ISSN 0159-6-71
ISBN 0 643 05914 8

Genetic Resources Communication
No. 31, 1999

Evaluation of introduced grasses and legumes for potential as sown forage at Narayen Research Station, subcoastal southeast Queensland, 1970-80

R.W. Strickland, R.G. Greenfield and D. Ratcliff

CSIRO Tropical Agriculture, 306 Carmody Road, St Lucia, Qld 4067, Australia

Evaluation of introduced grasses and legumes for potential as sown forage at Narayen Research Station subcoastal southeast Queensland, 1970-80

R.W. Strickland [1,2], R.G. Greenfield[1] and D. Ratcliff[3]

[1] *CSIRO Tropical Agriculture, Cunningham Laboratory, St. Lucia, Queensland, Australia.*

[2] *Present Address: 10 Finch Court, Albany Creek, Qld.4035 , Australia.*

[3] *CSIRO Mathematical and Information Sciences, St. Lucia, Queensland, Australia.*

Abstract

The adaptation of 100 legumes and 62 grasses to speargrass and brigalow soils at Narayen Research Station in subcoastal southeast Queensland was investigated in a series of experiments over the period 1970-80. Adaptation was determined by comparing persistence, spread and yield over several growing seasons.

No legume yielded more than Siratro (*Macroptilium atropurpureum* cv. Siratro) on either soil, but accessions of *Chamaecrista* and *Vigna* with similar yield had better persistence and spread on the speargrass soil. On the brigalow soil, accessions of *Macroptilium*, *Macrotyloma* and *Vigna* had the best persistence and seedling regeneration but lower yields than Siratro.

Accessions of several grasses, particularly *Chloris gayana*, *Digitaria milanjiana* and *D. eriantha* were as persistent but higher yielding than the accepted cultivars for the region, Biloela and Gayndah buffel grass and Petrie green panic.

Keywords

tropical grasses, tropical legumes, pasture, forage, adaptation

Introduction

Up to 1970, pasture research on speargrass and brigalow lands in southern Queensland indicated that rhodes grass (*Chloris gayana*) and buffel grass (*Cenchrus ciliaris*) were the most persistent and productive grass species on lighter textured soils, and green panic (*Panicum maximum* var. *trichoglume*) on the heavier textured soils (Eyles *et al.* 1985). Siratro was the most widely adapted, persistent legume under grazing on the lighter soils, even though lucerne (*Medicago sativa*) and finestem stylo (*Stylosanthes hippocampoides*) did persist in some regions. No herbaceous legume persisted on the heavier textured soils.

The work reported here investigated the adaptation of 100 herbaceous legume accessions and 62 grass accessions to the light textured (speargrass) and heavier textured (brigalow) soils at the CSIRO Narayen Research Station, in order to broaden the range of cultivars available for use on these soils.

Five experiments were conducted over the period 1970-1980. Two have already been published (Strickland and Haydock 1978; Strickland and Ford 1984), and the details of the remaining three experiments are presented here with some comment on potential new cultivars.

Correspondence: Dr B.C. Pengelly, CSIRO Tropical Agriculture, Cunningham Laboratory, 306 Carmody Road, St Lucia, Qld 4067, Australia, e-mail: bruce.pengelly@tag.csiro.au

Materials and Methods

Environment

Rainfall and frost incidence for the period 1970-80 are given for both sites in Table 1.

Table 1. Monthly rainfall (mm) and number of frosts during the months specified for the period 1969-1980 at Narayen. Light frost = grass minimum temperature of 1.9 to 0.1°C; heavy frost = 0°C or less. October-May rainfalls in bold type are above average.

	Months												Total
Year	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Oct-Mar
Rainfall													
Average[*]							(mm)						
	38	27	34	54	77	101	107	94	74	38	38	40	507
Speargrass													
1969/70	31	14	5	142	88	79	105	81	58	17	10	20	**553**
1970/71	0	9	49	63	29	207	121	345	12	9	12	19	**777**
1971/72	3	49	36	50	27	73	124	80	59	40	39	32	413
1972/73	1	15	0	130	99	15	138	130	53	1	31	28	**565**
1973/74	83	62	72	16	106	160	175	31	32	39	30	17	**520**
1974/75	12	59	51	63	114	52	51	109	37	17	0	33	426
1975/76	32	32	30	117	43	190	132	68	55	47	30	6	**605**
1976/77	29	6	46	62	116	61	80	49	73	25	119	6	441
1977/78	0	4	12	3	120	27	134	35	8	54	24	50	327
1978/79	84	105	55	22	99	71	20	69	58	26	17	37	339
1979/80	3	14	15	71	61	50	126	39	39	1	41	1	386
Brigalow													
1969/70	12	25	9	98	60	29	137	89	90	12	4	22	503
1970/71	0	11	50	89	37	103	85	363	25	9	16	21	**702**
1971/72	3	48	36	51	46	98	70	91	31	44	34	36	396
1972/73	1	8	0	166	92	9	102	116	62	1	23	25	**547**
1973/74	100	67	66	20	98	176	235	40	73	70	46	13	**642**
1974/75	11	72	52	48	110	62	42	99	35	5	0	31	396
1975/76	41	42	30	94	47	274	120	54	110	43	29	7	**699**
1976/77	27	7	42	61	132	56	81	57	78	28	113	7	465
1977/78	0	5	1	2	92	13	47	46	5	59	27	44	205
1978/79	70	109	57	6	86	73	16	100	87	22	18	42	368
1979/80	2	15	19	50	56	57	93	76	40	0	52	5	372

Frost

	Speargrass			Brigalow		
Year	Months	Light	Heavy	Months	Light	Heavy
1970	May-Sep	24	59	Apr-Sep	20	58
1971	May-Sep	28	34	May-Sep	30	36
1972	Apr-Sep	36	38	Apr-Oct	26	78
1973	May-Sep	13	10	May-Oct	31	22
1974	May-Sep	21	44	May-Oct	26	77
1975	May-Oct	28	22	May-Oct	22	60
1976	Apr-Oct	22	51	Apr-Oct	27	67
1977	May-Sep	14	28	May-Oct	30	76
1978	May-Sep	14	28	Apr-Oct	23	37
1979	May-Sep	20	34	May-Oct	30	60
1980	Jun-Sep	16	31	Jun-Sep	19	50

[*] Average from Hawkwood Post Office and Delubra 1887-1967, from Cook and Russell (1983)

Narayen Research Station (25°41'S, 150°52'E) is located 60 km west of Mundubbera, approximately 480 km north west of Brisbane. The speargrass soil is a podzolic with gritty coarse loamy sand to sandy loam surface, overlying clay subsoils at 30-50 cm depth, pH 6.0-7.0, relatively low in organic matter, deficient in N, P, S and Mo, but with an adequate level of K. The brigalow soil is volcanic (andesitic) red loam to clay at the surface to clay at 20 cm depth, pH 7.0-8.0 at the surface to pH 9.0 at shallow depth (10-20 cm).

N content is high, and P and K levels are moderate. The Narayen brigalow soils have been described in detail by Thompson (1998).

Accessions

The accessions used in the three experiments are listed in Tables 2-5, together with information on their origin, dry matter yields, and other agronomic information peculiar to each experiment. All experiments included cultivars, adapted to the region and in widespread commercial use in the 1980s, as standards.

Design and statistical analyses

A randomised block design was used for each experiment, with three replicates on each site in experiment 1, four replicates on each site in experiment 2, and three replicates on speargrass only in experiment 3. The analyses of variance used log transformed, weighted means of the cut samples ($g/2m^2$) in experiments 1 and 3, and untransformed yield ratings in experiment 2. Analyses were restricted to those accessions which persisted for four years on speargrass soil and three years on brigalow soil in experiment 1, and those which grew in two or more replicates in experiment 2.

The harvest (or year) x accession interaction in each experiment was investigated by regressing the mean yield of an accession against the mean yield for all accessions at each harvest – the fitted linear regression representing the average reaction of an accession to the changing "environmental conditions" (growing periods between harvest dates), as measured by the overall mean yield of all accessions. Accessions characterised by regression coefficients of the order of 1.0 have average stability over all environments (growing periods), those with coefficients greater or smaller than 1.0 have below or above average stability respectively (Finlay and Wilkinson 1963).

The slopes of the regression lines were compared for equality (homogeneity). Significant differences between them ($P<0.001$) indicated that some accessions showed different proportional responses to environmental change.

Experiment 1

The aim of this experiment was to compare the adaptation of 26 legumes and 24 grasses to speargrass and brigalow soils at Narayen.

Accessions

The accessions used in this experiment are listed in Table 2, together with information on their origin, establishment, persistence, spread and yield on each soil type.

Fertiliser

A standard basal fertiliser application of 500 kg/ha of a mixed fertiliser, containing 8.3, 8.3, 9.9 and 0.2 per cent N, P, K and Mo respectively, was incorporated into the speargrass soil before sowing. The area was top-dressed with 250 kg/ha superphosphate in September 1971 and 1972, and nitrogen (as urea) was applied to grasses only at the rate of 56 kg/ha in September and 56 kg/ha in February each year. No fertiliser was applied to the brigalow soil.

Management

Plots (2m x 8m on the speargrass site and 2m x 6m on the brigalow site) were sown with 30 germinable seeds per square metre on 17 and 18 January, 1970. The sites had been cultivated to a fine seed bed. Seed was hand broadcast onto the soil surface and covered by light raking. All legume seeds were hand scarified by sandpaper and inoculated with the appropriate rhizobia prior to sowing.

Table 2. The accessions used in experiment 1, their accession number (CPI), country of origin (Or), establishment (Est) rating (1=poor, 2=fair, 3=good), persistence (Per) - number of seasons observed in more than one replicate, spread (Spr) - 1-poor, 2=fair, 3=good, mean yield (yield as log g/2m^2), and mean coefficients (b) for the regression of accession means (logs) on overall mean (logs) on speargrass and brigalow soils.

		Speargrass						Brigalow				
Species	CPI	Or	Est	Per	Spr	Yield	b	Est	Per	Spr	Yield	b
Legumes												
Aeschynomene falcata cv. Bargoo		Par	3	4	2	1.85**	2.9*	1	-	-	-	-
Alysicarpus ovalifolius	CQ512	Aus	2	1	-	-	-	-	-	-	-	-
Chamaecrista rotundifolia cv. Wynn		Bra	3	4	3	2.13**	-0.8	1	-	-	-	-
Crotalaria rhodesiae	18417	Zam	-	-	-	-	-	-	-	-	-	-
Centrosema virginianum	33808	Mex	2	4	1	2.08**	0.9	1	-	-	-	-
Desmanthus virgatus	30205	Ind	2	2	-	-	-	1	2	-	-	-
Desmodium canum	CQ734	Aus	-	-	-	-	-	-	-	-	-	-
Desmodium tortuosum	CQ762	Aus	2	4	-	2.33*	4.2*	1	-	-	-	-
Indigofera nummulariifolia	40762	Sud	-	-	-	-	-	-	-	-	-	-
Macroptilium atropurpureum	18556	Arg	2	4	3	2.30	-1.0	1	2	-	-	-
M. atropurpureum cv. Siratro		Aus	3	4	3	2.61**	1.0	1	2	-	-	-
Macroptilium bracteatum	27404	Bra	2	4	2	2.35**	3.7*	1	-	-	-	-
Macroptilium lathyroides	30229	Ind	3	4	3	2.29	-2.8**	1	-	-	-	-
M. lathyroides cv. Murray		Aus	3	4	3	2.30	1.8	1	2	-	-	-
Macrotyloma africanum	24972	Zam	3	1	-	-	-	1	-	-	-	-
Macrotyloma africanum	24973	Zim	3	2	1	-	-	1	-	-	-	-
Neonotonia wightii	25702	Tan	2	2	-	-	-	1	2	-	-	-
Rhynchosia minima	33999	Cos	3	1	-	-	-	2	-	-	-	-
Stylosanthes fruticosa	25368	Zam	1	2	-	-	-	-	-	-	-	-
Stylosanthes fruticosa	41116	Swa	1	1	-	-	-	-	-	-	-	-
Stylosanthes hippocampoides	11493	Par	1	2	-	-	-	1	-	-	-	-
Stylosanthes humilis cv. Gordon		Aus	2	2	-	-	-	-	-	-	-	-
Stylosanthes macrocarpa	33832	Mex	-	-	-	-	-	-	-	-	-	-
Stylosanthes subsericea	33942	Mex	1	1	-	-	-	1	-	-	-	-
Stylosanthes viscosa	33831	Mex	1	2	-	-	-	1	-	-	-	-
Vigna sp.	17859	Ken	3	2	-	-	-	1	-	-	-	-
General means						2.25	1.0					
L.S.D. between accession means	(P<0.05)					0.11	3.6					
	(P<0.01)					0.16	4.8					
Grasses												
Andropogon gayanus	43156	Nig	1	1	-	-	-	1	1	-	-	-
Cenchrus setigerus	17655	Ken	2	4	-	1.84**	1.05	3	3	-	1.47	1.04
Cenchrus ciliaris cv. Gayndah		Ken	3	4	1	1.92	1.14**	3	3	-	1.48**	0.99
Chloris ciliata	32419	Uru	3	4	-	1.95	1.00	-	-	-	-	-
Chloris uliginosa	28288	Uru	1	1	-	-	-	-	-	-	-	-
Chloris distichophylla	26785	USA	3	2	-	-	-	-	-	-	-	-
Chloris gayana	17757	Ken	3	4	3	2.31**	0.97	3	3	3	1.82**	0.82**
Digitaria milanjiana	41188	Bot	2	4	3	2.05	0.92*	2	1	-	-	-
Digitaria erianthai	23854	SAf	2	4	2	2.05	0.92*	2	1	-	-	-
Digitaria polevansii	41183	SAf	2	4	1	2.09	0.93	2	2	-	-	-
Digitaria eriantha	16778 A	SAf	1	4	-	1.94	0.82**	1	1	-	-	-
Dactyloctenium aegyptium	34180	Kuw	3	1	-	-	-	-	-	-	-	-
Eragrostis curvula	30380	SAf	3	2#	3#	-	-	1	1	-	-	-
Eragrostis curvula	43217	Zim	3	2#	3#	-	-	-	-	-	-	-
Eragrostis superba	36443	Nig	3	4	-	1.89*	0.93	-	-	-	-	-
Panicum coloratum	16330	SAf	2	4	2	1.89*	1.04	2	1	-	-	-
Panicum coloratum	29881	Pak	3	4	2	2.08	1.03	1	1	-	-	-
Panicum maximum cv. Petrie		Ind	3	4	3	2.05	0.92	3	3	2	1.48*	0.93*
Paspalum plicatulum	27678	Uru	3	4	-	2.07	0.98	-	-	-	-	-
Paspalum malacophyllum	27690	Arg	1	4	2	2.07	1.08*	2	1	-	-	-
Setaria sphacelata	29307 B	Zim	3	4	1	1.96	1.14**	-	-	-	-	-
Urochloa mosambicensis	30654	Zam	3	4	3	1.84**	1.15**	3	3	2	1.43	0.95
Urochloa mosambicensis cv. Nixon		Zam	3	4	3	2.06	1.08*	3	3	2	1.13**	1.27**
Urochloa oligotricha	16734	Zim	2	4	2	2.00	0.78**	3	3	1	1.30**	1.01
General means						2.00	1.0				1.44	1.0
L.S.D. between accession means	(P<0.05)					0.14	0.11				0.06	0.09
	(P<0.01)					0.19	0.14				0.08	0.12

CPI. Non-prefixed numbers are Commonwealth Plant Introduction accessions; CQ numbers are CSIRO Queensland accessions. # Note. *Eragrostis curvula* accessions removed from speargrass area due to weed potential (strong seedling spread and unpalatability to cattle). *, ** , = different from general mean at P<0.05, P<0.01, respectively. Abbreviated origins are Australia, Botswana, Brazil, Costa Rica, India, Kenya, Kuwait, Mexico, Nigeria, Pakistan, Paraguay, S.Africa, Sudan, Tanzania, Uruguay, United States of America, Zambia, Zimbabwe.

On the speargrass site, the paddock which included the experiment was grazed by a farm herd of 20-30 cattle whenever sufficient feed was available over the period May 1970 – April 1971. The plots were sampled for dry matter yield of the sown species by cutting a 1 m wide strip across each plot with a sickle bar mower set to a height of 5 cm. Grasses were sampled for dry matter production 14 times, and the nine persistent legumes four times, over the period May 1971-April 1973. The area was sampled, grazed for 7-10 days, then topped with a slasher to provide ten 4 week (summer), two 8 week (spring), one 12 week and one 16 week (autumn/winter) regrowths of the grasses. The legume regrowths were one 4 week and two 8 week in summer and one 12 week in spring.

On the brigalow site, an old cultivation area, the experiment was swamped by weeds (*Eragrostis cilianensis, Urochloa panicoides* and *Portulaca oleracea*) from the outset. The plots were slashed in March 1970 to remove weed cover, but most accessions failed due to seedling defoliation and coincident moisture stress. The site was grazed by cattle in November 1970 and March 1971, topped with a slasher, and dry matter yields of the grasses remaining in two or more replicates measured on 7 occasions over the period May 1971-May 1972. The plots were topped with a slasher after each sampling to provide five 4 week (summer), one 8 week (spring), and one 12 week (summer/autumn) regrowths.

Results

Rainfall

October-May rainfall was above average in three of the four years from 1970/71 to 1973/74 (Table 1).

Establishment

Speargrass site. The single rating of 1, 2, or 3 for poor, fair, or good establishment, given in Table 2, represents the mean rating over three replicates for plant number and distribution within plots; less than three plants/square metre is poor (1), six or more evenly distributed is good (3). Three legumes (*Crotalaria rhodesiae, Desmodium canum* and *Indigofera nummulariifolia*) failed to establish even though seed germinated in the laboratory, and *Stylosanthes macrocarpa* had a few plants in one replicate only. All other accessions planted established in two or more replicates.

Brigalow site. No realistic assessment of the accessions' ability to establish on this soil was possible due to the excessive weed burden. The establishment data in Table 2 merely indicate the presence of that accession in two or more replicates.

Persistence

The data in Table 2 refer to the number of growing seasons after sowing that the accession was present in two or more replicates.

Speargrass site. Two of the annual legumes (*Alysicarpus ovalifolius, Macrotyloma africanum*), and the annual grass (*Dactyloctenium aegyptium*) failed to regenerate after the first season, and five perennial species (*Andropogon gayanus, Chloris uliginosa, Rhynchosia minima, Stylosanthes fruticosa* and *S. subsericea*) also failed after the first season.

Brigalow site. Although Table 2 indicates that five legumes persisted into the second season, there were only a few small plants of each and they died in the following winter. Only seven grasses persisted into the third season, after which the site was abandoned.

Spread

These data refer to spread either by seed or stolons. Good spread (3) indicates many seedlings, or new plants from rooted stolons, dispersed over a wide area out of the sown plot, e.g. many *Chamaecrista rotundifolia* seedlings established up to ten metres from the original plots. Poor spread (1) indicates few new plants in close proximity to the original plot, e.g. *Digitaria polevansii* had 2-6 new plants from stolon spread within 2 m of the plot.

Dry matter yields

There was marked variation (P<0.001) in the mean yield of the accessions in each case (Table 2).

Speargrass site - Grass yields. The total dry matter harvested over the sampling period ranged from 8500 kg/ha (*Cenchrus setigerus*) to 22500 kg/ha (*Chloris gayana*). Only *Chloris gayana* (17757) and *Digitaria milanjiana* (41188) had mean yields over all cuts significantly greater than the general mean (P<0.001, P<0.01 respectively). They had average stability and grew consistently well in all seasons. *Digitaria eriantha* (23854 and 16778A, *Panicum maximum* cv. Petrie and *Urochloa oligotricha* (16734) had above average stability (P<0.05 at least), growing well during periods when average yields were low (May and June, 1972), but below average when average yields were high (February 1972, 1973). *C. ciliaris* cv. Gayndah, *Setaria sphacelata* (29307B) and *U. mosambicensis* (30654) had below average stability (P<0.01), growing poorly in periods of low mean yields and being only average in periods of high mean yields. *Paspalum malacophyllum* (27690) and *U. mosambicensis* cv. Nixon, behaved similarly, but to a less marked degree (P<0.05) – their response was almost average.

Speargrass site - Legume yields. Total dry matter for the four harvests ranged from 1800 kg/ha (*Aeschynomene falcata*) to 9000 kg/ha (Siratro). Siratro, *Macroptilium bracteatum* (27404) and *Desmodium tortuosum* (CQ762) had mean yields over all cuts significantly greater than the general mean (P<0.001, P<0.01, P<0.05 respectively), but only Siratro, with average stability, performed consistently well over all growth periods. *M. lathyroides* (30229) had above average stability (P<0.01) but only performed well when average yields were low (December 1972). Two of the species with below-average stability (P<0.05), *D. tortuosum* and *M. bracteatum*, had average performance in the poorer growth period, but grew well in the better period (February 1973). The other species with above-average stability, *A. falcata*, had low yields in all growth periods. Even though this low growing species would have had a greater percentage of its dry matter production below the cutting height of 5 cm than the other species in this experiment, its yields were still low. Although *M. atropurpureum* (18556) grew better than average in the worst growth period (P<0.05), it had only average stability and average mean yield.

Brigalow site. Total dry matter yields for the seven cuts ranged from 11000 kg/ha (*U. mosambicensis* cv. Nixon) to 14,000 kg/ha (*Chloris gayana*). *C. gayana,* Petrie green panic and Gayndah buffel grass, had mean yields greater than the general mean (P<0.001, P<0.05, P<0.05 respectively), but only *C. gayana* (with above average stability (P<0.001)) performed consistently well in all growth periods. Although green panic had above average stability (P<0.05), its overall performance was close to the mean. *U. oligotricha* (16734), with average stability, consistently yielded less than the mean (P<0.01), and *U. mosambicensis* cv. Nixon, with below average stability (P<0.001), did not perform well, even when average yields were high.

Experiment 2

The aim of this experiment was to compare the persistence and production of a wider range of legumes than that tested in experiment 1 on both speargrass and brigalow soils.

Materials and Methods

The accessions used in this experiment are listed in Tables 3 and 4, together with information on their origin, yield rating, persistence, seedling regeneration, and phenology. Manually scarified seed (sandpaper abrasion) was sown in peat pots in a glasshouse at Samford in December 1973, the seedlings were inoculated with appropriate rhizobia two weeks later and planted in the field at Narayen in January 1974, approximately four weeks after germination. The accessions were planted in four randomised blocks on each site into soils that had been cultivated to control weed growth. Each plot consisted of four plants 1 m apart in a square. Plots were spaced 3 m apart and the area was oversown with green panic at 4 kg/ha.

Fertiliser

The speargrass site received a basal dressing of 500 kg/ha of a mixed fertiliser containing 8.3, 8.3, 9.9 and 0.2 per cent N, P, K and Mo respectively, which was incorporated into the soil prior to planting. The area was top-dressed with 250 kg/ha superphosphate in September 1974 and 1975. The brigalow site received no fertiliser.

Management

The legume seedlings were watered at planting and again two days later. Both sites received good rainfall (100 mm) on the fourth day after planting, which ensured good establishment of the legumes and green panic. All plots were inspected monthly from April to June 1974, September 1974 to April 1975, and September 1975 to April 1976, to provide data on survival of original plants, flowering dates, seeding dates, seedling regeneration, and legume yield ratings on a 1-5 scale. Representative plots with legume yield ratings of 1-5 were cut by hand from each replicate on both soils in June 1974, January 1975 and April 1976 to provide an estimate of actual yields. Yields (Y kg/ha) equivalent to the ratings (x) given in Tables 3 and 4, can be calculated from the following regression equations (i)-(iii) for the speargrass site and equations (iv)-(vi) for the brigalow site for years 1-3 respectively. The values given in parenthesis are the percentage variance accounted for by the regression.

(i) $Y = 163.1 - 113x$ (81.7%)
(ii) $Y = 45.2 - 18.2x$ (72.6%)
(iii) $Y = 150.1 - 56x$ (87.9%)
(iv) $Y = 33.1 - 4.7x$ (65.8%)
(v) $Y = 113.7 - 42.8x$ (87.9%)
(vi) $Y = 12.7 + 7.8x$ (81.6%)

Both sites were grazed by farm herds (20-30 cattle) for periods of 7-10 days after dry matter sampling, then topped with a slasher.

Results

Rainfall

October-May rainfall was above average in two of the four years from 1973/74 to 1976/77 (Table 1).

Persistence

Speargrass site. Not all of the original 16 seedlings per accession established successfully. Persistence in Tables 3 and 4 refers to the number of original plants present in years 2 and 3, expressed as a percentage of the original plants that established successfully in year 1. Six accessions persisted in only one replicate in the first year, a further four failed in three replicates in the second year, while 47 of the original 72 accessions persisted in two or more replicates in year three (Table 3). The most persistent (in terms of perennation and/or seedling regeneration) were in the genera *Aeschynomene, Chamaecrista, Clitoria, Desmodium, Galactia, Leucaena, Listia, Lotononis, Macroptilium, Macrotyloma, Neonotonia, Psoralea, Stylosanthes, Teramnus* and *Vigna*.

Brigalow site. The legumes were far less persistent on this site, with only 27 persisting in more than one replicate over the three years (Table 4). The majority failed after two years. The most persistent were in the genera *Aeschynomene, Clitoria, Lablab, Leucaena, Macroptilium, Macrotyloma, Neonotonia, Teramnus* and *Vigna*.

Table 3. Legumes grown on the speargrass site in experiment 2, their accession number (CPI), country of origin (Or), mean maximum yield rating for each of years 1-3 (Y1, Y2, Y3), mean maximum yield rating (Mean) over three years for those accessions which persisted in two or more replicates, percentage of plants established in year 1 persisting in years 2 and 3 (Per), new (New) seeding regeneration in years 2 and 3 (+ = seedlings present; - = no seedlings present), calendar months in which flowering was observed (Fl), and mean coefficient (b) for the regression of accession mean yield on overall mean yield. Accessions with yield ratings in brackets grew in one replicate only.

Species	CPI	Or	Yield rating				Per		New		Fl	b
			Y1	Y2	Y3	Mean	Y2	Y3	Y2	Y3		
Aeschynomene falcata cv. Bargoo		Par	2.3	1.9	2.0	2.1	93	79	+	+	11-5	0.73
Aeschynomene rugosus	60166	Ken	2.3	1.0**	-	-	50	-	-	-	11-5	-
Alysicarpus vaginalis	60169	Uga	1.5**	2.0	-	-	47	-	-	-	11-5	-
Chamaecrista mimosoides	60177	Saf	3.8**	3.5**	1.0***	2.8	-	-	+	+	11,3,4	-1.49*
Chamaecrista falcinella	60179	Zim	4.4***	2.4	1.2***	2.7	50	30	+	+	1-4	2.61
Chamaecrista rotundifolia	34719	Bra	2.9	3.8***	4.3***	3.7**	100	100	+	+	11-4	-1.15
Chamaecrista rotundifolia cv. Wynn		Bra	2.9	3.2*	3.5*	3.2	100	100	+	+	11-4	-0.22
Chamaecrista pilosa	57503	Ven	4.5***	5.0***	5.0***	4.8***	100	100	+	+	11-4	-0.92
Centrosema virginianum	33808	Mex	2.1	1.7	1.8*	1.9	81	63	+	+	11-3	0.83
Centrosema virginianum	57979	Bra	1.3***	-	-	-	6	-	-	-	-	-
Clitoria ternatea	37195	Hon	2.5	2.9	4.0**	3.1	75	75	-	-	11-4	0.18
Clitoria ternatea	50973	Sen	2.4	3.2*	3.5*	3.0	69	69	+	-	11-4	-1.29
Cyamopsis senegalensis	60225	Nam	(3.0)	(0.4)	(0.2)	-	-	-	+	+	11	-
Desmodium heterocarpon	57146	USA	2.6	2.3	1.8*	2.2	86	29	-	-	4	0.06
Dolichos sericeus	60218	Ken	(1.0)	(1.0)	-	-	100	-	-	-	-	-
Dolichos sericeus	60221	Ken	1.4**	2.0	2.5	1.9	73	64	-	-	-	-0.63
Dolichos sericeus	60223	Ken	(1.0)	(0.5)	-	-	50	-	-	-	-	-
Galactia striata	49740	Mex	3.1	1.6	1.3***	2.0	57	36	+	+	4	2.32
Lablab purpureus	60216	Uga	5.0***	4.0***	(4.0)	-	60	40	-	-	-	-
Leucaena leucocephala cv. Peru		Per	1.0***	0.1***	-	-	19	-	-	-	-	-
L. leucocephala cv. Cunningham		x	1.0***	2.0	2.7	1.9	67	58	-	-	3,4	-1.15
Listia heterophylla	18424	Zam	3.5*	2.2	2.8	2.8	100	100	-	-	9-5	1.00
Lotononis bainesii cv. Miles		Saf	4.5***	3.7***	3.3	3.8***	75	75	+	+	9-5	1.00
Macroptilium bracteatum	27404	Bra	2.3	2.8	2.5	2.5	43	43	+	+	1-4	-0.39
Macroptilium lathyroides	30229	Ind	5.0***	2.8	4.5***	4.1***	56	44	+	+	11-4	5.33***
Macroptilium martii	49780	Bra	4.0***	2.0	2.4	2.8	15	-	+	+	10-4	1.35
M. atropurpureum cv. Siratro		Aus	4.5***	3.9***	4.1***	4.2***	60	60	+	+	10-4	1.35
Macrotyloma africanum	24972	Zam	3.3*	1.3*	2.0	2.2	12	-	+	+	3,4	4.28**
Macrotyloma africanum	60207	Zam	3.0	2.0	2.5	2.5	20	10	+	+	3,4	2.37
Macrotyloma axillare cv. Archer		Ken	3.4*	3.6**	4.0**	3.7**	71	57	-	-	11-3	-0.04
Macrotyloma daltonii	60302	Zim	2.6	2.2	(2.5)	-	20	0	+	+	3,4	-
Macrotyloma daltonii	60303	Nam	4.8***	3.8***	4.4***	4.3***	30	-	+	+	3,4	2.34
Neonotonia wightii	60230	Tan	1.1***	1.2**	2.2	1.5**	20	13	-	-	-	0.44
Neonotonia wightii	60231	Uga	1.1***	2.6	(2.0)	-	92	33	-	-	-	-
Neonotonia wightii	60234	Zim	1.3***	0.7***	1.7*	1.2***	33	25	-	-	4	1.80
Neonotonia wightii	60235	Zim	1.5**	0.6***	1.9*	1.3**	50	30	-	-	4	1.80
Neonotonia wightii cv. Tinaroo		Ken	1.1***	1.4*	1.9*	1.5**	29	21	-	-	-	0.02
Pearsonia aristata	60315	Saf	(1.0)	(0.2)	-	-	100	-	-	-	-	-
Phaseolus sp.	57981	Bra	2.6	0.9*	-	-	75	-	-	-	-	-
Psoralea patens	CQ1455	Aus	1.6**	4.0***	3.1	2.9	75	57	-	-	10-1	-5.40***
Stylosanthes hamata cv. Verano		Ven	3.5*	2.9	4.5***	3.6**	-	-	+	+	1-4	2.42
Stylosanthes viscosa	33941	Mex	3.8**	1.4*	2.3	2.5	-	-	+	+	1-4	5.08***
Tephrosia paniculata	60366	Uga	(5.0)	-	-	-	-	-	-	-	-	-
Teramnus labialis	60371	Saf	1.4**	1.6	1.9*	1.6*	67	53	+	+	3,4	-0-14
Teramnus labialis	60373	Ken	1.0***	(1.3)	(1.0)	-	7	7	-	-	4	-
Teramnus labialis	60374	Ken	1.0***	0.2***	(0.1)	-	16	8	-	-	-	-
Teramnus labialis	60376	Uga	1.5**	0.8***	0.3***	0.8***	57	14	-	-	5	1.08
Teramnus labialis	60739	Saf	1.0***	0.6***	0.4***	0.7***	57	21	-	-	11,3	0.66
Teramnus labialis	60380	Zim	1.1***	2.2	1.5**	1.6*	73	60	-	-	11,3,4	-2.40**
Termanus labialis	60381	Ken	1.0***	0.5***	0.5***	0.7***	40	27	-	-	-	0.84
Trifolium semipilosum cv. Safari		Ken	1.0***	(1.0)	-	-	38	-	-	-	7	-
Vigna ambacensis	60442	Uga	4.5***	(0.2)	-	-	13	-	-	-	5	-
Vigna frutescens	60424	Zim	1.0***	1.1**	1.5**	1.2***	27	27	+	+	12-4	0.13
Vigna heterophylla	60427	Uga	2.0	-	-	-	-	-	-	-	4	-
Vigna luteola	60428	Uga	4.0***	3.1*	2.0	3.1	57	21	-	-	11,5	1.05
Vigna oblongifolia	60430	Saf	1.6**	0.6***	-	-	33	-	+	-	3,4	-
Vigna racemosa	60437	Uga	2.6	(2.0)	-	-	6	0	0	0	5	-
Vigna racemosa	60438	Uga	1.4**	-	-	-	-	-	-	-	-	-
Vigna unguiculata	57515	SAf	1.0***	0.7***	0.8***	0.8***	75	50	-	-	11-2	0.73
Vigna unguiculata	60442	SAf	2.5	-	-	-	-	-	-	-	5	-
Vigna unguiculata	60446	Zim	2.8	1.3*	3.3	2.4	70	70	+	+	2-5	5.52***
Vigna unguiculata	60447	Zim	4.4***	1.5*	4.0**	3.3*	75	75	+	+	1-4	7.27
Vigna unguiculata	60448	SAf	2.5	(1.0)	(3.0)	-	8	-	+	+	3,4	-

Species	CPI	Or	Yield rating				Per		New		FI	b
			Y1	Y2	Y3	Mean	Y2	Y3	Y2	Y3		
Table 3 continued												
Vigna unguiculata	60449	SAf	4.5***	4.1***	4.3***	4.3***	79	50	-	+	11-4	0.79
Vigna unguiculata	60450	SAf	3.0	2.6	3.0	2.9	70	60	+	+	11-4	0.99
Vigna unguiculata	60451	SAf	2.5	4.5***	4.5***	3.8***	87	87	+	+	11-5	-3.70***
Vigna unguiculata	60452	Ken	4.3***	4.3***	4.1***	4.2***	94	81	+	+	11-5	-0.10
Vigna vexillata	60421	Zim	3.6**	1.1**	3.4	2.7	19	19	+	+	11,2-4	6.93***
Vigna vexillata	60453	Ken	(4.0)	(2.0)	(2.0)	-	100	100	-	-	2,3	-
Vigna vexillata	60454	Tan	4.1***	3.8***	4.8***	4.2***	64	43	-	-	11-5	1.47
Vigna vexillata	60455	Ken	1.2***	1.4*	-	-	13	-	-	-	-	-
Vigna vexillata	60458	Mal	2.3	2.5	3.3	2.7	75	58	-	-	11-4	0.34
General means			2.6	2.3	2.7	2.5						1.00
L.S.D. between accession means	(P<0.05)		1.2	1.4	1.3	1.3						3.10
	(P<0.01)		1.5	1.8	1.7	1.7						4.09
	(P<0.001)		1.9	2.3	2.2	2.2						5.26

CPI. Non-prefixed numbers are Commonwealth Plant Introduction accessions; CQ numbers are CSIRO Queensland accessions. *, **, ***, significantly different from general mean at P<0.05, P<0.01, P<0.001 respectively.
Abbreviated origins are Australia, Brazil, Honduras, India, Kenya, Malawi, Mexico, Namibia, Paraguay, Peru, S. Africa, Senegal, Tanzania, Uganda, United States of America, Venezuela, Zambia, Zimbabwe. *L. leucocephala* cv. Cunningham (x) is derived from a cross between accessions originating in Peru and Guatemala

Spread

On the speargrass site, *Aeschynomene falcata, Chamaecrista mimosoides, C. falcinella, C. rotundifolia* (both accessions), *Lotononis bainesii, Macroptilium bracteatum, M. lathyroides,* Siratro, *Macrotyloma africanum* (both accessions), *M. daltonii* (both accessions), *Stylosanthes hamata, S. viscosa*, and *Vigna unguiculata* (60446, 60447, 60450, 60451) had spread extensively out of their plots (10-30 m) on completion of the experiment. On the brigalow site, only *M. lathyroides, M. africanum, M. axillare, M. daltonii* and *V. unguiculata* had any noticeable spread from seed.

Dry matter yields

The mean dry matter yield of the legumes over three years ranged from 160-2800 kg/ha on the speargrass site and 80-1300 kg/ha on the brigalow site. Accessions varied markedly in yield (P<0.001) in each year on each site.

Speargrass site. Only 13 of the 72 accessions had mean yields over three years greater than the general mean (P<0.05 at least). All cultivars had average stability over the three years, but cvv. Archer, Miles, Siratro and Verano performed better than cvv. Bargoo, Cunningham and Tinaroo (Table 3). Other accessions with average stability and acceptable yields were *C. rotundifolia* 34719 and cv. Wynn, *C. pilosa* 57503, *C. ternatea* 37195, *M. daltonii* 60303, *V. unguiculata* 60449, 60452, and *V. vexillata* 60454. Of the species with above average stability, only *V. unguiculata* 60451 performed well in all years. *M. lathyroides* 30229 was the only species with below-average stability to produce acceptable yields in all years.

Brigalow site. Siratro and five other accessions had mean yields over three years greater than the general mean (P<0.05 at least) (Table 4). The most consistently high producers were Siratro, *L. purpureus* and *V. vexillata* 60454, each of which had above average stability (P<0.01 at least). Of the species with average stability, *N. wightii* 60230 and *V. luteola* were consistently more productive than Tinaroo glycine and Cunningham leucaena. *C. ternatea* 50973, *M. lathyroides* 30229, and *M. bracteatum* 27404 were the best of the species with below-average stability, but their performance was far below that of Siratro.

Experiment 3

The aim of this experiment was to test the adaptation of a selected group of grasses to the speargrass environment at Narayen.

Table 4. Legumes grown on the brigalow site in experiment 2, their accession number (CPI), country of origin (OR), mean maximum yield rating for each of years 1-3 (Y1, Y3, Y3), mean maximum yield rating (Mean) over three years for those accessions which persisted in two or more replicates, percentage of plants established in year 1 persisting in years 2 and 3 (Per), seedling regeneration in years 2 and 3 (New) (+ = seedlings present; - = no seedlings present), calendar months in which flowering was observed (Fl), and mean coefficient (b) for the regression of accession mean yield on overall mean yield. Accessions with yield ratings in brackets grew in one replicate only.

Species	CPI	Or	Yield rating				Per		New		Fl	b
			Y1	Y2	Y3	Mean	Y2	Y3	Y2	Y3		
Aeschynomene falcata cv. Bargoo		Par	1.4***	0.4**	0.1***	0.6***	100	33	-	+	4,5	0.55*
Aeschynomene sp.	57978	Bra	2.3**	0.4**	(0.1)	-	50	-		+	4-6	-
Alysicarpus rugosus	60166	Ken	2.4**	0.4**	-	-	75	-	-	-	5,6	-
Alysicarpus vaginalis	60169	Uga	1.9***	0.4**	-	-	60	-	-	-	5	-
Chamaecrista mimosoides	60177	SAf	3.8	0.1***	-	-	-	-	+	-	3	-
Chamaecrista falcinella	60179	Zim	4.3**	0.1***	-	-	-	-	+	-	3	-
Chamaecrista rotundifolia	34719	Bra	1.9***	0.3***	(0.1)	-	64	-	+	+	3,4	-
Chamaecrista rotundifolia cv. Wynn		Bra	1.6***	0.5*	-	-	44	-	+	-	11,3,4	-
Chamaecrista pilosa	57503	Ven	4.1***	-	-	-	-	-	-	-	2,3	-
Centrosema virginianum	33808	Mex	3.4	0.4**	-	-	69	-	-	-	3,4	-
Centrosema virginianum	57979	Bra	2.6*	1.1	-	-	87	-	-	-	11,4	-
Clitoria ternatea	37195	Hon	4.8***	0.7	0.7**	2.0	38	25	-	-	3,4	2.03***
Clitoria ternatea	50973	Sen	4.6***	1.3	1.2	2.4	56	31	+	-	2,3	1.71***
Cyamopsis senegalensis	60225	Nam	3.8	-	-	-	-	-	-	-	2,3,4	-
Desmodium heterocardon	57146	USA	2.6*	1.0	-	-	94	-	-	-	-	-
Dolichos sericeus	60218	Ken	3.0	1.3	-	-	69	-	-	-	4-6	-
Dolichos sericeus	60220	Ken	2.1**	1.3	-	-	73	-	-	-	-	-
Dolichos sericeus	60221	Ken	2.6*	1.3	-	-	87	-	-	-	6	-
Dolichos sericeus	60223	Ken	2.6*	1.1	-	-	82	-	-	-	6	-
Galactia striata	49740	Mex	3.3	0.4**	-	-	42	-	+	-	4,5	-
Lablab purpureus	60216	Uga	4.3**	4.3***	4.0***	4.2***	93	67	-	-	5,6	0.06***
Leucaena leucocephala cv. Peru		Per	3.1	1.7	0.5***	1.8	78	33	-	-	-	1.21
L. leucocephala cv. Cunningham		x	3.4	1.9	2.0	2.4	67	33	-	-	6	0.70
Listia heterophylla	18424	Zam	4.9***	4.0***	-	-	100	-	+	-	9-1,4	-
Lotononis bainesii cv. Miles		SAf	5.0***	5.0***	-	-	100	-	+	-	10,5	-
Macroptilium bracteatum	27404	Bra	4.6***	1.9	1.6	2.7	100	20	+	-	4	1.48**
Macroptilium lathyroides	30229	Ind	5.0***	2.2**	2.3	3.1*	73	27	+	+	12,1-3	1.43*
Macroptilium martii	49780	Bra	5.0***	-	-	-	-	-	-	-	5	-
M. atropurpureum cv. Siratro		Aus	5.0***	4.5***	4.5***	4.7***	100	75	-	-	10-4	0.25***
Macrotyloma africanum	24972	Zam	3.6	0.1***	(0.1)	-	-	-	+	+	3,4	-
Macrotyloma africanum	60207	Zam	2.9	0.2**	0.1***	1.1***	-	-	+	+	3-5	1.42
Macrotyloma axillare cv. Archer		Ken	4.3**	3.3***	(0.1)	-	88	6	+	+	11-1,5	-
Macrotyloma daltonii	60302	Zim	3.3	(0.2)	(0.1)	-	-	-	+	+	3,4	-
Macrotyloma daltonii	60303	Nam	4.3**	0.1***	0.1***	1.5*	-	-	+	+	3,4	2.05***
Neonotonia wightii	60230	Tan	4.3**	2.4**	2.5*	3.0*	75	53	-	-	5,6	0.90
Neonotonia wightii	60231	Uga	3.5	2.0*	1.3	2.3	80	33	-	-	-	1.02
Neonotonia wightii	60234	Zim	2.8	1.5	1.8	2.0	100	47	-	-	4	0.56*
Neonotonia wightii	60235	Zim	2.6*	1.5	2.9***	2.3	82	62	-	-	4	0.36***
Neonotonia wightii cv. Tinaroo		Ken	1.0***	0.3**	(0.1)	-	63	38	-	-	6	1.33
Pearsonia aristata	60315	SAf	1.0***	0.3**	(0.1)	-	60	20	-	-	7	-
Phaseolus sp.	57981	Bra	4.0*	2.1*	-	-	64	-	+	-	6	-
Psoralea patens	CQ1455	Aus	1.0***	0.6*	(3.0)	-	67	17	-	-	11,3	-
Stylosanthes fruticosa	60352	Ken	1.9***	-	-	-	-	-	-	-	3	-
Stylosanthes hamata cv. Verano		Ven	4.3**	-	-	-	-	-	-	-	2-4	-
Stylosanthes viscosa	33941	Mex	2.5*	-	-	-	-	-	-	-	4	-
Tephrosia paniculata	60366	Uga	4.8***	1.0	-	-	25	-	-	-	5	-
Teramnus labialis	60371	SAf	2.8	1.5	1.5	1.9	100	60	-	-	4,5	0.62*
Teramnus labialis	60373	Ken	2.6*	0.4**	(0.1)	-	80	-	+	+	4	-
Teramnus labialis	60374	Ken	3.6	0.3**	0.6**	1.5*	44	6	-	-	5	1.66***
Teramnus labialis	60376	Uga	3.0	1.4	-	-	87	-	-	-	5	-
Teramnus labialis	60739	SAf	1.5***	1.1	1.0*	1.2**	75	44	-	-	11,5	0.29***
Teramnus labialis	60380	Zim	2.5*	1.4	0.7**	1.5*	88	25	-	-	3,5	0.79
Termanus labialis	60381	Ken	2.4**	0.8	0.6**	1.3**	59	12	-	-	5,6	0.88
Trifolium semipilosum cv. Safari		Ken	0.4***	0.7	-	-	71	-	-	-	9	-
Vigna ambacensis	60442	Uga	4.4**	-	-	-	-	-	-	-	5,6	-
Vigna angustifolia	60421	Zim	4.1*	(0.1)	(0.5)	-	-	-	+	+	3,4	-
Vigna frutescens	60424	Zim	3.5	0.1***	0.5***	1.4**	-	-	+	+	3,4	1.76***
Vigna heterophylla	60427	Uga	3.9	-	-	-	-	-	-	-	4	-
Vigna luteola	60428	Uga	4.8***	2.4**	3.0**	3.4**	100	29	-	-	4,5	1.16
Vigna oblongifolia	60430	SAf	2.4**	(0.1)	-	-	-	-	+	-	3,4	-
Vigna racemosa	60437	Uga	3.4	0.1***	-	-	20	-	-	-	5	-
Vigna unguiculata	57515	SAf	1.0***	0.1***	-	-	33	-	-	-	-	-
Vigna unguiculata	60442	SAf	3.8	(0.1)	(0.1)	-	-	-	+	+	3,4	-
Vigna unguiculata	60446	Zim	3.0	(0.1)	(0.5)	-	-	-	+	+	4,5	-

Species	CPI	Or	Yield rating Y1	Y2	Y3	Mean	Per Y2	Y3	New Y2	Y3	F1	b
Table 4 continued												
Vigna unguiculata	60447	Zim	3.9	(0.1)	-	-	-	-	+	-	3,4	-
Vigna unguiculata	60448	SAf	3.9	1.7	1.4	2.3	53	20	+	+	11,3,4	1.06
Vigna unguiculata	60449	SAf	4.5***	0.3**	(3.0)	-	56	6	-	-	3-5	-
Vigna unguiculata	60450	SAf	2.8	0.3**	-	-	19	-	-	-	3,4	-
Vigna unguiculata	60451	SAf	2.0***	0.9	(1.0)	-	53	-	-	+	11-5	-
Vigna unguiculata	60452	Ken	5.0***	0.4**	0.9*	2.1	69	13	+	+	3,4	2.14***
Vigna vexillata	60453	Ken	3.3	0.8	1.0*	1.7	50	38	-	-	4	1.19
Vigna vexillata	60454	Tan	4.8***	3.3***	4.5***	4.2***	94	94	-	-	11-4	0.41**
Vigna vexillata	60455	Ken	0.9***	1.2	-	-	38	-	-	-	-	-
Vigna vexillata	60458	Mal	3.0	1.5	(2.0)	-	80	10	-	-	4,5	-
General means			3.3	1.3	1.7	2.3						1.00
L.S.D. Accession means	(P<0.05)		1.1	1.0	1.1	1.0						0.53
	(P<0.01)		1.4	1.4	1.4	1.4						0.71
	(P<0.001)		1.8	1.7	1.8	1.8						0.92

CPI. Non-prefixed numbers are Commonwealth Plant Introduction accessions; CQ numbers are CSIRO Queensland accessions. *, **, ***, significantly different from general mean at P<0.05, P<0.01, P<0.001 respectively.
Abbreviated origins are Australia, Brazil, Honduras, India, Kenya, Malawi, Mexico, Namibia, Paraguay, Peru, S. Africa, Senegal, Tanzania, Uganda, United States of America, Venezuela, Zambia, Zimbabwe. *L. leucocephala* cv. Cunningham (x) is derived from a cross between accessions originating in Peru and Guatemala

Materials and Methods

The accessions used in this experiment are listed in Table 5. They were sown in three randomised blocks on 5 December 1975. Seed was hand broadcast in 7 m x 2 m plots onto cultivated soil at the rate of 60 seeds/sq m and covered lightly with a rake. Dry matter yields were measured by cutting a 1 m wide strip across each plot with a sickle bar mower to a height of 5 cm. Sown grass and weed were separated, oven dried (82ºC) and weighed separately.

Fertiliser

No basal mix was applied as this experiment was sown on the site of experiment 1. Superphosphate (250 kg/ha) was applied every September, and nitrogen (55 kg/ha) as nitram or urea was applied in September and January of each year.

Management

The paddock which included the experiment was grazed by a herd of 20-30 cattle whenever feed was available between June 1976 and January 1978. Thereafter, grazing was restricted to periods between sampling for dry matter production. Four to six week regrowths were measured in February and October 1978, January, April and August 1979, and January 1980, after exclusion of cattle and topping the area with a slasher.

Results

Rainfall

October-May rainfall was above average in only one of the five years from 1975/76 to 1979/80 (Table 1).

Establishment

Plots were rated for establishment on 15 January 1976 using the same scale as used in experiment 1. Two thirds of the accessions had very good establishment with 12-20 seedlings/m^2 evenly distributed within the plots. Four accessions (*Diplachne, Paspalum* and two *Sporobolus*) were never sighted.

Table 5. The grass species sown in experiment 3, their accession number (CPI), country of origin (Origin), establishment (Est) rating (1=poor, 2=fair, 3=good), mean yield (Yield) (log g/2m^2), mean coefficient (b) for the regression of accession mean yield (logs) on overall mean yield (logs), and mean percentage weed percentage (Weed) in plots at final sampling.

Species	CPI	Origin	Est	Yield	b	Weed
Brachiaria brizantha	15890	Tanzania	1	1.79	1.03	39
Brachiaria brizantha	59592	Kenya	2	1.95**	0.81	31
Brachiaria decumbens cv. Basilisk		Uganda	3	1.14***	0.61**	87*
Brachiaria decumbens	59611A	Kenya	1	-	-	99**
Brachiara decumbens	59614	Uganda	2	1.57	0.82	69
Cenchrus ciliaris cv Biloela		Tanzania	3	1.61	1.07	44
Cenchrus ciliaris	59624	Kenya	3	1.97**	1.04	26
Cenchrus ciliaris	59631	S. Africa	2	1.66	0.81	53
Cenchrus ciliaris	59634	S. Africa	1	1.65	0.98	54
Cenchrus mitis	59647	Kenya	1	-	-	100**
Digitaria eriantha cv. Premier		S. Africa	3	2.23***	0.90	8**
Digitaria gazensis	59707	Malawi	3	-	-	100**
Digitaria gazensis	59708	Malawi	1	-	-	100**
Digitaria macroglossa	16267	S. Africa	2	1.72	1.00	27
Digitaria milanjiana	41192	Botswana	3	2.26***	0.99	6**
Digitaria milanjiana	59720	Kenya	3	1.38**	1.52**	50
Digitaria milanjiana	59733	Tanzania	3	1.68	0.92	34
Digitaria milanjiana	59744	Malawi	1	1.49*	0.57**	96**
Digitaria milanjiana	59755	Zimbabwe	3	1.84	1.19	30
Digitaria milanjiana	59765	Kenya	3	1.89*	1.28	15*
Digitaria milanjiana	59770	Kenya	3	1.70	1.20	26
Digitaria milanjiana	59774	Mozambique	3	1.66	1.04	31
Digitaria milanjiana	59777	Zimbabwe	3	2.01**	1.01	16*
Digitaria milanjiana	59814	Kenya	1	1.72	0.92	23
Digitaria milanjiana	59819	Tanzania	1	1.94*	0.95	29
Digitaria milanjiana	59735	Tanzania	2	1.72	1.48**	28
Digitaria milanjiana	59682	Namibia	1	-	-	86*
Diplachne biflora	59843	Tanzania	-	-	-	100**
Panicum coloratum cv. Pollock		S. Africa	3	1.32***	0.67*	73
Panicum maximum var. *trichoglume* cv. Petrie		India	3	1.67	0.85	33
Paspalum aff. *P. rojassi*	57955	Brazil	-	-	-	100**
Sporobolus agrostoides	60100	Kenya	-	-	-	100
Sporobolus filipes	60102	Tanzania	-	-	-	100**
Sporobolus fimbriatus	60103	Zimbabwe	1	-	-	100**
Urochloa mosambicensis cv. Nixon		Zimbabwe	3	1.88	1.10	48
Urochloa mosambicensis	60136	Mozambique	3	1.72	1.06	25
Urochloa mosambicensis	60139	S. Africa	3	1.76	1.48**	13*
Urochloa mosambicensis	60151	Zimbabwe	1	1.56	1.02	50
Urochloa oligotricha	60122	Zambia	3	1.59	1.00	46
Urochloa stolonifera	60128	S. Africa	3	1.45**	0.67*	51
General Means				1.72	1.0	52
L.S.D. between Accession means		(P<0.05)		0.29	0.42	43
		(P<0.01)		0.39	0.55	57
		(P<0.001)		0.50	0.70	74

*, **, ***, = different from general mean at P<0.05, P<0.01, P<0.001 respectively

Persistence

Four of the accessions that established succumbed to frost and/or grazing in the first year. The rest persisted throughout the trial period, but *Brachiaria decumbens* 59611A and *Digitaria milanjiana* 59682 each had only a few plants in one replicate, as reflected by the final weed percentage.

Dry matter yields

There was a marked variation ($P<0.01$ at least) in the mean yield of the accessions at each cut, and the means over six cuts ranged from 130 kg/ha (*B. decumbens* cv. Basilisk) to 1400 kg/ha (*Digitaria milanjiana* 41192).

Seven accessions (Table 5) had mean yields greater than the general mean ($P<0.05$ at least). Of the five cultivars, *C. ciliaris* cv. Biloela, *P. maximum* cv. Petrie and *U. mosambicensis* cv. Nixon had average yields, while *B. decumbens* cv. Basilisk and *P. coloratum* cv. Pollock had below average yields ($P<0.001$). The species with above-average stability (*B. decumbens* cv. Basilisk, *D. milanjiana* 59744 ($P<0.01$), *P. coloratum* cv. Pollock and *U. mosambicensis* 60128 ($P<0.05$)) had below average yields ($P<0.05$ at least) and did not perform well in any environment. Of the species with average stability, seven were those with mean yields greater than the general mean (*D. eriantha* cv. Premier and *D. milanjiana* 41192 ($P<0.001$), *B. brizantha* 59592, *C. ciliaris* 59624, and *D. milanjiana* 59777 ($P<0.01$), and *D. milanjiana* 59765 and 59819 ($P<0.05$)). The species with below-average stability (*D. milanjiana* 59720, 59735, and *U. mosambicensis* 60139) performed well in the best environments only.

Weeds

The major "weeds" or unsown species in the experiment resulted from seedling regeneration of species used in experiment 1. These were *Chamaecrista rotundifolia*, Siratro, *M. lathyroides*, green panic, *Urochloa* spp. and *Chloris gayana*. The most widespread "weed" was *Chamaecrista rotundifolia*, a useful pasture legume. Weed content varied little over the last three samplings.

Discussion

All experiments had good establishment rains and all experienced moisture stress during the sampling period. The most severely affected were experiments 2 and 3 with below average rainfall in February, March and December 1974; January, March, April and May 1975; February and March 1978; and nearly all of 1979. Growing seasons were also shorter in 1971/72 and 1975/76 due to early frosts.

Only 50% of the legumes which established on the speargrass site in experiment 1 persisted more than 2 years. The *Stylosanthes* species probably succumbed to anthracnose in the wet summer of 1970/71. In experiment 2 however, legume persistence through perennation or seedling regeneration was generally satisfactory. On the brigalow soil, persistence in experiment 1 was negligible due to weed competition and severe defoliation, but was much better in experiment 2, particularly in the general *Aeschynomene, Chamaecrista, Clitoria, Leucaena, Macroptilium, Macrotyloma* and *Vigna.*

Grass persistence was satisfactory on speargrass soil in experiments 1 and 3, but poor on brigalow soil in experiment1.

Legume spread out of plots on the speargrass soils was particularly noticeable for *Aeschynomene, Chamaecrista, Lotononis, Macroptilium, Macrotyloma, Stylosanthes* (experiment 2 only) and *Vigna* species. On the brigalow soil, only *Chamaecrista rotundifolia, Macroptilium lathyroides, Macrotyloma africanum, M. daltonii* and *Vigna* species spread to any extent (experiment 2). We cannot explain the lack of observed seedling regeneration of Siratro on this site.

Mean dry matter yields of the grass cultivars on speargrass soil were exceeded by *Chloris gayana* 17757 (experiment 1) and *Digitaria milanjiana* 41192 and *D. eriantha* 38869 (experiment 3). Other accessions which performed well in comparison to the cultivars were *D. milanjiana* 41188 (experiment 1) and *Brachiaria brizantha* 59592, *Cenchrus ciliaris* 59624, *D. milanjiana* 59777 and 59819 (experiment 3). *D. milanjiana* 59777 was favoured for release in the Northern Territory in the 1980s (A. Cameron, personal communication) and *D. milanjiana* 41188 was surpassed by *D. milanjiana* 41192 in further investigations (Strickland and Haydock 1978). *D. eriantha* cv. Premier, sown as 38869 in experiment 3, was released in 1986 after further evaluation in a range of environments in south east Queensland. The stoloniferous *D. milanjiana* 41192 could warrant further evaluation in coastal and subcoastal areas receiving more than 600 mm annual rainfall, as it has all the characteristics of a good cultivar. However, it is similar to 40700, released in 1995 as cv. Strickland. It does not perform as well as Premier digit grass in drier areas of western Queensland (R.W. Strickland, unpublished).

On the brigalow site, *C. gayana* 17757 outyielded the existing cultivars Gayndah buffel grass, Nixon Sabi grass and Petrie green panic during the favourable rainfall conditions experienced in Experiment 1. However, it is uncertain if this accession would survive through extended dry periods at Narayen as Pioneer rhodes grass does not persist as well through such periods as Gayndah and Petrie (Jones *et al.* 1995).

No legume produced significantly more dry matter than Siratro on the speargrass soil in experiments 1 and 2, and the cultivars Archer, Miles and Verano were as productive as Siratro. Several accessions in the genera *Chamaecrista, Clitoria, Macroptilium, Macrotyloma* and *Vigna* had equally high mean yields and some of these (*Chamaecrista rotundifolia, C. pilosa* and *Vigna unguiculata*) had better persistence and seedling spread. *C. rotundifolia* cv. Wynn, sown as 34721 in experiments 1 and 2, was released as cv. Wynn in 1984, following further evaluation of accessions of this and other species at several sites in south east Queensland and northern New South Wales (Strickland *et al.* 1985). The annual species *M. lathyroides* and *M. daltonii* did perennate to some extent, but seedling regeneration contributed most to their high mean yields. Although *Clitoria ternatea* and *Vigna vexillata* were high yielding and persistent over the duration of experiment 2, there was insufficient seedling regeneration to enable long -term persistence in a pasture.

No legumes showed promise on the brigalow soil in experiment 1, though Siratro and *M. bracteatum* (the better legumes on the speargrass site, experiment 1) showed some promise in Experiment 2. Although the mean yield of Siratro was equalled by *Lablab purpureus* 60126 and *Vigna vexillata, L. purpureus* flowered too late for seed set before frosting and *V. vexillata* was a poor seeder with no seedling regeneration observed. The other cultivar which performed well for two growing seasons, Archer axillaris, died in three replicates during the second winter in this experiment. Siratro did set seed, but seedlings, needed to ensure longer-term persistence, were not observed. *M. lathyroides* and *V. unguiculata* had good seedling regeneration and produced reasonable yields. Archer axillaris, *C. ternatea* and *M. bracteatum* are capable of producing acceptable yields, provided sufficient seedling regeneration occurs to maintain the stand. Although *N. wightii* produced acceptable yields, its late flowering would mitigate against its long term survival where early frosts occur.

When a wide range of legumes were tested on two other brigalow soils in southern Queensland, during lower rainfall conditions, accessions of *Macroptilium, Macrotyloma* and *Vigna* failed to persist, unlike accessions of *Desmanthus virgatus* and *Indigofera schimperi* (Jones 1998). However, *Macroptilium bracteatum* has shown promise as a ley legume under average or above average rainfall conditions (Jones and Rees 1997).

The most important attributes of a pasture cultivar are persistence (through perennation and/or seedling regeneration) and the ability to grow well over a range of environments. The latter attribute is characterised by high mean yield and average ($b=1.0$) or above-average ($b<1.0$) stability in a Finlay Wilkinson type analysis. Accessions with these characteristics were *C. gayana* 17757 on speargrass and brigalow soils, *D. milanjiana* 41192 and *D. eriantha* cv. Premier on speargrass soil, Siratro on speargrass and brigalow soils, and *C. pilosa* 57503 on speargrass soil. Stability, characterized by the "b" value, and mean yield are both important attributes. For example, on the speargrass site in experiment 1, *M. lathyroides* 30229 and *M. lathyroides* cv. Murray, had similar mean yields, but had very different "b" values of -2.8 and 1.8 respectively (Table 2).

Finally, although the better accessions in these trials persisted for 3-5 years, this does not mean that they will persist in the long-term. Jones and Mannetje (1998) have pointed out how legumes can persist for many years at Narayen and then die out during consecutive dry years. The reason for this relates to the death of plants during such periods, the run-down of seed banks due to germination and seedling death following isolated rainfall events and lower or negligible seed set due to moisture stress. This caution is especially relevant to Experiments 1 and 2 which were carried out during periods of average or above average rainfall.

Acknowledgements

We thank the Australian Tropical Forages Genetic Resource Centre, CSIRO, Brisbane, for the supply of seed; and the farm staff of the CSIRO Narayen Research Station for land preparation, slashing and cattle management.

References

Cook, S.J. and Russell, J.S. (1983) The climate of seven CSIRO field stations in northern Australia. *Technical Paper No. 25, Division of Tropical Crops and Pastures, CSIRO, Australia.*

Eyles, A.G., Cameron, D.G. and Hacker, J.B. (1985) 'Pasture Research in Northern Australia – its history, achievements and future emphasis.' Research Report No. 4: (CSIRO Division of Tropical Crops and Pastures: Brisbane, Australia).

Finlay, K.W. and Wilkinson, G.N. (1963) The analysis of adaptation in a plant breeding programme. *Australian Journal of Agricultural Research* **14,** 742-754.

Jones, R.M. (1998) Evaluation of a range of tropical legumes on two clay soils in south-east inland Queensland. *Technical Memorandum No. 2, Tropical Agriculture, CSIRO, Australia.*

Jones, R.M. and Mannetje, L. 't (1997) Long term records of legume persistence and animal production from six legume-based pastures in subcoastal southeast Queensland. *Technical Memorandum No. 1, CSIRO Tropical Agriculture, Brisbane, Australia.*

Jones, R.M., McDonald, C.K. and Silvery, M.W. (1995) Permanent pastures on brigalow soil: the effect of nitrogen fertilizer and stocking rate on pastures and liveweight gain. *Tropical Grasslands* **29**, 193-209.

Jones, R.M. and Rees, M.C. (1997) Evaluation of tropical legumes on clay soil at four sites in southern inland Queensland. *Tropical Grasslands* **31**, 95-106.

Strickland, R.W. and Haydock, K.P. (1978) A comparison of twenty *Digitaria* accessions at four sites in south east Queensland. *Australian Journal Experimental Agriculture and Animal Husbandry* **18,** 817-824

Strickland, R.W. and Ford, C.W. (1984) *Cyamopsis senegalensis*: Potential new crop source of guaran. *Journal of the Australian Institute of Agricultural Science* **50,** 47-49.

Strickland, R.W., Greenfield, R.G., Wilson, G.P.M. and Harvey, G.L. (1985) Morphological and agronomic attributes of *Chamaecrista rotundifolia* Pers., *C. pilosa* L., and *C. trichopoda* Benth., potential forage legumes for northern Australia. *Australian Journal of Experimental Agriculture* **25,** 100-108.

Thompson, C.H. (1998) Soils of the crop rotation and grazing experiments in the brigalow area, CSIRO Narayen Research Station, Queensland. *CSIRO Tropical Agriculture, Brisbane, Australia.*