DRY MATTER PRODUCTION AND CHEMICAL COMPOSITION OF KENYA WHITE CLOVER, WHITE CLOVER AND SOME TROPICAL LEGUMES GROWN WITH *PENNISETUM CLANDESTINUM* IN CUT SWARDS ON THE EVELYN TABLELAND OF NORTH QUEENSLAND

K. A. SHAW* and T. J. QUINLAN†

ABSTRACT

Trifolium semipilosum *(cv. Safari, C.P.I.'s* 31996, 25347) T. repens *(cvv. Ladino, Louisiana, New Zealand and Irrigation)*, Lotononis bainesii *(cv. Miles)*, Desmodium intortum *(cv. Greenleaf)*, D. uncinatum *(cv. Silverleaf) and* Glycine wightii *(cvv. Tinaroo, Cooper and Malawi) were grown in association with* Pennisetum clandestinum *on two soil types on the Evelyn Tableland over a* 3.5 *year period. Cutting heights were 5 cm for the temperate (including* T. semipilosum) *and* 10 *cm for the tropical legumes. Lotononis was included as both a tropical and temperate legume.*

The three lines of T. semipilosum *were outstanding in their dry matter production and nitrogen and phosphorus content. The yields of all lines of* T. repens *were low and all eventually disappeared at the drier basalt site.* D. uncinatum *and* G. wightii *(cvv. Cooper and Tinaroo) were the highest yielding tropical legumes but their growing season was short.* D. intortum *was severely affected by rough brown weevil* (Leptopius corrugatus) *after yielding well in the first two years. The yields of* G. wightii *cv. Malawi and* L. bainesii *were low.*

INTRODUCTION

The Evelyn Tableland is situated at approximately 17° 30' south latitude and 145° 30' east longitude at an average altitude of 1 000 m above sea level. Average annual rainfall varies from 1 100 mm on the west to 2 000 mm on the eastern portion of the Tableland. Although most rain falls between November and March, showers continue until July after which a period of three to four months dry weather is usually experienced. Frosts, some quite severe, occur each year.

The soils, mainly krasnozems derived from basalt or krasnozem variants and xanthozem soils developed from acid volcanic parent material, are intensively phosphate deficient and also respond to molybdenum and potassium (Kerridge *et al.* 1972). The primary land use is for dairy and beef production with cattle being run on raingrown pastures for most of the year.

Research work with perennial temperate and tropical legumes has been virtually non-existent in this area. Tropical species, such as *Glycine wightii* (cvv. Tinaroo and Cooper) and *Desmodium intortum* (cv. Greenleaf), which are highly successful on the Atherton Tableland, are usually frosted before the completion of their growth cycle or have disappeared as a result of other causes in commercial plantings. The performance of white clover is erratic with occasional good years but more often the legumes make no contribution to the system. The reason for the instability of white clover is unknown. A decline in soil fertility, disease, insects and unsuitable management techniques have all been advanced as possible reasons for the poor performance of pasture legumes.

This paper reports the results of a study of a range of commercially available tropical and temperate legumes. Three lines of the high altitude tropical Kenya white clover (*Trifolium semipilosum*) were included. This species had shown promise in

* Queensland Department of Primary Industries, Walkamin 4872.
† P.O. Box 75, Yungaburra 4872.

the Millaa Millaa area (Gartner 1968) and could be expected to show greater frost tolerance and cool season growth than other tropical legume species.

MATERIALS AND METHODS

Thirteen pasture legumes (Table 1) were tested at two sites. The soil at site 1 was of basaltic origin whilst that at site 2 was derived from acid volcanic material. Both sites had originally been planted with kikuyu grass (*Pennisetum clandestinum*) but the pastures had degenerated to a run down stand at site 1 and to poor paspalum (*Paspalum dilatatum*)/narrow leaf carpet grass (*Axonopus affinis*) at site 2. Neither site had ever been fertilized.

TABLE 1

Legumes tested and planting rates

Species		Lines	Planting rate kg ha^{-1}
Tropical:	*Desmodium intortum*	cv. Greenleaf	1·5
	D. uncinatum	cv. Silverleaf	2·5
	Glycine wightii	cv. Tinaroo	5·0
	G. wightii	cv. Cooper	5·0
	G. wightii	cv. Malawi	5·0
	Lotononis bainesii	cv. Miles	1·0
Temperate:	*Trifolium semipilosum*	cv. Safari	8·0
	T. semipilosum	CPI 31996*	8·0
	T. semipilosum	CPI 25347	8·0
	T. repens	cv. Ladino	8·0
	T. repens	cv. Louisiana	8·0
	T. repens	cv. Irrigation	8·0
	T. repens	cv. New Zealand	8·0
	Lotononis bainesii	cv. Miles	1·0

* Commonwealth Plant Introduction (CPI).

Randomized block designs with three replicates of 6 m × 6 m plots surrounded by 1 m guard strips were planted by hand on 16-17 February 1970 on prepared seed beds. The tropical and temperate groups were grown in separate but immediately adjacent areas because of differences in their growth rhythms and management requirements. Lotononis was included in both groups because of its tolerance of frost and severe grazing (Bryan 1961). The seed of each legume species was inoculated with its recommended strain of *Rhizobium*.

At sowing each site received superphosphate Mo 12 and potassium chloride applications at 750 kg ha^{-1} and 125 kg ha^{-1} respectively. Annual maintenance dressings of superphosphate were 750, 500 and 250 kg ha^{-1} at site 1 while site 2, which has a higher phosphorus requirement, received 750, 500 and 500 kg ha^{-1} in succeeding years. Potassium chloride was applied at each site at 125 kg ha^{-1} annum^{-1} for the duration of the experiment.

Eight weeks after planting legume seedlings were counted in two 0.4 m^2 quadrats per plot. Eight harvests were taken at site 1. The harvest dates and regrowth periods are listed in Table 2. No growth was recorded after September in 1972 due primarily to lack of rain but also to insect attack. At site 2 only one six week regrowth harvest was made of the temperate legumes. The tropical legumes failed to establish.

The temperate legumes were harvested to 5 cm usually by cutting strips of 6 m × 1 m or 6 m × 0.5 m through each plot with a reciprocating mower. At harvest 1 and 2 three 0.4 m^2 quadrats were cut with hand shears. The tropical legumes were unsuited to mechanical harvesting and three 0.4 m^2 quadrats were cut to 10 cm with hand shears at each harvest. All material from hand cut samples was sorted into grass, legume and weed before oven drying. The mower harvested material was sub-sampled before sorting. Samples of harvested material were taken at harvests five, six and eight for nitrogen and phosphorus analyses.

Immediately after each harvest the uncut area of the plots was grazed to cutting height using high stocking densities. Plots were then topped to remove grazing irregularities and closed up until the next harvest or grazing. During the period when total dry matter production was not being measured plots were grazed and topped at four to six week intervals. Tropical and temperate legumes were grazed separately.

RESULTS

Climate

Temperate and rainfall data for site 1 are shown on Figure 1. The temperature data are from Herberton, a township at a similar altitude and receiving similar rainfall, 23 km north of site 1. No climatic data are available from the colder, wetter site 2.

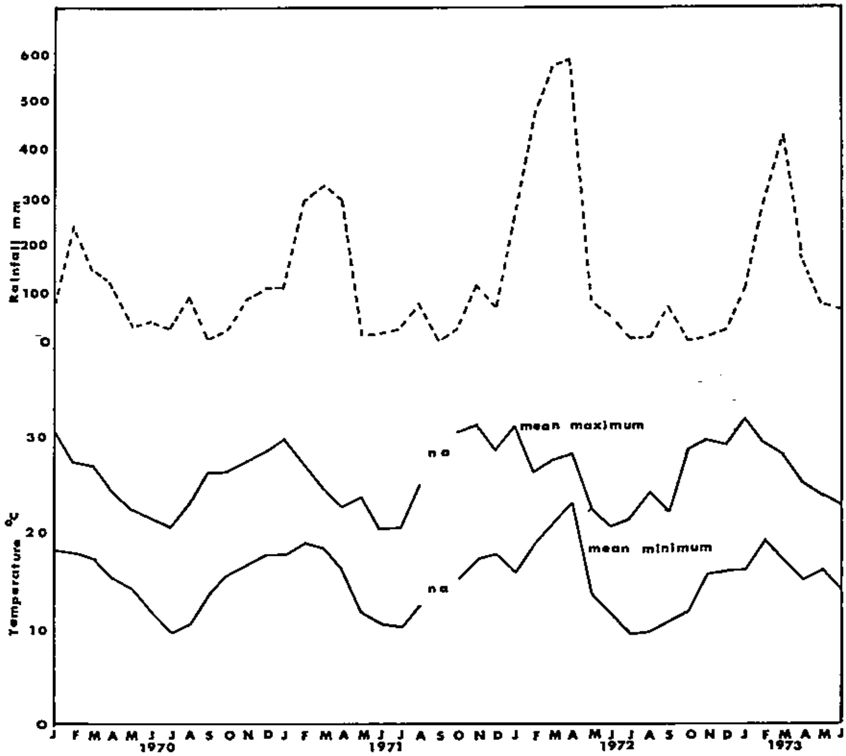

FIGURE 1

Temperature and rainfall data for site 1 over the trial period.

Establishment

At both sites the seedling emergence of all species except lotononis exceeded 20 plants m^{-2} eight weeks after sowing. Lotononis had not germinated at this time and seedlings were not observed until six months after planting.

On the basaltic soil (site 1) the cultivars of *T. repens* established satisfactorily. *T. semipilosum* introductions covered the plots rapidly but the leaves were small, and a pale orange to red colour. No nodules could be found on these plants during 1970. During March 1971, the Kenya white clover plots were re-inoculated by injecting a broth culture of *Rhizobium* strain CB 782 into the soil with a 20 ml disposable syringe without a needle. Within a month nodules had appeared and the plants began to grow vigorously.

Greenleaf and Silverleaf desmodium established well but high seedling mortality (from unknown causes) of the glycines reduced stand density. Lotononis did not establish until the second year.

On the acid volcanic soil (site 2) establishment of all species was poor. The growth of *T. repens* cultivars was very variable both within plots and at different times of year. The appearance of the *T. semipilosum* lines was similar to that at site 1 and these plots were also re-inoculated in March 1971. Small pale nodules were found in June 1971 but growth did not improve. The symptoms suggested that molybdenum deficiency may have been the cause of poor growth. During May 1972, 200 g Mo ha^{-1} as sodium molybdate was applied to all plots through a boom spray. The Kenya white clovers subsequently effectively nodulated and growth improved rapidly. The *T. repens* lines also responded to molybdenum but to a lesser extent.

Pests and diseases

After excellent early growth at site 1 the white clover lines became infected with rust (*Uromyces trifolii-repentis*) and pepper spot (*Sphaerulina trifolii*). Continual re-infection by those organisms was observed. Infection by these diseases at site 2, while not as severe, was responsible for very variable growth of the *T. repens* cultivars. The accessions of *T. semipilosum* appeared to be resistant to both rust and pepper spot.

Root knot nematode (*Meloidogyne* spp.) galls were observed on the roots of the Kenya white clover before nodulation but there was no obvious effect on growth after effective nodulation had occurred.

Pasture webworm (*Oncopera mitocera*) attack on all species over the severe dry season of 1972 left bare ground which allowed previously suppressed nut grass (*Cyperus rotundus*) to re-establish at the beginning of the wet season. Because of high legume content in the *T. semipilosum* plots and the slower regrowth of this legume compared with kikuyu, these plots were the last to recover. By May 1973 strong growth by the Kenya white clovers and kikuyu had again suppressed this weed. Apart from this instance weed content of all plots was negligible.

Initially both Greenleaf and Silverleaf were outstanding at site 1. By the beginning of 1972 however, Greenleaf had begun to decline and within six months had virtually disappeared, apparently due to infestations of the rough brown weevil (*Leptopius corrugatus*). Adults of this species were present in large numbers on Greenleaf in March 1972. Silverleaf desmodium appeared tolerant if not resistant to weevil attack. Root chewing by the weevil was observed on the Kenya white clovers without obvious suppression of growth. It is not known whether this legume is a host of the weevil or if it was attacked because of the disappearance of Greenleaf desmodium in the adjacent area.

Army worms (*Spodoptera* spp.) caused minor damage to the Kenya white clovers in May 1972 but did not attack the other legumes.

Dry matter yield

Eight harvests were taken from site 1 during the experiment. The period of active growth for the tropical legumes was usually short and they were only harvested when production was significant. Because the *T. repens* lines were relatively poor for much of the year only Louisiana was included in cuts 3 to 7 for a comparison with *T. semipilosum*. (Tables 2, 3).

TABLE 2

Dry matter production of temperate species in kg ha^{-1} (Site 1)

Treatment	Harvest 1 17.v.71 38 days*		Harvest 2 9.iii.72 40 days		Harvest 3 18.iv.72 38 days		Harvest 4 26.v.72 36 days		Harvest 5 30.vi.72 31 days		Harvest 6 11.viii.72 38 days		Harvest 7 27.ix.72 43 days		Harvest 8 31.v.73 40 days	
	Legume	Total	Legume	Total	Legume	Total	Legume	Total	Legume	Total	Legume	Total	Legume	Total	Legume	Total
Safari	1292†(a)§	1800 (a)	2611 (a)	5491 (a)	1786 (a)	2713 (a)	623 (a)	793 (a)	759 (a)	1002 (a)	418 (a)	503 (a)	19 (a)	33 (a)	1384 (a)	3746 (a)
CPI 31996	379 (a)	970 (b)	1504 (a)	4480 (ab)	1704 (a)	2959 (a)	958 (a)	1255 (a)	567 (a)	663 (a)	601 (a)	719 (a)	92 (a)	119 (a)	1285 (a)	4113 (a)
CPI 25347	486 (a)	1159 (b)	2514 (a)	4685 (a)	1970 (a)	2885 (a)	834 (a)	1187 (a)	636 (a)	786 (a)	317 (a)	519 (a)	56 (a)	72 (a)	950 (ab)	2940 (ab)
Ladino	16 (bc)	758 (b)	30 (cd)	2589 (cd)	—	—	—	—	—	—	—	—	96 (a)	151 (a)	0	2837 (ab)
Louisiana	13 (c)	625 (b)	8 (d)	2359 (cd)	10 (b)	1784 (b)	25 (b)	1094 (a)	3 (c)	596 (a)	48 (b)	246 (a)	53 (a)	127 (a)	0	2794 (ab)
Irrigation White	16 (bc)	682 (b)	36 (c)	2951 (cd)	—	—	—	—	—	—	—	—	22 (a)	67 (a)	0	2601 (b)
New Zealand	73 (b)	690 (b)	11 (cd)	1833 (d)	—	—	—	—	—	—	—	—	9 (a)	28 (a)	0	2274 (b)
Lotononis	17 (bc)	592 (b)	770 (b)	3420 (bc)	—	—	—	—	55 (b)	763 (a)	10 (b)	110 (a)	20 (a)	51 (a)	525 (b)	2794 (ab)

* Regrowth period.
† Legume results are retransformed means from log (x + 1) transformations.
§ Different letters denote significant difference ($p < 0 \cdot 05$) by Duncan's New Multiple range test.
—Not cut as yield was negligible.

TABLE 3

Dry matter production of site 1 tropical legumes in kg ha^{-1}

Treatment	Harvest 1: 17.v.71 38 days*		Harvest 2: 9.iii.72 40 days		Harvest 3: 31.v.73 40 days	
	Legume†	Total	Legume†	Total	Legume†	Total
Greenleaf	855 (a)	1833 (a)	1661 (ab)	6033 (a)	16 (c)	1934 (b)
Silverleaf	806 (a)	1817 (a)	2490 (a)	5039 (ab)	1066 (a)	3561 (a)
Tinaroo	279 (b)	715 (b)	733 (ab)	3288 (c)	1412 (a)	2627 (b)
Cooper	140 (b)	822 (b)	2103 (a)	4011 (bc)	883 (a)	1938 (b)
Malawi	90 (b)	599 (b)	574 (ab)	2935 (c)	604 (a)	2407 (b)
Lotononis	25 (b)	444 (b)	227 (b)	3050 (c)	130 (b)	2068 (b)

* Regrowth period.
† Retransformed means from log (x + 1) transformation.

Of the three lines of *T. semipilosum*, Safari responded quickest to re-inoculation, and at harvest 1 gave the highest dry matter yield. Thereafter no differences were observed in the three lines and their production was similar.

All three lines of Kenya white clover gave outstanding production. The legume dry matter (DM) production of each at site 1 in 1972 was c. 6000 kg ha^{-1} whereas Louisiana white clover only produced 225 kg ha^{-1} legume DM. *T. semipilosum* competed well with kikuyu. In most harvests the legume content on a dry matter basis exceeded 50%. Even after 10 weeks regrowth the Kenya white clover was able to compete strongly with the grass.

Under raingrown conditions the *T. semipilosum* lines made their strongest growth from February to May. Growth tapered off through winter with spring growth being dependent on temperature and rainfall. The failure of *T. semipilosum* to respond to spring rain (Figure 1) at harvest 7 is attributed to low temperatures during that regrowth period.

The Kenya white clovers tolerated frost better than most tropical legumes but not as well as lotononis. They are less frost tolerant than *T. repens* and continued severe frosting will burn off all top growth.

Only one harvest was taken from site 2 (Table 4). There was no vigorous growth at this site until additional molybdenum was applied.

TABLE 4

Dry matter production of site 2 temperate legumes in kg ha^{-1}

Treatment	Harvest 1: 1.vi.73 41 days*	
	Legume†	Total
Safari	1817 (a)	3350 (a)
CPI 31996	1125 (ab)	2667 (a)
CPI 25347	1707 (a)	3030 (a)
Ladino	76 (bc)	2021 (a)
Louisiana	274 (ab)	2278 (a)
Irrigation	70 (bc)	2737 (a)
New Zealand White	183 (ab)	2751 (a)
Lotononis	2 (c)	2474 (a)

* Regrowth period.
† Retransformed means from log (x + 1) transformations.

TABLE 5

Nitrogen and phosphorus percentages in plant samples at selected harvests (Site 1)

Treatment	Harvest 5 Legume 30.vi.72		Harvest 6 Legume 11.viii.72		Harvest 8—31.v.73			
					Legume		Grass	
	N	P	N	P	N	P	N	P
Safari	3·41 (a)	0·42 (a)	4·75 (a)	0·48 (a)	3·21 (a)	0·61 (a)	1·91 (a)	0·57 (ab)
CPI 31996	3·77 (a)	0·48 (a)	4·97 (a)	0·47 (a)	3·09 (a)	0·62 (a)	2·15 (a)	0·61 (a)
CPI 25347	3·77 (a)	0·49 (a)	4·97 (a)	0·49 (a)	3·10 (a)	0·62 (a)	1·97 (a)	0·62 (a)
Lotononis			3·41 (b)	0·37 (b)	3·26 (a)	0·47 (b)	1·32 (b)	0·44 (b)
Louisiana							1·28 (b)	0·41 (b)

Mineral composition

Plant samples were taken at 3 harvests representing winter, dry season and autumn growth periods. There was no difference between the three lines of Kenya white clover in either N or P (Table 5). At harvest 8, grass growing with Kenya white clover contained 50% more nitrogen than grass from *T. repens* or lotononis plots. There were no significant differences in N content (range 2.56 to 2.97%) or P content (range 0.40 to 0.46%) between the tropical legumes.

DISCUSSION

The DM yield of *T. semipilosum* compares very favourably with that obtained by Jones (1973) in a drier subtropical environment. The nitrogen content of Kenya white clover is similar to that measured by Jones (1973) but the phosphorus contents are much higher. In February 1973, Safari Kenya white clover was planted in adjacent 2 ha demonstration areas at both sites for evaluation under commercial grazing. By November 1974 these had developed into highly productive stands.

The slowness of the Kenya white clovers to form vigorous productive stands was thought to be a result of nodulation failure. Another possible cause was rugose leaf curl disease. Plants symptoms were similar to those described by Grylle, Galletly and Campbell (1972). Rugose leaf curl disease has, however, never been positively identified on any stand of Kenya white clover on the Evelyn Tableland.

In this experiment, white clover failed to persist even though soil fertility had been raised and the pasture managed to suit the legume. The reason appears to be a combination of disease and poor spring rain.

At site 1, Greenleaf desmodium could only be regarded as a short term legume because of its susceptibility to attack by the rough brown weevil. In an adjacent experiment where the soil was treated with dieldrin to control weevils, Greenleaf remained productive for five years (P. C. Kerridge, personal communication). The use of dieldrin on dairy pastures, however, is now illegal because of contamination in produce. Silverleaf, Cooper and Tinaroo can be regarded as permanent pasture legumes providing summer feed. Both Silverleaf and Cooper responded quickly to the first summer rains but flowered early and thereafter made little growth. While Tinaroo glycine did not respond as quickly to summer rains it did grow until cut back by the first frost. The yields of these legumes compare favourably with those obtained by Kyneur (1966) from kikuyu grass/Tinaroo glycine on a fertile basaltic soil near Kairi and by Gartner *et al.* (1974) from a range of tropical legumes grown with Petrie green panic near Malanda.

No conclusion could be drawn from the tropical legume performance at site 2 because of their early disappearance. The vigorous growth of *T. semipilosum* following Mo application and the known sensitivity of *D. intortum* and *G. wightii* to Mo deficiency (Kerridge *et al.* 1972) suggest that deficiency of this element was responsible for the failure of the tropical legumes.

Trifolium semipilosum has shown itself to be a pasture legume with outstanding promise for the Evelyn Tableland of North Queensland. In this trial Kenya white clover was tolerant of a wide variation of seasonal conditions, strong grass competition and attack by rough brown weevils. It grew well on both light and heavy textured soils and appeared resistant to two fungal diseases that affect white clover.

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REFERENCES

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

GARTNER, J. A. (1968)—*Trifolium* species at Millaa Millaa, north Queensland. *Plant Introduction Review* **5**: 49-55.

GARTNER, J. A., FERGUSON, J. E., WALKER, R. W., and GOWARD, ELVIE A. (1974)—Evaluating perennial grass/legume swards on the Atherton tableland in north Queensland. *Queensland Journal of Agriculture and Animal Sciences* **31**: 1-17.

GRYLLS, N. E., GALLETLY, J. C., and CAMPBELL, R. C. (1972)—A field study of rugose leaf curl infection in stoloniferous *Trifolium* species. *Australian Journal of Experimental Agriculture and Animal Husbandry* **12**: 521-4.

JONES, R. J. (1973)—The effect of cutting management on the yield, chemical composition and *in vitro* digestibility of *Trifolium semipilosum* grown with *Paspalum dilatatum* in a sub-tropical environment. *Tropical Grasslands* **7**: 277-84.

KERRIDGE, P. C., ANDREW, C. S., and MURTHA, G. G. (1972)—Plant nutrient status of soils of the Atherton tableland, north Queensland. *Australian Journal of Experimental Agriculture and Animal Husbandry* **12**: 618-27.

KERRIDGE, P. C., COOK, B. G., and EVERETT, M. L. (1973)—Application of molybdenum trioxide in the seed pellet for sub-tropical pasture legumes. *Tropical Grasslands* **7**: 229-32.

KYNEUR, G. W. (1966)—Seasonal productivity of some pure grass and mixed grass/glycine swards in a tropical highland environment. *Queensland Journal of Agriculture and Animal Sciences* **23**: 1-14.

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