, ,i.e., a starchy supplementary ration.

Wood., in "Animal Nutrition", states that a deep milking cow weighing say 12 cwt. would eat per day an amount of good pasture which would contain say 30 lb. of dry matter. This amount of dry matter would supply her with 15 lb. of starch equivalent and 3 lb. of digestible protein which is approximately the ration for a 12 cwt. cow giving 4 gallons Of milk per day. The great palatikility of suc'hherbage would probably induce her to eat even more than 30 lb. of dry matter per day in which case it would certainly provide an abundant ration. Even heavier milkers, therefore, require no extra food when they are on good well managed pasture.

Cows on Poor Pasture: If, however, the pasture is poor by nature, or if it is badly managed and allowed to grow long and benty, or for any other reason fits quality falls off as is often the case towards August and September in England, the case is very different. Under these circumstances the dry matter of the pasture may well/contain only 30 per cent. of starch equivalent and 5 per cent. of digestible protein. The 30 lb. of dry matter consumed by a cow per. day would in this case yield only 9 lb. of starch equivalent and 1.5 lb. of digestible protein. Subtracting the maintenance ration of a 12 cwt. cow which is approximately 7 lb, starch equivalent and .8 lb. of digestible protein the remaining 2 lb. of starch equivalent and .7 lb. of digestible protein is barely sufficient for the production of 1 gallon of milk.

Pasture, however, seldom becomes as poor as this. A more usual condition would be that the dry matter of the pasture as eaten would contain 40 per. cent. of starch equivalent and 7 per cent. of digestible protein which corresponds to a daily consumption per cow of about 12 lb. of starch equivalent to 2.1 of digestible protein. After subtracting maintenance requirements there would remain 5 lb, of starch equivalent and 1.3 of digestible protein, which would suffice for the production 'of 2 gallons of milk. This is a frequent occurrence in the late summer and autumn when it often happens that a supplement is necessary for cows yielding more than 2 gallons per day.

However, Woodman's work at Cambridge, (See Jour.Agri. Science, April, 1928, *p.284, for* discussion of feeding standards for cows of various yields and of other animals) that of Watson at the I.C.I.Laboratories, Jealott's Hill, and work *in* New Zealand at the Cawthron Institute show that on properly managed pasture 30 lb. of dry matter will produce 21 lb. of starch equivalent and 6 lb. or more of digestible protein. This would provide, a ration for a 12 cwt. cow and also enable her to produce 6½ gallons of milk, and there would still be an excess of digestible protein which would produce more milk if a starchy supplement could be added to the feed.

Watson (I.C.I. private publication) raises the point of the requirement of nutrients for' the production of the foetus. He status that the actual magnitude of this extra demand is not known accurately, though it is often taken as being equivalent to the nutrients necessary for the production of half a gallon of milk per day.

The foregoing are some of the theoretical considerations. In actual practice we-find cases of cows which are giving more milk on grass alone than theoretical considerations apparently ad&t. Thus I have records of two cows in Ireland which were giving 8 to 9 gallons of milk per day on grass alone for certainly the first six months of their lactation period. In New Zealand we have the case of Mr. J.M.Ranstead's cow Motangi Elizabeth 3rd. an account of whose production was given by me in detail in the "Dairyfarmer" for November 20th, 1930. This cow was fed entirely on intensively produced grass throughout the 365 days, except. for a period of two months when she received grass ensilage. Under C.O.R. test she produced on twice a day machine milking, 731,98 lb. of fat.

She also gave 17074.5 lb. of milk or an average of 4.68 gallons of milk, per day. Her maximum daily production was 78 lb. of milk per day, and this was at a time when no ensilage was being fed. The explanation must be that this cow was eating considerably more than 30 lb, of dry matter per day. That this is so is indicated by the quantity of ensilage eaten. Ensilage was fed from the 5th July to the 5th September and careful records of' the amount eaten daily were kept. On one day she ate 119 lb. of ensilage, However, there was no relation between the amount of ensilage eaten and her milk yield. Thus on three successive days she ate 119, 68 and 54 lb. of ensilage and her milk yields on these days were 29.4, 30.1, and 30.1 lb. She was also consuming quite good grass at the time she was eating ensilage.

In experiments at Jealott's Hill and also at the Manawaru farm in New Zealand, trials were made of supplementary concentrated feeds. In neither case was the feeding of concentrates justified by the financial returns,

It must be agreed,, however; that where a supplementary feed is fed to animals on good grass it should be of a starchy nature.

A point which is of considerable interest is to determine how far the measurement of growth, as obtained by grass cutting experiments, corresponds with the feed which could be obtained from the same area by grazing animals. It is difficult to get any exact comparison. However, it will be of interest to take the results of Mr. Hudson's trials at Ruakura where he has data showing the grass production per acre in his mowing trials.

In the year 1929-30, the plots receiving super in June and December 'and sulphate of ammonia in June and March gave a total yield of green grass of 33,800 lb, per acre. Taking the dry matter content as 20 per cent,. (high for Rigg's figures) this is equal to a total dry matter production of $\frac{33,800}{5}$ or 6,760 lb. of dry matter per acre. Turning to my own farm, "Grasslands", the following gives the stocking and the quantity of dry matter required to feed the stock:

Area 36½ acres available to stock.
Total theoretical production = 36½ x 6760 = 246,740 lb.dry matter.

31 cows at 25 lb. dry matter per head
= 775 lb. for 365 days = 282,875 lb. as dry matter.

3 horses) say
1 bull) 100 " " " " = 36,500 " " " "
17 yearlings 10 " " 150 " = 25,500 " " " "
161 ewes (180 lambs not included) at say 7 ewes to a cow to Jan.3rd. for 70 days.
= 23 cows at 25 lb. per day.
for 70 days = 70 x 575 = 40,250 " " " "

Total = 385,125 " " " "

In the calculation for my farm I have left out of consideration calves and lambs, and have been very conservative regarding dry matter theoretically required by the cattle. Yet in spite of this the dry matter requirements of the stock I have carried are 50 per cent. in excess of the dry matter produced on the intensively manured grass cutting plots at Ruakura. The production at Ruakura is considerably above that at Marton. It would be interesting to work out the dry matter requirements for the very large number of sheep carried on the grazing trials" at Marton.

One might 'say my cattle have been starved, but this is not the opinion of visitors, neither is it borne out by the production figure of nearly 240 fat per acre which makes no allowance for 'sheep carried. It may be, of course, that my system of manuring is resulting in a much larger production of dry matter per acre than is being obtained at Ruakura.

Mr. Hayward, at Ngarua, has milked 81 cows on 100 acres with a per acre production of 264 lb. of fat - a high producing herd.

His balance sheet for dry matter is as follows:-

81 cows at 25 lb. for 365 days = 739,125.

Mr. Hayward carried at least 30 head of young stock as well, which might require 10 lb, per head for 365 days.

30 young stock at 3,650 lb. each	=	109,500.
Bulls and horses carried would require say	=	30,000
Total		078,625.
The Ruakura grass cutting trials would give 100 x 6760	=	676,000.

These figures would indicate that the grass cutting experiments are on the low side as a measure of the food available to the grazing animal. This conclusion, however, is only arrived at by assuming that the cows at "Grasslands" and at Mr. Hayward's farm have eaten 25 lb. of dry matter per day. Let us see how far this assumption is justified. We shall be very near the mark if we take the average yield per cow both on Mr. Hayward's farm and on my own as 700 gallons per year. This is nearly equal to two gallons per cow per day for the whole year.

Now both Mr. Hayward's grass and my own were fed at the maximum stage of nutrition. Work already referred to earlier in the paper shows that we require the following nutrients for a two gallon cow for maintenance:-

7 lb. starch equivalent, and
.8 lb. digestible protein.

for two gallons of milk
5 lb. starch equivalent, and
1.2 lb. digestible protein.

a total of
12 lb. starch equivalent and
2.0 lb. digestible protein.

On properly managed pasture the 12 lb. of starch equivalent would be supplied by 19 lb,. of dry matter, and this dry matter would have an excess of 4 lb. of digestible protein over and above that required for the production of two gallons of milk. It would thus seem that 20 lb. of dry matter of the intensively treated grass produced by Mr. Hayward and myself would be sufficient for each cow.

This would alter the figures already given to the following:-

<u>"Grasslands"</u>:

theoretical requirements	$\frac{20}{25}$ x 285,125	=	308,100.
grass cutting trials		=	246,740.

<u>Mr, Hayward's farm.</u>

theoretical requirements	$\frac{20}{25}$ x 878,625	=	702,900.
grass cutting trials		=	676,000.

In the case of Mr. Hayward's farm the figures show fairly close agreement. In&e case of my own farm there is'not such a close agreement. My own impression is that the grass on my own farm has been fed at a much shorter stage than that on Mr. Haywards.

It would seem fairly clear, however, that both Mr. Hayward and I must have fed an excess of protein. Neither he nor I have had any breeding troubles with our stock. An indirect result must be that the dung produced on our own farms must be very rich in view of the: feeding of such a highly nitrogenous diet.

To this must partly be due the undoubted fact that there has been a wonderful improvement in the pastures on both farms.

The foregoing remarks are of a speculative nature and have been put forward merely to indicate that there is a field for checking up feeding standards by means of actual grazing records.

The above feeding standards have dealt only with the requirements of the animal for dry matter, starch equivalent and digestible protein. It will be of interest to see how far the mineral requirements of cows are satisfied on such pastures. For this purpose we will take Mr.Hayward's farm at Ngarua on which he milks 81 cows on 100 acres and on which. we estimate his theoretical requirements for dry matter for the total stock carried at about 700,000 lb.

Orr gives the following figures for the lime and phosphoric acid content of the dry. matter of good pasture - those being the average of twenty-four samples-

lime 1 per cent; phosphoric acid 0.74 per cent.

Rigg and Askew show that completely manured pastures at the Cawthron Research Institute are rather above this standard. Taking Orr's figures, ho-ever, the 700,000 lb, of dry matter produced on Mr.Hayward's farm will provide the animals with:

$700,000 \times \frac{0.74}{100}$ or 5,180 lb. of Lime.

and $700,000 \times \frac{1}{100}$ or 7,000 lb. phosphoric acid.

Allowing for the fact that Woodman's digestibility trial6 show that only about 45 per cent. of the mineral matter is digestible by the animal, the actual quantities digested by the animal could be 2,330 lb. of lime and 3,150 lb, of phosphoric acid.

Milk contain6 .161 per cent. of lime' and 0.189 per cent. of phosphoric acid. The cow, however, need6 minerals for herself and for the developing calf. In order to digest the amount of minerals required it is generally held that the cow must consume at least twice the amount of lime and phosphoric acid which is present in her milk.

We may therefore assume that for every 100 lb. of milk produced the cow need6 .322 lb. of lime and 0.378 lb. of phosphoric acid.

The milk production of Mr. Hayward's may be taken as 81 x 7,000 = 567,000 lb.

The following amount6 of minerals are required for this production.

Lime	.332 x 5,670	=	1,825 lb.
Phosphoric acid	4378 x 5,670	=	2,143 lb.

It would thus appear that on the intensively managed pasture the cows are able to obtain ample supplies of minerals since the pasture apparently supplies inadequate amounts of minerals. The feeding of steamed bone flour and salt I am sure, is an excellent practice, but the recent work on the chemical composition of pasture grass shows how largely the food value of pasture can be improved by intelligent management of intensively manured pastures.