Sward evaluation of eleven "Stylosanthes seabrana" accessions and *S. scabra* cv. Seca at five subtropical sites

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Abstract

Sown pasture development in the light-textured soils of the seasonally dry tropics and subtropics is based mainly on *Stylosanthes* species. *S. scabra* cv. Seca, the cultivar most widely sown, has poor long-term persistence and yield in lower-rainfall subtropical environments experiencing frosts and drought, particularly on clay soils. This study has identified accessions of "Stylosanthes seabrana" which perform well on clay soils in the subtropics, greatly extending the contribution that *Stylosanthes* species can make to beef production in northern Australia.

Although there was abnormally low rainfall during the first 2 years of the experiment, the stylos established and survived in all environments. Most "Stylosanthes seabrana" accessions were consistently superior to Seca in seedling and perennial plant density and yield at most sites, particularly in the third year of the experiment. Seca performed poorly in all attributes in all years with the lowest rank over all years indicating its lack of adaptation.

The accessions 92838B and 110361 were selected and released as cultivars Primar and Unica, respectively, in 1996. Primar appears better adapted to the more southerly subtropical sites with early frosts and a short growing season. Unica appears superior to Primar in central Queensland which normally has a longer summer growing season.

Introduction

Ecologically robust management systems have been devised that affect the relative persistence, growth and long-term productivity of *S. hamata* and *S. scabra* cultivars in improved pastures for the low-fertility, light-textured soils of the seasonally dry tropics and subtropics. The main factors affecting the balance of species in the pasture are: characteristics of the sown stylo; grazing pressure; soil fertility and fertiliser application; nitrogen supply from the stylo; the other species in the pasture; and differential grazing (Gardener 1984).

A stylo technology does not exist for the fertile, heavy-textured soils of central and southern Queensland where *S. hamata* and *S. scabra* cultivars are poorly adapted and low yielding and lack long-term persistence. The main objective of the studies reported in this paper was to develop 'new' stylo cultivars for fertile clay soils that would extend the technology into additional agroecological zones occupying a potential area in excess of 20 M ha in Queensland (Weston *et al.* 1981).

"Stylosanthes seabrana" (previously *Stylosanthes* sp. aff *S. scabra*) is a potential new forage plant for northern Australia; lines are frost-tolerant and are adapted to the heavy soils of central and southern Queensland, where *S. scabra* and *S. hamata* have not been successful. They have considerably out-performed *S. scabra* and *S. hamata* in preliminary trials in these areas (Edye and Hall 1993; Jansen and Edye 1996; Edye and Maass 1997). The two trials reported in this paper compared promising accessions of "Stylosanthes seabrana" on clay soils in the subtropics to identify productive and persistent accessions, and used *S. scabra* cv. Seca as a benchmark.

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Materials and methods

Sites

There were 5 sites and 4 soil types (Table 1) between latitudes 25° and 27°S. The original vegetation was box-sandalwood at Ballaroo, box-belah at Holyrood and brigalow at the 3 remaining sites. All sites were cleared before the experiments commenced. Native grasses dominated the ground flora except at Rostock and Brigalow Research Station (Trial 2) where *Cenchrus ciliaris* cv. Biloela predominated. The experimental areas were disced before sowing to reduce grass competition. All soils were heavy clays (40–52% clay) and fertile (pH 6.5–8.0; bicarbonate-extractable P 16–40 ppm) and were not fertilised before sowing.

All sites were considered marginal for Seca because of low average annual rainfalls (522–716mm; Table 2), severe frosts (–7.7°C ground temperatures) and heavy-textured soils. Frosts occur more frequently at Ballaroo and Rostock (average 106 days) and Roma (121 days) than at the remaining sites (Foley 1945).

Accessions

The “Stylosanthes seabrana” accessions included in the 2 trials were collected between latitudes 10° and 18° S in Brazil at altitudes from 400–1050m with an annual rainfall of 400–1500mm. The predominant vegetation was Caatinga, a deciduous forest, and there was a 6–8 month dry season.

Trial 1 (1991–95)

“Stylosanthes seabrana” accessions were compared with Seca at 2 sites in a randomised block with 3 replications. The plot sizes were 4m × 5m. Seed was hand broadcast at a rate of 5 kg/ha dehulled seed which was scarified 3 times to increase germination to 65–75 per cent, then inoculated with *Rhizobium* CB2126 and 1650.

The trial included 8 “Stylosanthes seabrana” accessions at Holyrood and 11 at Brigalow Research Station. No associate grass was sown and native grasses volunteered. The comparisons terminated in June 1994 and June 1995, respectively.

Table 1. Location, altitude and soil type at the 5 experimental sites.

Site	Nearest town	Lat.	Long.	Alt.	Soil type[1]
		(°S)	(°E)	(m)	
Ballaroo	Surat	27°14’	148°33’	270	Red Sodosol
Rostock	Surat	26°48’	149°28’	290	Self-mulching Grey Vertosol
Holyrood	Roma	26°49’	148°49’	305	Red Sodosol
Narayen (brigalow)	Mundubbera	25°41’	150°52’	332	Self-mulching Brown Vertosol
Brigalow Res.Stn	Theodore	24°50’	149°48’	152	Self-mulching Grey Vertosol

[1] Isbell (1996).

Table 2. Annual rainfall (October–September) at the experimental sites.

Site	Date sown	Year 1	Rainfall Year 2	Year 3	Year 4	Mean	Long-term mean
Trial 1			(mm)				
Holyrood	16.01.91	**385**[1]	**371**	**219**	**483**	**364**	582
Brigalow Res.Stn	18.12.91	**647**	**286**	**543**	706	**546**	674
Trial 2							
Ballaroo	10.01.94	**408**	**453**	644	—	**502**	522
Rostock	11.01.94	**616**	**566**	817	—	666	624
Holyrood	17.12.93	**483**	**458**	610	—	**517**	582
Narayen	08.12.93	**406**	**360**	**698**	—	**488**	716
Brigalow Res.Stn	15.12.93	**543**	706	897	—	715	674

[1] Rainfalls in bold type are less than the long-term mean.

Trial 2 (1993–96)

Eleven "Stylosanthes seabrana" accessions were compared with Seca at 5 sites in a randomised block with 3 replications. The plot sizes were 6m × 16m. The sowing rate was 3 kg/ha dehulled, scarified seed inoculated with *Rhizobium* CB2126 and 3053 before sowing. *Cenchrus ciliaris* cv. Biloela dominated the ground flora at Rostock and Brigalow Research Station and *C. ciliaris* cv. American was oversown at 1 kg/ha at the remaining sites excluding Narayen where native grasses and weeds volunteered.

The stylo seed was drilled to a depth of 0–10mm in rows spaced 50cm apart at Ballaroo, Rostock and Holyrood and hand broadcast at the 2 remaining sites. Trial 2 was terminated in June 1996.

Trials 1 and 2 were sown between December and January at the start of the wet season (Table 2). The swards were grazed during the dry season and/or mowed before the start of each growing season, with no grazing during the wet season. The 2 trials differed in date of sowing, seeding rate, plot size, associate grass, strain of inoculum and the "Stylosanthes seabrana" accessions included but some accessions were common to both trials.

Data recorded

The number of stylo seedlings and perennating plants were counted annually in autumn from Year 2 onwards. Dry matter yields were determined in May or June each year, either by cutting six to nine 0.5 m × 1.0 m quadrats per plot, or by estimating in the quadrats on a scale of 1–10, which was standardised by quadrat cuts.

Dry matter yield was not measured at Brigalow Research Station in Year 1 (due to weed competition) and at Rostock in Year 2 (due to accidental grazing).

Numerical methods

Analyses of variance. The data for the 12 accessions were transformed using a square root transformation in order to make the variances homogeneous before analyses of variance using the statistical package GENSTAT 5 (Payne *et al.* 1987). In Trials 1 and 2, annual plant counts and yields were analysed for each site and year. The Trial 2 data were analysed also over all sites for each attribute and year. Where the accession × site interaction was significant, contrasts between accessions and Seca were extracted using the regression method of Finlay and Wilkinson (1963). For each accession, a linear regression of the yield (or plant counts) on the mean yield (or plant counts) of all accessions for each site and year was computed. When there was a significant difference between slopes and/or intercepts, the interpretation of the adaptation of individual accessions over sites was simplified.

Ranking procedures. In Trial 2, a ranking procedure was used to summarise the performance of the 12 accessions grown at 5 sites over Years 1, 2 and 3. The accessions were ranked 1 (highest) to 12 (lowest) on square root-transformed means averaged over the 5 sites sampled for the 8 attributes recorded. The total of the 8 ranks was then ranked 1 to 12.

Results

Rainfall and frosting

Rainfall during both trials was below average in the majority of years at all sites and was mainly less than 600mm. In Trial 2, above average rainfall was recorded in Year 3 at all sites except Narayen. The lowest recording was 219mm at Holyrood (Trial 1, Year 3) and the highest at Rostock 817mm and Brigalow Research Station 897mm (Trial 2, Year 3) (Table 2). At Holyrood, between June 18–September 11, 1991, minimum grass temperatures were between −7.7°C and 0°C on 53 occasions.

Trial 1

At Holyrood (Table 3), initial seedling densities were high (16–36 plants/m^2) and seedling recruitment was high in subsequent years except during the severe drought in Year 3. In Year 4, 7 "Stylosanthes seabrana" accessions had higher ($P<0.05$) seedling densities (74–142 plants/m^2) than Seca (5 plants/m^2). The perennial plant densities were high in all years but declined during the drought in Year 3. In Year 4, 2 "Stylosanthes seabrana" accessions had higher ($P<0.05$) perennial plant densities (58–59 plants/m^2) than Seca (21 plants/m^2). Mean stylo yields were 891 and 714 kg/ha in Years 1 and 2 and increased dramatically to 3510 kg/ha in Year 4, when

"Stylosanthes seabrana" accessions 115994 and 115995 gave almost twice the yield of Seca although the differences were not significant (P>0.05) (Table 3). The drought in Year 3 prevented a harvest for yield. The plots were stylo-dominant in all years.

At Brigalow Research Station (Table 4), seedling and perennial plant densities were low in all years except Year 4. Most "Stylosanthes seabrana" accessions had higher (P<0.05) seedling and perennial plant densities than Seca. Mean stylo yields declined from 705 kg/ha in Year 1 to 357 kg/ha during the drought in Year 2 and increased to 1378 and 2746 kg/ha in Years 3 and 4, respectively. Most "Stylosanthes seabrana" accessions outyielded (P<0.05) Seca in Years 1 and 2. In Year 3, accessions 110361 and 115994 outyielded (P<0.05) Seca and gave 4.8–5.6 times the yield of Seca in Year 4 (1994–95) when rainfall was 4.7% above average. The complete experiment was not sampled in Year 4, but most "Stylosanthes seabrana" accessions were superior to Seca in plant density and yield. The plots were stylo-dominant in all years.

At both sites, most "Stylosanthes seabrana" accessions showed a remarkable propensity for increasing population densities when rainfall was below average. By the fourth year of both studies, most accessions had seedling densities >100/m^2, perennial plant densities >10/m^2 and yields >2500 kg/ha.

Trial 2

Seedling establishment. Mean initial seedling densities over all accessions were very low (1.1–3.4 plants/m^2) at all sites except Ballaroo and Rostock (14.2 and 30.3 plants/m^2, respectively).

Seedling recruitment was very low in Year 2 (<0.1–6.2 plants/m^2) but higher in Year 3 (0.7–41.8 plants/m^2), particularly at Brigalow Research Station.

The analyses over all sites showed significant (P<0.01) accession × site interactions in Years 1 and 2 but not in Year 3. Their slopes were >1 and differed significantly (P<0.01) from Seca with a slope <1. Their seedling densities were mostly above average at the better sites Rostock and Ballaroo in Year 1 and Brigalow Research Station and Narayen in Year 2, whereas Seca was below average at the majority of sites (Table 5). In Year 3, all "Stylosanthes seabrana" accessions except 105546B and 110370B had higher (P<0.05) seedling densities than Seca.

Perennial plants. In Year 2, mean perennial plant densities over all accessions were very low at Holyrood, Narayen and Brigalow Research Station (2.0–2.5 plants/m^2) and higher at Ballaroo and Rostock (7.9–8.7 plants/m^2). In Year 3, perennial plant densities were 6.4 and 10.9 plants/m^2 at Ballaroo and Brigalow Research Sta-

Table 3. Means (square root-transformed) for density of stylo seedlings and perennials and yield in Years 1, 2, 3 and 4 at Holyrood (Trial 1).

Accessions	Seedlings				Perennials			Yield			
CPI No	Yr 1	Yr 2	Yr 3	Yr 4	Yr 2	Yr 3	Yr 4	Yr 1	Yr 2	Yr 3	Yr 4
	(sqrt No/m^2)				(sqrt No/m^2)			(sqrt kg/ha)			
Seca	4.3	4.1	0.0	2.1	5.5	3.7	4.4	22.3	30.2	—[1]	48.4
104710	6.0	5.3	0.0	10.7	5.1	4.2	7.0	29.9	25.4	—	66.3
110340	3.8	4.8	0.0	4.6	4.4	2.8	3.1	20.9	25.0	—	39.9
110343	4.4	6.5	0.0	8.5	4.3	2.5	5.8	27.3	23.3	—	57.3
110370B	5.1	3.5	0.0	9.5	5.4	3.6	6.2	30.9	25.2	—	55.3
110372	4.4	7.3	0.0	11.8	6.0	2.9	7.6	32.2	27.4	—	58.1
110373	5.0	4.2	0.0	10.9	5.5	2.6	6.7	29.0	27.8	—	56.7
115994	4.6	7.7	0.8	9.4	5.1	4.2	7.4	37.8	29.5	—	69.4
115995	4.9	6.4	0.0	10.7	4.5	4.3	6.8	30.0	23.7	—	69.1
LSD (P=0.05)	1.9	1.4	0.5	3.3	1.3	1.6	2.9	9.7	13.0	—	28.2
Original data Range											
From	36	65	2	142	38	20	59	1513	932		4853
To	16	13	0	5	19	7	10	473	549		1616
Mean	24	35	tr[2]	90	27	13	41	891	714		3510

[1] Not sampled for yield.

[2] Trace.

Table 4. Means (square root-transformed) for density of stylo seedlings and perennials and yield in Years 1, 2, 3 and 4 on the Brigalow Research Station grey clay (Trial 1).

Accessions CPI No	Seedlings Yr 1	Seedlings Yr 2	Seedlings Yr 3	Seedlings Yr 4[1]	Perennials Yr 2	Perennials Yr 3	Perennials Yr 4[1]	Yield Yr 1	Yield Yr 2	Yield Yr 3	Yield Yr 4[1]
	(sqrt No/m²)				(sqrt No/m²)			(sqrt kg/ha)			
Seca	1.4	0.4	0.8	4.6	0.8	0.7	1.6	9.2	8.6	22.6	26.3
104710	2.4	1.0	2.3	15.9	1.3	1.2	2.9	13.9	12.2	38.5	57.7
105546B	2.6	1.1	1.7	16.2	1.6	1.5	4.3	36.8	22.0	41.2	49.2
110340	1.6	1.0	1.5	—	1.2	1.1	—	9.1	11.4	27.8	—
110341	2.3	1.8	1.6	—	1.6	1.7	—	26.6	16.6	33.2	—
110343	3.1	1.5	2.8	—	2.0	1.7	—	26.7	21.6	35.4	—
110361	2.8	2.4	2.6	23.7	1.6	1.7	3.1	32.5	22.1	45.4	62.2
110370B	2.5	1.9	1.0	—	2.0	1.6	—	32.4	21.9	30.7	—
110372	2.7	1.7	2.7	—	1.7	1.6	—	31.0	20.1	34.1	—
110373	2.4	0.3	1.6	—	1.5	1.3	—	18.7	16.0	23.8	—
115994	2.7	1.0	2.1	16.8	2.0	1.5	3.9	27.6	23.6	46.1	57.5
115995	2.7	0.8	2.0	16.1	1.7	1.5	2.9	26.6	16.5	36.1	53.5
LSD (P=0.05)	0.9	0.7	1.4	—	0.6	0.6	—	12.6	8.7	20.4	—
Original data											
Range											
From	10.2	5.8	8.4	561	4.2	3.0	18.3	1463	557	2455	3865
To	2.4	0.2	1.0	21	0.9	0.6	2.7	132	128	641	693
Mean	6.2	2.1	4.6	274	2.7	2.2	10.5	705	357	1378	2746

[1] Not analysed statistically.

Table 5. Mean density of stylo seedlings (square root-transformed) at each site in Years 1, 2 and 3 (Trial 2).

Accessions CPI No	Yr 1 BAL[1]	Yr 1 ROS	Yr 1 HOL	Yr 1 NAR	Yr 1 BRI	Yr 2 BAL	Yr 2 ROS	Yr 2 HOL	Yr 2 NAR	Yr 2 BRI	Yr 3 BAL	Yr 3 ROS	Yr 3 HOL	Yr 3 NAR	Yr 3 BRI
								(sqrt No/m²)							
Seca	3	3.7	1.6	1.6	1.2	0	0.3	0.1	0	0.1	0.3	0.2	0.9	0	0.7
92838B	5.3	6.3	1.8	1.6	0.2	0	0.7	0.7	1	2.6	2	0.8	4.1	0.7	4.3
104710	3.6	5.1	1.3	1.4	1.4	0.1	0.4	0.7	0.5	3.5	2.3	1	1.4	0.8	7.9
105546B	3.7	6.1	1.2	1.9	0.4	0	1.2	0.9	0.4	0.6	1.9	0	1	2.2	2.6
110343	4	5.7	2.3	1.5	0.9	0.2	0.1	0.7	1.3	1.6	3.5	0.6	2.9	0.6	3.7
110361	3.3	5.9	1.9	2.1	1.4	0	0.6	0.7	0.2	1.6	1.5	0.9	3.3	4.6	9.9
110370B	3.3	3.8	1.6	1.6	0	0.5	0	0.8	0.4	2	3.1	0.2	3.4	0.3	2.8
110370C	3.6	6.1	1.9	2.2	0.9	0	0.4	1.5	1.3	2.8	1.8	0.9	3.7	1	6
110372	3.5	6.7	1.8	1.8	1.2	0	0.1	0.6	0.6	4	0.8	0.9	0.9	4.7	4.4
110373	3.3	5.1	1.9	1.8	0.7	0	0.6	1.5	0.7	1.8	2.4	0.6	2.9	1.7	3.2
115994	3.7	5.2	1.7	2.4	0.9	0	0	0.6	0.8	2.6	1.2	1	2	4.4	4.6
115995	3.3	4.8	1.9	1.6	0.8	0	0	1.5	0.7	2	3.9	0.4	4	0.3	6.4
LSD (P=0.05)	1.8	1.8	0.9	0.8	1.1	0.3	0.9	1.3	1.5	2.1	2.6	0.9	2.2	4.2	8.4
Seedling density (plants/m²)[2]															
Range															
From	9.3	13.9	2.7	2.3	0.1	0.0	0.0	0.1	0.0	0.1	0.3	0.0	1.0	0.0	0.7
To	28.9	44.8	5.6	6.3	2.4	0.4	2.6	2.3	2.7	12.7	19.9	1.4	20.0	39.8	211.4
Mean	14.2	30.3	3.2	3.4	1.1	0.0	0.4	1.1	1.2	6.2	6.6	0.7	8.6	8.8	41.8

[1] BAL=Ballaroo; ROS=Rostock; HOL=Holyrood; NAR=Narayen; BRI=Brigalow Research Station.
[2] Original data.

tion, respectively, and 2.1–3.8 plants/m² at the remaining 3 sites.

The analyses over all sites showed that most of the "Stylosanthes seabrana" had higher ($P<0.05$) perennial plant densities than Seca. There were no accession × site interactions (Table 6).

Stylo yield. In Year 1, the mean stylo yields over all accessions were 709 kg/ha at Narayen and 96–261 kg/ha at the remaining sites sampled. At Brigalow Research Station, only trace stylo yields occurred due to severe competition from *C. ciliaris* cv. Biloela and weeds. The mean stylo yields increased in Year 2 to 231–1447 kg/ha and declined to 219–609 kg/ha in Year 3. In all years at all sites, excluding Years 2 and 3 at Holyrood, some "Stylosanthes seabrana" accessions had higher ($P<0.05$) yields than Seca, recording yields as high as 3243 kg/ha (Table 7).

Table 6. Mean density of perennating stylo plants averaged over all sites in Years 2 and 3 (Trial 2).

Accessions CPI No.	Year 2		Year 3	
		(No/m^2)		
Seca	2.0	(1.06)[1]	1.1	(0.95)
92838 B	7.7	(2.03)	7.0	(2.31)
104710	4.9	(1.55)	5.9	(2.08)
105546 B	4.1	(1.41)	2.9	(1.57)
110343	4.7	(1.59)	3.9	(1.84)
110361	5.2	(1.39)	10.9	(2.54)
110370 B	2.8	(1.39)	5.0	(1.89)
110370 C	5.9	(1.80)	7.5	(2.41)
110372	3.6	(1.30)	4.2	(1.80)
110373	4.0	(1.33)	4.5	(1.94)
115994	6.1	(1.70)	5.3	(2.21)
115995	4.3	(1.64)	5.1	(1.94)
LSD (P=0.05)		(0.37)		(0.68)
Mean	4.6	(1.52)	5.3	(1.96)

[1] Statistical analysis based on square root transformation given in brackets.

The analyses over all sites showed significant ($P<0.01$) accession × site interactions. In Year 1, their slopes were >1 and differed significantly ($P<0.01$) from Seca with a slope <1. Their yields were mostly above average at the better sites Rostock and Narayen whereas Seca was below average at all sites. In Years 2 and 3, the slopes of the accessions with site interactions did not differ significantly from Seca.

Associate grasses. The associate grass was predominantly *C. ciliaris* cv. American at Ballaroo and Holyrood and cv. Biloela at Rostock and Brigalow Research Station. The mean dry matter yields of the sown grass over the 3 years at these sites were 1.74 t/ha (Ballaroo), 4.45 t/ha (Rostock), 3.13 t/ha (Holyrood) and 3.51 t/ha (Brigalow Research Station). At Narayen, there was also strong competition from volunteer grasses and weeds. Trial 2 was grass-dominant at all sites in all years.

Stylo performance rating. The performance of the stylo accessions was summarised by ranking (1 to 12) all accessions for mean seedling establishment, number of perennials and yield over 5 sites for Years 1–3. The total ranks of the 8 attributes for each accession placed 92838B, 110370C, 115994, 110361 and 104710 in the order 1 to 5. Seca was ranked 12th over all attributes having performed poorly in each attribute in each year.

Discussion

The study has identified accessions of "Stylosanthes seabrana" which perform well on clay soils in the subtropics, greatly extending the contribution that *Stylosanthes* species can make to beef production in northern Australia. The accessions were drought resistant and survived frosts with a minimum ground temperature of −7.7°C. Seca is adapted to lighter textured soils in subtropical environments (<26°S) with rainfall exceeding 700mm per annum and 500mm in tropical environments (<20°S). Seca is more susceptible to frosts and drought and fails in long-term persistence and yield on clay soils (Edye 1997).

Stylo density

The "Stylosanthes seabrana" accessions and Seca have small seeds and will not establish if sown too deeply (>10mm) or if covered too deeply with soil, especially in cracking, self-mulching clay soils. Consequently, establishment is very dependent on soil-surface condition at sowing, distribution of rainfall following sowing and competition from grasses and weeds.

The initial seedling establishment in Trials 1 and 2 was variable between sites, but "Stylosanthes seabrana" accessions germinated and established more rapidly than Seca. The higher perennial plant densities in the "Stylosanthes seabrana" accessions is a decided advantage for permanent pastures. Perenniality and annual seedling establishment and survival are highly desirable attributes for adaptation to low-rainfall environments experiencing severe frosts. R.M. Jones (personal communication) recorded mortality rates of *ca* 82% of established Seca and Fitzroy plants during Winter 1989 at Narayen due to frosts and above average late autumn-early winter rainfall. Younger plants growing from seedlings were less affected. Mature Seca plants have few bud sites on the base of the stem

Table 7. Mean dry matter yield (square root-transformed) of stylo at each site in Years 1, 2 and 3 (Trial 2).

Accessions CPI No	Yr 1					Yr 2					Yr 3				
	BAL[1]	ROS	HOL	NAR	BRI	BAL	ROS	HOL	NAR	BRI	BAL	ROS	HOL	NAR	BRI
						(sqrt kg/ha)									
Seca	9.4	8.0	7.7	15.2	+[2]	21.3	+	36.4	16.3	6.1	20.0	2.1	9.9	12.5	10.0
92838B	16.3	19.6	12.7	30.9	+	34.9	+	47.8	56.7	13.1	28.4	17.9	15.4	19.5	27.4
104710	11.3	18.1	6.6	19.3	+	30.0	+	29.2	19.9	18.3	21.9	22.4	9.1	16.8	35.7
105546B	9.0	14.6	7.0	31.9	+	24.0	+	29.4	37.9	14.4	16.4	10.4	11.7	26.0	19.3
110343	12.5	17.3	12.9	22.9	+	25.4	+	40.6	19.0	13.6	16.6	10.6	16.7	10.4	17.3
110361	7.8	14.5	8.8	22.8	+	20.3	+	33.3	51.7	14.1	22.8	14.4	17.2	34.7	25.8
110370B	10.9	10.2	9.6	23.7	+	16.7	+	24.8	18.0	11.5	17.0	13.4	14.4	3.9	14.8
110370C	11.1	19.7	7.0	32.0	+	24.2	+	39.1	27.2	13.9	21.6	14.7	16.7	11.7	29.3
110372	10.3	20.1	8.0	30.1	+	19.9	+	25.3	41.5	19.5	14.3	5.4	8.4	22.0	20.4
110373	10.2	13.2	11.6	25.2	+	22.3	+	36.2	22.9	11.0	13.9	10.3	17.8	11.0	14.4
115994	11.5	17.0	8.9	29.2	+	29.0	+	42.7	54.2	17.5	25.3	19.7	11.8	39.6	32.7
115995	12.8	14.3	12.1	22.0	+	25.5	+	47.3	32.5	18.5	19.3	11.9	17.1	8.5	22.9
LSD (P=0.05)	6.1	6.0	4.0	14.2	–	8.1	–	25.4	25.4	9.6	11.7	11.4	13.4	17.7	14.7
Yield (kg/ha)[3]															
Range															
From	63	68	45	243	–	279	–	638	375	37	199	13	83	45	109
To	267	411	173	1028	–	1228	–	2296	3243	404	816	507	422	1666	1385
Mean	134	261	96	709	–	631	–	1447	1417	231	447	219	233	487	609

[1] BAL=Ballaroo; ROS=Rostock; HOL=Holyrood; NAR=Narayen; BRI=Brigalow Research Station.

[2] Not sampled.

[3] Original data.

from which to regrow. In contrast, "Stylosanthes seabrana" accessions have dense crowns at or below ground level with numerous bud sites for regrowth following frosts, drought, heavy grazing or fire.

Yield

Seca nodulates freely with indigenous Australian strains of *Bradyrhizobium* but it was also inoculated before sowing with CB1650 or 3053 which are effective nitrogen-fixing strains. "Stylosanthes seabrana" has a highly specific requirement for effective nitrogen-fixing strains. It nodulates sparingly with indigenous Australian strains (Date *et al.* 1996). Sparse nodulation mainly on tertiary roots was observed at Rostock and Holyrood. It is unlikely that the yield of Seca was limited by poor nodulation but this was probably so with the "Stylosanthes seabrana" accessions, particularly in Year 3. In spite of this, these accessions out-performed Seca and the herbage showed no signs of a nitrogen deficiency. Effective *Bradyrhizobium* strains that persist under field conditions have now been identified (R.A. Date, personal communication).

Adequate plant densities for high dry matter and seed yields must occur regularly to ensure the long-term persistence of legumes to ensure their colonising ability during favourable seasonal conditions can be realised. "Stylosanthes seabrana" is a strong perennial with some individual plants surviving 5 to 6 years (authors, unpublished data). Perennial plant densities for Seca of 4–5 plants/m^2 achieve maximum dry matter yields (Gardener 1984) and similar densities should ensure maximum yields from effectively nodulated "Stylosanthes seabrana" plants. In Year 3, 7 accessions had mean densities over all sites of 5.0–10.9 perennials/m^2 compared with 1.1 perennials for Seca in Trial 2.

The decrease in mean stylo yield of most accessions over all sites in Year 3 of Trial 2, with increased rainfall, was probably due to greatly increased competition from sown grasses, low perennating stylo plant densities and poor nodulation and adaptation. However, the more vigorous accessions 92838B, 110361 and 115994 gave satisfactory yields at Narayen (420–1666 kg/ha) and Brigalow Research Station (800–1074 kg/ha).

At Brigalow Research Station during 1994–95, when rainfall was above average, "Stylosanthes seabrana" accessions gave yields of 140–400 kg/ha in sown grass-dominant plots (Year 2, Trial 2) compared with 2400–3860 kg/ha in stylo-dominant plots (Year 4, Trial 1). Jones and Rees (1997) showed that sown grass on fertile soils depressed legume yield by 3-fold in the second year following above average rainfall.

Cultivar selection

Overall, the "Stylosanthes seabrana" accessions performed better than Seca in these studies showing a better adaptation to the environment. However, some accessions had to be selected for release.

For pasture plants in general, it seems more desirable to select for accessions with adaptability to a wide range of seasonal and edaphic conditions in high and low-yielding environments rather than select accessions for specific sites. Accessions 92838B, 110370C, 115994 and 110361 were consistently superior to Seca in seedling and perennial plant density and yield over all or most sites, particularly in Year 3 (Trial 2).

R. Boland (personal communication) screened 18 "Stylosanthes seabrana" accessions and *S. scabra* cvv. Seca and Siran for anthracnose resistance in a replicated field experiment during 1994 and 1995 at Southedge near Mareeba. Accessions 92838B, 110361, 115994 and Siran showed the highest resistance and did not differ significantly ($P>0.05$). Accession 110370C and Seca were more susceptible.

The highest ranked 4 "Stylosanthes seabrana" accessions produced seed yields >500 kg/ha in 1993 at Walkamin, near Mareeba. In 1996, the seed yield with irrigation was 1440 kg/ha for 110361 and 1010 kg/ha for 92838B (J.M. Hopkinson and B.H. English, personal communication).

Accessions 110361 and 92838B were released by the Queensland Herbage Plant Liaison Committee in August 1996 as the cultivars Unica and Primar, respectively, because of their anthracnose resistance and high seedling and perennial plant densities and yield, particularly in Year 3. Accession 115994 was not selected because anthracnose symptoms were present in seed-increase plots at Walkamin in 1995. Unica continues growth and produces seed over a longer period into the dry season than Primar which has vigorous seedling and early growth. Primar appears better adapted to regions experiencing early frosts. The two cultivars have been described (Anon. 1996).

Unica and Primar could be included in seed mixtures with Seca for regions that are not marginal for the latter cultivar. They could fill a role for subtropical environments similar to the use of *S. hamata* cvv. Verano and Amiga in seed mixtures with Seca for tropical environments.

Although Unica and Primar are adapted to the more fertile, heavier-textured soils, there is evidence that effectively nodulated plants will grow satisfactorily on a wider range of soil types including solodic soils. Effectively nodulated "Stylosanthes seabrana" gave approximately 5 times the dry weight of uninoculated controls in field trials on the Narayen granite soil and Lansdown podzolic with average rainfall conditions (R.A. Date, personal communication).

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References

ANON. (1996) Caatinga stylo *Stylosanthes* — 'Primar' and 'Unica'. *Plant Varieties Journal,* **9,** 19–20.

DATE, R.A., EDYE, L.A. and LIU, C.J. (1996) *Stylosanthes* sp. aff. *scabra* — a potential new forage plant for northern Australia. *Tropical Grasslands,* **30**, 133.

EDYE, L.A. (1997) Cultivar development within *Stylosanthes* in Australia. *Tropical Grasslands,* **31**, 503–508.

EDYE, L.A. and HALL, T.J. (1993) Development of new *Stylosanthes* cultivars for Australia from naturally occurring genotypes. *Proceedings of the XVII International Grassland Congress, Palmerston North and Rockhampton, 1993.* pp. 2159–2161.

EDYE, L.A. and MAASS, BRIGITTE L. (1997) The biogeography of *Stylosanthes hamata*, *S. scabra* and "Stylosanthes seabrana". *Tropical Grasslands* **30**, 417–423.

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.

FOLEY, J.C. (1945) Frosts in the Australian region. *Bulletin No 32. Commonwealth Meteorological Bureau, Commonwealth of Australia*.

GARDENER, C.J. (1984) The dynamics of *Stylosanthes* pastures. In: Stace, H.M. and Edye, L.A. (eds) *The Biology and Agronomy of* Stylosanthes. pp. 333–357. (Academic Press: Sydney).

ISBELL, R.F. (1996) *The Australian Soil Classification.* (CSIRO Publishing: Melbourne).

JANSEN, P.J. and EDYE, L.A. (1996) Variation within *Stylosanthes* sp. aff. *scabra* and comparison with its closest allies, *S. scabra* and *S. hamata*. *Australian Journal of Agricultural Research*, **47**, 985–996.

JONES, R.M. and REES, M.C. (1997) Evaluation of tropical legumes on clay soils at four sites in southern inland Queensland. *Tropical Grasslands*, **31**, 95–106.

PAYNE, R.W., LANE, P.W., AINSLEY, A.E., BICKNELL, K.E., DIGBY, P.G.N., HARDING, A.G., LEECH, P.K., SIMPSON, H.R., TODD, A.D., VERRIER, P.J., WHITE, R.P., GOWER, J.C. and WILSON, G.T. (1987) *Genstat 5 Reference Manual.* (Clarendon Press: Oxford).

WESTON, E.J., HARBISON, J., LESLIE, J.K., ROSENTHAL, K.M. and MAYER, R.J. (1981) Assessment of the agricultural and pastoral potential of Queensland. *Agriculture Branch Technical Report No 27. Queensland Department of Primary Industries, Brisbane*.

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