REFERENCES

ANNING, P. (1982)- Evaluation of introduced legumes for pastures in the dry tropics of northern Queensland. *Tropical Grasslands* **16:** 146–155.

BURT, R. L. and WILLIAMS, W. T. (1979)- Strategy of evaluation of a collection of tropical herbaceous legumes from Brazil and Venezuela. II. Evaluation in the quarantine glasshouse. *Agro-Ecosystems* **5:** 119–134.

CAMERON, D. G. and MULLALY, J. D. (1969) The preliminary evaluation of leguminous plants for pasture and forage in sub-coastal central Queensland, 1962–69. *Plant Introduction Review* **6**(2): 29–54.

CLEMENTS, R. J., WINTER, W. H. and THOMSON, C. J. (1986)—Breeding *Centrosema pascuorum* for northern Australia. *Tropical Grasslands* **20:** 59–65.

KRETSCHMER, A. E., SONODA, R. M. and SNYDER, G. H. (1980) Resistance of *Desmodium heterocarpon* and other tropical legumes to root-knot nematodes. *Tropical Grasslands* **14:** 115–120.

NORTHCOTE, K. H. (1971) "A Factual Key for the Recognition of Australian Soils". Third Edition (Rellim Technical Publications: Glenside, South Australia.

O'DONNELL, J. F. and SMITH, F. T. (1975)- Evaluation of a plant collection from South America and Africa. *Plant Introduction Review* **10**(2): 21–31.

STOCKWELL, T. G. H., CLEMENTS, R. J., CALDER, G. J. and WINTER, W. H. (1986) Evaluation of bred lines of *Centrosema pascuorum* in small plots in north-west Australia. *Tropical Grasslands* **20:** 65–69.

WINTER, W. H. (1978) Legume evaluation in N.W. Australia. CSIRO Division of Tropical Crops and Pastures Annual Report 1977 78, p. 38.

(Accepted for publication February 28, 1986)

EVALUATION OF BRED LINES OF *CENTROSEMA PASCUORUM* IN SMALL PLOTS IN NORTH-WEST AUSTRALIA

T. G. H. STOCKWELL*, R. J. CLEMENTS**, G. J. CALDER***, AND W. H. WINTER****

* Northern Territory Department of Primary Production, P.O. Box 1346, Katherine, N.T. 5780.
** CSIRO, Division of Tropical Crops and Pastures, Cunningham Laboratory, 306 Carmody Road, St. Lucia, Qld 4067.
*** Northern Territory Department of Primary Production, P.O. Box 4160, Darwin, N.T. 5794.
**** CSIRO, Division of Tropical Crops and Pastures, Darwin Laboratories, P.M.B. 44, Winnellie, N.T. 5789.

ABSTRACT

Seven bred lines and two parent accessions of Centrosema pascuorum *were grown for two years in a cutting trial at six sites in the Northern Territory and at one site near Kununurra, W.A.* Stylosanthes hamata *cv. Verano and* Macroptilium atropurpureum *cv. Siratro were included as controls at six sites. Herbage yield was measured towards the end of each wet season, and seed yields were measured during both dry seasons.*

In the first year, most C. pascuorum *lines yielded more herbage and seed than Verano and Siratro at most sites. Differences between* C. pascuorum *lines in mean herbage yield were small, but differences in seed yield were substantial. There were no line* × *site interactions for either herbage or seed yield. In the second year, however, the* C. pascuorum *lines generally gave poorer yields than Verano at each site, but again outyielded Siratro which performed poorly at all sites. There were significant* C. pascuorum *line* × *site interactions for both herbage and seed yield.*

One line, subsequently released as cv. Cavalcade, possessed a desirable combination of consistently high herbage yield over sites and years and good seed production, providing 22% more herbage (on average) and 118% more seed than its best parent.

INTRODUCTION

Centrosema pascuorum has been identified as a tropical pasture legume of considerable promise for the strongly seasonal rainfall areas of northern Australia (Winter 1978; Anning 1982; Clements *et al.* 1984), north-eastern Thailand (Topark-Ngarm and Moolsiri 1982) and several other countries in South-East Asia. It is an annual species native to Central and South America, first introduced to Australia in 1965. A breeding program conducted mainly at Katherine Research Station, N.T., from 1976 to 1981 (Clements *et al.* 1986) produced a number of elite lines for regional evaluation in north-west Australia. This paper describes the comparative performance of seven bred lines, the two best parent lines (Clements *et al.* 1984), and three widely-used commercial pasture legumes in cutting trials at seven sites in north-west Australia. The objective was to identify the best line for release to the pastoral industry.

MATERIALS AND METHODS

The following *C. pascuorum* accessions and bred lines were sown at seven sites: CPI* 40060; CPI 55697; 2/1, 2/2, 2/14, 2/19 and 2/24 (all F_7 derivatives from the cross CPI 40060 × 55697); 11/5 (from the cross CPI 55697 × Q* 9855); and 12/4 (CPI 55697 × Q10050). The parent lines Q9855 and Q10050 were not included because they were known to be too late-flowering for dryland pastures in most of the region (Clements *et al.* 1984). *Stylosanthes hamata* cv. Verano and *Macroptilium atropurpureum* cv. Siratro were included as control species at six of the seven sites, and a local variety (unnamed) of *Calopogonium mucunoides* was sown at two sites (Coastal Plains Research Station and Mt. Bundey).

The locations of the seven experimental sites, their average annual rainfalls and their soil types are detailed in Table 1. Rainfall during the experiment was similar to the average annual rainfall at each site in each wet season, except at Katherine Experiment Farm during the first wet season and at Kununurra during both wet seasons (Table 1). All sites received adequate rainfall during the establishment period, but two sites (Katherine Experiment Farm and Kununurra) received inadequate rain towards the end of the first wet season, which reduced seed yield and therefore second-year development of the stand.

TABLE 1

Details of experiment sites

Site	Location	Soil type and classification*	Rainfall (mm)		
			Long-term average	1980/81	1981/82
Coastal Plains Research Station (CPRS)	12°30′S 131°25′E	Hotham lateritic red earth, Gn 2.24	1400	1277	1250
Mt. Bundey Station	13°05′S 131°00′E	Batten massive yellow earth, Gn 2.64	1300	1403	1332
Douglas/Daly Research Farm (DD Tippera)	13°48′S 131°12′E	Tippera loamy red earth, Gn 2.11	1150	1355	1084
Douglas/Daly Research Farm (DD Blain)	13°48′S 131°12′E	Blain sandy red earth, Dr 4.51	1150	1355	1084
Katherine Experiment Farm (KEF)	14°29′S 132°15′E	Florina yellow podzolic, Gn 2.64	970	729	995
Victoria River Research Station (VRRS)	16°24′S 131°00′E	Emu loamy red earth, Gn 2.11	625	717	779
Kimberley Research Station, Kununurra	15°39′S 128°43′E	Cockatoo sandy red earth, Gn 2.11	770	554	1054

*Northcote (1971)

A completely randomised design with three replicates was used at each site. Individual plots were 3 × 3 m, with grassed pathways 3 m wide between plots. Superphosphate (250 kg ha^{-1}), muriate of potash (100 kg ha^{-1}) and zinc sulphate (7 kg ha^{-1}) were incorporated during cultivation of the seed bed at each site. No companion grass was sown, but native and volunteer grasses were allowed to invade. The sowing rate for all legumes was 5 kg viable seed ha^{-1}, except for *S. hamata* which was sown at 4.5 kg naked viable seed ha^{-1}. Seed was scarified to provide 92–100% soft seed, and inoculated with appropriate *Rhizobium* strains prior to sowing. The plots were sown in December–January at the beginning of the 1980/81 wet season, and the experiment continued for two years.

*CPI = Commonwealth Plant Introduction; Q = Queensland Government Introduction

Seedling establishment was measured after germinating rains each year, in one or two 0.5 × 0.5 m quadrats per plot. Herbage yield was measured once each year, towards the end of the wet season (April–May, depending on the site), by cutting two 1.0 × 0.5 m quadrats to ground level in each plot, except at Kununurra where a calibrated visual rating was employed. Dead material was removed from the plots late in the dry season when seed shattering was completed. Seed production was measured once each year, during the dry season (August), by sweeping and gathering seed from one 0.5 × 0.5 m quadrat per plot. Sieving, winnowing and flotation techniques were used to clean the seed.

In discriminating between *C. pascuorum* lines, both statistical analyses and ranking procedures were used. The lines were ranked from 1 (best) to 9 (worst) for each character at each site, and the mean rank of each line for each character was determined by adding its rank at each site and dividing by the number of sites.

RESULTS

Initial establishment varied between sites, ranging from poor (1–7 *C. pascuorum* plants m^{-2} on the Douglas/Daly Blain site) to good (10–30 plants m^{-2} at most other sites) to excellent (20–50 plants m^{-2} at Victoria River and Mt. Bundey). Good first-year stands developed subsequently at all sites except the Douglas/Daly Blain, which was invaded by annual grasses and weeds. Regeneration at the start of the second wet season was satisfactory (generally 10–200 seedlings m^{-2}) at all sites except Kununurra and Douglas/Daly Blain.

In the first year there were no significant interactions between lines and sites for either herbage or seed yields. Mean values and significant differences between *C. pascuorum* lines are therefore presented (Table 2). Seed yield varied more widely among *C. pascuorum* lines than did herbage yield. Line 2/2 had the second highest mean seed yield (and the best mean rank); it yielded 52% more seed than its female parent CPI 55697 and significantly more seed than the two lines (11/5 and 12/4) which had the highest herbage yields. Verano and Siratro were not included in the statistical analysis because they were not sown at all sites. They had lower herbage and seed yields than most *C. pascuorum* lines at most sites.

During the second year there were significant line × site interactions for both herbage and seed yield. Line 2/2 had the second highest mean herbage yield (3.1 t ha^{-1})

TABLE 2

Yields of herbage and seed of nine C. pascuorum *accessions,* S. hamata *cv. Verano and* M. atropurpureum *cv. Siratro during the establishment year.*
(Means over six sites in the Northern Territory and one site at Kununurra, W.A.)

Line	Herbage yield		Seed yield	
	(t ha^{-1})	mean rank +	(kg ha^{-1})	mean rank +
2/1	2.23 abc	5.3	221 ab	4.0
2/2	2.42 ab	4.3	243 a	3.1
2/14	2.12 bc	5.3	249 ab	3.7
2/19	2.13 bc	6.1	197 bcd	6.4
2/24	2.15 bc	6.1	210 abcd	4.8
11/5	2.66 a	2.9	158 cd	6.8
12/4	2.48 ab	3.7	142 d	5.8
CPI 40060	1.85 c	7.0	227 abc	4.8
CPI 55697	2.44 ab	3.9	160 abcd	5.5
Siratro*	1.08	—	10	—
Verano*	1.68	—	66	—

Within columns, numbers sharing a common letter do not differ significantly after square root transformation.
*Data for Siratro and Verano are included in the Table for comparison, but were excluded from the statistical analysis because they were not sown at all sites.
+ Low rank numbers denote good overall performance.

and the best mean rank (Table 3), and was the only line to yield at least 2.0 t ha^{-1} at every site. On average it outyielded its parent CPI 55697 by 22% and CPI 40060 by 40%. It also outyielded calopo and Siratro at the sites where they were sown. No. *C. pascuorum* line produced as much herbage as Verano.

TABLE 3

Herbage yields of nine C. pascuorum *accessions,* S. hamata *cv. Verano,* M. atropurpureum *cv. Siratro and* C. mucunoides *(calopo) at six sites in the Northern Territory during the second wet season (1981/82).*

Line	Herbage yield (t ha^{-1})							Mean rank +
	CPRS	Mt Bundey	DD Tippera	KEF	VRRS	DD Blain	Mean	
2/1	0.3 cd	1.6 ab	6.2 a	1.6 ab	1.0bc	3.7 abc	2.40 bcd	6.7
2/2	3.0 ab	2.1 a	3.8 a	3.4 a	2.6 ab	3.6 ab	3.10 a	3.7
2/14	0.3 cd	0.7 bc	4.2 a	1.4 ab	3.0 ab	3.0 abcd	2.10 d	7.0
2/19	0.4 cd	2.1 a	4.5 a	2.7 ab	0.6 c	2.9 abcd	2.21 cd	5.1
2/24	0.7 cd	2.1 a	4.8 a	4.1 a	1.6 abc	1.2 bcd	2.42 abcd	4.7
11/5	2.3 bc	2.1 a	5.5 a	1.6 ab	3.2 ab	2.9 abcd	2.93 abc	4.3
12/4	0.4 cd	1.7 a	5.4 a	3.0 ab	3.8 a	5.1 a	3.23 ab	4.0
CPI 40060	0.8 cd	1.8 a	5.9 a	1.9 ab	1.8 abc	1.1 cd	2.22 bcd	5.1
CPI 55697	0.6 cd	2.1 a	5.7 a	2.3 ab	0.4 c	4.2 a	2.55 abcd	4.8
Siratro	—	0.2 c	1.0 b	1.2 b	0.5 c	0.8 d	0.72	—
Verano	5.2 a	—	6.2 a	2.4 ab	3.6 a	5.2 a	4.55	—
Calopo	1.7 bcd	1.3 ab	—	—	—	—	—	—

Within columns, numbers sharing a common letter do not differ significantly after square root transformation.
+ Low rank numbers denote good overall performance.

The site interaction with seed yields in the second year (Table 4) was caused partly by wide fluctuations in the ranking of several lines (notably 12/4, 11/5 and 2/1, and to a lesser extent CPI 40060, 2/14 and CPI 55697). Line 2/2 had the most stable seed yield, highest mean seed yield (253 kg ha^{-1}), best mean rank, and was the only line to yield at least 100 kg seed ha^{-1} at every site. On average it outyielded CPI 55697 by 134%, CPI 40060 by 118%, and Verano by 300%. (The comparison with Verano should be interpreted with caution because Verano has much smaller seeds). Line 2/2 had higher seed yields than Siratro and calopo at all sites on which they were sown.

TABLE 4

Seed yields of nine C. pascuorum *accessions,* S. hamata *cv. Verano,* M. atropurpureum *cv. Siratro and* C. mucunoides *(calopo) at five sites in the Northern Territory during the second dry season (1982).*

Line	Seed yield (kg ha^{-1})						Mean rank +
	CPRS	Mt Bundey	DD Tippera	KEF	VRRS	Mean*	
2/1	42 cd	104 ab	343 a	106 ab	87 de	136 abc	5.4
2/2	385 a	124 a	403 a	118 ab	236 bcd	253 a	2.2
2/14	113 bc	39 bcd	363 ab	121 ab	538 ab	235 ab	4.0
2/19	46 bcd	76 ab	162 abc	108 ab	55 de	89 c	6.4
2/24	134 bc	79 ab	281 abc	121 a	182 cd	159 abc	4.0
11/5	270 ab	53 ab	117 bcd	16 bc	464 abc	184 abc	5.9
12/4	56 bcd	73 abc	150 abc	50 abc	802 a	226 abc	5.8
CPI 40060	156 abc	102 ab	69 cd	76 ab	176 cd	116 abc	5.6
CPI 55697	84 bcd	53 abc	243 abc	124 a	34 de	108 c	5.7
Siratro	—	4 cd	6 d	1 c	7 e	4	—
Verano	116 bc	—	83 cd	44 abc	88 de	83	—
Calopo	3 d	2 d	—	—	—	—	—

Within columns, numbers sharing a common letter do not differ significantly after square root transformation.
*Data from the Douglas/Daly Blain site are excluded; seeds were almost completely destroyed by fire during the dry season.
+ Low rank numbers denote good overall performance.

DISCUSSION

This experiment confirms results obtained during the breeding program at a single site (Clements *et al.* 1986), and shows that several bred lines of *C. pascuorum* have higher and more consistent herbage and seed yields than their parents during the first two years after sowing. Line 2/2 (recently released as cv. Cavalcade) was the best line both in this experiment and in the final stages of the breeding program (Clements *et al.* 1986). CPI 40060 and 55697, the parents of 2/2, were previously identified as the best of the small number of *C. pascuorum* accessions that had been introduced by 1976 (Clements *et al.* 1984, 1986).

In contrast to previous experience at Katherine (Clements *et al.* 1984), *C. pascuorum* lines did not yield as much herbage as *S. hamata* cv. Verano during the second growing season. This result was consistent at most sites (the Florina soil type at Katherine Experiment Farm was a possible exception) and was particularly obvious at Coastal Plains Research Station. There appears to be a trend for *C. pascuorum* to perform relatively worse on the poorer types of soil, and this needs further study. Burt *et al.* (1979) reported that in north-eastern Brazil, *C. pascuorum* was found mainly on the more fertile soils.

C. pascuorum is clearly worthy of attention from pasture agronomists in the Northern Territory and other areas having a similar climate. It is widely adapted in the Top End of the Northern Territory and has excellent seed production characteristics which should reduce seed costs and aid regeneration under grazing. Research on establishment, fertilizer requirements, grazing management, animal production and long-term persistence is needed.

ACKNOWLEDGEMENTS

We thank Mr. C. J. Thomson and Mr. A. C. Brooks (CSIRO) and Mr. D. Cooke and Mr. J. G. L. Koomen (NTDPP) for their able technical assistance. Mr. L. J. Phillips (CSIRO) multiplied seed of *C. pascuorum* lines for this experiment. CSIRO staff were supported financially by the Australian Meat Research Committee.

REFERENCES

ANNING, P. (1982) Evaluation of introduced legumes for pastures in the dry tropics of northern Queensland. *Tropical Grasslands* **16:** 146–155.

BURT, R. L., ISBELL, R. F. and WILLIAMS, W. T. (1979) Strategy of evaluation of a collection of tropical herbaceous legumes from Brazil and Venezuela. I. Ecological evaluation at the point of collection. *Agro-Ecosystems* **5:** 99–117.

CLEMENTS, R. J., WINTER, W. H. and REID, R. (1984) Evaluation of some *Centrosema* species in small plots in northern Australia. *Tropical Grasslands* **18:** 83–91.

CLEMENTS, R. J., WINTER, W. H. and THOMSON, C. J. (1986)—Breeding *Centrosema pascuorum* for northern Australia. *Tropical Grasslands* **20:** 59–65.

NORTHCOTE, K. H. (1971) "A Factual Key for the Recognition of Australian Soils". Third Edition. (Rellim Technical Publications: Glenside, South Australia.)

TOPARK-NGARM, A. and MOOLSIRI, A. (1982) Forage yield and perenniality of new introduced twining pasture legumes. II. Performance in the second year. Khon Kaen University Pasture Improvement Project Annual Report for 1981–82, pp. 13–16.

WINTER, W. H. (1978) Legume evaluation in N.W. Australia. CSIRO Division of Tropical Crops and Pastures Annual Report 1977–78, p. 38.

(Accepted for publication February 27, 1986)

USE OF FIRE FOR SPELLING MONSOON TALLGRASS PASTURE GRAZED BY CATTLE

M. H. ANDREW

C.S.I.R.O. Division of Tropical Crops and Pastures, Darwin Laboratories, PMB 44, Winnellie, N.T., 5789, Australia

ABSTRACT

Continuous grazing of preferred patches in set-stocked, unburnt pastures of native monsoon tallgrass results in the death of the perennial grass plants within several years. In paddocks of this pasture type at Katherine, N.T., in which half of each paddock was burnt in rotation each dry season, cattle strongly preferred to graze in those halves which had