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EFFECT OF NITROGEN FERTILIZER ON GROWTH RATE OF HEREFORD HEIFERS GRAZING PASPALUM DILATATUM DOMINANT PASTURE

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SUMMARY

Factors affecting growth rates of Hereford steers grazing a predominantly paspalum (*Paspalum dilatatum*) pasture with and without nitrogen fertilizer at 1 and 2 animals per acre were investigated in 2 x 2 factorial experiments over a period of 4 years. Fertilization with ammonium sulphate, which was applied in early summer only in the first two years and in early summer and autumn in the remaining two years, resulted in large increases in dry-matter pasture yields in each year.

The overall body-weight advantage of cattle grazing the fertilized compared with the unfertilized pasture was negligible at both stocking rates. This lack of response was attributed largely to loss by weathering of stems and seed-heads and of leaves which had died as a result of shading. The suppression of white clover growth by fertilizer was probably also a factor.

It was concluded that stocking rates considerably greater than those permitted by optimum carrying capacity would be required during the period of maximum pasture growth for the efficient utilization of either fertilized or unfertilized paspalum pasture.

I. INTRODUCTION

As there are 780,000 ac of predominantly paspalum (*Paspalum dilatatum* Poir.) pastures in the over-45 in. rainfall zone in Queensland (Anon. 1960), methods of increasing productivity of animals grazing these pastures warrant investigation.

Nitrogen fertilizer applied at rates up to 400 lb nitrogen per acre to grass mixtures containing paspalum has resulted in linear dry-matter yield responses (Brett 1955; Hegarty 1958; Henzell 1963). Although similar results have been obtained with other pasture species, this increased yield has not always resulted in increased animal productivity (Paltridge 1955; Davies, Greenwood, and Watson 1966). The objective of this investigation was to study factors affecting the growth rate of Hereford cattle grazing paspalum-dominant pasture with and without nitrogen fertilizer.

II. MATERIALS AND METHODS

Experimental area.—This consisted of eight paddocks each of 2 ac at the Animal Husbandry Research Farm at Rocklea, Brisbane. The dominant species was paspalum, but Queensland blue couch (*Digitaria didactyla* Willd.), green couch (*Cynodon dactylon* (L.) (Pers.)) and white clover (*Trifolium repens* L.) were also present. Shade and water were provided in each paddock.

Experimental animals.—During the course of the experiments, three lots of Poll Hereford non-pregnant heifers, 12 to 18 months of age, were purchased 1–3 months prior to their entry into the experimental paddocks. Between purchase and experimental use the cattle were kept on paspalum pasture, inoculated against babesiosis, blackleg and tetanus, and tested with negative results for brucellosis, bovine contagious pleuropneumonia, *Leptospira pomona* and *L. hyos* and tuberculosis. Initially and throughout the experiment, cattle tick (*Boophilus microplus* Can.) populations were maintained at very low levels by strategic dipping in 0·045% Coumaphos suspension. Faecal worm egg counts, which were done initially and at approximately 4-weekly intervals, showed negligible burdens of internal parasites at all counts. As cattle grazing in the experimental area consistently showed low liver copper reserves (Harvey *et al.* 1963) the experimental animals received initially two intravenous injections of 80–100 ml, depending upon body weight, of 0·125% copper sulphate 2 weeks apart and thereafter were treated at approximately 8-weekly intervals with 150 ml of the copper solution.

Pasture management.—Ammonium sulphate was applied by a mechanical spreader. Initially, the adjustment on the machine resulted in an application equivalent to 75 lb nitrogen per acre, but thereafter the fertilizer was applied at a rate equivalent to 65 lb nitrogen per acre. Apart from the initial application in January 1961, fertilizer was applied in the early summer growing period in each year from 1961 to 1964. In 1963 and 1964 additional applications were made in autumn.

Paddocks were stocked with experimental cattle from March 15, 1961, to August 17, 1961, from November 8, 1961, to July 18, 1962, and from November 28, 1962, to completion of the experiment on April 28, 1965. Experimental cattle were replaced on November 28, 1962, and November 4, 1964.

During intervals between experiments, paddocks were harrowed to spread manure and sprayed with hormone preparations to control weeds. In the period from October 1 to October 18, 1962, all paddocks were intensively stocked with non-experimental cattle to bring them to a uniform basis with respect to pasture availability.

Pasture sampling.—An estimate of the total dry matter (D.M.) available was obtained by weighing pasture which was cut to a height of about 1 in. above ground level in six randomly thrown 2 ft square quadrats in each paddock. Quadrat pasture samples were collected each month. An appreciation of the error associated with quadrat measurements was obtained on one occasion by comparing the results when the whole procedure for determining pasture yield was duplicated on the same day by the same operator.

During the first three years of the experiment, information on pasture growth resulting from fertilizer treatment in the absence of direct animal effects was obtained by weighing pasture cut within 10 ft x 10 ft wooden cages (exclosures) randomly placed in each paddock. In months when there was sufficient pasture to cut, one strip of pasture 8·25 ft by 3 ft was cut to a height of 2 in. and another similar strip was cut to a height of 4 in. above ground level in each exclosure.

Species ground cover determinations were made by line transects, using a rod 100 in. long and divided into 1 in. sections. In each paddock four random lines 100 ft long were used and 3 transect measurements were made per line.

Body-weight.—Cattle were yarded between 7.30 a.m. and 8.00 a.m. and weighed between 8 a.m. and 9 a.m. at fortnightly intervals. Fasted body-weights determined after 18 hr off feed and water were obtained (a) immediately before the cattle were brought into the paddocks, (b) after 1 year of uninterrupted grazing and/or (c) immediately after they were removed from the paddocks.

Faecal sampling.—Samples of about 0·5 lb were taken from the rectum of each animal on the days that the animals were weighed, and bulked to give one sample for each of the eight groups.

Chemical analysis.—After the pasture samples from the quadrats and exclosures had been weighed they were finely chaffed and 2 lb representative samples were dried in a forced-air oven at 100°C. Moisture content was determined and samples of dried and hammer-milled pasture were analysed for protein by a macro Kjeldahl technique. Samples of similarly dried and milled faeces were analysed for protein by the same technique and ash was determined after igniting 2 g samples at 600°C for 1 hr.

Statistical analysis.—In the analysis of body-weight changes with time, intervals were chosen which coincided as far as possible with known seasonal effects on pasture growth.

These were:—

November 30 to February 28—summer: high temperatures and rainfall resulting in rapid growth of pasture to maturity.

March 1 to May 31—autumn: appreciable pasture regrowth when soil moisture was adequate.

June 1 to August 31—winter: low temperatures and rainfall with occasional frosts; pastures dormant.

September 1 to November 30—spring: new growth.

During these time intervals, growth rates were reasonably linear and analysis of variance of the slopes of linear regressions of body-weight on time were used to assess treatment effects. The same time intervals were used in analysing pasture and faecal data.

When analysing percentage paspalum, clover and couch from species ground cover determinations, the arc sine transformation (Snedecor 1946) was applied to the data.

Experimental design.—As four of the paddocks contained relatively more blue couch than the others, a design incorporating two groups of four similar paddocks was used. The following treatments of the 2 x 2 factorial were allocated at random to the four paddocks within each group.

Stocking Rate	Fertilizer Treatment
1/1 ac	0
1/1 ac	+
2/1 ac	0
2/1 ac	+

The cattle used in the initial stocking of the experimental paddocks were allocated at random to the treatments, but replacement animals were blocked on initial body-weight and the animals within each block were allocated at random to the treatments.

III. RESULTS

Body-weight.—The mean body-weight gains per animal from each of the main treatments (stocking rate and fertilizer) are expressed in Table 1 as differences between fasted body-weights. There were significantly higher body-weight gains per animal in the low than in the high stocking rate treatment in all but one period, but high stocking resulted in a greater overall body-weight gain per acre. The only advantage from nitrogen fertilizer was in the period from November 1964 to May 1965, but was this was offset by the significantly lower body-weight gains of cattle in the fertilized paddocks during the period from December 1963 to November 1964.

An analysis of variance of fortnightly linear components of growth rate showed in most cases significant differences in the stocking rate treatment means and occasional differences in the nitrogen treatment means (Table 2). In the low-stocked paddocks there were better growth rates in most seasons, but in summer 1961-62 and 1963-64, higher stocking resulted in greater body-weight gains. Nitrogen fertilizer showed to marked advantage only in winter 1962 and in summer 1964-65. In spring 1964 there were significant interactions of fertilizer treatment and stocking rate on growth rate, with high stocking and no fertilizer showing to advantage. In this season white clover appeared to be dominant in the unfertilized paddocks, particularly in those grazed at the high stocking rate.

TABLE 1

Effect of Stocking Rate and Nitrogen Treatment on Changes in Mean Fasted Body-weight for Different Periods

Period	Mean Change in Fasted Body-Weight (lb)				Necessary Differences for Significance	
	1/ac	2/ac	No Nitrogen	Nitrogen	5%	1%
16.iii.61 to 18.viii.61 ..	90·8**	5·1	41·9	54·0	18·0	24·6
9.xi.61 to 19.vii.62 ..	214·8**	131·8	166·5	180·0	26·5	36·3
29.xi.62 to 12.xii.63 ..	362·5**	177·0	250·8	288·8	46·8	64·2
12.xii.63 to 5.xi.64 ..	222·8	243·1	253·0*	212·9	30·2	41·6
29.xi.62 to 5.xi.64 ..	585·3**	420·1	503·8	501·6	60·0	82·4
5.xi.64 to 10.v.65	104·5**	−70·4	−3·8	37·9*	31·1	42·7

* Significantly greater at 5% level

** Significantly greater at 1% level

TABLE 2

Effect of Stocking Rate and Nitrogen Treatment on Fortnightly Growth Rate

Season	Mean Growth Rate (lb/2 wk)				Necessary Differences for Significance	
	1/ac	2/ac	No Nitrogen	Nitrogen	5%	1%
Autumn, 1961	23·10**	18·05	19·89	21·26	2·79	3·81
Winter, 1961	−1·05**	−15·40	−9·15	−7·30	3·39	4·64
Summer, 1961–62 ..	7·17	9·46**	8·85	7·78	1·28	1·75
Autumn, 1962	7·33*	5·99	6·63	6·70	1·31	1·80
Winter, 1962	−2·02**	−13·31	−9·85	−5·47*	3·42	4·67
Summer, 1962–63 ..	9·52	9·81	9·79	9·54	1·17	1·60
Autumn, 1963	6·16	3·22	5·17	4·21	4·27	5·87
Winter, 1963	6·38**	1·01	3·21	4·18	1·77	2·43
Spring, 1963	8·94**	2·30	5·30	5·94	2·02	2·77
Summer, 1963–64 ..	7·03	9·34**	8·31	8·05	1·01	1·39
Autumn, 1964	4·59	5·39	4·22	5·76	1·77	2·44
Winter, 1964	2·34**	−0·72	0·85	0·77	1·96	2·69
Spring, 1964	1·39	1·79*	2·09**	1·09	0·37	0·50
Summer, 1964–65 ..	12·71**	−0·62	1·68	10·41**	3·78	5·19
Autumn, 1965	−4·41*	−8·38	−6·75	−6·05	3·41	4·69

* Significantly greater at 5% level

** Significantly greater at 1% level

Exclosure pasture.—The results of analysis of variance of pasture yields inside cages as affected by nitrogen treatment and height of cutting above ground level at each sampling are given in Table 3. There generally were significant dry-matter responses to nitrogen in cages in those samplings immediately subsequent to nitrogen application. Cutting the pasture to 2 in. rather than 4 in. above ground level resulted in significantly greater amounts of dry matter in three of the four samplings in 1961 and in December 1962 and January 1963.

TABLE 3

Effect of Nitrogen Treatment and Height of Cut on the Amount of Dry-matter Pasture in Cages

Date of Cutting	Mean D.M. Pasture (lb/ac)				Necessary Differences for Significance	
	No Nitrogen	Nitrogen	2 in. cut	4 in. cut	5%	1%
17.iii.61	1,325	2,622**	2,466**	1,481	675	960
28.iv.61	137	191*	227**	100	49	70
23.x.61	471	568	820**	220	305	434
5.xii.61	1,763	3,145**	2,531	2,376	623	887
11.i.62	1,343	1,658	1,330	1,670	604	859
8.ii.62	828	706	879	654	366	520
14.iii.62	765	913	764	914	356	518
16.iv.62	484	710	719	475	376	535
10.xii.62	120	261	273*	109	147	209
23.i.63	1,954	4,148**	3,908**	2,194	1,089	1,548
27.ii.63	1,116**	488	770	834	322	458
5.iv.63	803	643	856	590	284	405
5.ii.64	2,511	3,953	3,731	2,733	1,561	2,243

* Significantly greater at 5% level

** Significantly greater at 1% level

The variance of dry-matter pasture yields between the two blocks of four paddocks was examined in the analysis, but differences between paddock means generally were not significantly different. The effect of stocking rate also was taken out in the analysis of variance, and the treatment means of paddocks with the high stocking rate were significantly higher than treatment means of paddocks with the low stocking rate in December 1961, April 1963 and February 1964.

The percentages of protein in the pasture inside cages are given in Table 4.

Quadrat pasture and faecal protein concentrations.—An analysis of variance of data obtained during the same time intervals as those used in the analysis of body-weights showed that nitrogen fertilizer significantly increased mean available pasture in autumn 1961 and 1964 after fertilizing in January in 1961 and March in 1964 (Table 5). In 1964 the higher yields persisted until winter.

TABLE 4

PERCENTAGE PROTEIN IN THE DRY-MATTER PASTURE IN CAGES

Season	No Nitrogen		Nitrogen	
	2 in. cut	4 in. cut	2 in. cut	4 in. cut
Autumn, 1961	9·7	8·5	11·1	10·9
Spring, 1961	14·2	13·0	12·2	13·6
Summer, 1961–62	10·0	8·7	10·2	9·3
Autumn, 1962	12·1	10·9	11·7	11·2
Summer, 1962–63	9·1	8·2	11·0	11·1
Autumn, 1963	9·5	9·9	10·7	11·2
Summer, 1964	10·1	8·8	13·6	14·5

TABLE 5

EFFECT OF STOCKING RATE AND NITROGEN TREATMENT ON DRY-MATTER PASTURE YIELD ESTIMATED FROM QUADRAT MEASUREMENTS

Season	D.M. Pasture (lb/ac)				Necessary Differences for Significance	
	1/ac	2/ac	No Nitrogen	Nitrogen	5%	1%
Autumn, 1961	1,173	1,087	717	1,543**	424	779
Winter, 1961	536	466	415	587	371	680
Summer, 1961–62 ..	3,901*	1,821	2,207	3,515	1,759	3,228
Autumn, 1962	2,282*	1,102	1,506	1,878	701	1,287
Winter, 1962	1,637	1,233	1,720	1,149	1,183	2,729
Summer, 1962–63 ..	2,335	1,849	1,772	2,412	1,117	2,051
Autumn, 1963	2,773*	1,622	2,125	2,270	796	1,461
Winter, 1963	1,520*	642	1,207	956	523	960
Spring, 1963	†	†	†	†	†	†
Summer, 1963–64 ..	1,838*	633	983	1,487	659	1,209
Autumn, 1964	2,631**	756	1,167	2,220*	622	1,141
Winter, 1964	1,933**	245	812	1,365*	402	737
Spring, 1964	1,018**	162	628	551	339	781
Summer, 1964–65 ..	850	†	†	†	†	†
Autumn, 1965	793	†	†	†	†	†

† Pasture was too short to cut
* Significantly greater at 5% level
** Significantly greater at 1% level

The results of duplicate measurements of pasture yield by the same operator on the same day showed large differences between estimates. Differences up to 650 lb dry matter per acre were found between duplicate measurements when the estimated pasture yield was between 1,000 and 2,000 lb dry matter per acre. Differences up to 200 lb dry matter were found when the estimated pasture yield was below 500 lb dry matter per acre.

Crude protein percentage in pasture tended to be higher, particularly in summer and autumn, in paddocks at the high stocking rate. Nitrogen fertilizer generally was without effect, although in winter 1961 and 1963 protein was significantly higher in pasture in the fertilized paddocks (Table 6). In winter and spring 1964, when high stocking and no fertilizer favoured the growth of white clover of high protein content, there were significant interactions of fertilizer treatment and stocking rate on pasture protein percentage.

TABLE 6

EFFECT OF STOCKING RATE AND NITROGEN TREATMENT ON PERCENTAGE OF CRUDE PROTEIN IN QUADRAT PASTURE SAMPLES

Season	Crude Protein (%)				Necessary Differences for Significance	
	1/ac	2/ac	No Nitrogen	Nitrogen	5%	1%
Autumn, 1961	6·21	5·78	5·50	6·49	1·50	2·76
Winter, 1961	5·30	5·49	4·61	6·18*	1·07	1·97
Summer, 1961–62 . .	7·83	9·13	9·10	7·87	1·56	2·86
Autumn, 1962	6·30	6·70	6·30	6·70	0·78	1·43
Winter, 1962	5·79	6·26	6·02	6·03	1·36	3·14
Summer, 1962–63 . .	9·48	10·60*	10·32	9·76	0·74	1·36
Autumn, 1963	6·64	7·17*	6·67	7·13	0·49	0·90
Winter, 1963	6·53	6·62	5·99	7·15**	0·39	0·72
Spring, 1963	†	†	†	†	†	†
Summer, 1963–64 . .	7·57	10·48**	9·14	8·91	1·08	1·99
Autumn, 1964	6·76	8·77	8·03	7·49	2·19	4·01
Winter, 1964	5·46	9·88**	8·73*	6·61	1·17	2·16
Spring, 1964	8·42	14·98*	15·54**	7·86	3·17	7·31
Summer, 1964–65 . .	7·61	†	†	†	†	†
Autumn, 1965	4·80	†	†	†	†	†

† Pasture too short to cut
* Significantly greater at 5% level
** Significantly greater at 1% level

The effect of nitrogen treatment on mean faecal protein concentration, shown in Table 7, was similar to its effect on pasture protein concentration. However, apart from the seasonal effect of white clover on pasture and faecal composition, high stocking did not result in an increase in faecal protein as it did with pasture protein concentration.

Species ground cover.—At the first sampling in December 1963, clover was significantly depressed both in fertilized and in low-stocked paddocks. A similar trend was evident at the second sampling in May 1964 but the apparent depressing effect of low stocking on clover growth did not attain significance. At this sampling the effect of low stocking was to increase the paspalum component (Table 8). As expected, there was a higher percentage of clover in winter than in summer.

Pasture observations.—After application of fertilizer the grass appeared to be a darker green than that in the unfertilized paddocks. In the unfertilized

TABLE 7

EFFECT OF STOCKING RATE AND NITROGEN TREATMENT ON PERCENTAGE OF CRUDE PROTEIN IN ORGANIC MATTER FAECES

Season	Protein in O.M. Faeces (%)				Necessary Differences for Significance	
	1/ac	2/ac	No Nitrogen	Nitrogen	5%	1%
Autumn, 1961	11·88	11·50	11·74	11·64	0·50	0·91
Winter, 1961	10·76**	9·86	9·85	10·77**	0·33	0·61
Summer, 1961–62 ..	13·75	14·46	14·63	13·58	1·34	2·46
Autumn, 1962	15·03	12·57	12·75	14·85	6·62	12·15
Winter, 1962	11·09	11·14	11·11	11·13	1·83	3·37
Summer, 1962–63 ..	15·89	16·44	16·49	15·84	2·59	4·76
Autumn, 1963	15·02*	13·74	14·33	14·43	1·03	1·89
Winter, 1963	13·43	12·40	12·07	13·76	2·03	3·73
Spring, 1963	13·38	12·94	13·21	13·11	1·36	2·50
Summer, 1963–64 ..	13·93	14·98	14·27	14·63	1·40	2·58
Autumn, 1964	12·18	13·60	13·20	12·58	1·59	2·92
Winter, 1964	11·87	13·10*	13·13*	11·85	1·09	1·99
Spring, 1964	15·83	19·74*	20·02**	15·54	2·16	3·97
Summer, 1964–65 ..	14·85	16·61*	15·99	15·48	1·76	3·23
Autumn, 1965	10·66	13·09*	12·13	11·63	1·55	2·84

* Significantly greater at 5% level
** Significantly greater at 1% level

TABLE 8

EFFECT OF STOCKING RATE AND NITROGEN TREATMENT ON SPECIES GROUND COVER

Date of Sampling	Pasture Component	Species Ground Cover (%)			
		1/ac	2/ac	No Nitrogen	Nitrogen
2.xii.63	Paspalum ..	97·1	91·4	91·8	96·8
	Couch grass	0·9	3·8	3·0	1·4
	Clover ..	0·5	2·0*	2·0*	0·4
22.v.64	Paspalum ..	85·4*	67·7	71·2	82·7
	Couch grass	8·7	11·6	6·6	14·2
	Clover ..	1·2	9·6	12 8	0·4

* Significantly greater at 5% level

paddocks and in those stocked at two animals per acre, the sward remained in a vegetative condition for longer during summer and seedhead production appeared to be lower in these paddocks. However, there was a high degree of selective grazing in all paddocks. The cattle selectively grazed short regrowth in summer and autumn and clover growth was apparent in these closely cropped areas. In summer, tall growth of grass around dung and urine patches was evident and these patches were ignored by the cattle until pasture shortage occurred in late autumn or winter.

Damage to the pasture by leaf-eating caterpillars was noticed when pasture inside cages was sampled and the cut areas inside cages appeared to become couch grass dominant.

IV. DISCUSSION

In spite of an application of 465 lb nitrogen per acre over the four years of the experiments, the overall body-weight responses from fertilizer were negligible. At the best, seasonal advantages from nitrogen were small and these advantages were narrowed in some seasons, due presumably to compensatory gain of cattle in the unfertilized paddocks. In addition, the suppression of white clover by nitrogen fertilizer in one year removed much of the overall benefit that nitrogen fertilizer might otherwise have had on body-weight gain.

Although animal productivity was not increased, the fertilizer increased dry-matter pasture yield as shown by quadrat and exclosure pasture data. However, a quantitative assessment of this increase in yield cannot be made as there were large errors between duplicate estimations in quadrat pasture measurements and the estimates within exclosures were affected by a number of factors, including damage to leaf by caterpillars, height of cutting above the ground, the tendency for the cut areas to become couch grass dominant and the effect of the outside environment on the pasture yield inside the cages. Other errors associated with estimations of pasture yield from measurements inside cages have been indicated by Cowlishaw (1951).

The interrelationships between animal productivity and pasture growth are complex and presentation of data on a seasonal basis together with inherent inaccuracies in some of the techniques result in apparent anomalies. Nevertheless, examination of the data permits some general observations to be made.

In summer the pasture available in the unfertilized and high-stocked paddocks, as assessed by crude protein analysis, tended to be of higher quality than that in fertilized and low-stocked paddocks. This was reflected in a trend towards consumption of higher quality feed, as assessed by faecal protein concentration, in the unfertilized and high-stocked groups, which in turn resulted in comparable or better growth rates in these groups during all summers except 1964-65. In this summer, lack of feed availability in these paddocks resulted in the markedly poorer performance of these groups.

In winter, animal performance in the unfertilized and high-stocked groups was either poorer than or comparable with that in the fertilized and low-stocked paddocks. Although available pasture was sometimes of better quality and pasture eaten was sometimes of higher quality, low availability combined with poorer pasture growth was the major factor responsible for the low performance in the unfertilized and high-stocked groups.

High faecal protein concentrations relative to crude protein concentrations in quadrat pasture samples suggest from the findings of Moir (1960) that the quality of the selectively grazed pasture was much higher than that of the total pasture available. As the selected diets had a higher quality at each sampling date, the poorer quality pasture which was rejected could not have been eaten at any time by the cattle. However, most of the additional pasture produced by fertilizer was removed, since the quadrat pasture yield data showed relatively large differences between available pasture in fertilized and unfertilized paddocks in summer, but relatively small differences in winter. Observations indicated that the parts of plant rejected were stems and seedheads and leaves which had died as a result of shading. This material subsequently disintegrated by weathering. It follows that there was greater wastage associated with nitrogen fertilizer and this finding is in agreement with that of Jones (1967).

In summer and autumn the pasture cut from quadrats consisted almost entirely of paspalum and the results of analyses of these samples indicate that nitrogen fertilizer had negligible effect on the crude protein content of this species. This finding is in agreement with that of Henzell (1963), but his data suggest that larger amounts of fertilizer may have increased pasture protein concentration. With some pasture species, nitrogen fertilizer has markedly increased the crude protein percentage (Alexander *et al.* 1961; Holmes 1949; Stewart and Holmes 1953) and has increased the digestibility of protein and dry matter (Woelfel and Poulton 1960). It is possible that pastures in which crude protein percentage and digestion coefficient are increased by the application of nitrogen fertilizer are those which would give the greatest animal production response in a continuous grazing system.

Over the four years of the investigation, there was more production per animal but less production per acre at the low than at the high stocking rate. However, not only did low stocking result in inefficient usage of summer pasture, but it adversely affected clover growth in spring, as shown by the significant interaction between stocking rate and nitrogen fertilizer on growth rate. This interaction, which also has been noted by others (Alder and Newton 1964), poses the question of what effect a very high stocking rate in summer might have had in overcoming the depressing effects of nitrogen on clover growth.

The results suggest that in experiments designed to assess the effect of fertilizer on animal productivity it would be desirable to use increments of stocking rate up to levels considerably above normal carrying capacity during the period of maximum pasture growth. When stocking rates above normal carrying capacity result in the greatest body-weight gains for a limited period, the pasture probably would be most efficiently utilized by diversifying land usage.

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