TROPICAL GRASS AND LEGUME YIELD ON A SOLOTH SOIL IN SUB-COASTAL SOUTH-EASTERN QUEENSLAND

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ABSTRACT

Twelve grasses and six legumes were grown for five years in small plots on a soloth soil in sub-coastal south-eastern Queensland.

Callide Rhodes grass (Chloris gayana) *and pangola grass* (Digitaria decumbens) *were the most productive and persistent grasses, the latter requiring two years to achieve maximum stand density. Siratro* (Macroptilium atropurpureum) *was the only legume to persist.*

INTRODUCTION

Within the sub-coastal area of south-eastern Queensland there are approximately 3000 km^2 of duplex soils similar to that at the experimental site; grazing is almost entirely based on native grasslands.

Prior to 1970, most tropical pasture investigations for south-eastern Queensland had been conducted in coastal areas where rainfall was higher and more reliable than that in the sub-coastal areas (Bryan 1961, Henzell 1963, Shaw *et al.*, 1965, Bryan and Evans 1971). Work by Mannetje (1967) and Jones and Rees (1972) in the 1960's had demonstrated that some tropical pasture species could also be successfully grown in sub-coastal areas receiving between 700 and 1000 mm of rain annually. However, rainfall appeared to restrict the species which could be grown, and their productivity.

This paper describes two experiments which assessed a range of tropical grasses and legumes on a soloth soil in the sub-coastal area.

MATERIALS AND METHODS

Site

In January 1971 two field experiments were established on a soloth soil (Dy 3.41; Northcote 1965) at Undulla, twenty-six kilometres south-east of Ipswich. Average annual rainfall was 870 mm. The soil had a sandy-loam A horizon (15–20 cm in depth) overlying a massive, mottled yellow clay B horizon. The pH of the surface soil (0–10 cm) was 5.6, available P (B.S.E.S. method)—11 ppm and replaceable K—0.13 me %.

The easterly sloping site, which had been contoured, was previously a tropical pasture containing a range of tropical grasses and legumes. Only a few Siratro plants remained from the original planting; vegetation consisted mainly of blue couch (*Digitaria didactyla*) and pitted blue grass (*Bothriochloa decipiens*) with sedge (*Cyperus brevifolius*) on the lowest contour.

Design and treatments

Twelve grasses (Table 3) were planted in a randomized block experiment with three replications. Grasses were grown with either Siratro or fertilizer nitrogen.

Six legumes (Table 5) were planted with green panic (*Panicum maximum* var. *trichoglume* cv. Petrie) in a separate randomized block experiment with four replications. *Lotononis bainesii* (lotononis) failed to establish and was replanted in January 1972.

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Fertilizer management

Nitrogen at 56 kg ha^{-1} as ammonium nitrate was applied at planting (January 12, 1971) to pure grass treatments only. In subsequent years, a similar amount was applied in October and again in January.

Five hundred kg ha^{-1} of molybdenized superphosphate (0.02% Mo) was applied at planting to both grass and legume experiments with a maintenance dressing of 250 kg ha^{-1} of superphosphate annually. One hundred and twenty-five kg ha^{-1} of muriate of potash was applied every alternate spring.

Measurements

Dry matter production was measured by cutting one 2.4 m × 0.9 m quadrat from each plot, sorting the material into planted grass, legumes and other species and drying at 80°C. After sampling the area was grazed by beef cattle and mown to 10 cm. The experiment was harvested twice each summer, the first sampling in December or January, and the second in April or May depending on seasonal conditions.

Climate

Rainfall records for Ipswich, the closest recording centre, are presented in Table 1. Summer rainfall was above average in each year. Excessively wet conditions and low levels of radiant energy limited growth during mid-summer in 1973/74 and 1974/75. Low spring temperatures in 1974 restricted growth early in the growing season.

TABLE 1

Rainfall (mm) for five years (1971-76) *and mean maximum and minimum temperatures* (°*C*) *at Ipswich,* 26 *km north-west of the experimental site.*

	Rainfall (mm)							Temperature (°C)	
Month	1971	1972	1973	1974	1975	1976	Mean*	Mean** Max.	Mean Min.
January	224	116	94	483	132	188	128	32.1	20.7
February	333	203	165	43	209	211	122	31.0	20.4
March	49	110	32	239	112	113	103	30.1	18.6
April	18	138	14	83	45	24	58	28.2	15.3
May	23	32	12	42	1	49	47	24.0	11.6
June	2	29	15	46	33	14	53	21.6	8.9
July	26	3	208	11	31	–	44	20.9	6.9
August	48	17	47	49	26	–	34	22.9	8.8
September	42	10	19	67	78	–	43	25.9	11.1
October	60	424	87	63	104	–	66	28.4	15.3
November	119	86	91	129	145	–	75	30.8	17.2
December	130	136	118	18	109	–	103	31.8	19.0
Total	1074	1304	902	1273	1025	599†	876	–	–

*Rainfall average from 104 year data.
**Temperature averages from 15 year data.
†Total for six months only.

RESULTS

Grass experiment

Callide Rhodes grass produced significantly higher sown grass dry matter yields than the other grasses over a five year period ($P < 0.05$) (Figure 1). However there was no significant difference in total herbage yields from Callide Rhodes, *Panicum maximum* Q14734 and pangola grass plots. Higher weed yields in the latter two

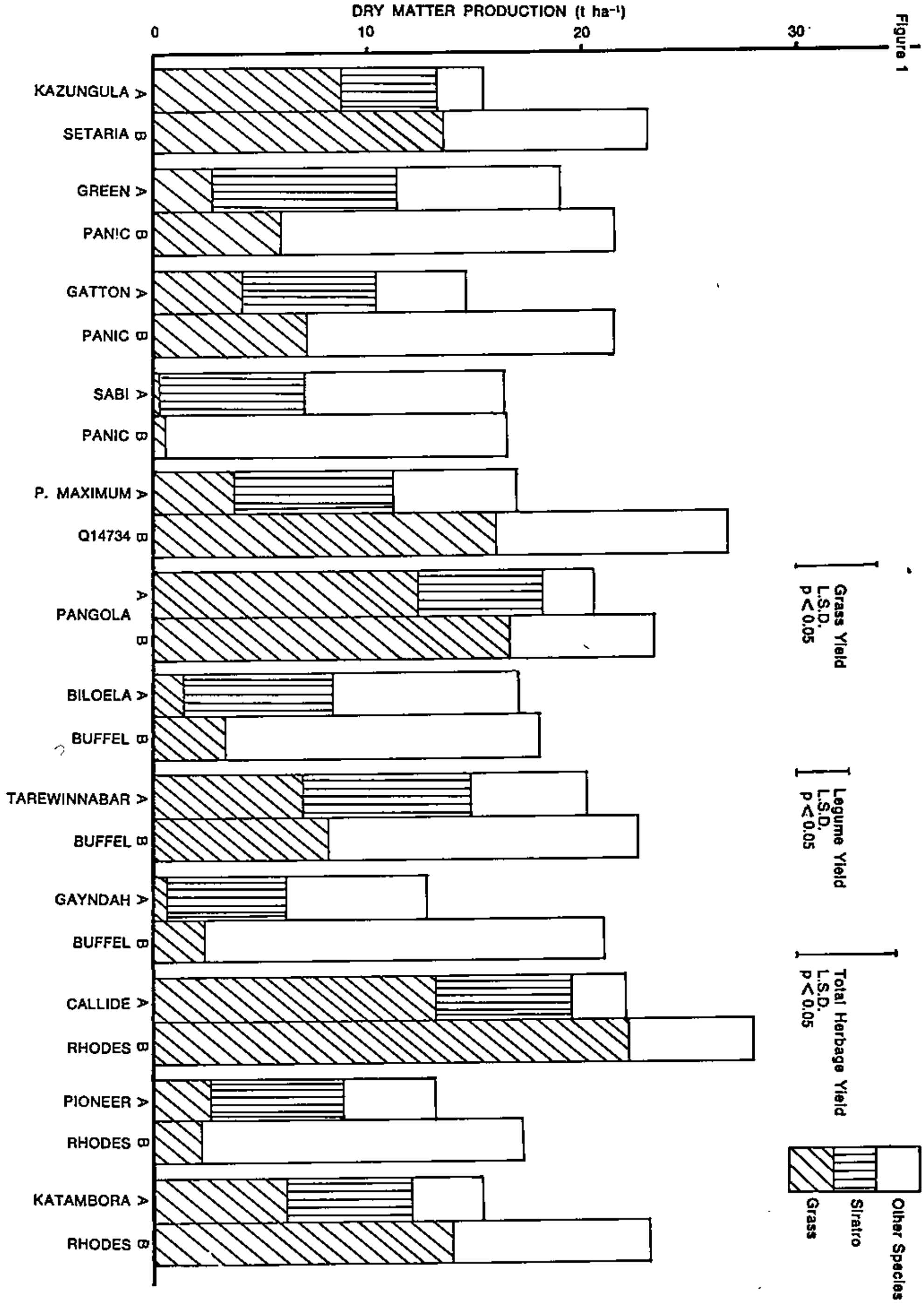

FIGURE 1

Total and component dry matter production (t ha^{-1}) of twelve grasses grown with Siratro (Histogram A) or fertilized with 112 kg N ha^{-1} annum^{-1} (Histogram B) over the period January 1971 to June 1976.

treatments compensated for differences in sown grass yields. Sown grass yields from pangola plots were higher than those from Kazungula setaria, *P. maximum* Q14734 and Katambora Rhodes grass ($P < 0.05$).

Irrespective of grass species, the nitrogen fertilized treatments had higher sown grass and total herbage yields than the grass/legume treatments ($P < 0.05$) (Table 2). However, combined sown grass and legume yields of the mixtures outyielded sown grass yields of the nitrogen treatments ($P < 0.05$).

TABLE 2

The effect of nitrogen source on five years' pasture production (t ha^{-1}) on a soloth soil (data averaged for grass species).

Source of N	Dry Matter Yields (t ha^{-1})		
	Sown Grass	Sown Grass + Legume	Total*
Nitrogen fertilizer	9.4 a†	9.4 b	21.9 a
Legume	5.2 b	11.7 a	17.0 b

†In any column treatments with the same letter do not differ ($p < 0.05$).
*Total = Grass + Legume + Other Species.

Grass yields varied between years; all except those of Callide Rhodes, pangola and Kazungula setaria declined with time (Table 3). In 1971/72, *P. maximum* Q14734, green panic and Tarewinnabar buffel outyielded all other grasses ($P < 0.05$). Callide Rhodes was the highest producing grass in the next two years with yields of Tarewinnabar buffel and Katambora Rhodes (1972/73) and pangola (1973/74) plots not differing significantly.

Pangola grass outyielded ($P < 0.05$) the other grasses in 1974/75 although yields of all grasses were low. Poor production of *P. maximum* lines and *C. ciliaris* cultivars continued in 1975/76 while yield of Callide Rhodes improved.

There were few significant differences in yield of Siratro (Table 4) even though there were large differences between the yields of the companion grasses (Table 3). No evidence of a negative correlation between grass and legume yields could be detected.

Siratro outyielded other legumes except in the establishment year ($P < 0.05$) (Table 5). In 1973/74 lotononis outyielded all but Siratro ($P < 0.05$). Measurements were terminated in 1974 when Siratro was the only legume persisting.

DISCUSSION

Callide Rhodes grass consistently gave high yields in combination with Siratro and with fertilizer nitrogen. Dry matter yield of pangola and Kazungula setaria improved throughout the experiment. *P. maximum* Q14734 was productive in the first three years but yields declined in the last two seasons. It was observed that this grass was rarely grazed by cattle which were used to remove pasture bulk after sampling.

Buffel grasses were low yielding in this environment except for cv. Tarewinnabar. Green and Gatton panic produced above average yields in the establishment year, maintaining similar levels of production in the next two years. All grasses exhibited a reduction in vigour after the excessively wet conditions in 1973/74 and 1974/75, but panic and buffel cultivars failed to recover in 1975/76 under favourable conditions. This difference in recovery is possibly due to differences in tolerance of waterlogged conditions (Anderson 1973). Yield of pangola was less affected during this period, confirming its well known tolerance of waterlogged conditions.

TABLE 3

Dry matter production ($t\ ha^{-1}$) of twelve grasses grown on a soloth soil in sub-coastal south-eastern Queensland over the period 1971 to 1976 (Data averaged for nitrogen source).

Grass Treatment	1971/72		1972/73		1973/74		1974/75		1975/76	
	Sown Grass	Total*	Sown Grass	Total	Sown Grass	Total	Sown Grass	Total	Sown Grass	Total
Setaria anceps cv. Kazungula	0·2 de**	1·0 cde	1·1 def	3·7 abc	3·9 bc	6·6 abc	1·3 b	1·5 b	4·7 b	6·4 c
Panicum maximum var. *trichoglume* cv. Petrie	1·5 abc	2·1 bcd	1·0 def	4·3 ab	1·1 ef	6·8 abc	0·2 cd	1·1 bcd	0·2 de	6·0 c
Panicum maximum cv. Gatton	1·4 bc	2·2 bc	0·8 def	3·2 bc	1·9 e	5·9 bc	0·6 c	1·1 bcd	1·0 de	5·6 c
Panicum maximum cv. Sabi	0·1 de	0·8 e	0·1 f	2·7 c	0·0 f	5·3 c	0·1 d	0·8 cd	0·1 de	6·8 bc
Panicum maximum Q14734	2·3 a	3·7 a	1·9 bcd	3·2 bc	4·0 bc	7·1 ab	0·6 cd	1·4 b	1·2 de	6·6 c
Cenchrus ciliaris cv. Biloela	0·9 cd	1·6 bcde	0·5 ef	3·6 bc	0·9 ef	5·7 bc	0·0 d	1·0 bcd	0·1 de	5·6 c
Cenchrus ciliaris cv. Tarewinnabar	2·2 ab	2·8 ab	2·7 ab	4·8 a	2·0 de	5·9 bc	0·2 cd	1·4 bc	0·5 de	6·5 c
Cenchrus ciliaris cv. Gayndah	0·7 cde	1·7 bcde	0·2 f	3·4 bc	0·5 f	5·3 c	0·0 d	1·1 bcd	0·0 e	5·4 c
Chloris gayana cv. Callide	1·4 bc	2·1 bcd	3·0 a	4·1 ab	5·4 a	7·7 a	1·1 b	1·3 bcd	6·8 a	9·8 a
Chloris gayana cv. Pioneer	0·1 de	1·0 cde	0·6 ef	2·9 c	0·1 f	5·2 c	0·3 cd	0·8 d	1·4 d	5·3 c
Chloris gayana cv. Katambora	0·2 de	1·1 cde	2·3 abc	3·6 ab	3·1 cd	6·7 abc	1·1 b	1·2 bcd	3·3 c	6·6 c
Digitaria decumbens (pangola)	0·0 e	0·9 de	1·4 cde	3·4 bc	4·5 ab	6·8 abc	2·7 a	2·7 a	6·0 a	8·1 b

**In any column treatments with the same letter do not differ ($p < 0{\cdot}05$).
*Total = Grass + Legume + Other species.

TABLE 4

Production of Siratro ($t\ ha^{-1}$) in association with the twelve grass species.

Grass Species	Siratro yields ($t\ ha^{-1}$)				
	1971/72	1972/73	1973/74	1974/75	1975/76
Setaria anceps cv. Kazungula	0·25 a*	1·27 ab	1·27 c	0·03 b	1·50 b
Panicum maximum var. *trichoglume* cv. Petrie	0·50 a	2·41 a	3·39 a	0·12 b	2·10 b
Panicum maximum cv. Gatton	0·33 a	1·25 ab	2·36 abc	0·16 ab	2·00 ab
Panicum maximum cv. Sabi	0·46 a	1·31 ab	2·27 bc	0·14 ab	2·57 ab
Panicum maximum Q14734	0·33 a	1·52 ab	2·69 ab	0·19 ab	2·55 ab
Cenchrus ciliaris cv. Biloela	0·18 a	1·36 ab	3·13 ab	0·16 ab	2·17 ab
Cenchrus ciliaris cv. Tarewinnabar	0·63 a	1·36 ab	2·62 ab	0·32 a	3·00 a
Cenchrus ciliaris cv. Gayndah	0·52 a	0·95 b	2·52 ab	0·04 b	1·55 b
Chloris gayana cv. Callide	0·54 a	1·12 b	2·37 abc	0·16 ab	2·27 ab
Chloris gayana cv. Pioneer	0·31 a	0·81 b	2·25 bc	0·04 b	2·69 ab
Chloris gayana cv. Katambora	0·46 a	0·71 b	2·18 bc	0·06 b	2·38 ab
Digitaria decumbens (pangola)	0·35 a	1·52 ab	2·03 bc	0·02 b	1·78 ab

*In any column treatments with the same letter do not differ ($p < 0{\cdot}05$).

TABLE 5

Dry matter production ($t\ ha^{-1}$) of six legumes grown in association with Panicum maximum *var.* trichoglume

Legume Species	1971/72		1972/73		1973/74		3 year summation	
	Legume	Total*	Legume	Total	Legume	Total	Legume	Total
Lotononis bainesii cv. Miles	0·00 a**	3·76 a	0·36 b	2·06 b	1·02 b	3·17 ab	1·38 b	9·00 ab
Macroptilium atropurpureum cv. Siratro	0·27 a	2·01 a	1·71 a	3·80 a	2·32 a	3·86 a	4·30 a	9·68 a
Macrotyloma axillare cv. Archer	0·34 a	2·81 a	0·21 b	1·55 b	0·14 c	2·00 b	0·69 bc	6·36 bc
Stylosanthes guianensis cv. Cook	0·24 a	2·71 a	0·09 b	1·64 b	0·23 c	2·61 ab	0·57 bc	6·97 bc
Stylosanthes guianensis cv. Endeavour	0·01 a	2·10 a	0·18 b	1·45 b	0·38 c	2·30 b	0·56 bc	5·85 c
Stylosanthes guianensis cv. Oxley	0·00 a	2·91 a	0·01 b	2·61 b	0·00 c	3·08 ab	0·01 c	8·60 ab

*Total includes Grass + Legume + Other species.
**In any column treatments with the same letter do not differ ($p < 0{\cdot}05$).

The relative levels of production of most grasses was similar to those obtained by Jones and Rees (1972) on a prairie-like soil in a similar sub-coastal environment although in their experiment the buffel cultivars persisted well. Excessively heavy summer rainfall was also recorded in their experiment but it occurred in the final year of measurement so there was no information on its effect on species' persistence. In their experiment, green panic showed a similar yield depression in the very wet year.

Grass yields from Kazungula setaria, *P. maximum* Q14734, pangola and Callide and Katambora Rhodes grass were greater in the nitrogen fertilized compared to the grass/legume treatments. However the data does not indicate whether the lack of response to nitrogen by the other grasses was due to insufficient plant numbers or to the fact that those species were unresponsive to nitrogen.

The results confirm that Siratro is the only legume which is likely to persist on duplex soils in this environment. Lotononis grew better than the other legumes, but the unreliability of its performance (Jones, Griffiths Davies and Waite 1967) was again demonstrated. None of the other legumes established well, with stand density being rapidly reduced by the effects of frost and waterlogging. Despite the poor performance of the commercial *Stylosanthes* cultivars, this genus appears to hold promise of alternative legumes for this soil type (Lowe, unpublished data).

CONCLUSIONS

Current pasture recommendations include green and Gatton panic (Anonymous, 1970). These grasses are capable of producing over 1 200 kg ha^{-1} $year^{-1}$ of dry matter for five years in association with Siratro on similar soil types (Lowe, unpublished data). Their poor performance in this experiment does not necessarily indicate their unsuitability, as the chance of receiving a similar summer rainfall to that in 1973/74 is low ($< 6\%$ probability). However it does suggest that their usage should be limited to sites where waterlogging is minimal.

Callide and Katambora Rhodes, Kazungula setaria and pangola do not suffer from these limitations and should be included in future pasture recommendations. Because pangola must be planted vegetatively, it will probably be restricted to special purpose pastures of limited area. At present a seed supply problem exists with Callide Rhodes, but when this is overcome, its value for pasture improvement in the sub-coastal area should be considerable.

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REFERENCES

ANDERSON, E. R. (1973)—Effects of flooding on some tropical grasses. M. Agr. Sc. Thesis, University of Queensland.

ANONYMOUS (1970)—Pasture planting guide—2. *Queensland Agricultural Journal* **96**: 265-77.

BRYAN, W. W. (1961)—*Lotononis bainesii* Baker—a legume for sub-tropical pastures. *Australian Journal of Experimental Agriculture and Animal Husbandry* **1**: 4-10.

BRYAN, W. W. and SHARPE, J. P. (1965)—The effect of urea and cutting treatments on the production of pangola grass in south-eastern Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* **5**: 433-41.

BRYAN, W. W. and EVANS, T. R. (1971)—Grazing trials on the Wallum of south-eastern Queensland. 3. A nursery grazed by sheep. *Australian Journal of Experimental Agriculture and Animal Husbandry* **11**: 633-39.

HENZELL, E. F. (1963)—Nitrogen fertilizer responses of pasture grasses in south-eastern Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* **3**: 290-99.

JONES, R. J., GRIFFITHS DAVIES, J. and WAITE, R. B. (1967)—The contribution of some tropical legumes to pasture yields of dry matter and nitrogen at Samford, south-eastern Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* **7**: 57-65.

JONES, R. M. and REES, M. C. (1972)—Persistence and productivity of pasture species at three locations in sub-coastal south east Queensland. *Tropical Grasslands* **6**: 119-34.

MANNETJE, L. 'T (1967)—Pasture improvement in the Eskdale District of south-eastern Queensland. *Tropical Grasslands* **1**: 9-20.

NORTHCOTE, K. H. (1965)—A factual key for the recognition of Australian Soils. *C.S.I.R.O. Divisional Report* 2/65. Adelaide.

SHAW, N. H., ELICH, T. W., HAYDOCK, K. P. and WAITE, R. B. (1965)—A comparison of seventeen *Paspalum* species and naturalized *P. dilatatum* under cutting at Samford, south-eastern Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* **5**: 423-32.

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