A COMPARISON OF BEEF PRODUCTION FROM NITROGEN FERTILIZED PANGOLA GRASS AND FROM A PANGOLA GRASS—LEGUME PASTURE

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ABSTRACT

Pangola grass (Digitaria decumbens) *was grazed by beef cattle in south east Queensland for three years. Treatments, mean liveweight gains (L.W.G.) and average stocking rates were (a) with 448 kg nitrogen/ha/year—1106 kg/ha L.W.G. at 5.6 beasts/ha, (b) with 168 kg nitrogen/ha/year—699 kg/ha L.W.G. at 4.3 beasts/ha, and (c) with legumes—507 kg/ha L.W.G. at 3.6 beasts/ha.*

All pastures were predominantly pangola grass, even the grass-legume pasture having 70% pangola grass and only 17% legume at the end of the experiment. The mineral composition of the pastures appeared adequate, except for low values in winter.

INTRODUCTION

An experiment was conducted at Beerwah, Queensland, over a five year period to assess the value of pangola grass (*Digitaria decumbens*) for beef production on the Wallum of south-eastern Queensland, comparing the value of nitrogen fertilized grass and a grass-legume mixture. Direct comparisons of grass-legume pastures and pure grass pastures fertilized with nitrogen have been made under cutting for yields of dry matter and crude protein (see reviews by Bryan 1962 and 1969), but the only comparisons we could find using tropical pastures under grazing were made in Florida (Koger et al 1961, Warnick et al, 1965) where the amounts of nitrogen used (38-76 kg/ha) were low.

Motta (1963) and Oakes (1960) in the more favourable environment of the wet tropical Caribbean obtained live weight gains with steers of 1060 kg/ha at a stocking rate of 5.8 beasts/ha and 1180 kg/ha at a stocking rate of 2.3 beasts/ha respectively, and Evans (1969) in a preliminary trial at Beerwah had obtained 1275 kg/ha with 448 kg N/ha/annum at a stocking rate of 7.4 beasts/ha. In another trial at Beerwah (Bryan 1968) gains of 300 kg/ha were obtained from a pangola-legume mixture. Information on the direct comparison of nitrogen and legumes is necessary for comparative production outputs and for an economic appraisal of the two systems.

MATERIALS AND METHODS

The experiment occupied a transect across a major depression. The area was cleared in 1962-63 and well cultivated to eliminate marked micro-relief and heavy weed cover, especially *Juncus prismatocarpus*.

The Wallum fertilizer mixture of 625 kg superphosphate, 625 kg calcium carbonate, 125 kg potassium chloride, 8 kg copper sulphate, 8 kg zinc sulphate and 280 g molybdenum per hectare (Bryan 1968) was broadcast in early November 1964 and disced in. The design was a randomised block with three treatments and

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three replications. Plots 1 to 3 were on a nodular podzolic soil (type 2 of Thompson 1958), plots 4 and 5 on low humic gley soils (types 4 and 6) and plots 6 to 9 on humic gley soils (types 13 and 14), i.e. replication No. 1 was on fairly dry soil and the other replicates on progressively wetter soils. Plot 6 (treatment 3) was in the lowest position and subject to sufficient intermittent flooding in wet periods to adversely affect pasture and animal production from it. Plot size was 0.81 hectare. Treatments were

1. Low N. Pangola grass with 112 kg N/ha/year in 1966 and 1967
   168 kg N/ha/year in 1968-1970.
2. High N. Pangola grass with 449 kg N/ha/year.
3. Grass-Legume. Pangola grass and the legumes *Phaseolus layhydroides* cv. Murray, *Desmodium uncinatum* cv. Silverleaf, *Trifolium repens* cv. Grasslands Huia, each sown at 2.24 kg/ha, and *Desmodium intortum* cv. Greenleaf and *Lotononis bainesii* cv Miles each sown at 1.12 kg/ha. The strains of *Rhizobium* used were respectively CB 756, CB 627, T.A. 1 plus UN 229, CB 627 and CB 376, all known to be fully effective. Pangola grass sprigs were planted by hand at 1.8 m centres in late November, and legumes sown on November 27, 1964.

Calcium ammonium nitrate was used in the first two years and in this period 163 kg/ha calcium carbonate was added annually to treatment 3, this being the amount of calcium added to treatment 1. In subsequent years ammonium nitrate became available and was used, and no further adjustments for calcium were made. Annual applications of 500 kg/ha single superphosphate and 250 kg/ha potassium chloride were made, half in September and half in February, this being twice the amount used in previous experiments (Bryan 1968).

Applications were made in September (41.25%), January (41.25%) and April (17.5%) for the first three years, based on the growth curve of pangola of Bryan and Sharpe (1965). In the last two years the distribution became 25% in September, 15% in each of December and February and 22.5% in both April and July, after information on the effect of different distributions on live weight gain became available from another experiment (unpublished data).

Throughout 1965 the area was grazed intermittently. By December 1965 the trial was considered sufficiently well established to withstand continuous stocking and the experiment was begun. Two tester animals were maintained at all times on each plot (i.e. a minimum of 2.47 beasts/ha). An attempt was made to exert similar grazing pressures on all treatments by adjustment of stocking rates, on the basis of live weight changes per head, aided by our knowledge of mean live weight fluctuations at the station over a period of years, together with a visual assessment of the pasture. An animal was added only when testers were gaining a minimum of 0.8 kg/head/day and removed only when gains were less than 0.25 kg/head/day. This was an attempt to adjust stocking rates to a very variable environment. No changes were made at intervals less than a month and in all years except 1970 there were only one or at most two changes of stocking rate. In 1970 for the first time the amount of feed became limiting in some plots and three changes were necessary in those plots. Hereford heifers were used for the first two years, steers thereafter. In either case animals were introduced at 13-16 months of age and kept until they attained a live weight of approximately 430 kg. Water and shade were provided in each plot. Cattle were weighed directly off pasture once a month; initial and final weights were taken after holding for 16 hours without feed or water.

After the second year several changes were made. The low N treatment was increased to 168 kg N/ha because in the first years the amount of dry matter per head in this treatment had been approximately the same as in high N and greater than in the legume treatment, but nitrogen concentrations had been low. The low quality of the feed offered had resulted in poor animal performance. At the same time stocking rates were increased in all treatments, partly because this was then considered feasible and partly in an attempt to maintain younger, more nutritious feed and to maximise production per hectare. Because of these changes, the results of the last three years are regarded as the more critical ones in reflecting treatment differences.

Botanical composition was determined in summer and winter by the dry weight rank method of 't Mannetje and Haydock (1963) and dry matter on offer by the electronic capacitance meter (Jones and Haydock 1970). Samples for chemical determinations were hand plucked at random over each paddock to approximate what the animals were grazing.

In most years climatic conditions were reasonable for pasture growth. In 1970, with nine successive months of below average rainfall and a succession of severe frosts throughout the winter, pasture production was severely reduced from April to November on replicates 2 and 3. In 1969 a complete absence of frost allowed consistent pasture production giving high live weight gains, even though rainfall was below average.

RESULTS

Animal data

Stocking rates and liveweight gain per head.

The mean annual stocking rates are given in Table 1, and the times at which stocking rates were changed in Table 2.

TABLE 1

Mean annual stocking rates (SR.—beasts/ha) and live weight gains (LWG—kg/ha) on pangola grass at two levels of nitrogen fertilizer and with legumes

Period	High N S.R.	High N LWG	Low N S.R.	Low N LWG	Grass-legume S.R.	Grass-legume LWG	LSD of LWG $P=0.05$	LSD of LWG $P=0.01$
1966	3.8	627	2.6	267	2.6	523	150	—
1967	2.7	668	2.47	415	2.47	579	N.S.	
1968	5.1	931	3.8	683	3.8	456	259	—
1969	5.8	1559	4.4	857	3.7	618	239	345
1970	5.9	828	4.7	558	3.2	448	N.S.	
1966-67	3.25	647	2.53	341	2.53	551	106	151
1968-70	5.6	1106	4.3	699	3.6	507	139	193
1966-70	4.6	923	3.6	556	3.2	525	89	120

It was possible to increase the stocking rate by 1 to 2 beasts/ha after year 2, and to carry more animals on the nitrogen treatments than on the grass-legume mixture. Liveweight gains per head per day (Table 3) show an overall increase in gains for low N, almost no change for high N and a decrease of approximately 33% for grass-legume pastures when stocking rates were increased. There were no differences in the mean annual daily gain for the five year period between low N and grass-legume treatments.

Seasonal effects on animal performance are well illustrated in Table 3 and Fig. 1.

It was possible from cumulative liveweight change curves (Fig. 1) to divide the year into three distinct periods, mid-summer-autumn, late autumn-winter and spring-early summer as regards liveweight gain per head. Increase in stocking rates had no adverse effect on daily gains from either nitrogen treatment in autumn or

TABLE 2
Changes in stocking rate (beasts/ha)

Period	High N	Treatment Low N	Grass-Legume
Dec. '65 to Mar. '66	3.70	2.47	2.47
April '66	4.94	3.70	3.70
May to Oct. '66	3.70	2.47	2.47
Nov. '66	2.47	2.47	2.47
Dec. '66 to Mar. '67	3.70	2.47	2.47
April to Oct. '67	2.47	2.47	2.47
Nov. '67	3.70	2.47	2.47
Dec. '67 to Mar. '68	4.94	3.70	3.70
April to May '68	6.17	4.94	4.94
June '68 to June '69	4.94	3.70	3.70
July '69 to Feb. '70	6.17	4.94	3.70
Mar. to May '70	7.41	4.94	3.70
June '70	6.67	4.45	2.96
July to Oct. '70	5.43	4.45	2.96
Nov. to Dec. '70	6.67	4.45	2.96

winter, but decreased weight gains in spring and early summer. During the last three years gains at this time were less than in the December-May period. The grass-legume treatment showed a slight reduction in daily gains for December-August as stocking rate was increased, and a 50% reduction in spring and early summer. These responses in daily liveweight changes suggest that stocking rate may have affected the adequacy of available dry matter in spring, a period when rapid growth of pasture should provide a high quality feed.

TABLE 3
Daily live weight gain (kg/head)

	Treatment	Period 12/12 to 1/5 (140 days)	1/5 to 21/8 (112 days)	21/8 to 11/12 (112 days)	Annual average
1966-67	High N	0.70	0.21	0.74	0.56
	Low N	0.52	—0.10	0.67	0.375
	Grass-Legume	0.78	0.12	0.86	0.60
1968-70	High N	0.83	0.24	0.49	0.54
	Low N	0.73	0.22	0.46	0.49
	Grass-Legume	0.66	0	0.43	0.39
1966-70	High N	0.78	0.23	0.59	0.54
	Low N	0.65	0.09	0.54	0.44
	Grass-Legume	0.71	0.05	0.60	0.47

Although the stocking rate on grass-legume pastures was approximately 50% greater than that used in previous experiments (Bryan 1968), the daily liveweight gains in December-May were twice as great, viz. 0.71 kg compared to 0.35 kg/head/day, with little difference in performance in the May-December period. The reason for the greater animal production at these higher stocking rates is not clear, but the occurrence of a higher legume content (24%) and use of twice the amount of superphosphate in maintenance dressings are probably the most important contributing factors. There was a marked difference in performance on low N pasture in winter between years 1-2 and years 3-5, the rate changing from −0.10 kg/day to +0.22 kg/day despite an increase in stocking rates, and coinciding with an increase from 112 to 168 kg N/ha. Over these periods the gain in high N was practically constant at 0.21 to 0.24 kg/day. High N was generally superior to low N in liveweight gain per head per day.

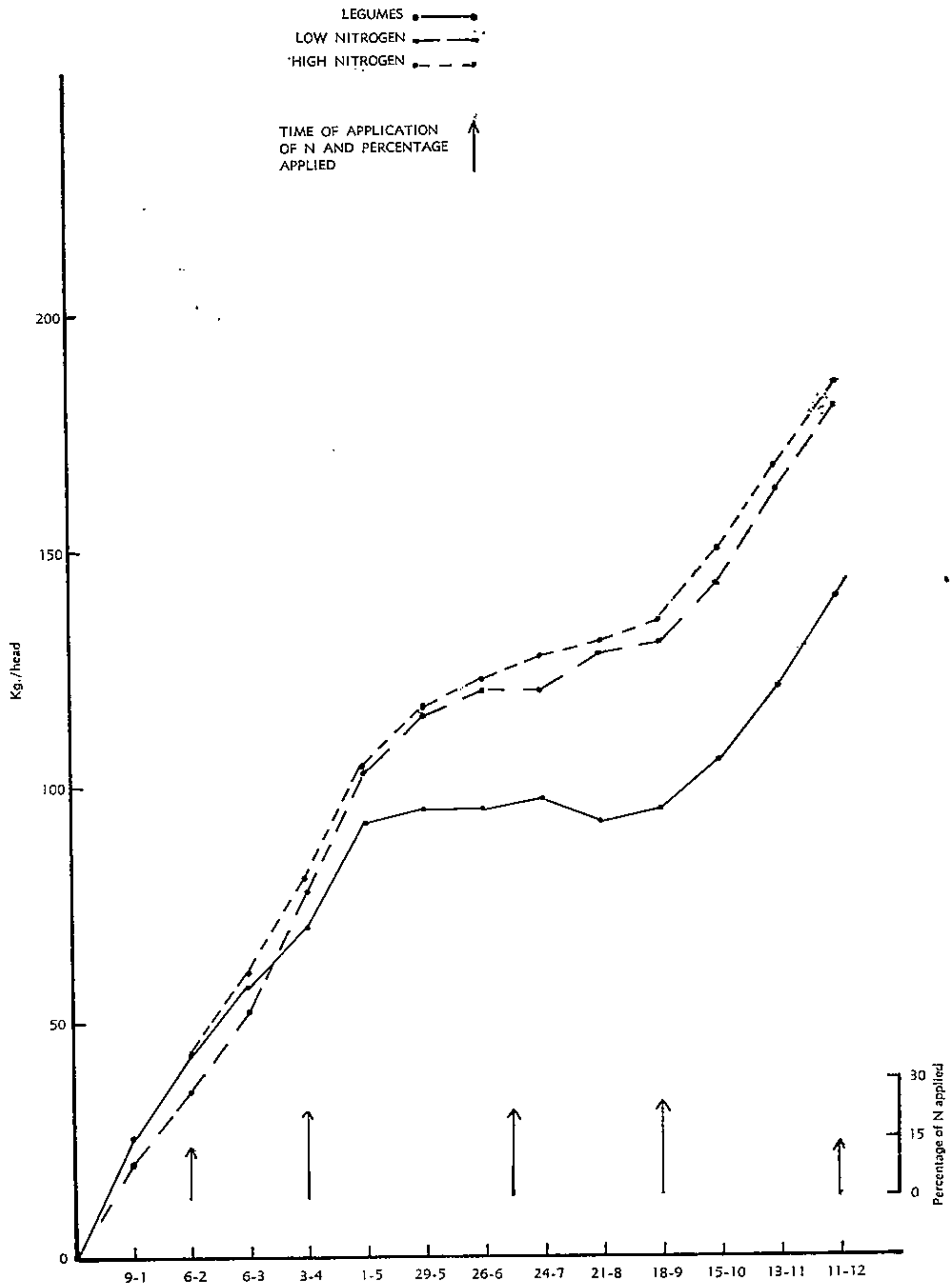

FIGURE 1

Cumulative mean annual liveweight gain (kg/head), 1968 to 1970. (Weighing dates were approximately the same in each year).

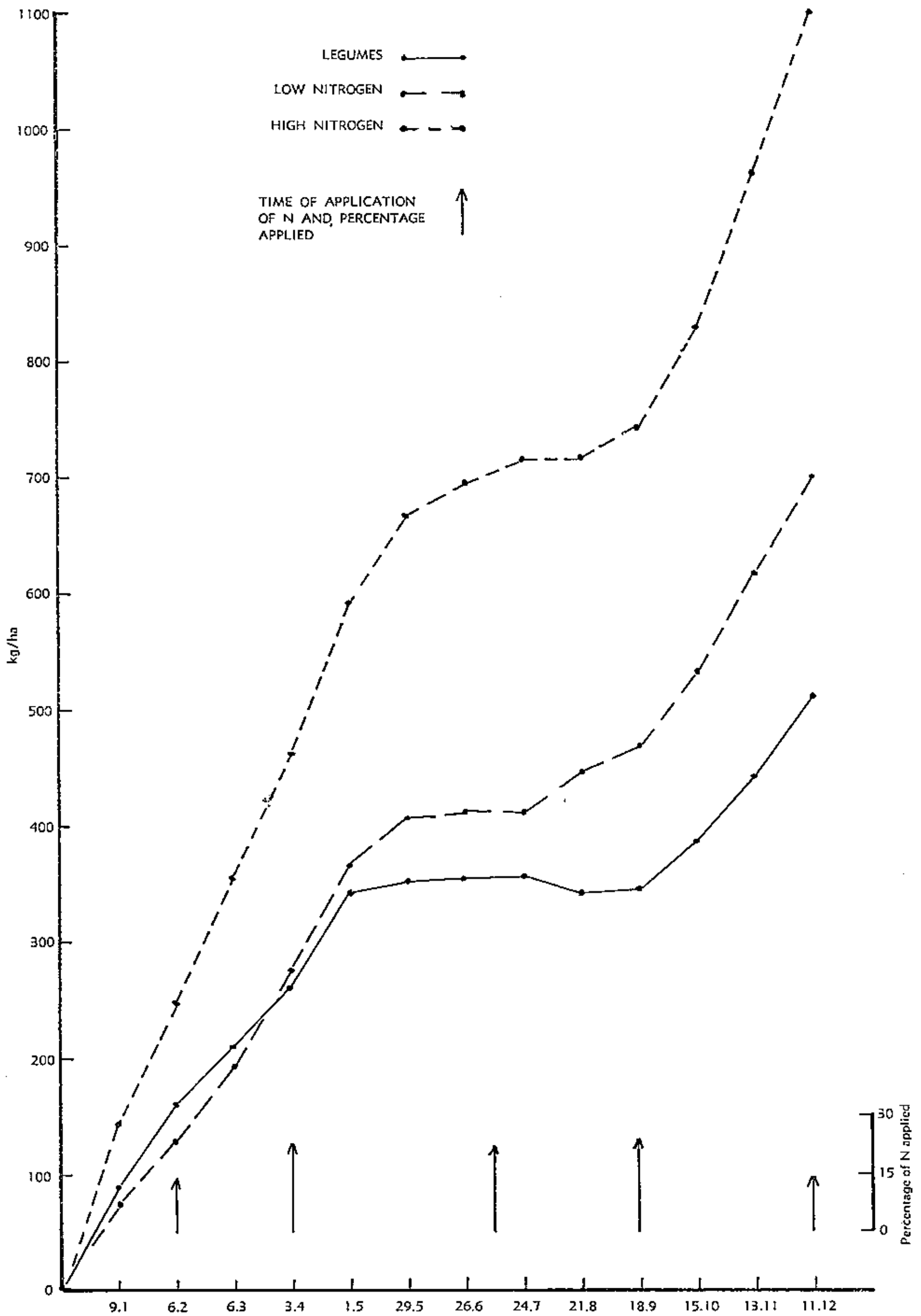

FIGURE 2

Cumulative mean annual liveweight gain (kg/ha), 1968 to 1970. (Weighing dates were approximately the same in each year).

Liveweight gain per unit area

The animal live weight gains per hectare are given in Table 1. Animal production from the grass-legume treatment was uniform over the years, being within ± 18% of the mean. High N outyielded low N in all years and generally significantly so.

One feature of Table 1 is the marked change in production from low N after the second year, i.e. after increasing the N applications. It has not been possible to confirm this change statistically because the yield of high N plots also increased in the last three years although the production from the grass-legume treatment continued as before. In the low N treatment the plots were yellow, unthrifty, rather weedy, often below critical levels of chemical composition and not very well grazed in the first two years. After this they became denser, healthier and were much more uniformly grazed. The high N plots were always dense, healthy, uniformly grazed and generally of satisfactory chemical composition.

Because of the changes after the second year it is considered that the last three years are most representative of treatment. If this be accepted then the production was almost exactly 500 kg/ha for legumes, 700 for low N and 1100 kg/ha for high N. On this basis, assuming linearity, the annual N input of the legume mixture was between 110 and 130 kg N a hectare. Cumulative live weight gain curves (kg/ha) are shown in Fig. 2.

Pasture data

Botanical composition

There was a steady decline in the mean legume content of the grass-legume plots from 40% at the end of the first year to about 17% in the last year. The decline in legume content was accompanied by a rise in sown grass from 50 to 70%, weed being fairly constant at about 10% (Table 4).

TABLE 4

Botanical composition (dry weight %) and dry matter on offer of different treatments

Treatment		Dec. 1965	Jun. 1966	Dec. 1966	Jul. 1967	Nov. 1967	Sep. 1968	Jul. 1969	Nov. 1969	Dec. 1970
High N	Pangola (%)	95.3	96.6	93.3	N.S.*	N.S.	N.S.	99.7	N.S.	99.6
	Weed (%)	4.7	3.4	6.7	N.S.	N.S.	N.S.	0.3	N.S.	0.4
	Dm on offer (kg/ha)	5410	2700	2090						1820
Low N	Pangola (%)	83.3	90.4	81.1	N.S.	N.S.	N.S.	98.7	N.S.	88.6
	Weed (%)	16.7	9.6	28.9	N.S.	N.S.	N.S.	1.3	N.S.	11.4
	DM on offer (kg/ha)	3740	2390	1750						1030
Grass-Legume	Pangola (%)	24.3	32.4	50.5	60.6	71.6	64.3	79.3	69.3	69.8
	Legumes (%)	67.6	42.6	41.8	33.1	22.3	26.4	11.7	17.2	16.4
	Weed (%)	8.1	25.0	7.7	6.3	6.1	9.3	9.0	13.5	13.8
	DM on offer (kg/ha)	2500	951	1430	2110	1000				575

* N.S. = Not sampled.

Of the legumes, *D. uncinatum* failed to establish and *P. lathyroides,* which established well, had disappeared after the establishment year, as is commonly the case. *L. bainesii* established well but only maintained itself on the drier soil, and this was also largely the case with *D. intortum. T. repens* established satisfactorily on all soils but persisted better on wet ones where it became the only legume of consequence (Table 5).

TABLE 5

Distribution of legumes in summer according to soil type (percentage of dry matter on offer)

Year	*D. intortum* Soil N.P.*	*D. intortum* Soil H.G.†	*D. uncinatum* Soil N.P.	*D. uncinatum* Soil H.G.	*L. bainesii* Soil N.P.	*L. bainesii* Soil H.G.	*T. repens* Soil N.P.	*T. repens* Soil H.G.	Total legumes Soil N.P.	Total legumes Soil H.G.
1965	23	16	3	2	49	17	7.6	25	83	60
1966	28	6	0	0	23	0.3	4.8	26	56	32
1967	27	2	trace	trace	0	0	1.4	17	28	19
1968	20	0	2	0	5	0.5	2.0	25	29	25
1969	2	0	0	0	16	0.4	6.2	10	24	10
1970	5.5	0	0	0	22	0.1	9.4	8.8	37	9
Mean 1966-70	16.5	1.6	0.4	0	13.2	0.3	4.8	17.3	34.8	19.0

* N.P. = Nodular podzolic soil.
† H.G. = Humic gley soil.

The high N plots were practically pure pangola grass, particularly in the later stages. The low N plots, on the other hand, averaged at least 10% weeds, the grass being less aggressive with the lower level of nitrogen application. The main weed species were *Juncus prismatocarpus, Axonopus affinis, Kyllinga brevifolia, Rhynchelytum repens* and *Paspalum urvillei.*

In the first year the mean amounts of dry matter on offer were:—high N 3400, low N 2620 and grass-legume 1630 kg/ha. Net liveweight gains were respectively 627, 267 and 523 kg/ha with no relationship of dry matter yield on offer to live weight gain. Evidently low N pastures had adequate dry matter but were of low quality, grass-legume pastures had lower yield but higher quality.

Chemical composition

N, P, K, and Ca concentrations of the legumes were adequate for normal plant growth at all times (Table 6). The same was true of the pangola grass growing with legumes, which had higher values for P and K than either of the nitrogen treatments.

The grass in high N plots had the highest N values. Both high N and low N grasses were of adequate chemical composition during periods of active growth but deficient in P and K in the cooler months. Low N grass was also low in N in winter and was consistently lower than high N grass in N, P and K for the first two years; thereafter there was little difference in P and K.

TABLE 6

Chemical composition of pastures (on dry matter basis) in summer and winter.

Treatment	High N	Low N	Grass-legume	
Component	Grass	Grass	Grass	Legume
		Winter means (3 winters)		
N%	1.19	0.55	1.14	2.80
P%	0.13	0.12	0.19	0.21
K%	0.97	0.84	1.39	2.01
Ca%	0.27	0.39	0.38	1.09
		Summer means (6 summers)		
N%	1.92	1.25	1.45	3.42
P%	0.22	0.19	0.28	0.30
K%	1.78	1.75	2.32	2.76
Ca%	0.27	0.29	0.32	0.94

DISCUSSION

In the pure grass treatments the changes in botanical composition were too small to have any marked effect on animal performance, which was more likely to be affected by chemical composition, especially nitrogen content. It is, however, noteworthy that the high N plots had consistently much less weed than the low N plots.

The decline in legume content of the grass-legume treatment, although accompanied by an increase in pangola grass, was sufficient to affect livestock production; in two of the last three years the lowest liveweight gains from this treatment were recorded, whereas in both the nitrogen treatments all yields in the last three years were above those of the first two. There was a decrease in amount of legume on offer as well as in percentage. At the end of the experiment, plot 1 still had 30% legume and plot 8 over 12%, but plot 6, which had been intermittently flooded, was down to 5%. This had a marked effect on animal production, where a mean of 396 kg/ha was recorded from plot 6, compared with a mean of 589 kg/ha for the other two legume plots. Despite this the mean overall annual live weight gain of 525 kg/ha is the best yet obtained on a mixed pasture in this region.

The amount of dry matter on offer in low N paddocks was always greater than in grass-legume ones and generally not much less than in the high N treatment. This could indicate that the low N paddocks were undergrazed but the data of Table 3 do not support this.

Even with what were considered to be adequate amounts of N, P, K, S and Ca applied more often than once annually there was a marked reduction in N, P, and K contents of grass in winter and early spring compared with summer. This trend, added to the seasonal trend of dry matter production (Bryan and Sharpe 1965) means less material of lower nutritive value in the trough of the year. In the light of this information it is surprising that the cumulative live weight change curves are not flatter than they are from May to September.

It is not known if the observation that grass associated with legumes had a generally better P and K composition than grass grown with nitrogen has general validity, but it is a point worth checking under other circumstances. In the first two years the grass-legume treatment had a lower amount of dry matter on offer than the nitrogen treatments, yet liveweight gain of cattle was higher per unit of dry matter, which must be some reflection of quality.

The use of different stocking rates for different treatments is justified only so long as the live weight gain per head is not seriously depressed at the higher stocking rates. As the live weight gain per head was highest on the high N treatment it is clear that the higher stocking rate imposed in this treatment did not depress animal performance. The same general argument applies to the other different stocking rates imposed on the other treatments, i.e. the higher stocking rates were generated by the ability of the pasture to carry more stock.

There was a serious limitation in this experiment in that only one stocking rate could be used in any treatment at any time. Thus any bias due to under- or over-stocking cannot be determined. It seems likely from the data in Table 1 that on the basis of live weight gains per head the grass-legume treatment was overgrazed in 1968 and high N was undergrazed in 1969. This would adversely affect both these treatments in relation to low N. On the whole any bias seems to be towards conservative values.

The live weight gain per head was low in low N for the first two years, and this was due to the low quality of the pasture, since the amount of dry matter available per animal was about the same as in the high N treatment. There was a period of no gain for five months in winter, as against a period of one month with high N in those years. The shape of the high N curve did not change in the next three years, but the low N curve (now for 168 kg N) now coincided with it.

The production of 1100 kg/ha on the high N treatment is approximately the same as that obtained by Motta (1963) and Oakes (1960) in the Caribbean. This was not as high as the 1275 kg of Evans (1969) also at Beerwah, but his pasture was older and denser and carried a stocking rate of 7.4 beasts/ha throughout.

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