PERFORMANCE OF EIGHT TROPICAL LEGUMES AND LUCERNE AND OF FOUR TROPICAL GRASSES ON SEMI-ARID BRIGALOW LAND IN CENTRAL QUEENSLAND

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ABSTRACT

Eight tropical legumes and Hunter River lucerne were grown in mixed pastures with four grasses through two complete summers on brigalow land at Taroom in central Queensland. The pastures were grazed intermittently by cattle.

After good establishment six of the tropical legumes failed viz. Glycine wightii *C.P.I. 23411 and C.P.I. 18419,* Phaseolus bracteatus *C.P.I. 27404,* P. atropurpureus *cv. Siratro,* Dolichos axillaris *C.P.I. 17814,* D. uniflorus *cv. Leichhardt. The perennial* G . wightii *cv. Cooper persisted and the annual* P. lathyroides *C.P.I. 26667 regenerated, but at 2000 and 4500 plants per acre respectively the final densities were low, and yields were less than 10 lb per acre over the final period when lucerne yielded 460 lb per acre. At this time lucerne still had 40,000 plants per acre. Lucerne markedly suppressed the yield of the associated grasses* Sorghum almum *cv. Crooble,* Panicum maximum *var.* trichoglume *cv. Petrie,* Cenchrus ciliaris *cv. Nunbank,* Chloris gayana *cv. Pioneer.*

In the first season S. almum *contributed 95% of the grass yield, but the proportion declined thereafter. There were no significant differences in yield or quality between the other three grasses. In successive cuts grass regrowth of similar age showed a marked drop in all four species for percentage of nitrogen and phosphorus and for* in vitro *digestibility.*

INTRODUCTION

The environment of the brigalow lands has been described by Isbell (1962), Coaldrake (1964), and Johnson (1964). Even on fertile brigalow soils the need for pasture legumes is eventually as great as elsewhere (Davies, 1952, 1960; Hutton, 1968). In summer the sown grasses in use in this region are of adequate nutritive value (Smith, 1970), and thus summer growing legumes (both tropical legumes and lucerne) are required primarily for the maintenance of soil nitrogen. However, there is scope for legumes to contribute directly to animal nutrition in winter which allows a further important role for the winter growth of lucerne in this environment (Coaldrake, 1970).

This trial sought to evaluate lucerne and eight tropical legumes selected from preliminary trials at a number of sites in the brigalow region. The experiment was designed to test these legumes in competition with the four grasses most widely used in the brigalow region. The short-lived *Sorghum almum* is often used in admixture with a perennial grass to provide high production until the perennial grass is strongly established. This feature was incorporated in the design.

METHODS

Site

The experiment was located in the Robinson Creek valley north west of Taroom (lat. 26° 20'S., long. 149° 25'E), on sedentary clay loam (Isbell, 1962). The site was on an area cleared for about 25 years from brigalow and belah association interspersed with grassy areas carrying *Bauhinia caronii* (Johnson, 1964).

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The area had formerly been planted to grass and legume trials and had been fertilised with 1 cwt. superphosphate and 7 lb copper sulphate per acre in 1955. A year prior to this experiment the area was ploughed and fallowed and recultivated as necessary to control weed growth.

Design

The experimental design was a split-plot replicated three times with the grasses as main plots and the legumes as sub-plots in a randomized block.

The grass treatments were:

Sorghum almum cv. Crooble with (1) *Panicum maximum* cv. Petrie, ("green panic"). (2) *Cenchrus ciliaris* cv. Nunbank ("buffel grass") (3) *Chloris gayana* cv. Pioneer, ("Rhodes grass") and (4) alone.

S. almum was planted at 1 lb per acre in association with the other grasses and at 3 lb per acre in the treatment in which it was planted alone. The associate grasses were planted at 2 lb per acre.

The legume treatments were:

Control—no legume	*Phaseolus bracteatus* C.P.I. 27404
Glycine wightii cv. Cooper	*Phaseolus atropurpureus* cv. Siratro
Glycine wightii C.P.I. 23411	*Dolichos axillaris* C.P.I. 17814
Glycine wightii C.P.I. 18419	*Dolichos uniflorus* cv. Leichhardt
Phaseolus lathyroides C.P.I. 26667	*Medicago sativa* cv. Hunter River

These legumes were sown at a rate equivalent to 2 lb per acre at 70% germination. Each was inoculated with an appropriate strain of *Rhizobium* in peat carrier and then lime pelleted (Norris, 1964).

The main plots, which were 0.75 acre in size, were fenced and provided with water troughs and cattle shelters. Legume sub-plots were thus 0.075 acre each.

Experimental procedure

Molybdenised (0.3% Mo) superphosphate at 160 lb per acre was applied to the area on Sept. 20th 1966 and the pasture species were sown by hand on the following two days. The soil was moist to within 4 inches of the surface (following good winter rains) and about 2 inches of rain fell eight days later resulting in emergence.

Plants of all species were counted 23 days after sowing and legumes only 54 days after sowing in five 4.36 sq. ft random quadrats in each sub-plot in two replicates.

There were two periods of rotational grazing (Jan.-Feb. 1967 and Nov. 1967-Feb. 1968) separated by eight months due to dry weather and the winter of 1967.

Each grass treatment was grazed by a separate herd rotating around the three replicates. The cattle numbers were adjusted to achieve full defoliation in about 3 weeks so that each replication would have approximately a six-week regrowth period.

Presentation yields of pasture constituents were sampled immediately prior to the grazing of each replication. Three 10.89 sq. ft quadrats were cut in each sub-plot in random positions. Individual pasture components, both sown and volunteer, were cut and bagged separately, and legume numbers were counted. Components were dried in an oven at 95°C and weighed.

Bulked samples from the third grazing cycle were ground in a Christy Norris mill, digested by the Kjeldahl method using a selenium catalyst, and analysed for N and P using an auto analyser. The ground samples were also used to determine their relative digestibility by the *in vitro* technique (McLeod and Minson, 1969).

RESULTS

First Summer

Rainfall for the period January 1966 to April 1968 is shown in Table I as the mean of readings at "Nunbank" homestead (1.5 miles N.E.) and "Bimbadeen" homestead (2 miles S.E.). Rainfall in the first summer (October-April inclusive) after planting was 14.1 inches, and in the second summer 24.5 inches. Rainfall probabilities tabulated by Anon (1965) for an 81 year record at Taroom (16 miles from the site) show a probability of 50% for a total of 16 inches of rain over this period.

TABLE 1

Rainfall over the experimental period (inches)
(Average of "Nunbank" and "Bimbadeen" recordings)

	Jan.	Feb.	Mar.	Apl.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1966	2.9	1.6	0.9	0.3	1.2	1.5	0.6	4.4	2.3	0.9	0.7	2.8	20.1
1967	5.8	1.3	2.4	0.2	1.8	4.4	0.6	0.3	0	2.4	1.0	3.4	23.6
1968	8.3	4.0	2.9	2.5					(PART OF YEAR)				17.7

Seedlings present 23 days after sowing on the two replications are shown in Table 2. The three to four-fold increase in *S. almum* seedling numbers in Treatment 4 reflects the increased seeding rate on this treatment. The three associate grasses had about half the seedling numbers of all other species and their numbers were not significantly different. Further reference to Table 2 shows that *S. almum* and buffel grass established better, relative to the number of viable seeds sown, than green panic or Rhodes grass (c.f. Coaldrake and Russell, 1969).

TABLE 2

Germination counts at 23 days after planting. Seedlings per 0.001 acre
(Means of 18 sub-plots)

	Viable seeds sown per 0.001 acre	Grass Treatment+ 1	2	3	4	
Sorghum almum	109	18.6	20.6	24.0	77.7	327*
Green Panic	620	9.2				
Buffel grass	140		15.1			
Rhodes grass	900			8.4		
Legumes (9)		23.5	24.4	29.0	28.2	

* Number of seeds from seeding rate on treatment 4.

\+ *Grass Treatments*

1. *Sorghum almum* with Green panic
2. *Sorghum almum* with Buffel grass
3. *Sorghum almum* with Rhodes grass
4. *Sorghum almum* alone

Table 3 shows the legume counts during the life of the experiment. Lucerne numbers were initially about seventeen times as great as those of the tropical legumes, but three to four times as many viable lucerne seeds were planted. At the first two counts differences between the tropical legumes were not significant, and there were no significant differences due to grass treatment.

After 5.8 inches of rain in January 1967 grazing commenced on Jan. 28th when four sets of three 2-year-old Hereford steers were put on the first replication. Dry hot weather in February made it unwise, with regard to persistence of the tropical

TABLE 3

Legume persistence

(Legume numbers per acre)

Legumes	Nos of viable seed per acre	Plant Numbers 1966 15th Oct.*	1966 15th Nov.*	1967 Nov.-Dec.+	1968 Jan.-Feb.+	1968 2nd May+	** % success by 2/5/68
Glycine wightii-Cooper	126,000	9,300	18,500	3,000	4,000	2,000	1.6
G. wightii-C.P.I. 23411	101,000	3,800	500	200	0	100	0.1
G. wightii-C.P.I. 18419	154,000	10,300	12,500	800	400	300	0.2
Phaseolus lathyroides	71,000	12,300	24,000	100	400	4,500	6.3
P. bracteatus	60,000	6,300	7,000	100	200	200	0.3
P. atropurpureus-Siratro	56,000	12,000	18,800	400	100	200	0.4
Dolichos axillaris	92,000	8,800	2,800	0	0	0	0
D. uniflorus	28,000	9,800	13,000	0	0	0	0
Lucerne-Hunter River	320,000	164,000	270,000	52,500	54,200	40,400	12.6

* Means of 8 sub-plots
\+ Means of 12 sub-plots
** Final number of plants as a percentage of viable seed sown.

legumes, to heavily graze replications II and III. The cattle were therefore removed and the plots in these replications were mown in mid-March at 4", a height chosen to conserve growing points on the tropical legumes (Jones, 1967). Eight months later there was no differential effect of these two treatments.

The dry matter yields of the two replications grazed in the first season (Table 4) show that *S. almum* contributed a mean of 95% of all constituents. The yield of *S. almum* planted alone was not significantly greater than its yield when planted with associate grasses.

An important effect was that the yield of *S. almum* in the lucerne sub-plots (2290 lb D.M./acre) was significantly lower ($P < 0.05$) than the mean yield in the other legume sub-plots (3700 lb D.M./acre) which were not significantly different from each other.

TABLE 4

Presentation dry matter yields of Sorghum almum *and of all constituents (in parenthesis) for each grazing period*

Yields in lb D.M. per acre

By grass treatments	Grazing cycles Jan.-Feb. 1967*	Nov.-Dec. 1967	Jan.-Feb. 1968
1. *S. almum* & G. panic	3510 (3720)	340 (630)	1420 (2150)
2. *S. almum* & Buffel	2880 (3070)	280 (660)	650 (1460)
3. *S. almum* & Rhodes	3390 (3590)	410 (510)	1230 (1630)
4. *S. almum* alone	4220 (4270)	510 (710)	1500 (1890)
By legume sub-treatments			
1–9. Mean of Trop. legs+	3700	420	1270
10. Lucerne	2290	20	570

An analysis of variance of log (x + a) transforms showed significant differences only between the sub-treatment means shown here.
* Mean of 2 Reps.
\+ Mean of 6 sub-plots in the first cycle and of 9 sub-plots in the 2nd and 3rd cycles.

Yields of associate grasses and legumes were very small and contributed less than 5% of the total yield. The yields of the three associate grasses were not significantly different. Lucerne yield (53 lb per acre) was significantly ($P < 0.001$) higher than that of the "best" tropical legume, Cooper glycine (18 lb/acre). The denser stand of *S. almum* in the Treatment 4 did not significantly suppress legume yield at this stage.

Second Summer

With the exception of June, the next eight months were very dry and it was not possible to graze again until Nov. 7th 1967 when four groups of three yearling Hereford heifers were rotated round the experiment through two complete cycles, spending approximately three weeks on each replication. As more rain fell cattle numbers had to be increased.

Averaged over 6 cuts the mean yield of lucerne was 350 lb per acre, but none of the tropical legumes yielded even 10 lbs per acre per cut.

Survival of the legumes over the whole experiment is shown in Table 3. Plant numbers increased over a period of 54 days for all except *G. wightii* 23411, and *D. axillaris*. These decreased by more than 60% in the interval of 23 days between the first and second counts.

By the first grazing Siratro, *G. wightii* 18419 and *D. biflorus* were yielding insignificant amounts. The proportionate reduction in plant numbers over the dry winter of 1967 when the experiment was not grazed was similar for the remaining three legumes including lucerne. The final count showed 4500 *P. lathyroides* plants per acre. This increase must have been due to regeneration; the legume had set seed earlier. The number of Cooper glycine had dropped to 2000 per acre and of lucerne to 40,000 per acre.

Yields of *S. almum* in the second grazing cycle were a tenth of those in the first season, but after rain those in the third grazing cycle increased three-fold (Table 4); (the increase was largely in one replication). There were no significant differences in main plot yields in either cycle for total yield or for *S. almum* alone. In the presence of lucerne the yield of *S. almum* continued to be significantly ($P < 0.001$) reduced below that in any of the other legume sub-plots.

The yields of associate grasses over the second summer, whilst still low (mean overall yield of green panic = 190 lb D.M. per acre; of buffel = 280 lb D.M. per acre; of Rhodes grass = 180 lb D.M. per acre) were proportionately greater compared with *S. almum* than in the first summer. The rain in January 1968 produced a four-fold increase in yield in one replication. The differences in yield between the associate sown grasses were not significant and although the association with lucerne appeared to reduce yield this reduction also was not significant.

At this stage the experiment had been running through two full summers of good rainfall, six of the nine legumes had been completely or nearly eliminated without setting seed, and the associate grasses were taking over from the *S. almum* in the usual manner (Yates *et al.,* 1964. Coaldrake & Russell, 1969). It was therefore decided to terminate the experiment.

A general decline in nutritive value of grass samples in the third grazing cycle, as gauged by three indices, is shown in Fig. 1. The declines were significantly linear ($P < 0.025$) and there were no significant differences between species. Table 5 shows that despite the considerable increases in yield of all four species in the second harvest, because of a decrease in nitrogen content there was only a slight increase in yield of digestible crude protein (except for Rhodes grass which rose appreciably). However yields in the third harvest were so much greater that D.C.P. yields were much increased (with the exception of Rhodes grass).

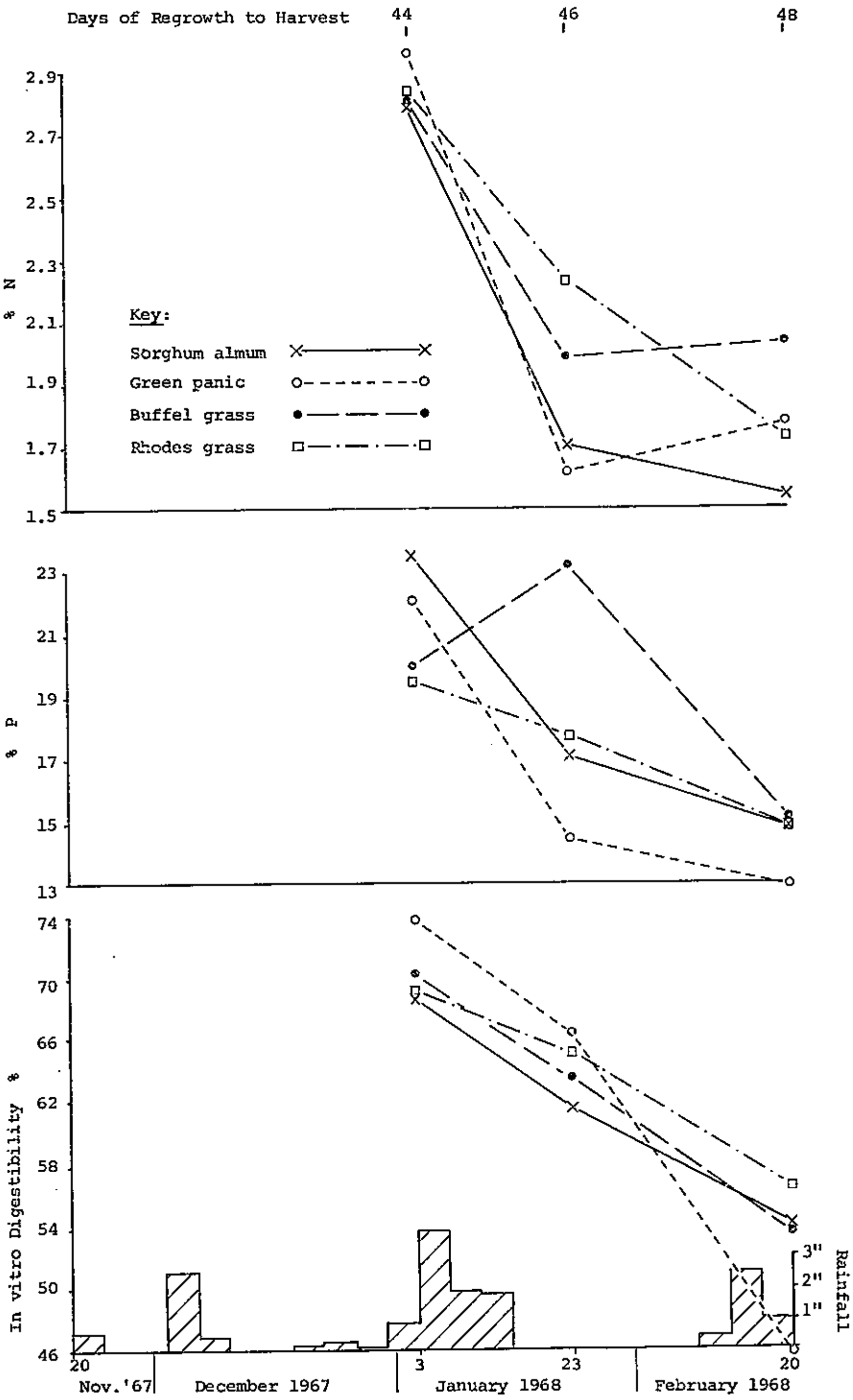

FIGURE 1

Nutritive indices of four grasses at three successive harvests. The histogram of rainfall is in units of four days.

TABLE 5

Yields of digestible crude protein (lb per acre) in the 3rd grazing cycle

		Regrowth (Days)	*D.C.P. %	D.M. Yield lb/acre	D.C.P. Yield lb/acre
Rep I	harvested on 3-1-68	44			
	Sorghum almum		12.9	162	20.9
	Green panic		13.9	66	9.2
	Buffel grass		13.0	117	15.2
	Rhodes grass		13.2	42	5.5
	Total+			218	28.4
Rep II	harvested on 23-1-68	47			
	Sorghum almum		6.4	486	31.1
	Green panic		5.9	142	8.4
	Buffel grass		8.1	111	9.0
	Rhodes grass		9.5	205	19.5
	Total+			600	40.3
Rep III	harvested on 20-2-68	48			
	Sorghum almum		5.4	2944	159.0
	Green panic		6.9	764	52.7
	Buffel grass		8.5	1009	85.8
	Rhodes grass		6.7	130	8.7
	Total+			3420	195.8

* Derived from C.P. using the relation $y = 0.957x - 3.75$ (Milford & Minson, 1965).
\+ Note Design.

DISCUSSION

At the commencement of grazing in the second summer only lucerne and Cooper glycine were present in acceptable numbers, and the yield of the latter was only a trace. After two grazing cycles counts in May, 1968 showed that the numbers of the five perennial tropical legumes present had not decreased so drastically under grazing as in the previous 11 months without grazing.

There are several possible reasons for this initial decrease. Competition from grasses, and particularly *S. almum,* was severe. This is clearly illustrated by there being no difference in yield of *S. almum* when planted at 1 lb of seed per acre with Rhodes grass, or buffel grass, or green panic, or at 3 lb of seed per acre alone; it was obviously fully exploiting the environment. Competition for the occasional light fall of rain must have been very severe. Observations over the period confirmed that all plants were usually under severe stress. Most legumes had shed their leaves and their crowns were difficult to locate. Whilst in moister environments infrequent or no defoliation encourages the growth of legumes such as Siratro (Jones, 1967) and glycine (Whiteman, 1969) this treatment was unlikely to have had an ameliorative effect here, because no differences appeared between the replicates which were grazed and those which were mown to 4 in.

The annual *P. lathyroides* regenerated because of seeding before grazing, and perhaps as a result of soil disturbance during grazing, but the counts and yield were both much reduced in the second (wetter) season.

It can be argued that legume densities were not satisfactory (Table 3), and that the tropical legumes should have been planted at, say, 5 lbs of seed per acre.

Edye (1967) in an experiment with *G. wightii* cv. Cooper at Lawes (Expt. 1) sown at 5 lbs per acre achieved five times the plant density reported here, but a yield of 880 lbs DM per acre as against the first summer yield of Cooper in this experiment of 18 lbs DM per acre. However, the October-April rainfall in Edye's experiment was 30 inches compared with only 14 inches in this experiment. These differences of performance in relation to rainfall suggest that an increased seeding rate in our experiment would have had little effect on yield. Again it is our experience from preliminary trials in this semi-arid environment that higher plant densities mitigate against the legumes themselves because of mutual competition. To this extent it was unfortunate that the lucerne densities were not comparable; previous experience had shown that it is extremely risky to plant lucerne in this environment at less than 2 lbs per acre (e.g. Cameron, 1968). The success of the lucerne must therefore be attributed in part to its suppression of grass competition.

As shown in the results section rainfall over the two summers concerned was by no means low for this region, and there were no obvious symptoms of nutrient deficiency and disease. The results suggest that the tropical legumes would still not have persisted or made a significant yield contribution at triple the seedling rate but lucerne made a significant yield contribution at a density which was initially too high.

The successful establishment of lucerne in what is considered to be a marginal planting time in the brigalow region (Cameron, 1968) was the result largely of weather pattern in the year concerned; the sheltering effect of *S. almum* may have helped.

The initial establishment and growth of *S. almum* was typical (e.g. Yates et al., 1964) and its dry matter contribution was 95 per cent of the total yield (sown and unsown). Subsequently production of *S. almum* decreased and there was an increase in proportion of the associate grasses. They contributed less than 5% of the total in the first season, 20% in the first grazing cycle of the second season and 16.5% in the second grazing cycle. From past experience it is likely that all three grasses would have outyielded *S. almum* by the third season. Despite the plant density being three times as great in Treatment 4, in which *S. almum* was planted alone at 3 lb per acre, the yield of *S. almum* in this treatment was never significantly greater than in the others at 1 lb per acre. This suggests that on well prepared land with good rainfall, the optimum seeding rate of *S. almum* is about 1 lb per acre. There was no evidence that the higher plant density of Treatment 4 reduced the yields of associated plants as might have been expected.

Table 5 shows that even when grass yields were least (220 lb DM/acre in 44 days) the daily production of D.C.P. was approximately 0.7 lb per acre. The daily requirement of D.C.P. for beef animals is 0.7 to 1.0 lb (N.R.C., 1963). With nitrogen requirements adequate for one beast per 1½ acre or better, animal production would have been limited only by the supply of digestible energy. In the brigalow region this function is fulfilled more satisfactorily in summer by grasses than by legumes.

There was a marked linear reduction in nitrogen and phosphorus contents and of *in vitro* digestibility of the four sown grasses in the period December 1967 to February 1968, despite the regrowth periods differing by only four days:—from 44 to 48 days (Figure 1). Nitrogen contents of the first harvest were high. Rhodes grass had a level comparable with that noted by Henzell and Oxenham (1964) for Rhodes grass of similar age grown in summer outside the brigalow region but fertilised with nitrogen. However, phosphorus levels were approximately at the critical level (Andrew and Robins, 1970). This is consistent with the growing recognition that many brigalow soils are marginal for phosphorus.

The marked fall in digestibility is not easy to explain. The steep fall in nutritive value of grasses with increased growth after rain has been noted before in this environment. Coaldrake *et al.* (1969) in a grazing trial in the brigalow region noted the high feeding value of regrowth during dry conditions. Production of large amounts of grass after heavy summer rains raises problems of utilization. The low quality demonstrated in analyses of total plants is offset by selective grazing. It seems likely that a grass capable of more sustained growth during dry periods, which are protracted in this environment, is more suitable for grazing.

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