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SEASONAL PRODUCTIVITY OF SOME PURE GRASS AND MIXED GRASS/GLYCINE SWARDS IN A TROPICAL HIGHLAND ENVIRONMENT

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SUMMARY

Elephant grass produced approximately 25,000 lb of dry matter per acre in the first year of a cutting experiment in northern Queensland, and far outyielded seven other grasses grown in swards with and without the legume *Glycine javanica* cv. Tinaroo.

In mixed swards, glycine increased the protein content of kikuyu grass and pangola grass in the second year, but this was accompanied by a decrease in the yield of dry matter by the grass. Legume yields were generally far lower than grass yields and the total yields of the mixed swards did not show any significant increases over those of the pure grass. The presence of the legume tended to increase the yield of protein by the mixture, particularly during the winter of the second year, and this is discussed in terms of probable effect on animal production.

I. INTRODUCTION

The general pasture conditions and stock management practices in the dairying districts on the Atherton Tableland of the Cairns hinterland of Queensland have been outlined by Mawson (1953) and Gartner (1965). The pastures support approximately 1 beast to 3-5 ac, giving a production of only 88-144 gal of milk per acre per annum.

The mean annual rainfall varies from approximately 100 in. at Millaa Millaa at the southern end of the Tableland to 50 in. at Kairi, which is approximately 35 miles north of Millaa Millaa. At all centres the rainfall is markedly monsoonal, mainly occurring during the period October–March. The rains of October–December are usually associated with storms of variable incidence interspersed with hot dry spells.

The mean maximum temperature at Atherton (approximately 10 miles south-west of Kairi) for the two hottest months (December and January) is 82·5°F, and that for the coldest month (August) is 50°F. Frosts are common and widespread during July and August.

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Fig. 1.—African star grass and glycine, February 1962.

The bulk of the pastures consists of permanent swards of the introduced grasses paspalum (*Paspalum dilatatum* Poir.), kikuyu grass (*Pennisteum clandestinum* Hochst.) and narrow-leaf carpet grass (*Axonopus affinis* Chase), often in admixture. In small favoured localities, white clover (*Trifolium repens* L.) may be found, but its contribution to the value of the pastures has not been critically assessed.

The extreme seasonality of pasture growth is probably the most serious factor limiting high milk production from Atherton Tableland pastures. This problem is complicated by the restriction placed on grass growth by the low level of soil nitrogen. Henzell (1962, 1963) has shown the effect of soil nitrogen deficiency on similar pastures. The incorporation of legumes into these pastures should result in improved animal production by increasing the level of available soil nitrogen and providing succulent green feed for cattle during periods when grass is of limited value to stock.

The value of the tropical species *Glycine javanica* L. as a perennial pasture legume for the Atherton Tableland has been described by Kyneur (1960). The incorporation of this legume into district pastures was increased when commercial supplies of seed of the "Tinaroo" cultivar became available. The contribution of this legume to the seasonal supply of dry matter and protein by several commonly used exotic grasses was examined under the tropical highland conditions of the Atherton Tableland at the Kairi Research Station during 1961-62.

Fig. 2.—Pure sward of kikuyu grass, February 1962.

II. MATERIALS AND METHODS

The following grass species were grown with or without Tinaroo glycine:—

1. Elephant grass (*Pennisetum purpureum* Schum. (C.P.I.7838)).
2. African star grass (*Cynodon plectostachyum* Pilger).
3. Kikuyu grass (*Pennisetum clandestinum* Hochst.).
4. Green panic (*Panicum maximum* var. *trichoglume* (K. Schum.) Eyles).
5. Rhodes grass (*Chloris gayana* Kunth).
6. Guinea grass (*Panicum maximum* Jacq.).
7. Molasses grass (*Melinis minutiflora* Beauv.).
8. Pangola grass (*Digitaria decumbens* Stent).
9. Narrow-leaf carpet grass (*Axonopus compressus* (Swartz) Beauv.).
10. Paspalum (*Paspalum dilatatum* Poir.).

The experiment was laid down in randomized blocks with four replications, using a split plot arrangement with legume treatments as sub-plots and grasses as main plots. Main plot dimensions were 80 ft x 20 ft. The soil was a krasnozem derived from basalt.

Elephant, African star, kikuyu and pangola grasses were planted vegetatively in drills 3-4 in. deep and 3 ft apart in January 1961. All other grasses were planted with seed sown at 10 lb/ac in shallow drills 1 ft apart. Inoculated seed of Tinaroo glycine was sown at 10 lb/ac.

The plots were sampled at the end of each of five periods of growth, which were January–April 1961; April–October (1961); October 1961–January 1962; January–April 1962; and April–May 1962. Quadrats 20 ft x 5 ft were cut with a tractor-mounted reciprocating blade mower. The same area was sampled on each occasion. At the completion of sampling, the plots were mown to the height of the sample cut and the mown material removed. The plots were not grazed.

Fig. 3.—Pure stand of guinea grass, February 1962.

The cut material was separated into grass and legume components and weighed *in situ.* Moisture content of subsamples was determined by drying at 140°F in a forced-draught oven. Protein determinations were made on the dried material.

Weed growth was prolific during the first 6 weeks after planting and was controlled in the pure grass areas by an application of 1 lb acid-equivalent of 2,4-D per acre. In the legume areas, weeds were controlled by mowing at a height of 6 in. in March 1961.

No fertilizer was used until February 1962, when the whole area was top-dressed with superphosphate (containing 0·03% molybdenum) at 3 cwt/ac.

III. RESULTS

Paspalum and narrow-leaf carpet grass failed to establish satisfactorily because of faulty germination and were eliminated from the experiment.

The yield data for (a) the period from planting in January 1961 until the end of the autumn growing period in April 1961, and (b) the winter–early spring period from April to October, 1961, are presented in Figure 4.

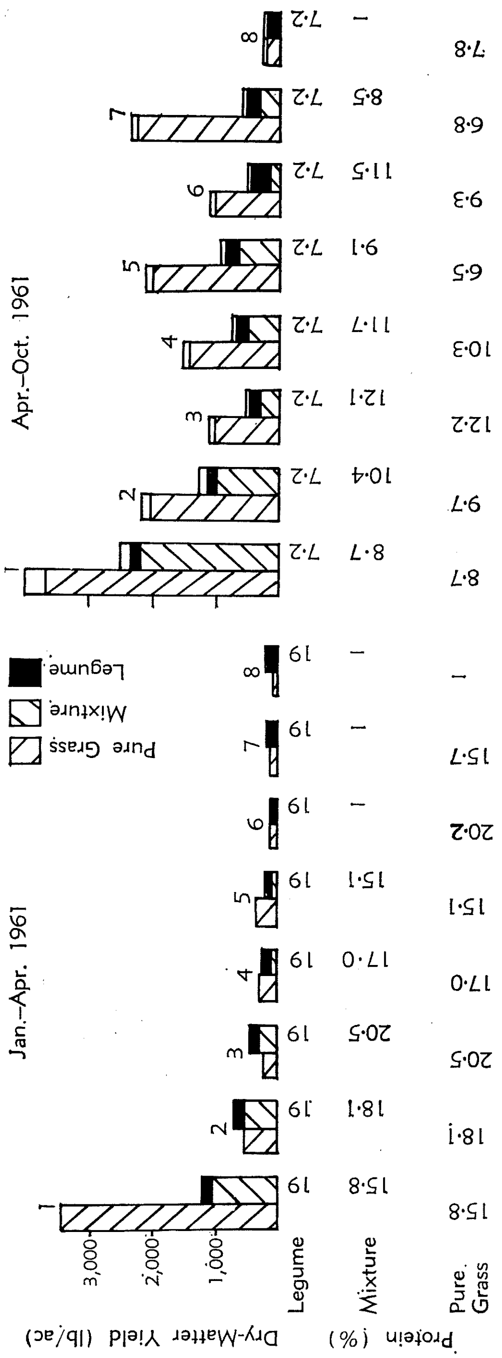

Fig. 4.—Dry-matter yields and protein content of pure grasses and mixed swards during the periods January-April 1961 and April-October 1961. Protein yields for the latter period are shown by the open sections at the heads of the various columns. The protein percentages for "Mixture" refer to the grass in the mixture.

At the first sampling there were small differences in favour of the mixtures in African star, kikuyu, molasses and pangola grasses, but at the second sampling none of the mixtures showed higher yields than the pure grasses. African star

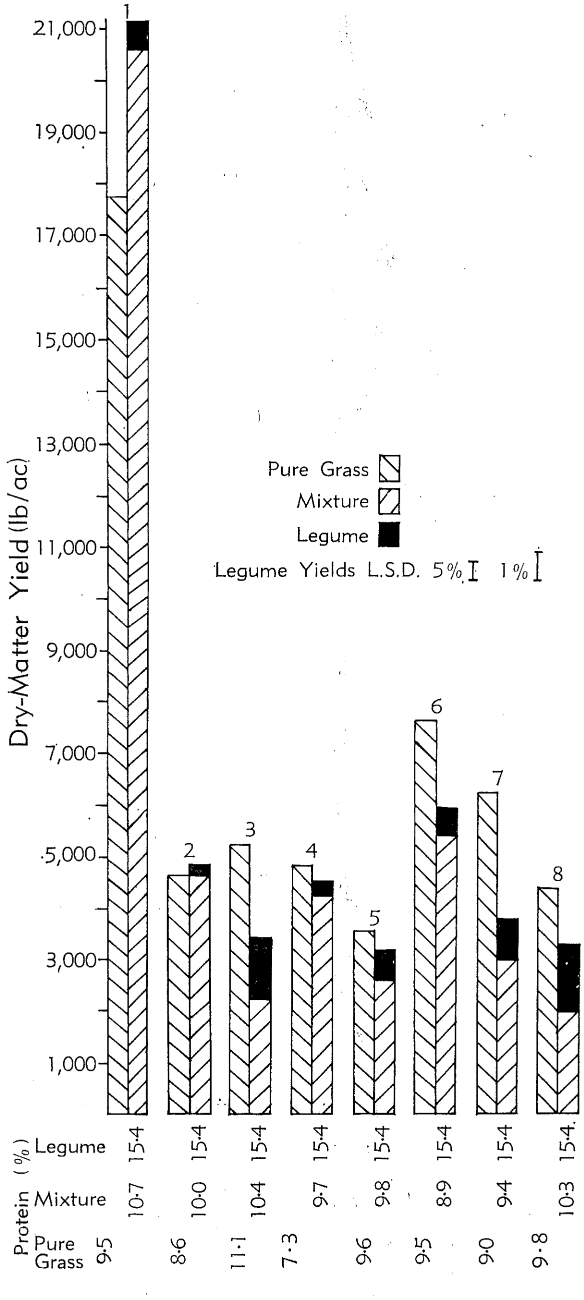

Fig. 5.—Dry-matter yields and protein content of pure grasses and mixed swards during the period October 1961-January 1962. The protein percentages for "Mixture" refer to the grass in the mixture.

grass had formed a complete ground cover within 3 months from planting, whereas the kikuyu grass was slower, contained more weeds and was affected by an infestation of a leaf spot disease (*Helminthosporium* sp.). The symptoms disappeared during the winter and were not observed again during the course of the experiment.

The percentage crude protein attained high levels in all grasses—particularly in kikuyu grass and guinea grass, which showed a content of approximately 20% in April 1961. In October the yield and protein content of glycine were low. This may be attributed to the heavy seed crop set in September with subsequent heavy leaf fall; the material harvested in October consisted almost entirely of dried stalk with some seed pods.

The results of the sampling of the spring–early summer growing period of 1961-62 are presented in Figure 5. Legume yields were still low in comparison with grass yields. Except for elephant grass, none of the grasses in admixture with the legume yielded higher than when growing alone.

There were considerable variations in legume yields according to grass species, and in the case of kikuyu and pangola grasses the legume yields were significantly greater than those found in other mixtures. The higher legume yields tended to raise the protein status of the mixed pasture, but this effect was associated with reduced dry-matter yields of the grass component.

Table 1 summarizes the production over the first 12 months. In the pure grass swards the dry-matter yield of elephant grass was significantly greater than in the other species, the yield variations between which did not attain statistical significance. The yields of the mixed swards were apparently lower than those of the pure grasses, but these differences did not attain statistical significance except in the case of molasses grass, where the pure grass sward was significantly higher yielding.

The growth produced during the late summer and autumn in 1962 is recorded in Figure 6. Molasses grass was almost eliminated after the cutting in January and the only regrowth present in April came from small scattered seedlings, which provided insufficient material for harvest.

Legume yields again were low in comparison with grass yields, except in the pangola grass mixture, but there the grass yield was particularly low. The variation with respect to species of associated grass did not attain statistical significance. The higher protein contents of African star, kikuyu, Rhodes and pangola grasses in the mixtures were not accompanied by increased yields of grass dry-matter.

TABLE 1

YIELD OF DRY MATTER AND PROTEIN PRODUCED BY SWARDS OF PURE GRASSES AND GRASS-LEGUME MIXTURES, JANUARY 1961—JANUARY 1962

Species	Pure Grass			Mixture								
				Grass			Legume			Total Mixture		
	Dry Matter (lb/ac)	Protein		Dry Matter (lb/ac)	Protein		Dry Matter (lb/ac)	Protein		Dry Matter (lb/ac)	Protein	
		%	lb/ac		%	lb/ac		%	lb/ac		%	lb/ac
1. Elephant grass	24,798	10·2	2,527	23,789	10·8	2,553	524	15·3	80	24,313	10·8	2,633
2. African star grass	7,062	9·5	671	6,093	10·7	654	381	15·0	58	6,474	11·0	712
3. Kikuyu grass	6,563	11·6	759	2,822	11·5	325	1,444	15·3	221	4,266	12·8	546
4. Green panic	6,456	8·3	538	4,895	10·1	494	504	13·9	70	5,399	10·5	564
5. Rhodes grass	5,662	9·1	504	3,220	9·4	315	649	14·3	94	3,869	10·8	409
6. Guinea grass	8,618	9·5	821	5,449	8·9	486	778	13·9	108	6,227	9·5	594
7. Molasses grass	8,681	8·5	737	3,331	9·1	305	941	14·2	134	4,272	10·3	439
8. Pangola grass	4,595	9·7	442	2,016	10·3	208	1,567	14·7	230	3,583	12·2	438

Necessary differences for significance ($P < 0{\cdot}05$), dry matter
Individual grass combinations .. 4,435
Pure grass *v.* total mixed sward .. 2,945

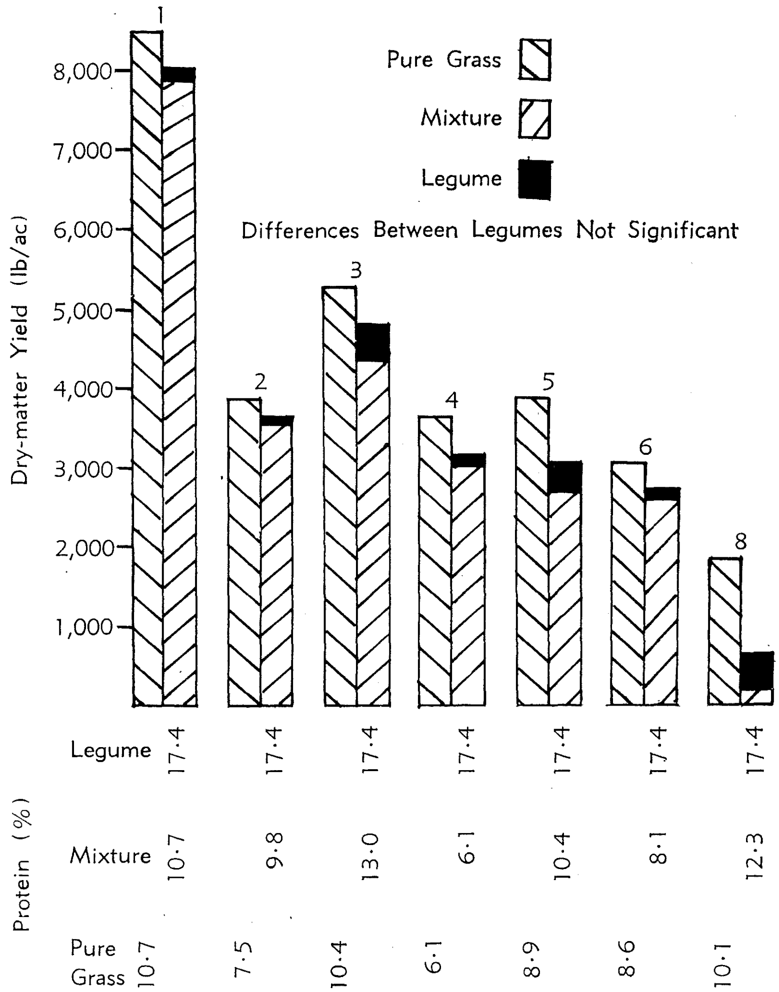

Fig. 6.—Dry-matter yields and protein content of pure grasses and mixed swards during the period January-April 1962. The protein percentages for "Mixture" refer to the grass in the mixture.

Production during the winter of 1962 is shown in Figure 7. In the mixed swards, elephant grass again gave the highest yields, followed by kikuyu grass, which significantly outyielded African star grass, green panic, guinea grass and pangola grass. The dry-matter yield of Rhodes grass was better than those of African star, green panic, guinea and pangola grasses. The highest yields of legume were found in the green panic, Rhodes grass and pangola grass mixtures.

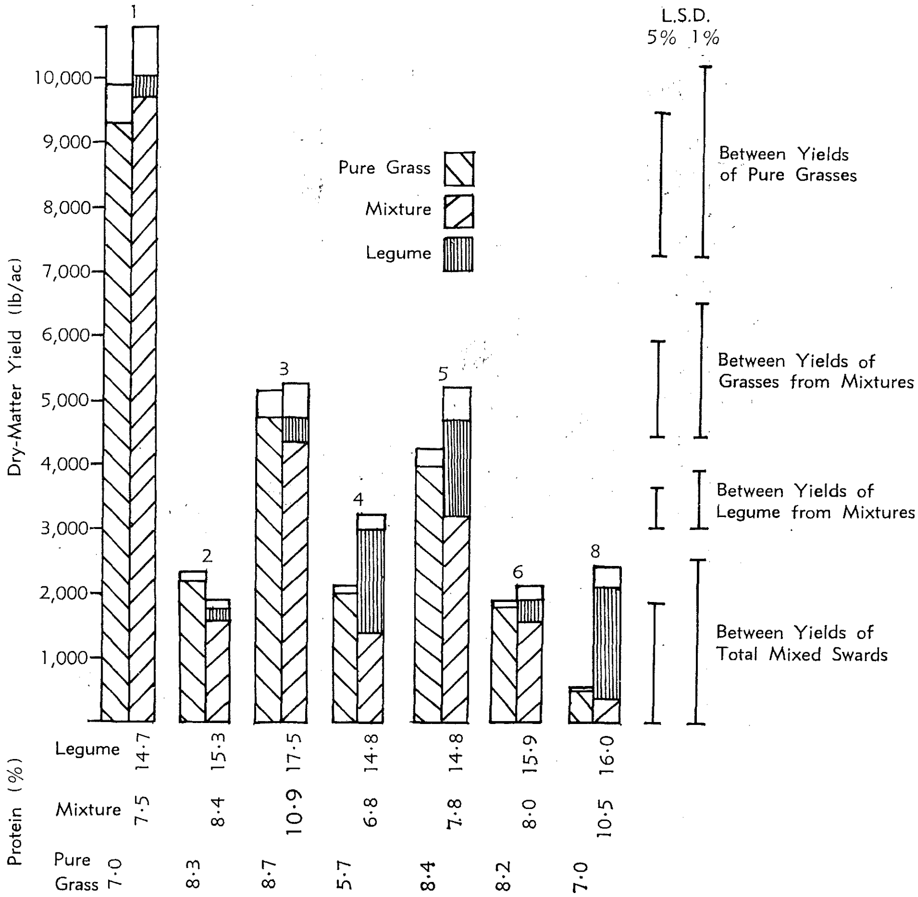

Fig. 7.—Dry-matter yields and protein content of pure grasses and mixed swards during the period April-August 1962. Protein yields are shown by the open sections at the heads of the various columns. The protein percentages for "Mixture" refer to the grass in the mixture.

The total dry-matter yields of the mixtures showed apparent small increases over those of the pure grasses (except for African star and kikuyu grasses); but the differences were not statistically significant. The dry-matter yields of the grasses in the mixtures were less than those of the pure grasses (except for elephant grass), but these differences also failed to attain statistical significance.

The crude protein content of some grasses appeared to have been increased by the presence of the legume, and data presented in Table 2 illustrate this effect. Overall, the protein content of grasses from the mixtures was highly significantly greater than that of the pure grasses, but the differences were significantly in evidence only for kikuyu and pangola grasses. The main difference in grass species in protein content was that kikuyu grass showed the highest mean level (9·69%), which was significantly greater than that of Rhodes and guinea grasses, which was greater than that of green panic.

TABLE 2

PROTEIN CONTENT (%) OF GRASSES GROWN WITH AND WITHOUT GLYCINE, AUGUST 1962
DRY-MATTER BASIS

Sward	Pure Grass	Grass with Glycine	Mean
Kikuyu grass	8·75	10·62	9·69
Green panic	5·72	6·80	6·26
Rhodes grass	8·38	7·82	8·10
Guinea grass	8·18	8·00	8·10
Pangola grass	7·00	10·45	8·72
Mean	7·60	8·74	8·17

Necessary difference for significance—

	(P<0·05)	(P<0·01)
Individual combinations ..	1·85	2·49
Grass species	1·31	1·76
Pure grass *v.* Mixture ..	0·83	1·12

The dry-matter production data from the pure grasses for the full period of the experiment are summarized in Figure 8. They show that elephant grass far outyielded the others. The next most productive grass was kikuyu grass, while pangola grass produced the least dry matter. The differences between African star, green panic, Rhodes and guinea grasses were small.

IV. DISCUSSION

At the end of the first growing period (January–April 1961), the yields of the African star, kikuyu and pangola grass mixtures were slightly higher than those of the pure grasses. This could have been due to the effect of mowing for weed control, which removed very little foliage from the prostrate type grasses.

The elimination of molasses grass by the cutting in January 1962 is attributed to the density of the stand and the low cutting, which removed all growing points. At previous samplings, using a similar cutting height, the stand was less dense and there were growing points at ground level which were not removed. Caro-Costas and Vicenti-Chandler (1961) reported that molasses grass was severely depressed by close (0-3 in.) cutting.

The generally low yields of pangola grass were surprising and no explanation can be offered for them at this stage. This species has been reported by Caro-Costas and Vicenti-Chandler (1961) as producing yields similar to those of guinea grass.

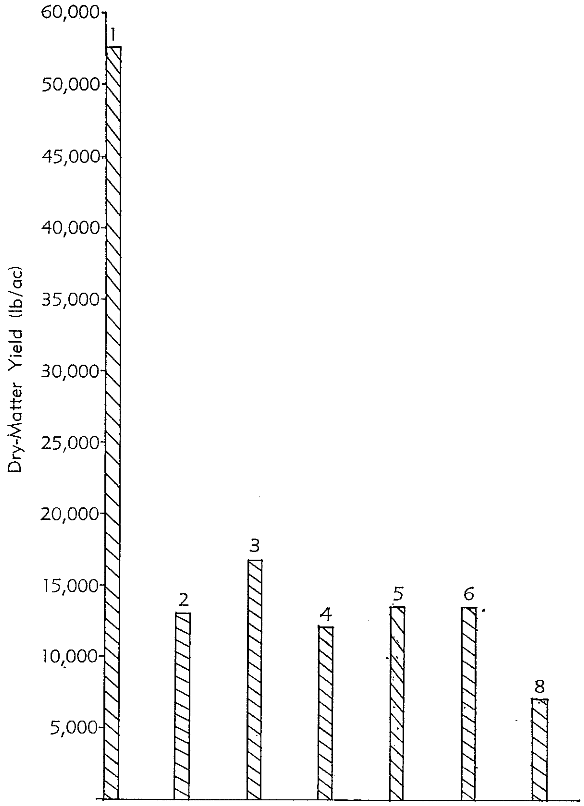

Fig. 8.—Dry-matter yields produced by seven pure grass swards when sampled five times over a period of 19 months (January 1961-August 1962).

The most productive grass was elephant grass, which yielded approximately 25,000 lb of dry-matter containing 2,500 lb of protein during the first year. These figures are comparable with those of Caro-Costas and Vicenti-Chandler (1961), who reported an annual yield of 33,000 lb dry-matter and 2,700 lb protein per acre from elephant grass which had received 800 lb nitrogen per acre over a 2-year period. In the Kairi experiment, yields and protein contents of all grasses were high and this could have been due to the high level of mineralized nitrogen in the soil on which the experiment was located. The area had been used for several years for the production of summer and winter leguminous grazing crops for pigs and the experiment was established on well-fallowed ground. Rainfall of 30-35 in. was well below normal (50 in.) in 1961; 43·72 in. were received in 1962.

The high level of soil fertility and the resultant high grass yields could also be advanced as an explanation for the relatively low yields of legume. However, Hutton (1962) reported that improved genotypes of *Phaseolus atropurpureus* gave high yields in association with Rhodes grass in the second season of growth, the mixture yielding approximately 8,000 lb of legume dry-matter plus 7,000 lb of grass dry-matter in four harvests during a period of 9 months. At Kairi, the Rhodes grass mixtures yielded 5,300 lb of grass dry-matter plus only 800 lb of legume dry-matter over a similar period in the first season of growth. Hutton's data show that significant increases in dry-matter yields of the grass occurred when the legume yield exceeded 4,500 lb dry-matter per acre over a 9-month period.

In the Kairi experiment, glycine did not produce a statistically significant increase in the dry-matter yields of the grass component or the total mixed sward at any sampling. The legume increased the protein content of two of the grasses at the final sampling (August 1962), but this effect was associated with an apparent decrease in grass yield. This could be explained in terms of competition for light offered by the broad-leaved climbing legume when associated with a grass of prostrate growing habit.

Figure 7 shows that the amount of protein produced by the mixtures was greater than that found in the pure grasses during the period April–August 1962. This could be attributed to the legume and the extra protein could be expected to improve animal production, as it was in the form of succulent green leaf.

The yields of green panic and guinea grass tended to decline during the second year. This suggests that these species may require the high level of soil fertility which existed at the commencement of the experiment but which probably was reduced significantly by the end of the first year. Kikuyu and Rhodes grasses did not show such a decline. This suggests that they may be capable of more efficient use of a soil of lower fertility or that they are more tolerant of winter conditions. Kikuyu grass demonstrated a rather long growing season, with high yields in summer, autumn and winter. It was leafy and succulent at all times and was a satisfactory associate of the legume.

The yields of elephant grass suggest that high levels of animal production might be obtained from this species. Assuming the digestibility to be 40-50%, a yield of 25,000 lb of dry-matter could contain 10,000-12,500 lb T.D.N. per acre per annum. Elephant grass might support 2 cows per acre per annum if all the grass was utilized. However, full utilization could be achieved only under a system of zero grazing with conservation and deferred consumption. If normal grazing were practised the theoretical carrying capacity might be half, or less, of the abovementioned rate.

Under normal grazing and without conservation the yearly carrying capacity would be limited by the winter/spring pasture growth. During the period April–August 1962, elephant grass produced 9,300 lb of dry matter (7% crude protein) or 3,700-4,600 lb T.D.N. per acre in the period of 120 days. The theoretical animal requirement over this period would be 1,800 lb T.D.N. per cow per acre. Thus, on theoretical grounds the pasture might support 1 cow per acre under normal grazing during the period and this could be improved if excess summer growth were conserved and used during this period.

Making similar assumptions in the case of kikuyu grass, the data suggest that this grass has a potential carrying capacity equal to approximately half that of elephant grass. Thus, the critical autumn/spring production of kikuyu grass was 4,700 lb of dry matter, which could provide 1,900-2,400 lb of T.D.N. per acre. This might support 1 cow per 2 ac under normal grazing, but should be capable of higher rates with conservation and deferred consumption of the excess summer pasture.

The theoretical carrying capacities shown by these pastures were derived from the high yields obtained in the first year, and it is difficult to extrapolate from a cutting experiment. It is extremely doubtful if these yields could be maintained in the absence of an additional supply of nitrogen. The initial high yields of the pure grass swards and the apparent failure of the legume to increase the yields of the mixed swards suggest that the use of nitrogenous fertilizer on the pure grasses may offer a more efficient means of energy production.

However, this method may not increase the value of the grass during the critical winter period, when the direct contribution of the legume in providing green leafy feed may equal or exceed the value of increased summer growth of grass treated with nitrogen. Long-term studies to evaluate the properties of various legumes and of fertilizer nitrogen in improving pasture production are in progress at this Station.

V. ACKNOWLEDGEMENTS

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