The Use of Nitrogenous Fertilizer and its Effect on Pasture Herbage

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Introduction

ECONOMICALLY, the nitrogen supply is by far the most important. It may be, and probably usually is impossible to grow good grass or legumes without the addition of lime, phosphorus, or potassium, or all of them, but it is comparatively a simple matter to supply these deficiencies. But with mineral deficiencies corrected, the most difficult problem remains, viz., that of supplying, utilising and conserving nitrogen. There are two methods of supplying nitrogen, namely, by application of nitrogenous fertilisers and by providing for its fixation by legumes or micro-organisms.

In recent years considerable attention has been given to nitrogenous manuring of grassland in order that nitrogenous fertilisers may be used to best advantage. (2, 4, 9). However, there is considerable evidence that its use is followed by a gradual disappearance of the legumes from the flora, especially if the applications of nitrogen are large. This method of supplying nitrogen needs much more study which should take into consideration all factors concerned with the permanency of desirable pasture plants and their economic utilisation.

The other method of supplying nitrogen to pasture is by natural fixation. Natural fixation has one important argument in its favour: it is nature's way of doing it. This means that the plant community which is a natural one, is receiving nitrogen in response to natural requirements rather than in response to man's desires, which, although admirable, may sometimes lead to practices that destroy rather than build.

Although, there is abundant evidence to show that both legumes and nitrogenous fertlisers materially influence the yields of herbage, opinion is divided regarding their relative contribution and value. In New Zealand great store is set by the contribution from white clover which, under conditions of intensive grazing, has been estimated to be equivalent to 2,000 lb. of sulphate of ammonia per acre and the whole nitrogen economy is almost exclusively dependent on this plant (5). In Holland increased output from pasture is only possible by application of heavy dressings of nitrogen and much doubt is thrown on the use of legumes as a source of nitrogen supply. These differences of opinion are primarily due to differences in climate and to a certain extent, differences in the types of swards or in the manner of utilising the herbage.

Under conditions of grazing, the ultimate influence of either the legume or added nitrogenous fertiliser is magnified by returns of nitrogen to the sward in the dung and urine of the grazing animal, as shown by Sears (5), and Watkin (10), when several fertility

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This article is based on an experiment conducted at the Nottingham University School of Agriculture, England.

cycles may occur in one grazing season. It is reasonable to assume that these cycles from sward to the grazing animal and back to the sward, are greatly accelerated by mixed stocking, which obviates the fouled patch. This rejected herbage must be regarded as a site of locked-up nitrogen. Furthermore, grazing prevents the crowding out of the legume which results from unchecked growth of grasses following applications of nitrogenous fertilisers.

Under conditions where the herbage is cut and carted off the field the picture is very different. Here, considerable quantities of nitrogen are removed from the field and further growth of herbage depends, amongst other things, on fresh supplies of available nitrogen —further applications of nitrogenous fertiliser, or further from the leguminous nodules if the legume can be induced to persist under these conditions.

To ascertain the contribution of white clover in an ungrazed sward, and at the same time to gather information on ancillary issues of the interaction of white clover and nitrogenous fertilisers a trial was laid down at the Nottingham University Farm in 1951. The results of this trial are mainly in accordance with published findings, but are of interest in generally supporting the conclusions recently reached by Walker *et. al.* (6, 7, 8, 9).

Eighteen treatments comprising interactions of two grasses S.24 perennial rye grass (*Lolium perenne*) and S.37 cocksfoot (*Dactylis glomerata*) with two legumes S.100 white clover and wild white clover at three levels of nitrogenous fertiliser application, namely nil (0N), 2 cwt. per acre (2N) and 10 cwt. per acre (10N), were each replicated eight times. The nitrogenous fertiliser applied was "Nitro-chalk" containing 15.5% nitrogen. Single applications of fertiliser were given each year, and during the first year plots were grazed to allow a successful establishment of the clovers. Analysis of soil samples taken prior to this application of fertiliser showed no appreciable difference in total content of soil nitrogen. The results reported here refer to the first cut of the 1953 season, when three silage cuts were taken. The principle object of this trial was to estimate the inter-relationship of white clover and nitrogenous fertiliser in the absence of the grazing animal.

The data relating to the first cut of herbage may be regarded as indicative of the happenings in any sward cut for conservation.

Results

Effect of Nitrogen on the Botanical Composition. Even before cutting the first time, changes in the composition of the sward were apparent following the application of "Nitro-chalk". The major change was a reduction in the proportion of the legume, this reduction being much greater, where the companion grass was cocksfoot rather than perennial ryegrass, and much greater at the higher levels of "Nitro-chalk" application of both grasses. Another important feature is that nitrogenous manuring improved the botanical composition in the direction of a sward consisting of valuable grasses and produced a dense herbage of a "soft" and succulent type.

Effect of Nitrogen on the Percent Dry Matter. In each case, added nitrogenous fertiliser resulted in a reduced percentage of dry matter in the herbage.

This effect was most apparent with the first cut of herbage, where untreated averaged 20.0 per cent. D.M., that which received 2 cwt. " Nitro-chalk " averaged 18.1 per cent. D. M., and that which received 10 cwt. " Nitro-chalk " averaged 16.3 per cent. D. M. The presence of the legume did not, materially affect the dry matter percentage.

Effect of Nitrogen on the Yield of Dry Matter and Crude Protein. The yield of dry matter and crude protein are presented in Table 1..

As might be anticipated nitrogenous top dressings gave increased yields of dry matter, although the increases were by no means proportional to the quantities of nitrogen applied. Although in the majority of cases where nitrogenous fertilizer was applied an increase in yields due to the presence of white clover was apparent, in no case could these increases be regarded as significant. In fact the contribution from white clover without fertilizer nitrogen (under these conditions) over the season in no way approached the increased yields from a single application of 2 cwt. "Nitro-Chalk" per acre. A further point of importance is that a single heavy application of fertilizer showed an effect over all three subsequent cuts, whereas the effect of an application of 2 cwt. per acre was virtually lost after the first cut. The yields of dry matter from the second and third cuts of this treatment were generally lower than those from plots which had received no fertilizer in the first instance, thus supporting the contention that when herbage is cut and removed from a field, further growth depends upon fresh supplies of available nitrogen. In this case the white clover had been sufficiently suppressed to make little material contribution. In the high-nitrogen plots there were sufficient residual nitrogen to show an effect in the second and third cuts, despite a rainfall of 4.67 inches in the interval between applying fertilizer and the first cutting.

The results (Table 1) also indicate that very high yields of crude protein could be obtained by the application of nitrogenous fertilizers. Nitrogen at all rates raised the yield of crude protein in the first cut, the highest being obtained from the heaviest dressing. The figures also demonstrate the relatively low protein content of the grass alone plots, receiving no nitrogen. A noteworthy feature is that the grass-legume mixtures made the highest contribution only in the absence of nitrogen.

TABLE 1—Yields of Dry Matter and Crude Protein—First cut (lb. per acre)

Treatment	*Dry Matter*			*Crude Protein*		
	0N	*2N*	*10N*	*0N*	*2N*	*10N*
S_{24} alone	1,981	3,353	4,670	181	439	767
S_{24} + S_{100} White clover	2,395	3,598	4,963	321	543	830
S_{24} + Wild White clover	2,505	3,542	4,933	271	483	885
S_{37} alone	1,640	3,356	5,522	195	449	1,120
S_{37} + S_{100} White clover	1,797	3,118	5,479	276	452	1,181
S_{37} + Wild White clover	2,062	3,161	5,610	277	516	1,148

TABLE 2—Percentage Crude Protein, CaO and P_2O_5 content in Dry Matter
FIRST CUT

Treatment	Percent Crude Protein			Percent CaO			Percent P_2O_5		
	0N	2N	10N	0N	2N	10N	0N	2N	10N
S_{24} alone	9·18	13·11	*16·43	1·30	1·16	1·46	1·01	0·84	0·78
S_{24} + S_{100} white clover	†13·40	15·09	*16·72	1·59	†1·63	1·29	1·02	0·95	*0·70
S_{24} + Wild white clover	10·85	13·63	*17·12†	1·66	†1·51	*1·26	1·00	0·87	*0·86
S_{37} alone	11·93	13·39	*20·29	0·98	1·24	1·18	0·85	0·94	*0·64
S_{37} + S_{100} white clover	15·36	14·50	*21·57†	1·53	1·58	1·39	0·97	0·91	*9·68
S_{37} + Wild white clover	13·47	16·33	*20·47†	1·43	1·40	1·42	0·93	0·99	*0·66

* Nitrogen effect significantly different at 5 per cent. level.
† Clover effect significantly different at 5 per cent. level.

Effect of Nitrogen on the Composition of Dry Matter. The results of the analyses of the percent crude protein, CaO and P^2 O^5content, are shown in Table 2.

Apart from revealing the increase in crude protein content of dry matter following the application of nitrogenous fertilisers, an effect which has been demonstrated on very many occasions (1, 2, 4), these results showed an increase in crude protein due to the presence of white clover. This increase was masked only at the higher level of fertilizer application, and in other cases ranged between 2 and 4.5 per cent. increase—the higher figures resulting in the absence of fertilizer nitrogen.

In every case the presence of white clover resulted in an increase content of Ca 0 in the dry matter, the increase being directly related to the increase in the proportion of clover. " Nitro-Chalk " in itself had no direct influence on the Ca 0 content in the pure grass swards, but through the suppression of clover in the mixed swards it indirectly resulted in a reduced Ca 0 content. This effect was especially great in the plots which received the higher nitrogen dressings. Without clover, the Ca 0 content of the herbage was remarkably constant for both grasses at all levels of fertilizer application.

The presence or absence of clover had little influence on the content of P_2O_5 in the herbage, whereas " Nitro-Chalk " applications significantly reduced the P_2O_5 content. The total weight of P_2O_5 varied only slightly from plot to plot, irrespective of treatment, but with higher yields of dry mtter, particularly from the heavier fertilizer applications, the percentage of P_2O_5 was reduced.

Effect of Nitrogen on the CaO/P_2O_5 Ratio. The influence of nitrogenous fertiliser on the CaO/P_2O_5 ratio is shown in Table 3.

Table 3.—Effect of Nitrogen on the CaO/P_2O_5 ratio

Treatment	0N	2N	10N
S_{24} Alone	1·28	1·38	1·87
S_{24}+S_{100} White clover	1·55	1·71	1·84
S_{24}+Wild White clover	1·66	1·73	1·46
S_{37} Alone	1·05	1·31	1·84
S_{37}+S_{100} White clover	1·57	1·62	2·04
S_{37}+Wild White clover	1·53	1·41	2·15

These interactions considerably altered the ratio of CaO to P_2O_5, which aspect has been regarded as of great consequence in herbage for the dairy cow in particular (3). Both the presence of white clover (through its effect of increasing the CaO content) and the use of nitrogenous fertilizers (through their effect in leading to a reduction in the P_2O_5 content) resulted in an increase in the CaO: P_2O_5 ratio. The fertilizer applications had by far the greater effect in this respect, and at the 10 cwt. "Nitro-Chalk" level the ratio was as high as 2.15 to 1.

Discussion and Summary

The results of this trial confirm the effects of clover and nitrogenous fertilizer on the quantities and quality of the herbage produced for conservation, as distinct from their effects on a sward which is grazed. Under these conditions, white clover is materially productive only in the absence of nitrogenous fertilizers, and even then the contribution from white clover is not so great as the increase obtained from an application of 2 cwt. "Nitro-Chalk" per acre. Against this, the single moderate applications of fertilizer resulted in reduced yields of herbage in the second and third cuts, due to the suppression of white clover. Heavy dressings of fertilizer nitrogen (10 cwt. "Nitro-Chalk" per acre) resulted in a considerable increase in the yields of herbage and of dry matter, but at the same time the effects of such dressings on the quality of the herbage must be considered.

If crude protein content can be regarded as the true criterion of herbage quality, then quality was improved; but if the CaO: P_2O_5 ratio is of significance, then the reverse is true. Furthermore, the reduction in dry matter resulting from heavy fertilizer applications is of great consequence, particularly where hay has to be made under adverse weather conditions.

These results add support to the suggestion made by Watkin (10) who, doubting the advisability of applying small quantities of nitrogenous fertilizer to the whole of pasture on a particular farm, tentatively recommends the application of heavy quantities of fertilizer to the less leguminous portion of the pasture and no fertilizer nitrogen to the leguminous fields, unless it is desired to reduce the legume content purposely. This argument would appear to apply in the case of grazed or cut swards alike.

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