# INITIAL EVALUATION OF *STYLOSANTHES* SPECIES ON TWO SOILS OF THE MAYVALE LAND SYSTEM, NORTH-WEST QUEENSLAND

T. J. HALL*

## ABSTRACT

*In four field experiments in the Mayvale land system, north-west Queensland, twenty-two introductions of six* Stylosanthes *species were evaluated on two soil types.* S. guianensis *and* S. subsericea *lines did not persist beyond two years.* S. hamata *cv. Verano and some lines of* S. scabra, S. viscosa *and* S. humilis *produced between* 4 000 *and* 8 000 *kg per hectare dry matter on a deep sandy yellow earth, with superphosphate applied at establishment. On a mottled grey earth, yields of the same lines were less than* 4 000 *kg per hectare.*

*Highest nitrogen and phosphorus contents recorded in the legumes in the early flowering stage were* 2.10% *and* 0.14% *respectively.*

*Successful establishment was obtained in the presence of superphosphate on both cleared and cultivated seedbeds and in untreated open* Melaleuca *spp. woodland on a burnt soil surface. On the grey earth soil, all lines responded in the second season to superphosphate applied at establishment.*

*The potential value of these species is discussed in relation to the management systems of the area.*

## INTRODUCTION

Native grasses on the low fertility sandy soils of north-west Queensland are deficient in energy and protein for up to eight months of each year and there is a year-round deficiency in dietary phosphorus (Bishop 1974a). The introduction of a legume into these pastures could improve their nutritional quality for beef cattle and increase soil nitrogen for the subsequent establishment of higher quality grasses.

Townsville stylo (*Stylosanthes humilis*) was the most successful legume of those tested by Bishop (1974b) on two soils of the Mayvale land system. It yielded around 2 000 kg $ha^{-1}$ with applied phosphorus, and showed potential as a companion legume for *Urochloa mosambicensis.* In the south-east Gulf of Carpentaria region, naturalized Townsville stylo occurs to some degree on almost all properties in the Normanton-Croydon area and along the Gilbert and Staaten Rivers (Bishop 1972). It is a weak competitor with tall grasses, and heavy grazing of covering grass is necessary for persistence in a mixed pasture. This requirement is difficult to meet under the extensive cattle raising system practised in the low *Melaleuca* woodland and open forest communities where tall grasses such as *Sorghum plumosum, Chrysopogon fallax* and *Aristida* spp. are common. More recent introductions of *Stylosanthes* species with different plant structures and growth habits to Townsville stylo may be better suited to this environment.

Climate of the region is monsoonal, with Normanton receiving 88 per cent of its mean annual rainfall of 934 mm from December to March. Soils, geology, geomorphology, climate and vegetation of the Leichhardt-Gilbert area have been described by Perry *et al.* (1964). A detailed survey of soil associations and vegetation communities in part of the Mayvale land system, which includes the experimental sites, was reported by Webb *et al.* (1974).

The aim of the present work was the field evaluation of a range of *Stylosanthes* species on two soils of the sandy forest country in the Mayvale land system of north-west Queensland.

* Department of Primary Industries, P.O. Box 53, Cloncurry, Qld. 4824.

## MATERIALS AND METHODS

Four experiments were conducted at three sites on Glenore Station, south-east of Normanton. Experiments 1 and 2 were located at the site described and designated 'B' by Bishop (1974a). This site (No. 101) was described in detail by Webb *et al.* (1974). Experiment 4 was established 1 km east of site B, on the same soil type. These sites are approximately 24 km south-east of Normanton (latitude 17°40′ S, longitude 141°05′ E) on a mottled grey earth (Gn2.94) of the Blackbull Association. Experiment 3 was established at site 'A' of Bishop (1974a) which corresponds with sample site number 115 of Webb *et al.* (1974). It is located 40 km south-east of Normanton on a sandy yellow earth (Gn2.34) of the Gum Creek Association.

Analytical data for the profiles show that both soils have low levels of available P (1 to 12 ppm), total N (0.02 to 0.03%) and exchangeable cations (1 to 4 m. equiv. %) and a pH range of 5.3 to 6.1 (Webb *et al.* 1974). Detailed data for surface samples (0 to 10 cm) have been presented by Webb (1975).

Design, planting date, establishment fertilizer, seeding rate, plot size, data collection details and species planted in the four experiments are shown in Table 1. Sites were inaccessible during the wet season; consequently, opportunity for sampling and observations on establishment and early growth were restricted.

Experiments 1, 2 and 3 were planted into cultivated seedbeds after clearing trees while experiment 4 was established after a burn, on an uncultivated surface and with no timber treatment. Uninoculated podded seed and establishment fertilizer were hand broadcast, and cultivated plots were lightly raked after planting. No maintenance fertilizer dressings were applied.

Experiments 1, 2 and 3 were grazed lightly during the dry season after sampling while experiment 4 was continuously grazed although grazing was light during the growing season. Material remaining at the end of the dry season in experiments 1, 2 and 3 was mown and removed.

Native grasses, predominantly *Aristida hygrometrica*, were mown and *A. pruinosa* tussocks and *Melaleuca viridiflora* seedlings were cut out of plots in experiment 3 on February 16, 1972 (establishment season). Experiments 1, 2 and 3 were burnt by wildfires in July 1973. Experiment 3 was also burnt by wildfires in June 1972 and 1974 and in October 1975.

Rainfall at Glenore homestead (3 km from experiments 1 and 2, 4 km from experiment 4, and 19 km from experiment 3) for the main wet season months from December 1969 to March 1977 and Normanton's long term average rainfall are shown in Table 2.

Experiments 1 and 2 were flooded, to a depth up to 4 m, for about 14 days in the abnormal 1973–74 wet season.

## RESULTS

### *Plant populations*

*S. humilis* had higher seedling and mature plant counts than most other species (Table 3). At site B in 1970 (experiment 1), Greenvale strain had a higher seedling population ($P < 0.05$) than all other lines with the exception of *S. guianensis* C.P.I. 38357.

In 1972, Lawson had the highest mature plant population ($P < 0.01$) at site B (experiment 2) and a higher population ($P < 0.05$) than all other lines with the exception of *S. scabra* Q8240 at site A (experiment 3). Verano populations were comparable with those of other *S. humilis* lines at both sites.

Populations of *S. subsericea* and perennial species, particularly cvv. Cook and Endeavour, were low at both sites in 1972.

TABLE 1

*Details of experiments*

| Experiment No. | Site | Design | Planting date | Plot size | Establishment fertilizer | Fertilizer rate (kg ha$^{-1}$) | Seeding rate (kg ha$^{-1}$) | Parameter and Sampling date | Sampling area |
|---|---|---|---|---|---|---|---|---|---|
| 1 | B | 7x3 RB | 7.i.70 | 2m x 5m | Complete* | 500 | 14 – 20 | Population 14.iii.70 | 4, 0.2m x 0.2m |
| | | | | | | | | Dry Matter 18.iv.70<br>19.v.71<br>5.v.72 | 2, 1m x 0.4m<br>2, 1m x 0.4m<br>1, 1m x 0.5m |
| 2 | B | 12x3 RB | 15.xii.71 | 3m x 6m | Super King** | 120 | 15 | Population 11.v.72 | 2, 1m x 0.5m |
| | | | | | | | | Dry Matter 11.v.72<br>9.v.73<br>5.v.77 | 2, 1m x 0.5m<br>2, 1m x 0.5m<br>2, 1m x 1m |
| 3 | A | 12x3 RB | 16.xii.71 | 3m x 6m | Super King | 120 | 15 | Population 10.v.72 | 2, 1m x 0.5m |
| | | | | | | | | Dry Matter 10.v.72<br>11.v.73<br>22.v.74 | 2, 1m x 0.5m<br>2, 1m x 0.5m<br>0.86m x 2.9m |
| 4 | Near B | 2x9x3 RB | 11.xii.75 | 2m x 10m | Superphospate | 300/0 | 15 – 20 | Dry Matter 29.iv.76<br>10.v.77 | 2, 1m x 1m<br>2, 1m x 1m |

* N:P:K – 1.75:8.3:8.3
** P:S – 19:1.6

*Experiment 1*

| | |
|---|---|
| *S. subsericea* | CPI 38605 (Q8436) |
| *S. scabra* | Q8240 |
| *S. humilis* | CPI 40278 |
| *S. humilis* | (Greenvale strain) |
| *S. guianensis* | CPI 40568 |
| *S. guianensis* | CPI 33437 |
| *S. guianensis* | CPI 38357 |

*Experiment 2 and 3*

| | |
|---|---|
| *S. humilis* | cv. Lawson |
| *S. humilis* | cv. Gordon |
| *S. humilis* | cv. Paterson |
| *S. humilis* | (Greenvale strain) |
| *S. viscosa* | CPI 33941 |
| *S. subsericea* | CPI 38605 |
| *S. scabra* | Q8240 |
| *S. scabra* | CPI 34925 |
| *S. hamata* | cv. Verano |
| *S. guianensis* | cv. Endeavour |
| *S. guianensis* | CPI 34911 |
| *S. guianensis* | cv. Cook |

*Experiment 4*

| | |
|---|---|
| *S. hamata* | cv. Verano |
| *S. humilis* | (commercial) |
| *S. guianensis* | CPI 40255 |
| *S. scabra* | cv. Seca |
| *S. scabra* | CPI 40205 |
| *S. scabra* | CPI 34925 |
| *S. scabra* | Q8240 |
| *S. viscosa* | CPI 40264 |
| *S. viscosa* | CPI 34904 |

TABLE 2

*Rainfall (mm) for the months December to March at Glenore Station for the duration of the experiments*

| Month | 1969–70 | 1970–71 | 1971–72 | 1972–73 | 1973–74* | 1974–75 | 1975–76 | 1976–77 | Mean 1969-77 Glenore (excluding 1973–74) | Mean 1969-77 Normanton | Normanton (104-year mean) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| December | 217 | 163 | 122 | 38 | (231) | 169 | 215 | 177 | 157 | 177 | 145 |
| January | 94 | 18 | 214 | 151 | (965) | 244 | 483 | 126 | 190 | 299 | 265 |
| February | 76 | 184 | 326 | 394 | (289) | 236 | 360 | 216 | 256 | 300 | 255 |
| March | 111 | 184 | 381 | 33 | (359) | 58 | 78 | 212 | 151 | 195 | 158 |

* Normanton rainfall—Glenore recording station flooded.

TABLE 3

*Seedling (Experiment 1) and mature plant populations (Experiments 2 and 3) in the establishment season (plants m$^{-2}$)*

| | | Experiment | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Species | | Mar 1970 | May 1972 | May 1972 |
| *S. humilis* | cv. Lawson | | 67(5.83)† | 31(4.02)† |
| *S. humilis* | cv. Paterson | | 11(2.46) | 16(2.92) |
| *S. humilis* | cv. Gordon | | 26(3.66) | 17(2.99) |
| *S. humilis* | Greenvale strain | 402 | 36(4.32) | 17(3.02) |
| *S. humilis* | CPI 40278 | 6 | | |
| *S. subsericea* | CPI 38605 | 4 | 7(1.95) | 9(2.20) |
| *S. viscosa* | CPI 33941 | | 3(1.34) | 6(1.88) |
| *S. scabra* | Q8240 | 14 | 3(1.42) | 22(3.42) |
| *S. scabra* | CPI 34925 | | 4(1.63) | 12(2.57) |
| *S. hamata* | cv. Verano | | 46(4.82) | 14(2.72) |
| *S. guianensis* | cv. Cook | | 3(1.39) | 2(1.21) |
| *S. guianensis* | cv. Endeavour | | 1(0.97) | 8(2.14) |
| *S. guianensis* | CPI 34911 | | 1(0.97) | 10(2.38) |
| *S. guianensis* | CPI 38357 | 305 | | |
| *S. guianensis* | CPI 40568 | 212 | | |
| *S. guianensis* | CPI 33437 | 130 | | |
| L.S.D. (P=0.05) | | 138 | (0.72) | (0.91) |

† Transformation $\sqrt{x} + .05$ used for analysis.

## *Dry matter yields*

In the establishment season, highest yielding species (Table 4) were *S. humilis* lines (experiments 1, 2 and 3) and Verano (experiment 4). At site B, the Greenvale strain (4 370 kg ha$^{-1}$) had the highest yield ($P < 0.01$) in experiment 1, and Lawson (1 380 kg ha$^{-1}$) and the Greenvale strain (1 090 kg ha$^{-1}$) were highest yielding lines ($P < 0.01$) in experiment 2. At site A (experiment 3), Lawson, Gordon, Greenvale strain and Verano were highest yielding lines, producing over 3 800 kg ha$^{-1}$. In the second year, yields of *S. humilis* and Verano showed little change while *S. scabra* yields increased eight fold.

With superphosphate at site C (experiment 4), Verano had the highest yield in both the establishment season (1 560 kg ha$^{-1}$) and the second season (2 520 kg ha$^{-1}$). At this site, yield of all lines was increased in the first two seasons by the addition of superphosphate. Legume yields under *Petalostigma banksii* trees were higher ($P < 0.01$) than in other areas throughout experiment 4 in the second season.

After six seasons without maintenance fertilizer dressings, Verano yielded 1 750 kg ha$^{-1}$ compared with 810 to 1 050 kg ha$^{-1}$ from *S. humilis* lines at site B (experiment 2). Re-establishment of other species following flooding in 1974 was erratic.

The yield of native species was highly variable between and within treatments at both sites A and B, but generally inversely proportional to legume yield. At site B, a uniform cover of native species, predominantly *Schizachyrium fragile* and *Gomphrena flaccida*, yielding 1 390 kg ha$^{-1}$, grew over all plots of experiment 2 in the establishment year. By the second season, perennial grasses (*S. plumosum* and *C. fallax*) contributed to the native species yield which varied from 350 to 1 640 kg ha$^{-1}$ between treatments.

Mean yield of native species at site A (experiment 3) in the first and second seasons was 980 and 1 320 kg ha$^{-1}$ respectively.

TABLE 4

*Dry matter yield of* Stylosanthes ('000 *kg ha*$^{-1}$) *at the end of each growing season in the four experiments*

| Harvest | | Experiment 1 | | | Experiment 2 | | | Experiment 3 | | | Experiment 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | April 1970 | May 1971 | May 1972 | May 1972 | May 1973 | May 1977 | May 1972 | May 1973 | May 1974 | April 1976 | | May 1977 | |
| | | | | | | | | | | | +P | —P | +P | —P |
| *S. humilis* | Lawson | | | | 1.4 | 3.4 | 0.9 | 4.0 | 4.5 | 4.3 | | | | |
| *S. humilis* | Paterson | | | | 0.2 | 0.4 | 0.8 | 1.9 | 3.4 | 6.4 | | | | |
| *S. humilis* | Gordon | | | | 0.4 | 1.0 | ‡ | 5.2 | 5.5 | 8.0 | | | | |
| *S. humilis* | Greenvale | 4.4 | 4.1 | 4.7 | 1.1 | 2.6 | 1.0 | 3.8 | 4.4 | 4.7 | | | | |
| *S. humilis* | Commercial | | | | | | | | | | 0.8 | 0.3 | 1.6 | 0.5 |
| *S. humilis* | 40278 | 0.2 | 4.9 | 7.2 | | | | | | | | | | |
| *S. subsericea* | 38605 | ‡ | 0.1 | ‡ | 0.1 | 0.7 | ‡ | 2.4 | 4.9 | ‡ | | | | |
| *S. viscosa* | 34904 | | | | | | | | | | 0.3 | ‡ | ‡ | ‡ |
| *S. viscosa* | 33941 | | | | ‡ | 1.4 | ‡ | 0.8 | 4.5 | 4.3 | | | | |
| *S. viscosa* | 40264 | | | | | | | | | | 0.1 | ‡ | ‡ | ‡ |
| *S. scabra* | Q8240 | ‡ | 6.2 | 17.2 | 0.4 | 0.7 | ‡ | 1.3 | 10.7 | 5.4 | 0.2 | ‡ | 1.2 | ‡ |
| *S. scabra* | 34925 | | | | 0.1 | 1.3 | ‡ | 0.7 | 12.0 | 4.9 | 0.3 | ‡ | 0.9 | 0.1 |
| *S. scabra* | 40205 | | | | | | | | | | 0.3 | ‡ | 1.8 | 0.5 |
| *S. scabra* | Seca | | | | | | | | | | 0.7 | ‡ | 2.1 | 0.5 |
| *S. hamata* | Verano | | | | 0.3 | 4.0 | 1.7 | 4.4 | 8.6 | 8.3 | 1.6 | 0.3 | 2.5 | 1.0 |
| *S. guianensis* | 40255 | | | | | | | | | | 0.8 | 0.2 | ‡ | ‡ |
| *S. guianensis* | Cook | | | | 0.1 | 0.3 | ‡ | 0.1 | ‡ | ‡ | | | | |
| *S. guianensis* | Endeavour | | | | 0.1 | 0.4 | ‡ | 0.9 | 0.6 | ‡ | | | | |
| *S. guianensis* | 34911 | | | | ‡ | 0.7 | ‡ | 0.4 | 1.4 | ‡ | | | | |
| *S. guianensis* | 38357 | 0.3 | 0.5 | ‡ | | | | | | | | | | |
| *S. guianensis* | 40568 | 0.3 | 1.3 | ‡ | | | | | | | | | | |
| *S. guianensis* | 33437 | ‡ | 1.2 | 4.0† | | | | | | | | | | |
| L.S.D. P=0.05 | | 0.4 | 3.0 | NA | 0.4 | 1.6 | NA | 2.3 | 3.5 | 2.7 | 0.5 | | 0.7 | |

‡Yield less than 50 kg ha$^{-1}$
†Heavily contaminated with *S. humilis*
NA=Not analyzed

*Nitrogen and phosphorus contents*

Nitrogen content (Table 5) of whole plant material was less than 2.0% for most species at all sampling times in the four experiments. *S. scabra* CPI 34925 and *S. guianensis* 34911, 40255 and Endeavour occasionally contained 2.1% nitrogen.

Phosphorus content of whole plant material of all lines at flowering ranged from 0.03 to 0.14%, with the majority in the range 0.07 to 0.10%, for the duration of the four experiments. Verano and Seca had consistently low phosphorus levels, from 0.03% to 0.09%. At site C (experiment 4) phosphorus levels of Verano and Seca were not affected in the second season by establishment superphosphate, whereas the phosphorus content of *S. scabra* Q8240, CPI 40205 and 34925 and commercial *S. humilis*, was increased ($P < 0.05$).

After six seasons without maintenance fertilizer at site B (experiment 1), *S. humilis* lines were maintaining consistent nitrogen and phosphorus contents, 1.76% and 0.08% respectively, while Verano had lower levels of 1.24% N and 0.04% P.

In the first season after cultivation, native species had 0.35% N and 0.07% P at site B (experiment 2) and 1.15% N and 0.12% P at site A (experiment 3). These differences are attributed to species composition. At site B, native species were *S. fragile* and *G. flaccida*, while at site A there was a high proportion of the vines *Vigna canescens* and *Polymeria longifolia* with *Aristida* spp.

By the second season, grasses were predominant in the native species component at both sites. Nitrogen and phosphorus contents were 0.59% and 0.09% respectively at site A, and 0.45% and 0.07% respectively at site B.

Nitrogen and phosphorus yields were correlated with dry matter yields at most sampling times. Exceptions were in experiment 2 where *S. scabra* Q8240 in 1972 and *S. viscosa* CPI 33941 in 1973 had higher nitrogen and phosphorus yields than indicated by dry matter alone. Also, in 1977, there were no differences in nitrogen and phosphorus yields between Verano and *S. humilis* lines as the higher yielding Verano had lower nitrogen and phosphorus contents.

*Response to soil type*

Dry matter yields of legume were higher ($P < 0.01$) on the sandy yellow earth (site A) than on the mottled grey earth (site B) for the first two seasons in experiments 2 and 3, although there were no differences in overall plant populations in the 1972 establishment year.

In the establishment year and in the second season, overall phosphorus content of the 12 lines (experiments 2 and 3) was higher ($P < 0.05$) at site A (0.098% and 0.087% respectively) than at site B (0.077% and 0.058% respectively). There were no differences in overall nitrogen content between sites in the first season; however, in the second season, the lower yielding stylos on the grey earth had a higher nitrogen content (1.58%) than did the same lines on the yellow earth (1.42%).

## DISCUSSION

In these experiments *S. humilis* yields of 4 000 to 8 000 kg ha$^{-1}$ on the fertilized sandy yellow earth were well below the 10 000 kg ha$^{-1}$ recorded by Jones (1973) on a well fertilized deep siliceous sand on Cape York Peninsula. These yields however, compare well with the highest yield (3 100 kg ha$^{-1}$), recorded from 10 lines (including Greenvale) grown in the Normanton district on a grey earth in 1966 and 1967 (Cameron *et al.* 1977) and exceed those recorded on a low fertility sandy loam near Townsville in 1965 and 1966 (Cameron 1967). It would appear that if early flowering lines experience moisture stress from March onwards seed production and subsequent regeneration are reduced. It is noticeable that the late flowering cv. Gordon had disappeared from the grey earth by the sixth year.

TABLE 5

*Nitrogen content of* Stylosanthes *species at the early flowering stage of growth in the four experiments*

| Legume | | 1 | 2 | | | 3 | | | 4 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1972 | 1972 | 1973 | 1977 | 1972 | 1973 | 1974 | 1976 +P | 1976 —P | 1977 +P | 1977 —P |
| *S. humilis* | Lawson | | 1.7 | 1.3 | 1.8 | 1.6 | 1.2 | 1.8 | | | | |
| *S. humilis* | Paterson | | 1.9 | 1.9 | 2.0 | 2.0 | 1.5 | 1.7 | | | | |
| *S. humilis* | Gordon | | 1.8 | 1.6 | – | 1.7 | 1.5 | 1.8 | | | | |
| *S. humilis* | Greenvale | 1.6 | 2.0 | 1.3 | 1.9 | 1.6 | 1.4 | 1.7 | | | | |
| *S. humilis* | Commercial | | | | | | | | 1.8 | 1.9 | 1.7 | 1.5 |
| *S. humilis* | 40278 | 1.2 | | | | | | | | | | |
| *S. subsericea* | 38605 | | 1.8 | 1.9 | – | 1.8 | 1.6 | – | | | | |
| *S. viscosa* | 34904 | | | | | | | | 1.9 | 1.5 | – | – |
| *S. viscosa* | 33941 | | 1.9 | 1.9 | – | 2.0 | 1.7 | 1.7 | | | | |
| *S. viscosa* | 40264 | | | | | | | | 1.8 | – | – | – |
| *S. scabra* | Q8240 | 1.6 | 1.9 | 1.8 | – | 1.8 | 1.2 | 1.9 | 1.8 | – | 1.6 | 1.7 |
| *S. scabra* | 34925 | | 1.8 | 1.3 | – | 1.9 | 1.3 | 2.1 | 2.0 | 1.4 | 2.0 | 2.0 |
| *S. scabra* | 40205 | | | | | | | | 1.7 | – | 1.7 | 1.4 |
| *S. scabra* | Seca | | | | | | | | 1.4 | 1.8 | 1.2 | 1.1 |
| *S. hamata* | Verano | | 1.6 | 1.3 | 1.2 | 1.7 | 1.3 | 1.6 | 1.7 | 1.5 | 1.4 | 1.3 |
| *S. guianensis* | 40255 | | | | | | | | 1.9 | 2.2 | – | – |
| *S. guianensis* | Cook | | 1.9 | 1.4 | – | 1.7 | – | – | | | | |
| *S. guianensis* | Endeavour | | 1.7 | 1.6 | – | 2.1 | 1.5 | – | | | | |
| *S. guianensis* | 34911 | | 1.8 | 1.5 | – | 2.1 | 1.5 | – | | | | |
| *S. guianensis* | 33437 | 1.5 | | | | | | | | | | |
| L.S.D. (P=0.05) | | NA† | NS | NS | | 0.4 | NS | NS | NA† | | 0.4 | |

– Negligible material, not analyzed.
† Samples bulked and not statistically analyzed.

The *S. guianensis* lines failed to persist into the third season. Also they did not yield well in the first two seasons, so must be considered unsuited to the southern Gulf environment. Similarly *S. subsericea*, which yielded over 2 400 kg $ha^{-1}$ in each of the first two years, failed to appear in the third season. It is believed that a combination of a fire across the experiment in the 1973 dry season and the disease *Colletotrichum gloeosporioides* may have been responsible for its disappearance. It has been heavily affected by this disease elsewhere in North Queensland (Anning 1977).

*S. viscosa* lines were slow to establish in the first season on both soil types (experiments 2, 3 and 4); however, CPI 33941 yielded well in the second and third seasons and has some potential. In particular it had comparatively high N and P contents and was the first species to re-establish in experiment 2 following the deep flood of January 1974. This species has a short growth habit and could be adversely affected by competition from the taller growing native grasses.

Perhaps the most outstanding species grown was *S. scabra.* The lines of this species were not seriously affected by mid-dry season fires for the first three years in experiment 3, although a hot fire in October of the fourth year killed most of the original plants. On this occasion there was a high fuel load of native grass around the plots and only the tops of the *S. scabra* had been grazed. On the other hand, the Verano and *S. humilis* plots had been heavily grazed and were not burnt.

The lower yields of the two *S. scabra* lines in 1974 (experiment 3) compared with 1973 were due to a modified sampling technique. Only new season's material above 30 cm was harvested where previously young plants were clipped at 10 cm. Stems above 30 cm were suitable for grazing.

Differences in yields between the two soil types are hard to explain. The deep sandy yellow earth (experiment 3) produced higher legume yields than the mottled grey earth (experiment 2) in the above average rainfall of the establishment year (1971–72) and again in the slightly below average second season. This contrasts with the *S. humilis* yields reported by Bishop (1974b) for the well below average rainfall years of the late 1960s, when the reverse applied. In the present experiments rainfall was adequate and soil moisture not limiting for the main growing season (February–April) on either soil. It is unlikely that the cultural differences in seedbed preparation would have influenced the second year yields; mature plant populations at the end of the first growing season were similar on both soils.

Phosphorus fertilizer appears to be necessary for establishment and growth of these introductions on these soils. This was demonstrated by the significant yield response from all surviving species in the second year of experiment 4 and the limited spread of any species from the fertilized plots.

A long residual effect of phosphorus was obtained when Verano, for example, was still able to yield 1 750 kg $ha^{-1}$ in the sixth year on the grey earth.

Phosphorus deficiency may still occur in cattle grazing these stylo pastures. The phosphorus content of tops at early flowering, in these experiments, was less than 0.15%. At most samplings, phosphorus was around 0.1% which is well below the growth requirements of beef cattle (National Research Council 1970) and less than levels reported by Jones (1968) for *S. humilis* on a solodic soil near Townsville. They are similar to levels recorded for *S. humilis* on the Tippera clay loam at Katherine (Norman 1965, Fisher and Campbell 1972). Nitrogen content of *S. humilis* on the Mayvale soils is similar to levels recorded for this species at Katherine (Norman 1965) and lower than levels recorded at Townsville (Jones 1968).

There are a number of environmental features that call for specific characteristics in the legumes that are likely to be of value in the livestock industries of the lower Gulf region. Perhaps the two most important hazards are disease and fire.

*C. gloeosporioides* is the most notable disease and it appeared during this study. Lesions were present on the leaves and stems of most species, but on the whole, damage to mature plants was minimal. This disease is suspected as being responsible for the disappearance of *S. subsericea*; however, restricted access to the sites during the wet season prevented a definite assessment.

Burning is an accepted management tool for the grasslands of this area. Where not purposely lit, wildfires burn most areas at least every second year. Any introduced legume should therefore have some fire tolerance. Short, leafy perennial species could be more vulnerable to fires as the tall native grasses fall over after maturity early in the dry season, creating a high fuel load near ground level.

In 1977, some mature *S. scabra* plants died through a combination of fire killing tops, and larvae of an unidentified species of the *Cerambycidae* family eating the centres of roots and lower stems.

Spread from the fertilized plots has been negligible although a few *S. scabra* plants established outside the areas of experiments 2 and 3. Naturalized *S. humilis* has spread rapidly under heavy grazing on shallow duplex soils close to Normanton and Croydon in the above average wet seasons of the 1970s; however, there has been very little spread away from roadsides on well grassed sandy soils of the Mayvale land system. The author has observed *S. scabra* CPI 40205 and cv. Seca to spread down shallow watercourses in other areas of sandy soils in the region. The higher legume yields under *P. banksii* trees in both nil and added phosphorus plots in experiment 4 suggest that these microhabitats could be used to assist initial legume establishment.

The time of the year when individual species are most valuable will differ markedly. Verano, which generally behaves as an annual in this area, and *S. humilis* are relatively palatable even towards the end of the growing season, and would be suited to selected paddocks where grass and legume grazing could be controlled, as required, to maintain a stable pasture. Leaf fall and the low nutritive value of old mature stems of these species, indicate that grazing should commence well before mid-year. This is before the period when nutritional supplements are usually required to maintain cattle weights. On the other hand, *S. scabra*, which is a tall woody browse shrub, appears the type of plant most suited to the extensive cattle husbandry practices currently used in the sandy forest country. It is of low palatability until the mid-dry season and able to retain green leaf throughout the year, so is available for grazing much further into the dry. It has the ability to make new growth in early spring after grazing, and was the only species to show some spread from plots. Furthermore, the species has an ability to establish on a wide range of light textured soils around the southern Gulf when planted with superphosphate on undisturbed surfaces (Hall unpublished). The successful establishment of *S. scabra* lines after early wet season planting on both burnt and unburnt country in the Mayvale land system supports results from Katherine. There, Miller and Perry (1968) demonstrated that *S. humilis* can be established on untreated soil surfaces in uncleared annual or perennial native pastures, given favourable weather conditions.

Dicotyledonous weeds were not a problem in the fertilized experimental areas. Weed species, such as *Hyptis suaveolens, Crotalaria* spp. and *Sida* spp. which occur on loamy river frontages of the Gulf, particularly after fertilizing with superphosphate (Hall unpublished), did not appear in these experiments. *Melaleuca viridiflora* seedlings established on the sandy yellow earth (experiment 3) and seedlings of *M. viridiflora, M. symphocarpa* and *Eucalyptus microtheca* grew in cleared and cultivated plots on the grey earth (experiments 1 and 2). No weeds or tree seedlings grew on the undisturbed grey earth (experiment 4).

The two soil types in these experiments are similar physically and nutritionally to a wide range of soils in the southern Gulf. Consequently Verano, and some lines of *S. scabra, S. viscosa* and *S. humilis* which are well adapted to the Mayvale land system, could have much wider application in the region. The more productive lines now require evaluation under grazing management regimes compatible with the existing beef industry framework.

ACKNOWLEDGEMENTS

I thank Mr D. G. Cameron and Mr G. R. Lee for assistance in preparing the paper; Mr H. G. Bishop for establishing and sampling experiment 1 in the first season; Mr P. McIntyre, Mr G. Hansen and Mr D. L. Shirley for field assistance; Mr P. K. O'Rourke and Miss Janet Gowdie for statistical analyses; and Agricultural Chemistry Branch of the Queensland Department of Primary Industries for chemical analyses. Financial support obtained from the Australian Meat Research Committee is gratefully acknowledged.

REFERENCES

ANNING, P. (1977)—Observations on the performance of a range of commercial pasture plants under grazing on the friable red earths at Lakeland Downs—Cape York Peninsula 1973-1976. Queensland Department of Primary Industries Agriculture Branch Project Report No. P-5-77.

BISHOP, H. G. (1972)—Townsville stylo in the Gulf Country. *Queensland Agricultural Journal* **98**: 212-14.

BISHOP, H. G. (1974a)—Pasture investigations in the sandy forest country of north-west Queensland. 1. Nutritional requirements. *Queensland Journal of Agricultural and Animal Sciences* **31**: 329-35.

BISHOP, H. G. (1974b)—Pasture investigations in the sandy forest country of north-west Queensland. 2. Species evaluation. *Queensland Journal of Agricultural and Animal Sciences* **31**: 337-44.

CAMERON, D. F. (1967)—Flowering time and the natural distribution and dry matter production of Townsville lucerne (*Stylosanthes humilis*) populations. *Australian Journal of Experimental Agriculture and Animal Husbandry* **7**: 501-08.

CAMERON, D. F., BISHOP, H. G., MANNETJE, L. 'T, SHAW, N. H., SILLAR, D. I., and STAPLES, I. B. (1977)—The influence of flowering time and growth habit on the performance of Townsville stylo (*Stylosanthes humilis*) in tropical and sub-tropical Queensland. *Tropical Grasslands* **11**: 165-75.

FISHER, M. J. and CAMPBELL, N. A. (1972)—The initial and residual responses to phosphorus fertilizers of Townsville stylo in pure ungrazed swards at Katherine, N.T. *Australian Journal of Experimental Agriculture and Animal Husbandry* **12**: 488-94.

JONES, R. K. (1968)—Initial and residual effects of superphosphate on a Townsville lucerne pasture in north-eastern Queensland. *Australian Journal of Experimental and Animal Husbandry* **9**: 521-27.

JONES, R. K. (1973)—Studies on some deep sandy soils in Cape York Peninsula, North Queensland. 2. Plant nutrient status. *Australian Journal of Experimental Agriculture and Animal Husbandry* **13**: 89-97.

MILLER, H. P. and PERRY, R. A. (1968)—Preliminary studies on the establishment of Townsville lucerne (*Stylosanthes humilis*) in uncleared native pasture at Katherine, N.T. *Australian Journal of Experimental Agriculture and Animal Husbandry* **8**: 26-32.

NATIONAL RESEARCH COUNCIL (1970)—Nutrient Requirements of Domestic Animals 4. Nutrient Requirement of Beef Cattle. National Research Council, Washington D.C.

NORMAN, M. J. T. (1965)—The response of a Birdwood grass—Townsville lucerne pasture to phosphate fertilizers at Katherine, N.T. *Australian Journal of Experimental Agriculture and Animal Husbandry* **5**: 120-24.

PERRY, R. A., SLEEMAN, J. R., TWIDALE, C. R., PRICHARD, C. E., SLATYER, R. O., LAZARIDES, M., and COLLINS, F. H. (1964)—General report on lands of the Leichhardt - Gilbert Area, Queensland. 1953-54. C.S.I.R.O. Australia, Land Research Series No. 11.

WEBB, A. A. (1975)—Plant nutrient status of soils of the Mayvale land system, North Queensland. *Queensland Journal of Agricultural and Animal Sciences* **32**: 19-25.

WEBB, A. A., BEESTON, G. R. and HALL, T. J. (1974)—The soils and vegetation of part of the Mayvale land system in the Gulf of Carpentaria Region. Queensland Department of Primary Industries, Agricultural Chemistry Branch Technical Report No. 5.

(Accepted for publication October 19, 1978).