Evaluating pasture species for less fertile soils in a subtropical aseasonal low rainfall zone

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Abstract

Grasses, legumes, saltbushes and herbs were evaluated at 6 sites in southern inland Queensland to identify potential pasture and forage plants for use on marginal cropping soils. The region experiences summer heat waves and severe winter frosts. Emphasis was on perennial plants, and native species were included. Seedlings were transplanted into the unfertilized fields in either summer or autumn to suit the growing season of plants, and watered to ensure establishment. Summer-growing grasses were the most successful group, while cool season-growing perennials mostly failed. Summer legumes were disappointing, with *Stylosanthes scabra* and *Indigofera schimperi* performing best. Some lines such as *I. schimperi* and the *Eragrostis* hybrid cv. Cochise were assessed as potential weeds owing to low animal acceptance. Native *Rhynchosia minima* grew well at some sites and deserves more study. *Cenchrus ciliaris* was always easy to establish and produced the highest yields. Persistence of some *Digitaria* and *Bothriochloa* species, *Eragrostis curvula* and *Fingerhuthia africana* at specific sites was encouraging, but potential weediness needs careful assessment. Standard species were identified to represent the main forage types, such as *Austrostipa scabra* for cool season-growing grasses, for incorporation into future trials with new genetic materials. The early field testing protocol used should be considered for use elsewhere, if unreliable rainfall poses a high risk of establishment failure from scarce seed.

Resumen

En 6 sitios localizados en el interior de la región sur de Queensland, Australia, se evaluaron gramíneas, leguminosas, arbustos de tierras salinas (“saltbushes”) y hierbas con el fin de identificar potenciales plantas forrajeras para suelos agrícolas marginales. La zona se caracteriza por veranos con altas temperaturas e inviernos con heladas severas. En el trabajo se dio énfasis a especies perennes y se incluyeron algunas nativas. El establecimiento se hizo por plántulas trasplantadas a campo sin fertilización, ya sea en verano o en otoño (dependiendo de la temporada de crecimiento de las especies), y se aplicó riego para asegurar su establecimiento. Las gramíneas de crecimiento en verano constituyeron el grupo más exitoso mientras que las especies perennes de crecimiento en la época fría fracasaron en su mayoría. Las leguminosas de verano mostraron un pobre desempeño; de éllas, *Stylosanthes scabra* e *Indigofera schimperi* tuvieron el mejor desarrollo. Algunas líneas como *I. schimperi* y el híbrido de *Eragrostis*, cv. Cochise, presentaron características de malezas debido a su baja aceptabilidad por el ganado. La leguminosa nativa *Rhynchosia minima* creció bien en algunos sitios y amerita ser más estudiada. La gramínea *Cenchrus ciliaris* fue siempre fácil de establecer y produjo los mayores rendimientos. La persistencia de algunas especies de *Digitaria* y *Bothriochloa*, de *Eragrostis curvula* y *Fingerhuthia africana* fue alentadora en algunos sitios, pero su potencial de maleza requiere de una evaluación cuidadosa. Se identificaron las especies que pueden servir como representantes estándares de los principales tipos de forraje, tales como *Austrostipa scabra* como gramínea de crecimiento en época fría, para incluirlas en futuros ensayos con nuevos materiales genéticos. Se sugiere usar este protocolo de pruebas de campo iniciales para otros lugares, donde la falta de lluvias confiables y la escasez de semilla presenten un alto riesgo de fracaso en el establecimiento de las plantas.

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Introduction

In the Condamine-Maranoa region of southern inland Queensland, Australia (25–29° S), sclerophyllous woodlands and dense tall shrublands dominate the natural vegetation. Native pastures dominated by summer-active grasses are a common forage base for livestock. Their replacement by sown pastures after tree clearing or the infusion of forage legumes seems a good option in some cases (Miller et al. 1988). However, after such disturbance, woody regrowth can thrive and the poisonous pimelea (*Pimelea trichostachya*) (MLA Australia 2010) can proliferate, especially on abandoned cultivation land. Buffel grass (*Cenchrus ciliaris*) has been a major exotic pasture success story, but it tends to become a monoculture.

The better structured soils of the region are almost fully utilized for crops, so some less fertile, poorly structured soils are now cropped intermittently in response to market forces. Soil structure on these poorer soils soon breaks down (Douglas 1997), as reported in other countries (Bot and Benites 2005). Significant areas of native pastures have also been seriously degraded, with wiregrasses (*Aristida* spp.) assuming dominance. Thus, sown pasture species are needed to restore structure to some soils between cropping periods and to augment native pastures, as exists in other subtropical parts of the world, e.g. the Sahel and the Cerrado region in Brazil (Pearson et al. 1995).

Effective rainfall for establishing sown pasture seedlings is unpredictable and most cropping enterprises depend upon stored subsoil moisture to fill the seed of grain crops. Median summer rainfall (October–March) ranges from 300 to 400 mm, median winter rain is 175–200 mm (Rainman 2003), and droughts and floods are common. Frosts are common (20–60) in winter (Hammer and Rosenthal 1978) and high summer temperatures (>38 °C on many days) routine.

In the mid-1980s, we began to evaluate pasture and forage species that were best adapted agronomically for various roles in that environment and to identify benchmark species against which existing and future genetic material could be compared. The potential roles were: permanent pasture; short-term pasture; legume-augmented native pasture; and soil conservation. We focused on less fertile land that could be cropped intermittently, because that allowed agronomic intervention in a low to moderate cashflow environment. While a range of forage cultivars already existed for fertile soils, e.g. Rhodes grass (*Chloris gayana*), lucerne (*Medicago sativa*), leucaena (*Leucaena leucocephala*), forage sorghums (*Sorghum* spp.) and oats (*Avena sativa*) (Thompson 1988; Blacket 1992), only buffel grass was suitable for infertile soils. Some plants native to the region were included to ensure that our assessment was not biased by perceived virtues of exotic species (Davis et al. 2011).

Materials and Methods

Trial site details

We used 5 low-elevation (200–300 masl) field sites on commercial farms, chosen to provide a range of soil types and regional locations; 2 in the Roma district (26.5° S, 149° E; Sites L and N), and 3 near St George (28° S, 149° E; Sites M, U and W). Preliminary screening of accessions and seed increase were also done at Toowoomba (27.5° S, 151.9° E; Site T). Details of the soils and original vegetation at each site are given in Table 1. Site U had grown only one prior wheat crop, while most sites had grown several crops, and Site N had been intermittently cropped for 15 years beforehand.

Soils at the sites varied markedly (Table 1). Two sites (L and W) had a strong duplex profile with a thin, hard-setting, slightly acid loam overlying an impermeable clay subsoil that became saline-sodic at depth. Three other sites (M, T and U) had a gradational increase in clay content with depth, were non-saline and had a general red coloration. At the sixth site (N), the duplex soil was not hard-setting, was alkaline throughout and had carbonate nodules at depth. A strongly bleached A2 horizon at sites L and W was evidence of an impervious subsoil and waterlogging in abnormally wet seasons. Site T was similar to infertile, friable, red cracking clays found south of Roma (Slater and Carroll 1993).

Species evaluated

Since effective rainfall (that which wets the upper 15 cm of soil) can occur at any time, we evaluated both summer- and winter-active species, and included less-traditional forage plants such as non-legumes and browse shrubs, because their higher mineral contents may counter-balance the low levels in the local, grass-dominant pastures. Perennial species were favored, because land can be exposed to erosion for long periods in this environment with annual species. A long assessment period was required to ensure meaningful conclusions were reached.

We chose our test plants on the basis of experience by many pasture agronomists in Queensland and New South Wales, particularly Blumenthal et al. (1985), Day and Silcock (1985), Scattini (1985), Strickland and Greenfield (1988) and Bellotti et al. (1991). Well-regarded species from semi-arid regions overseas were also sourced, e.g. *Dorycnium hirsutum* and wheatgrasses (*Agropyron* spp.). The plant accessions tested at field sites are listed in Table 2 along with their homeland and principal traits.

Table 1. Details of the soil and surrounding vegetation at each trial site.

Feature	Site					
	L	M	N	T	U	W
Original vegetation[1]	Poplar box /belah	Yellow-jacket /mulga	Poplar box /yarran	Dense stringybark	Poplar box /sandalwood	Poplar box /wilga
Soil type[2]	Dy2.43	Gn2.11	Dd1.43	Gn3.11	Dr2.23	Dr2.43
Surface soil structure	Hard-setting loam	Firm loamy sand	Loose clay loam	Friable clay loam	Moderately hard-setting sandy loam	Hard-setting silty loam
Surface soil color	grey	red	grey	red	red	brown
Surface clay (%)	17	8	26	30	29	32
Surface pH[3]	6.7	5.7	8.2	6.3	6.4	6.5
Surface bicarb. extr. P (ppm)	27	2	3	14	5	16
Surface CEC[4] (meq/100 g)	8	2	23	15	6	8
Surface org. C (%)	0.5	0.5	0.5	3.5	0.9	0.8
A horizon depth (cm)	20	90	20	60	25	20
A2 horizon bleach[5]	++	-	-	-	-	++
B horizon pH	7.0	5.1	9.0	7.8	5.9	7.5
B horizon EC[6] (mS/cm)	0.11	0.01	0.26	0.03	0.02	0.42

[1]Poplar box = *Eucalyptus populnea;* Belah = *Casuarina cristata;* Mulga = *Acacia aneura;* Yellow jacket = *Eu. intertexta;* Stringybark = *Eu. eugenioides;* Yarran = *A. omalophylla;* Sandalwood = *Eremophila mitchellii;* Wilga = *Geijera parviflora.*
[2]Northcote Principal Profile Form classification (Northcote 1971).
[3]pH 1:5 water assay.
[4]Cation exchange capacity.
[5]++ = strong bleach; - = no A2 horizon bleach.
[6]Electrical conductivity.

Table 2. List of accessions evaluated, their key traits and the sites where not sown (**-**).
An **x** at a site means that the accession survived there for at least 6–7 years, while **t** means a tiny amount remained in 1 replicate after 6–7 years.

Species	Cultivar	Plant type[1]	Homeland[2]	Accession	Site					
					L	M	N	U	W	T
Summer growers										
Andropogon ischaemum		PT	Mexico	CPI90727						-
Andropogon ischaemum		PT	USA	CPI99868						-
Andropogon ischaemum		PT	USA	CPI99869			**x**			-
Anthephora pubescens		PT	South Africa	Q20321	**x**	**x**		**x**		-
Bothriochloa barbinodis		PT	USA	CPI99572						-
Bothriochloa barbinodis		PT	USA	CPI99867						-
Bothriochloa ewartiana[3]		PT	St George	TN47	**x**	**x**	**x**	**x**	**x**	**x**
Bothriochloa glabra	(Swann)[4]	PT	Uncertain/Qld.	CPI11408			**x**	**x**		-[5]
Bothriochloa insculpta		PS	Zimbabwe	CPI69517	**x**		**x**	**x**	**x**	-[5]
Bothriochloa insculpta		PS	Zambia	CPI52193	**x**	**x**	**x**	**x**		-[5]
Bothriochloa insculpta	Hatch	PS	Zimbabwe/Qld.	Hatch	**x**		**x**	**x**		-[5]
Bothriochloa pertusa	Medway	PS	Uncertain/Qld.	Medway	**x**	**x**	**x**	**x**	**x**	-[5]
Cenchrus ciliaris		PT	Namibia	CPI60733	**x**		**x**		**x**	-
Cenchrus ciliaris		PT	Somalia	CPI71914	**x**	**x**	**x**	**x**	**x**	-
Cenchrus ciliaris		PT	South Africa	CPI73390	**x**	**x**[6]	**x**	**x**		-
Cenchrus ciliaris		PT	South Africa	CPI73393	**x**	**x**	**x**	**x**	**x**	-
Cenchrus ciliaris		PT	Ethiopia	Q10077	**x**	**x**	**x**	**x**	**x**	-
Cenchrus ciliaris	Biloela	PT	Tanzania/Qld.	Biloela	**x**		**x**	**x**		-
Cenchrus ciliaris	Gayndah	PT	Kenya/Qld.	Gayndah	**x**		**x**	**x**	**x**	

Continued

Species	Cultivar	Plant type[1]	Homeland[2]	Accession	Site					
					L	M	N	U	W	T
Cenchrus hybrid		PT	Bred, USA	CPI61135	**x**	**x**	**x**	**x**	**x**	-
Cenchrus setiger		PT	Kenya	CPI17655	**x**	**x**	**x**	**x**	**x**	-
Chloris gayana	Pioneer	PS	Uncertain/Aust.	Pioneer						-
Chloris truncata[3]		PT	Miles	TN45	**x**				**x**	
Dactyloctenium sp.		PS	Peru	Q9143						-
Dactyloctenium sp.		PS	Ethiopia	Q10878						-
Dichanthium aristatum		PT	Uncertain/Bundaberg	TBA1014			**x**			-[5]
Dichanthium aristatum		PT	Uncertain/Rockhampton	TBA1024						-
Digitaria abyssinica		PS	Yemen	CPI89982						**x**
Digitaria brownii[3]		PT	Charleville	TN57					**x**	
Digitaria eriantha		PS	South Africa	CPI26832	**x**		**x**			-
Digitaria milanjiana		PS	South Africa	CPI41192	**x**	**x**	**x**	**x**		-
Digitaria milanjiana		PS	Zimbabwe	CPI59786	**x**	**x**	**x**			-
Digitaria smutsii	(hybrid)	PT	Bred, Aust.	TBA9						-
Digitaria smutsii	(Premier)[4]	PT	South Africa	CPI38869	**x**	**x**	**x**			-
Enteropogon acicularis[3]		PT	Moree	TN1					**x**	
Eragrostis bicolor		PT	South Africa	CPI98920	**x**	**x**	**x**	**x**		-
Eragrostis hybrid	Cochise	PT	USA	CPI99872	**x**	**x**	**x**	**x**		-
Eragrostis lehmanniana		PT	South Africa	CPI98954			**x**[6]			-
Eragrostis lehmanniana		PT	South Africa	CPI98960	**x**[6]	**x**		**x**		-
Eragrostis lehmanniana		PT	USA	CPI99871	**x**	**x**	**x**	**x**		-
Eragrostis obtusa		PT	South Africa	CPI98952	**x**[6]		**x**	**x**		-
Eragrostis obtusa		PT	Sthn Africa/West. Aust.	WA80/1987	**x**		**x**	**x**	**x**	-
Eragrostis superba		PT	Botswana	CPI59853	**x**		**x**			-
Eragrostis truncata		PT	South Africa	CPI98987						-
Leptochloa dubia		PT	USA	CPI99865	**t**					
Leptochloa fusca		PT	USA	CPI99880						**x**
Panicum antidotale		PT	Uncertain/Aust.	TBA1				**x**		
Panicum coloratum	Bambatsi	PT	Zimbabwe/Qld.	Bambatsi	**x**		**x**			-
Panicum decompositum[3]		PT	SW Queensland	TN8	**t**					
Panicum kalaharense		PT	South Africa	CPI73576						-
Panicum stapfianum		PT	South Africa	CPI73577	**x**	**x**	**x**	**x**		-
Pappophorum mucronulatum		PT	USA	CPI99877						
Schmidtia pappophoroides		PT	Botswana	CPI43715		**x**	**x**			-
Setaria incrassata	Inverell	PT	Zimbabwe/NSW	Inverell			**x**			-
Sorghum hybrid	Silk	PT	Bred, Queensland	Silk						-
Sporobolus actinocladus[3]		PT	Charleville	TN9						
Sporobolus fimbriatus		PT	South Africa	CPI60781	**x**					-
Themeda triandra[3]		PT	Talwood	TN35	**x**		**x**	**x**		**x**
Trichachne californica		PT	USA	CPI99561						
Trichloris crinita		PT	USA	CPI99879						
Urochloa oligotricha		PT	Zimbabwe	CPI60127	**x**		**x**			-
Urochloa stolonifera	(Saraji)[4]	PS	South Africa	CPI60128	**x**		**x**		**x**	-
Acacia angustissima		LW	Mexico	CPI84971	**x**		**x**	**x**		-
Chamaecrista rotundifolia[7]	(Wynn)[4]	LH	Brazil	CPI34721						-
Clitoria ternatea		LH	Kenya	CPI20733						-
Cullen patens[3]		LH	Charleville	CN63						
Desmanthus virgatus		LH	Mexico	CPI85178	**x**		**x**			
Desmanthus virgatus		LH	Mexico	CPI90751						
Galactia sp.		LH	Argentina	CPI78425	**t**					
Glycine tomentella[3]		LH	Allora	WRI3						**x**
Indigofera schimperi		LH	Zimbabwe	CPI69495			**x**			-
Indigofera schimperi		LH	Kenya	CPI73608						-
Leucaena leucocephala		LW	USA	CPI61815				**x**		-
Leucaena leucocephala	Cunningham	LW	Bred, Qld.	Cunningham						-
Lysiloma watsonii		LW	Mexico	CPI62129						-
Macroptilium atropurpureum		LH	Mexico	CPI90334						
Macroptilium atropurpureum		LH	Mexico	CPI90454						**x**
Macroptilium atropurpureum		LH	Mexico	CPI90455E						
Macroptilium atropurpureum		LH	Mexico	CPI90821						
Macroptilium atropurpureum	Siratro	LH	Bred, Qld.	Siratro						**x**

Continued

Species	Cultivar	Plant type[1]	Homeland[2]	Accession	Site: L	M	N	U	W	T
Macroptilium lathyroides		LH	USA	CPI38841						
Macrotyloma daltonii		LH	Namibia	CPI60303						-
Phaseolus filiformis		LH	Mexico	CPI85005						
Phaseolus sp.		LH	Mexico	CPI90752	x					x
Rhynchosia minima		LH	Zimbabwe	CPI52704						x
Rhynchosia minima[3]		LH	W. Qld.	TN15	x	x	x			
Rhynchosia minima[3]		LH	Tambo	TN24	x		x			
Stylosanthes fruticosa		LH	Sudan	CPI40615						
Stylosanthes fruticosa		LH	Sudan	CPI41219						-
Stylosanthes scabra		LH	Brazil	CPI55872	t					-
Boerhavia dominii[3]		OH	Augathella	TN27			x			
Evolvulus alsinoides[3]		OH	Charleville	TN6	x			x	x	
Merremia aurea[7]		OH	Mexico	CPI84982						-
Sida brachypoda[3]		OH	Charleville	TN7				x		
Aseasonal growers										
Dichanthium sericeum[3]		PT	Talwood	TN36	x		x	x		x
Eragrostis curvula		PT	South Africa	CPI30374	x	x	x	x		-
Eragrostis curvula		PT	South Africa	CPI98914	x	x	x	x		-
Eragrostis curvula		PT	South Africa	CPI98926	x	x	x	x		-
Eragrostis curvula	(Consol)[4]	PT	South Africa/NSW	SCS4663	x	x	x	x		-
Eragrostis intermedia		PT	USA	CPI99554				x[6]		-
Eriochloa pseudoacrotricha[3]		PT	Miles	TN44			x			
Fingerhuthia africana		PT	South Africa	CPI98990					x	
Thyridolepis mitchelliana[3]		FT	Charleville	TN22		x[6]		x		
Acacia aneura[3]		LW	Charleville	TN59	x			x		-
Cassia sturtii[3]		LW	Australia/Israel	CPI79501	x		x	x	x	-
Cullen patens[3]		LH	Charleville	TN29				x		
Cullen tenax[3]		LH	Charleville	CN55			x			
Cullen tenax[3]		LH	SW. Qld.	TN12	x					
Cullen tenax[3]		LH	Toowoomba	WRI19	x					
Medicago sativa	Trifecta	LH	Bred, Aust.	Trifecta						-
Atriplex canescens		CW	Mexico	CPI85166	x					
Atriplex halimus		CW	Israel	CPI79496						x
Sanguisorba minor		OH	Uncertain/New Zealand	Q22947						x
Winter growers										
Agropyron elongatum	Largo	FT	Turkey	Q20701						x
Agropyron trichophorum	Luna	FS	USSR/USA	Q20704						
Austrostipa scabra[3]		FT	Morven	TN10	x			x		
Bromus inermis		FS	Iran	Q20711						
Elymus scaber[3]		FT	Toowoomba	TN49						x
Oryzopsis miliacea		FT	Spain	CPI36101						
Stipa tenuissima		FT	France	Q20715						x
Dorycnium hirsutum		LH	Uncertain/New Zealand	Q22941						x
Medicago laciniata[7]		LH	Uncertain/Aust.	TBA7						-
Medicago laciniata[7]		LH	Uncertain/Bourke	TBA13			-	-	-	-
Medicago murex[7]	(Zodiac)[4]	LH	Italy	CD64.11.1						-
Medicago murex[7]		LH	Italy	WA5320						
Medicago polymorpha[7]	Circle Valley	LH	Bred, West. Aust.	Circle Valley					-	-
Medicago polymorpha[7]	Serena	LH	Bred, West. Aust.	Serena		-			-	-
Ornithopus compressus[7]		LH	Italy	CS146						-

[1]Plant type is described by 2 letters, the first denoting: C=Chenopod, F=C3 grass, L=Legume, P=C4 grass and O=Other; and the second indicating growth form: H=Herbaceous, S=Sward, T=Tussock and W=Woody plant; [2]Nearest Australian town if a native species; [3]Native species; [4]Brackets used if the cultivar name was given later to the accession; [5]Not sown in our trials at this site, but grew well in other trials on adjacent land; [6]Discrimination from similar-looking accessions not certain after many years; [7]Annual species.

Details of the origins of each accession can be had by contacting the senior author or by sourcing either the CSIRO Quarterly List of Introductions, starting at CPI11408 in Nbr 16 (1948) through to CPI33946 in Nbr 75 (1963) or thereafter in The Australian Plant Introduction Review (CSIRO:Australia), New Series, Volumes 1 (1964) through to CPI99880 in volume 17 (1985). For cultivars sourced from commercial seed or local ecotypes, that have probably undergone genetic shift since their introduction, their original homeland is named followed by "/ecotype collection locality", such as Zimbabwe/Qld.

Plants tested were grouped for presentation of results on their main season of growth, their perenniality and their growth form (Table 3). The seasonal classes are based on the potential season of growth in the subtropical South Queensland environment. Aseasonal means plants that can grow at any time of the year, when soil moisture is adequate and there are no severe night frosts. Wet winters normally result in mild nights and very few frosts severe enough to freeze green leaf tissue, while in dry winters, morning radiation frosts as cold as -7 °C are common (Hammer and Rosenthal 1978).

Planting details

To minimize field establishment failure, seedlings were transplanted after effective rain and watered intermittently until follow-up rain occurred. Thereafter they competed with local weeds and pests under controlled grazing without the assistance of fertilizer. Some accessions with low seed supplies were increased beforehand at Toowoomba (Site T; 640 masl), and species with many potential accessions available were screened to short-list the agronomically promising lines and to eliminate those which failed badly, such as Russian wildrye (*Psathyrostachys juncea*), which was extremely susceptible to a stem rust and failed to set seed. In a few cases, nursery plants provided vegetative material for field sowings, when germination difficulties severely limited potential sowing numbers.

Glasshouse procedures

Seedlings and a few grass transplants were established in a glasshouse in Toowoomba. Sieved soil from each site was poured into 15 cm deep expanding blocks of hexagonal paper pots (2.5–4 cm diameter). The soil was wet up with tap water and fertilized with mono-ammonium phosphate (MAP) prior to sowing the seeds. Legume and other non-grass seeds were scarified with sand-paper to remove impervious coatings if necessary, and saltbush fruits were clipped to expose the seed inside and then leached of salt, but grasses were sown untreated as clean seed with any glumes and short awns. When germination rates for grasses were low, plant numbers were augmented with plants struck from nursery ramets, using material from many different parent plants.

After sowing, legume tubes were inoculated with an appropriate rhizobial slurry. Seedlings remained in the glasshouse for 3–5 weeks, until adequate rain had fallen at the trial sites. Sometimes additional MAP was applied to keep larger plants healthy. When excessive seedling numbers occurred, stands in the tubes were thinned, so that grasses tillered and non-grasses suffered limited competitive stress. Just prior to sowing, the tops of large plants were clipped to reduce transpiration load and all were placed outside for a few days to 'harden-up' in natural sunlight and wind.

Field procedures

At field sites, seedlings were sown in rows as spaced plants into a fenced area of wheat stubble. The rows, 3 m apart, were centered along 1 m wide strips sprayed for weed control with glyphosate (1 kg a.i./ha) just before planting. Rows, containing 10–15 randomly located accessions, were blocked into each of the 2 replicates sown at a site. A line of 6 holes at 1 m spacings was dug with a mattock for each replicate of an accession and filled with water. Then the tubed seedlings were planted singly, the soil refilled around them, and each plant rewatered from either a nearby farm dam or the Toowoomba city supply. Until reasonable follow-up rains fell, plants were rewatered about once a week (Table 4). Summer and autumn sowings of appropriate species occurred at each field site (dates given in Table 4). When enough plants failed to establish, accessions were resown after

Table 3. Numbers of accessions tested in each major forage type group.

Type of plant (totals)		Summer growers		Aseasonal growers		Winter growers		All seasons	
		Exotic	Native	Exotic	Native	Exotic	Native	Exotic	Native
Grasses (78)	Perennial	52	9	5	3	5	2	62	14
	Annual	2						2	0
Legumes (43)	Perennial	19	3	1	5	1		21	8
	Annual	1				7		8	0
	Perenn. shrubs	4			2			4	2
Chenopods (2)	Perenn. shrubs			2				2	0
Others (5)	Perennial	1	3	1				2	3
Totals (128)	Perennial herbs	87		15		8		110	
	Annual herbs	3		0		7		10	
	Perennial shrubs	4		4		0		8	

rain the following year at an equivalent time. The initial sowing at each site was of summer-active species, when wheat stubble was still sturdy, but by the autumn sowing, the stubble had often thinned and weeds were established.

Domestic stock were excluded by hinge-joint fences and plants were ungrazed until the majority were well established and had flowered and seeded. This time period varied greatly as sites experienced widely differing growing conditions (Table 4).

Grazing management

The owner's stock currently in the paddock (mainly cattle but sometimes sheep and horses) were allowed to graze the plots, for only a few days initially, and stock were completely excluded for some time after the autumn sowing and again for many weeks after resowings in the second year. From about 2 years after the final resowings, plots were left open to grazing for extended periods. As some paddocks beside our plots were recropped, no domestic stock had access for extended periods, usually during winter, but local marsupials and rabbits often more than compensated for this. Grazing pressure steadily increased as the plots aged, partly due to the worsening below average rainfall seasons after 1990.

Data collection

Periodic recordings were made of the number of plants surviving in each plot, their vigor, flowering and seeding status, and general condition. Later, numbers of seedling recruits plus the distance spread from their original plots were recorded. After 5–6 years, the fences were removed and plots subjected to normal grazing. The persistence and spread of surviving plants was monitored for at least 15 years and some lines that showed weed potential were dug out. Sites U and N were replowed by the owners in 1999 and 2003, respectively, providing an opportunity to assess the ability of persistent lines to resist such practices.

Other influences

At Site M, the coarse native wiregrasses amongst the rows were rarely grazed and became quite rank. Hence we occasionally slashed or burnt the whole plot, beginning in November 1988, a management strategy commonly used to control wiregrasses. Site W was exposed to appreciable spray drift (glyphosate + 2,4-D) in autumn 1990, sufficient to defoliate trees beside the plots and brown the foliage of most plants being evaluated.

Results and Discussion

Seasonal rainfall

Table 4 summarizes the rainfall received around sowing times for each site, while Table 5 and Figure 1 present the seasonal rainfall received at each site during the first 6 years. During the first few years, growing conditions in the cool season were better and in summer were drier than 'normal' (Rainman 2003). After the initial years of reasonable rainfall, a prolonged period of below average rainfall occurred (1991–1994). From 1995 seasons were more favorable, enabling long-term persistence, spread and possible weed potential to be assessed.

Table 4. Sowing times, early rainfall received and key site management events during the first 2 years at each site, except the Toowoomba nursery.

Event	Site				
	L	M	N	U	W
First summer sowing date	30.10.86	21.10.86	5.2.86	3.12.85	5.12.85
Pre-sowing rain (mm in 2 wk)	56	55	10	33	51
Watering period after summer sowing (d)	12	21	12	18	27
Rain in 3 months after sowing (mm)	213	115	67	101	100
Winter sowing date	26.6.87	19.5.87	23.7.86	30.7.86	30.7.86
Pre-sowing rain (mm in 2 wk)	13	45	12	45	35
Watering period after winter sowing (d)	25	12	0	19	14
Rain in 3 months after sowing (mm)	61	132	161	167	138
First grazing	15.9.88	27.3.88	2.11.87	26.2.87	9.3.88
Notes	Grasses selectively eaten by locusts after summer sowing	Burnt on 16.11.88	Locusts, mostly non-grass eaters, e.g. *Monistria* sp.	Sheep camped in trial site in June 1988	Crop spray drift damage in May 1990

Early growth and establishment

The perennial summer-active grasses were the easiest group to establish and their early productivity was generally good. *Digitaria abyssinica, D. brownii, Themeda triandra, Dactyloctenium* spp. and *Cullen patens* were the most difficult species to germinate reliably, and often fewer than 12 plants were sown per site. Lines with the poorest establishment after transplantation (see Supplementary Table A) included a shrub (*Atriplex halimus*) and the grasses *Dactyloctenium* spp., *Eragrostis truncata* and *Andropogon ischaemum*. Perennial cool season-growing lines established well only at Site T (Toowoomba nursery), where the *Agropyron* species, *Elymus scaber* and *Bromus inermis* grew vigorously and spread in a relatively competition-free environment. Wynn cassia (*Chamaecrista rotundifolia*) grew but failed to set seed at any site, in contrast with its mediocre performance in other studies in the region (Strickland et al. 2000). Overall establishment was: quite good at Sites N and U, where only 16 accessions failed within a year; fair at Sites L and W (both hard-setting, strongly duplex soils); and poor at Site M (acidic, infertile), where 48 accessions were lost within the sowing year.

During planting out, healthy root nodules were seen on many legumes, including leucaena, *Desmanthus virgatus* and lucerne. Locusts were a major problem during the establishment period of the summer-active species and rabbits and marsupials selectively targeted new sowings in dry seasons. Usually a few plants of each accession survived at each site for at least the first growing season and also flowered, while all sown plants of the better-adapted lines survived for years.

Agronomic performance

On overall agronomic performance, 22 out of 128 accessions achieved a rating of ≥3 (out of 5) over the 5 field sites, while 74 had a rating of <2 (poor). Of the highly rated ones, only 2 were native (out of 27 natives), while 18 of the poorly rated lines were native species. Agronomic performance for individual accessions is reported in detail in Supplementary Tables A and B, while Table 2 shows those which persisted well at one or more sites.

In broad terms, the summer-active perennial grasses performed best and the winter-active perennial grasses the worst, despite an aseasonal rainfall pattern and several wet autumns and springs (Figure 1). Of the minor groups tested, e.g. shrubs and saltbushes, none gave an agronomically encouraging performance. Mulga (*Acacia aneura* TN59) persisted well at Sites L and U, but grew slowly. Although *A. angustissima* and *Indigofera schimperi* persisted well, they showed weed potential because of low palatability and root suckers, and were removed from 1995 onwards. Some *Eragrostis* spp. had low palatability and high seed set, e.g. Cochise and all 3 *E. lehmanniana* lines, and were dug out systematically over 3–5 years in the mid-1990s. Native species and tropical grasses generally set seed in their first growing season, notable exceptions being *Themeda triandra* and *Cassia sturtii*. However, many exotic species failed to set seed in the first year after planting despite fair shoot growth, e.g. *A. ischaemum*, *Dorycnium hirsutum*, *I. schimperi*, *Atriplex* saltbushes, *Merremia aurea*, *A. angustissima* and leucaena.

By plant type category. Grasses. The buffel grasses were clearly superior as a group, but on some soils (Sites L and N) *Digitaria* and *Bothriochloa* species showed greater early promise. At Site M, new season growth from buffels was often quite yellow, indicating possible low available soil nitrogen and hence low protein content. The Gayndah buffel type, such as CPI71914, CPI60733 and CPI73390, generally performed better than the Biloela type, like CPI73393 and cv. Biloela. CPI71914 had a leafy, low, tight crown structure and the ability to produce new plants close to parent plants. The hybrid *Cenchrus* CPI61135 grew well at most sites without gaining a potential ‘commercially promising’ rating.

Table 5. Comparison of seasonal conditions at the trial sites over the period 1986–1991 against the long-term data shown in Figure 1. Numbers are the total for all 3-monthly seasons based on 20 seasons (5 years) for Sites L and M and 24 seasons for Sites N, U and W. Seasons (summer, autumn, winter and spring) are described in the Figure 1 caption.

Season type	Site				
	L	M	N	U	W
Much wetter than usual	4	4	4	4	3
Typical seasonal total	9	8	6	9	6
Much drier than usual	7	8	14	11	15

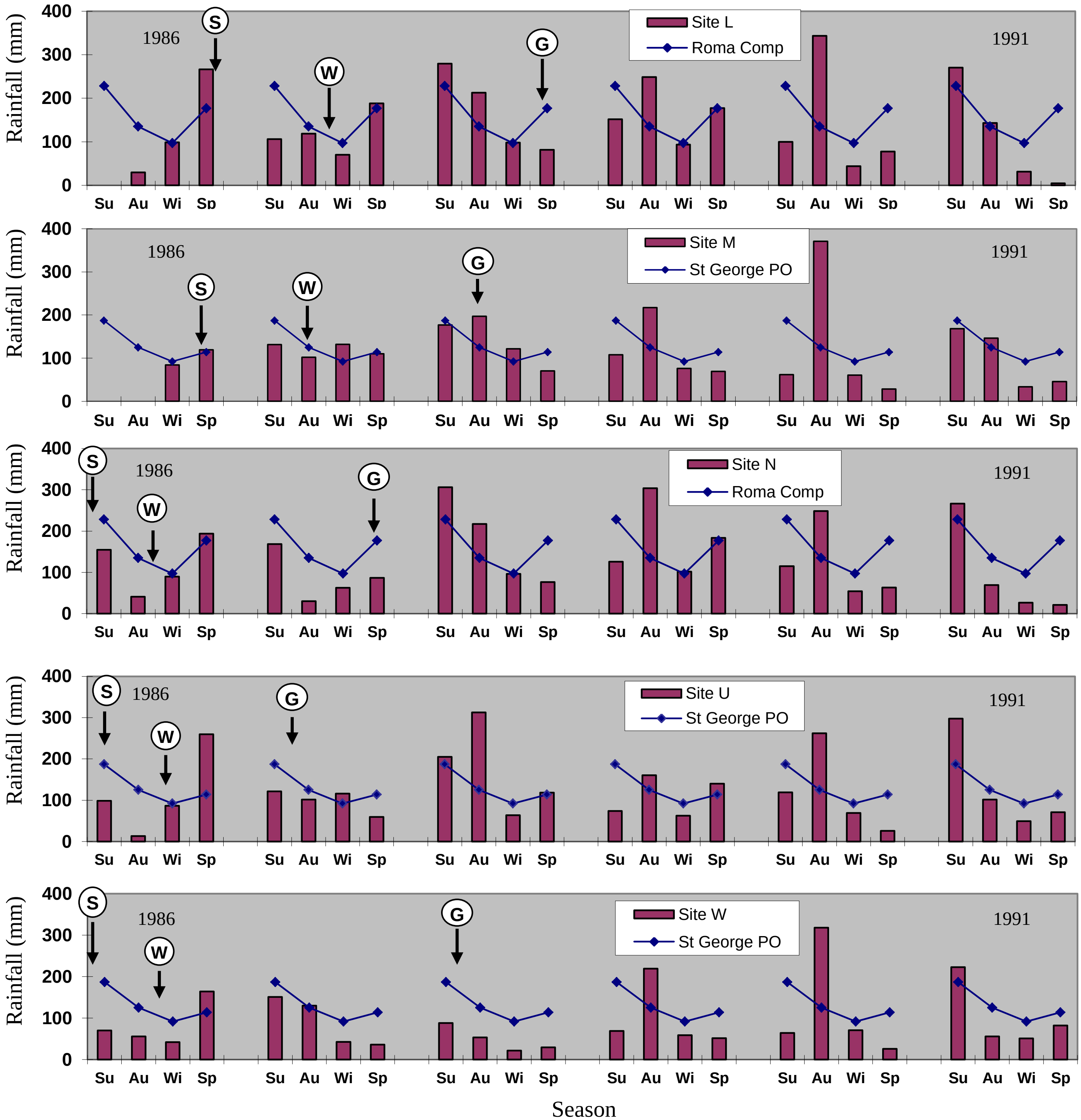

Figure 1. Seasonal rainfall experienced at each field site during the first 6 years (1986–1991) after the trial began, compared with the nearest long-term rainfall station.
Su = Summer (Dec–Feb); Au = Autumn (Mar–May); Wi = Winter (Jun–Aug); Sp = Spring (Sep–Nov)
Long-term seasonal rainfall (points joined by lines) was extracted from Rainman (2003) for Roma Composite and St George P.O.
Labelled arrows on each graph indicate when major events occurred: S = first sowing of summer-active plants; W = first sowing of winter-active plants, and G = first grazing of the site.

Eragrostis lines grew and seeded very well, as expected, but long-term persistence and palatability were variable (Table 2 and Supplementary Table B). *Eragrostis superba* had large seedhead spikelets and was quite leafy but had variable and generally low palatability. The *E. curvula* lines fell into 2 groups: the *conferta* form, which has a dense seedhead and thick, stiffly erect culms; and var. *curvula,* which has long, thin leaves and large, open seedheads that often droop. The former were usually palatable (CPI98914), but none was noticeably more so than the commercial cultivar Consol.

Fingerhuthia africana (a winter-green C4 grass) showed colonizing ability, frost tolerance and persistence on hard-setting solodics, as well as reasonable growth, but was not eaten readily by stock. The *Urochloa* species tested grew well initially at all sites and the stoloniferous CPI60128 showed good vigor and tolerance of moisture stress and appeared quite palatable. Amongst the other non-commercial species, only *Panicum stapfianum* and *Bothriochloa ewartiana* scored 3 or better overall before the drought (Supplementary Table A).

Rhodes grass and silk sorghum grew poorly in the dry summers on the relatively infertile soils chosen, but several *Digitaria*, *Dichanthium* and *Bothriochloa* species performed creditably, e.g. Premier, TBA9 (a bred variant), CPI26832, CPI41192 and CPI59786 (Supplementary Table B). *Digitaria abyssinica* is regarded as a potential weed (Invasive.org 2006) because of aggressive rhizomes and low palatability.

The exotic *Bothriochloa* species usually outperformed the exotic *Dichanthium* species, but native *Dichanthium sericeum* (Queensland bluegrass) grew well at all sites except M, and the naturalized Medway strain of *B. pertusa* from central Queensland was outstanding at Sites N, U and W. It shows great potential as a sward-forming grass for use in erosion control and is leafier than most other strains of the species. CPI11408 (*B. bladhii* ssp. *glabra*) produces prostrate tillers on winter and spring growth to resist grazing, but its seedheads are later erect and avidly browsed by cattle. This puts seeding in jeopardy and may partly explain why it has not persisted at our sites. Now released as cv. Swann, its origins are unclear, as it is not an *Andropogon ischaemum* as its passport data indicate. It may not even be from Guyana, but rather a contaminant from a nursery site in Australia. Prostrate tillers were recorded seasonally for other lines such as TN22, TN47 and TBA1024.

Herbaceous legumes. The performance of the summer-growing legumes was not encouraging. On the sandy red soil at Site M, only *Stylosanthes* and TN15 *Rhynchosia minima* established well but frosts damaged them severely each winter. Native *R. minima* and *Cullen tenax* lines have grown very well at Site L and reasonably at Site N, and their persistence is better than that of most other summer-active legumes. Both sites had reasonable soil fertility and Site N was a non-acidic soil with carbonate at depth. *Desmanthus virgatus* was not impressive but persisted well initially, and seeded quite freely once it had grown some foliage, but neither line developed into a noticeable stand at any site. The *Phaseolus* species CPI90752 from Mexico was one of the most persistent perennial legumes but produced only low yields, akin to those of native *Glycine tabacina* or *G. tomentella*, which grow at our sites. The atro bean group (*Macroptilium atropurpureum*) came from a wide range of material from the homeland of the species (Reid 1983) and some had good crown frost tolerance; however, most were susceptible to leaf rust and to persistent summer droughts. None outperformed the commercial cultivar Siratro, which is still not highly regarded in this region (Jones 1998).

Of the annual winter-active legumes, yellow serradella (*Ornithopus compressus*) was the most consistent performer. *Medicago murex* grew satisfactorily but seemed to lack adequate hardseededness for persistence in the aseasonal rainfall environment. The 2 lines of naturalized *Medicago laciniata* tested (TBA7 and TBA13) grew poorly; they persisted and set seed and were difficult to distinguish from other local genotypes of the species. Naturalized woolly burr medic (*Medicago minima*) built up noticeably at Site U during the trial and was seasonally abundant at Site N.

Others. Sheep's burnet (*Sanguisorba minor*) did not survive long at the 5 field sites, although it persisted and regenerated from seed for many years at Site T. It was extremely palatable to stock and wilted easily in hot weather, but did not suffer from any obvious pests or diseases. While the other herbaceous plants, TN6 (*Evolvulus alsinoides*), TN7 (*Sida brachypoda*) and TN27 (*Boerhavia dominii*), showed potential as standards for comparisons, they offered no agronomic benefits over the many existing local herbs. Native mulga sida (TN7) and tropical speedwell (TN6) grew reasonably at some sites but produced little edible dry matter. Seed is easy to germinate and TN6 regenerates freely from seed. TN6 has broader soil tolerance than TN7 and TN27 and its seed was easier to collect and germinate. However, TN27 came from a fertile cracking clay soil and may be different physiologically from the *B. dominii* found on our trial site earths.

Saltbushes did not thrive, even where very saline subsoils existed and grass competition was minimal, such as at Site W.

By growing season category. Summer-active species. Most summer-growing accessions at Sites U, M and L set seed. Initial persistence was good for most grasses, but legume persistence at Sites M and W was poor, except for a few *Stylosanthes* plants. This study emphasized the importance of survival after occasional hot, dry summers, either as plants or in a long-lived seedbank. Most summers were drier than 'normal' during our trials and the performance of these grasses augers well, especially as they had negligible disease issues.

Summer-growing legumes performed poorly but improved summer rainfall might enhance their long-term performance, if they set adequate amounts of hard seed to allow regular recruitment of new plants. Most have significant hardseededness (*Stylosanthes* and *Macroptilium*) but the latter atro beans were like Siratro and lacked the ability to compete with summer grasses and persist in a grazed pasture (Keating and Mott 1987). The most successful summer legumes were *R. minima* accessions but they rarely produced much growth. They suffer from legume little leaf virus and have sticky hairs on seed pods that shatter before drying out, making commercial seed production difficult.

Winter-active species. Cutleaf medic (*M. laciniata*), yellow serradella (*O. compressus*) and common wheatgrass (*E. scaber*) flowered in the first growing season and regenerated from seed at Site U. *Elymus scaber* had few pests or diseases, but seemed to require a fertile soil for adequate growth. Very erect tillering at all times makes it vulnerable to excessive grazing pressure in rangeland grazing systems. Rough corkscrew grass TN10 (*Austrostipa scabra*) performed creditably and is an obvious choice for a standard against which to compare similar grasses. It is not palatable once dry in summer and its persistence during consecutive dry years is weak, but it does have a very persistent seedbank from which to regenerate, when better cool season rainfall returns. Its sharp seed is most undesirable for wool producers, and its use in field comparisons would have to be well controlled, so as not to result in long-term problems where it was sown.

Aseasonal growers. These include the native *Cullen* species (formerly *Psoralea*), mulga, *Cassia sturtii* and mulga Mitchell grass (*Thyridolepis mitchelliana*), as well as saltbushes, lucerne, *Eragrostis curvula* and *Fingerhuthia africana*. Mulga Mitchell seems unsuited to competing with vigorous grasses in better rainfall environments and, even where it occurs naturally, the Charleville strain (TN22) performed poorly, seemingly unsuited to soils containing any significant amount of clay. As the mulga accession TN59 survived with a very clayey subsoil at Site L, once past the seedling establishment stage, it could be the forage shrub benchmark for semi-arid acid soils, since it grew well at Site U also. However, the species has failed to impress in almost all other semi-arid parts of the world outside Australia, where the soils are generally alkaline, such as the Middle East and North Africa, or are unsuitable in other ways (Gwaze 1989).

Persistence

Long-term persistence of perennial pasture plants is very important to graziers worldwide, as low returns on investments make resowing of pastures unappealing (Murphy 1992). Persistence of the tested lines is summarized in Table 2 based on data collected in 1994 and 1995 from the 5 field sites and in 1991/92 at Site T. Only the following 7 accessions persisted in the long term at all field sites sown, 5 of them being *Cenchrus* species: CPI17655 *C. setiger*; CPI71914 *C. ciliaris*; CPI73393 *C. ciliaris*; Q10077 *C. ciliaris*; CPI61135 *Cenchrus* hybrid; Medway *Bothriochloa pertusa* and TN47 *B. ewartiana*.

Fourteen others survived the drought well at all but one site (Table 2; 8 *Eragrostis* species; 5 perennial grasses; and a native shrub, *C. sturtii*). These species are adapted to a wide range of soil types, which is advantageous for a successful commercial cultivar. Queensland bluegrass is not in this list, because it is not adapted to acid soils despite its good reputation regionally. In general, the native species (TN codes) showed selective site adaptation and persisted well only at particular sites, despite initially growing well everywhere, e.g. TN10, TN24 and TN27.

A wide range of other species that survived for 6–8 years and recruited seedlings at the less stressful, higher rainfall Toowoomba site, did not survive long at any of the 5 field sites (Table 2). They included legumes, saltbushes, sheep's burnet and the C3 winter-active Eurasian grasses like *Agropyron elongatum* and *Bromus inermis*.

Future research and commercial needs

The evaluation technique

Establishing a small population of plants in the field from very limited seed supplies proved successful for initial testing. When seedlings or cuttings were grown in the glasshouse, the majority then established in the field with only limited supplementary watering. Planting out after good rain (surface soil wet to >20 cm depth) was most important, but young, pre-flowering plants must be used. If an adequate taproot does not form on non-grasses after transplantation, their drought tolerance may be reduced. This cannot be discounted amongst our results, but we have no direct evidence of it happening. Our method entails more pre-sowing effort but labor costs compared with infrastructure and equipment costs will vary depending on where the study is done and are adaptable to local resource availability. However, in an holistic sense, the major cost is the production, storage and acquisition of exotic seeds. Their death or loss without growth of replacement plants or meaningful data collection is a huge loss.

Locusts, rabbits and kangaroos

Defoliation of small seedlings could seriously compromise the evaluation of an accession. Locusts were a constant threat, particularly in late spring, and could be quite selective, preferring wilted grasses; they were particularly damaging to Rhodes grass seedlings. Winter-active herbaceous species were generally not eaten, because locusts were inactive at that time. Nocturnal rabbits and kangaroos could also heavily overgraze and kill sown plants in small plots, without being seen, and strip planting amongst coarse, unpalatable native species can accentuate this problem. In other countries, small grazers such as jack rabbits (Mexico), antelope (Africa) and capybara (South America) would have a similar effect. Kangaroos appear to prefer *Urochloa* lines to buffels, which might explain why *U. mosambicensis* has not been a commercial success in western Queensland. It has become a seasonally prominent roadside species since the 1980s, indicating it has good climatic adaptation.

Species performance compared with existing commercial cultivars

Perennial legumes. This study supports other studies that highlight a serious shortage of perennial herb legumes for pastures in semi-arid subtropical Australia (Jones 1998; Strickland et al. 2000; Clem et al. 2001). The stylos tested failed to persist in meaningful numbers, and young seedlings were often yellow and presumably died. Yellow color can indicate poor nodulation, but most *Stylosanthes* species are non-specific in their cowpea rhizobial symbiosis (Date and Norris 1979). Lack of sufficient frost tolerance may also have been an issue. Recently there has been interest in Caatinga stylo (*S. seabrana*), which has persisted in other trials (Peck et al. 2012) but was not included in ours. While Siratro and its relatives were very disappointing, their failure did not seem to be due to pests or diseases and was replicated on adjoining trials and in other studies (Clem et al. 2001).

Winter-active grasses. The next most important deficiency in current commercial pasture plants for this region is winter-active grasses. While many *Eragrostis* species grew well in winter, when soil moisture was available, most were seasonally unpalatable, making them a future weed risk. As *E. curvula* is a declared weed in nearby New South Wales and regarded as weedy in the Darling Downs and Kingaroy regions east of the Maranoa (DAFF 2013), we are unwilling to subject them to wider testing.

Annuals. Annual medics such as *Medicago minima*, *M. polymorpha* and *M. laciniata* are slowly spreading in this region as their level of hardseededness and their rhizobial symbionts slowly alter genetically and adapt, we consider, to the environment. Their burrs are contaminants in wool and mohair, and their foliage has potential to cause bloat in good spring seasons. Sown cultivars of barrel medic (*M. truncatula*) grow and persist well on some sandy red earths and we failed to identify anything better adapted to acid soils. Inadequate hardseededness seemed to be a major deficiency of the medic lines that we tested. Yellow serradella grew well for some years, especially on sandier soils, but eventually died out. Whether a bigger area, that was less susceptible to overgrazing by rabbits and kangaroos, would have improved their persistence is not known.

Native species. Few of the native species tested showed promise agronomically. Queensland bluegrass was the best for the more friable, low acidity soils (Supplementary Table B) and it is already recommended for specialized rehabilitation purposes (Huxtable 2003). Desert bluegrass TN47 also showed potential on all soils, but it was more difficult to establish this pasture from seed and to achieve good increase in the stand from a few plants. Once established, it was very persistent but had only moderate palatability (Supplementary Table B) and would be best suited for long-term pastures, while Queensland bluegrass has a valuable role in short-term, legume-rich ley pastures in farming systems. Kangaroo grass TN35 had weaker plant perenniality but better seedling recruitment than TN47, plus the added historical weakness of susceptibility to overgrazing.

The native legumes tested gave low yields and could not be considered for commercialization. Their seed can be difficult to harvest but germinates easily after scarification (if appropriate). The shrubby legumes mulga and *C. sturtii* have no apparent commercial forage role in the Maranoa, where there are so many other plants with better growth rates, palatability and digestibility. CPI79501 returned to Australia after giving good results in Israel, so it may still have potential overseas somewhere.

Summer-growing perennial grasses. This group offers the greatest scope for sown pastures in the region, establishing well, growing satisfactorily, seeding and then persisting for some years. Their ultimate value depended mainly on their persistence after the 1992/93 drought, seedling recruitment ability and palatability. Buffel grass hybrid line CPI61135 has a non-hairy seed and persisted well but was not as productive as other buffels, nor was its seedling recruitment as extensive. A similar assessment applies to white Birdwood grass CPI17655 that, though in Australia since 1952, has still not been commercially released. CPI71914 was rated more highly than the similar cv. Gayndah at most sites (Supplementary Table A), but the small advantage does not justify the expense and complications involved in setting up a seed production industry for it. As most people find Gayndah indistinguishable from cv. American, its release would make cultivar integrity very hard to maintain.

Premier digit grass did not recruit seedlings and its high palatability meant that it was often overgrazed in a mixed pasture, so did not persist as well as in higher rainfall areas (McDonald et al. 1998). While stoloniferous *Digitaria* species grew quite well, they also produced few seedlings and did not persist well, whereas the equivalent stoloniferous *Bothriochloa* species persisted better and produced more seedlings. Medway Indian couch grass was the best of these (Supplementary Tables A and B), but with its relatively low dry matter yield and vigorous sward production, it is regarded as a weed threat by some people. It is seasonally palatable and resistant to heavy grazing and could have a role stabilizing local waterways and embankments that cannot be slashed. It was not killed by intermittent light cultivation but is susceptible to prolonged drought. As it seeds freely, eradication schemes would require the use of herbicides.

Inverell purple pigeon grass performed poorly away from the heavy clay soils, where it is used commercially. Pioneer Rhodes grass, Bambatsi panic and Hatch creeping bluegrass all showed insufficient persistence to be considered for commercial recommendation on the soil types studied. The climate is too dry and drought-prone for current Rhodes grass cultivars and Bambatsi needs more friable, fertile soils to persist. We recorded no seedlings of Bambatsi anywhere, which is the norm. Hatch also failed to cope here and was rated lower than CPI52193 (Supplementary Table A), which resembles the Bisset cultivar, both of which root down at the nodes much better than Hatch.

These trials have failed to identify new commercial pasture cultivars for arable, poorly structured soils in the subtropical aseasonal rainfall region of southern inland Queensland. However, we have identified pasture species for use as standards in any future assessment program (Table 6). In view of the global diversity of the plants tested, we consider pasture users in many other subtropical regions could benefit from this information.

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Table 6. Recommended standard species or cultivars, against which new forage germplasm for infertile soils in southern inland Queensland should be assessed prior to commercial release.

Plant type	Recommended standard species or cultivar[1]
Summer growers	
perennial grass	*Cenchrus ciliaris* cv. Gayndah
annual grass[2]	- (*Urochloa panicoides* or *Dactyloctenium radulans*)
perennial legume	*Rhynchosia minima* or (*Stylosanthes seabrana*)
annual legume	- *Chamaecrista rotundifolia* cv. Wynn
perennial shrub	- (*Leucaena leucocephala* cv. Tarramba)
perennial non-legume herb	*Evolvulus alsinoides*
Aseasonal growers	
perennial grass	*Eragrostis curvula* cv. Consol
perennial legume	*Medicago sativa* cv. Trifecta
perennial shrub	*Acacia aneura* (St George *latifolia* type)
perennial saltbush	(*Atriplex nummularia*)
Winter growers	
perennial grass	*Austrostipa scabra*
annual grass	- (*Lolium rigidum*)
perennial legume	-
annual legume	(*Ornithopus compressus* cv. Paros or *Medicago truncatula* cv. Paraggio)
perennial shrub	- (*Medicago arborea*)

[1]Species in parentheses were not assessed in this experiment; **-** = none can be recommended yet, but an alternative is named; some of the alternatives are naturalized, known or potential weedy species and should be used with care.

[2]Annual species which are self-regenerating and persistent.

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Supplementary Table A. Summary of overall field performance by each accession on a 1 (very poor) to 5 (very good) scale, as well as for ease of establishment, persistence, spread and yield in the first 6–7 years after sowing.

Accession	Early growth	Spread	Persistence	Yield	Overall rating	Best/worst sites[1]	Notes
Summer growers							
CPI 90727	1.5	1	2.5	1.5	1.2	L/M	
CPI 99868	3.2	1.5	3	1.5	2.2	N/W	
CPI 99869	3.2	1.5	2.2	1.5	2	N/L	
Q 20321	4.2	1	3.2	2.2	1.8	M/W	
CPI 99572	2.2	1	1.8	1.5	1.2	U/L	
CPI 99867	2.2	1	2.5	1.5	1.5	L/M	
TN 47	2.5	1	3.5	2.5	3	W/M	
CPI 11408	3	1.5	3	2.2	2.8	U/M	Did best at site U
CPI 69517	3.5	2.2	3.2	2.2	2.8	L/N	
CPI 52193	3.5	2.5	3.5	2.5	3.2	U/W	
Hatch	3.2	2	2.8	2.8	2.8	L/M	Very good at site L
Medway	4.5	2.8	4	2.2	3.5	U/M	Dense thatch of litter
CPI 60733	4.5	1	4.2	2.8	3	N/W	
CPI 71914	4.8	1.2	5	3.2	3.8	U/L	Like a hairy cv. Gayndah
CPI 73390	3.5	1.2	3.5	2.8	3.2	U/W	Very poor at site W
CPI 73393	4.5	1.2	4.5	3.5	3.8	U/L	Erect like cv. Biloela
Q 10077	4.5	1	4.5	2.5	3	N/L	
Biloela	4.5	1.2	4	3.5	3.8	U/M	Grew well at site W
Gayndah	4.2	1.5	4.5	3.2	3.8	U/N	Died out at site T
CPI 61135	4.2	1	4	3.2	3	U/N	
CPI 17655	4.5	1.2	3.8	3	3.2	W/N	Green seedhead
Pioneer	3.5	2.2	2.2	2	2	L/U	
TN 45	3.8	2.5	1.5	1.5	1.8	W/M	
Q 9143	1.8	1	1.2	1	1	W/L	
Q 10878	1.5	1.2	1.5	1	1	W/M	
TBA 1014	3.5	1	1.5	1.5	1	N/L	
TBA 1024	3.5	1.2	1.5	1.5	1.2	U/W	
CPI 89982	2	1.5	1.5	1	1.2	U/W	Good growth at site T
TN 57	2	1	2.5	1.2	1.2	W/L	
CPI 26832	3	2.2	3.8	3.5	3.5	U/L	
CPI 41192	4	2	3.8	3.2	3.5	U/N	
CPI 59786	4	1.8	2	2.2	2.2	W/U	
TBA 9	3.2	1	2.5	1.8	1.8	U/L	
CPI 38869	3.8	1	3.2	2.5	2.5	U/W	
TN 1	2	1	2.2	1.5	1.5	N/L	
CPI 98920	3.5	1.5	3.8	3.5	3	M/L	
CPI 99872	4	1.2	3.5	3.2	2.5	M/W	
CPI 98954	2	1.2	1.5	1.5	1.2	M/W	
CPI 98960	3	1	2.8	2.2	1.5	M/N	
CPI 99871	3.5	1.5	4.2	2.8	2.2	N/L	
CPI 98952	2.2	1	2.5	1.8	1.2	W/M	
WA 80/1987	4	1.5	3.5	2.2	1.5	W/L	Good persistence
CPI 59853	4.5	1	3.8	3	3.2	W/U	
CPI 98987	1.5	1	1.2	1	1	U/W	
CPI 99865	4.5	1	1.8	2	1.5	L/M	Good at site T
CPI 99880	3.5	1	1.5	1	1	L/M	
TBA 1	2.5	1	2.8	1.5	1.5	U/M	
Bambatsi	3.5	1	2.2	1.8	1.5	N/W	
TN 8	2.5	1	3.2	1.8	1.5	N/M	
CPI 73576	2.8	1	2.2	1.5	1.2	L/W	
CPI 73577	4.2	1	4	3.5	3.8	L/M	

Continued

Accession	Early growth	Spread	Persistence	Yield	Overall rating	Best/worst sites[1]	Notes
CPI 99877	3	1	2.2	1.5	1.5	U/L	OK at site T
CPI 43715	3.2	1.2	3.5	2.8	2.5	M/W	
Inverell	3	1	2.5	3.5	2.5	W/M	
Silk	4.8	1	1.2	2.2	2.2	L/W	
TN 9	1.8	1	2.5	1	1	N/U	
CPI 60781	3.2	1	2.5	1.8	1.5	U/N	No weedy features
TN 35	1.8	1.5	3.5	2	2.2	U/M	Native at site M
CPI 99561	3.2	1	2.2	1.5	1.2	U/W	
CPI 99879	2.5	1	1.8	1.5	1.5	W/L	
CPI 60127	4	1.2	2.2	2.2	2.2	M/U	
CPI 60128	4.2	2.5	4.5	3	3.8	U/W	
CPI 84971	3.5	1	3.2	2	2	U/M	Large site differences
CPI 34721	3.8	1	1.2	1.5	1.2	L/N	First year critical
CPI 20733	3.2	1	1.8	1	1	N/W	
CN 63	2	1	1	1	1	U/W	Trashy seed
CPI 85178	2.2	1	2.8	1.2	1.5	U/M	
CPI 90751	3	1	2.2	1.5	1.5	U/M	
CPI 78425	3.5	1.5	2	1.5	1.8	L/W	
WRI 3	3	1.2	1.2	1.2	1.2	N/W	Did well at site T
CPI 69495	2.8	1	3.8	2.5	2.5	U/M	
CPI 73608	2	1	2.2	1.5	1.5	L/M	
CPI 61815	2.1	1	1.5	1	1	U/M	Never >1 m tall
Cunningham	2.2	1	1.5	1.2	1.2	L/W	
CPI 62129	2	1	1.2	1	1	L/W	Failed to grow at all sites
CPI 90334	3.2	1	1.8	1.5	1.5	U/W	OK at site T
CPI 90454	3.5	1	1.8	1.5	1.5	U/W	Good at site T
CPI 90455E	3.8	1	1.5	1.5	1.5	U/M	
CPI 90821	2.8	1	2	1.5	1.5	U/M	
Siratro	4.2	1	1.5	1.2	1.2	U/M	
CPI 38841	4.8	1	1.5	1.8	1.2	L/M	Bushy habit
CPI 60303	2.8	1	1	1	1	L/U	Always very poor color
CPI 85005	2.8	1	1.2	1.2	1	L/M	OK at site T
CPI 90752	3.2	1	1.8	1	1	U/M	
CPI 52704	3.8	1.2	1.5	1.8	1.5	N/W	
TN 15	3	1.5	2.5	2	2.5	W/U	
TN 24	2.5	1.8	2.5	2.5	2.5	N/M	
CPI 40615	4.2	1	2	2.5	1.8	U/N	Annual at site T
CPI 41219	3.5	1	1.5	2	1.8	M/W	
CPI 55872	3.5	1	2.8	2.2	2.5	U/N	
TN 27	2.2	1.2	1.5	1.2	1	N/M	
TN 6	4.2	1.2	2.5	1.5	1.2	U/M	
CPI 84982	2.2	1	1.5	1	1.2	U/L	
TN 7	2.5	1.2	2.8	1.8	1.5	U/N	
Aseasonal growers							
TN 36	3	2.2	2.5	2.5	3	L/M	
CPI 30374	4	1	3.5	3.2	3	M/W	Lack of spread unusual
CPI 98914	4	1.2	3.2	2.5	2.5	U/W	
CPI 98926	4.5	1.2	2.8	3.5	2.5	M/W	
SCS 4663	4	1	3.2	2.8	3	M/N	
CPI 99554	3.2	1	1.5	2	1.5	M/W	
TN 44	4.5	2	1.5	1.8	2.5	L/M	
CPI 98990	4	2.5	3.2	2.2	3.2	W/U	Large site differences
TN 22	2.5	1	2.2	1.5	1.8	M/L	
TN 59	2.5	1	3.8	1.5	1.8	U/W	
CPI 79501	3.2	1	4.2	2.2	2.5	W/N	

Continued

Accession	Early growth	Spread	Persistence	Yield	Overall rating	Best/worst sites[1]	Notes
TN 29	2.5	1.2	2.2	1.8	1.8	U/W	Large site differences
CN 55	3.8	1.5	1.8	1.5	1.5	L/M	Sporadic presence
TN 12	3.8	1.2	1.5	1.5	1.5	U/M	
WRI 19	3.2	1.2	1.2	1.5	1.8	U/M	
Trifecta	4.5	1	3	2.8	2.5	L/W	
CPI 85166	1.8	1	1.8	1.2	1.2	L/M	
CPI 79496	1.5	1	1.5	1	1	N/U	
Q 22947	3.5	1	1.8	1	1	N/M	OK at site T
Winter growers							
Q 20701	4.2	1	1	1.5	1	W/M	Grew well at site T
Q 20704	3.2	1	1	1.2	1	W/M	Grew well at site T
TN 10	3.2	2.5	3	2	2.8	W/L	
Q 20711	3	1	1	1.5	1	W/U	Grew well at site T
TN 49	3.8	1.5	1.5	1.5	1.5	N/U	Very good at site T
CPI 36101	3.5	1	1	1.5	1	W/M	OK at site T
Q 20715	4	1	2	1.5	1.2	W/M	Grew well at site T
Q 22941	2.5	1	2.2	1.2	2	L/N	
TBA 7	3.2	1.5	2.2	1.5	1.8	U/M	
TBA 13	2.8	1.8	3	2	2.2	L>M	Poor color –Rhizobium?
CD 64.11.1	2.5	1	2	2.5	2.2	U/M	Disappeared in 5 yr
WA 5320	3.8	1.5	2.5	2.5	2.5	L/W	
Circle Valley	3.5	1.5	2.2	2	2.2	M/W	Semi-erect growth
Serena	3	1.5	2	1.8	1.8	L/N	
CS 146	4.2	1.5	2.8	2.5	3	U/N	

[1]Soil information:
Site L – hard-setting, grey, shallow duplex soil with impervious sodic subsoil; good available P
Site M – deep, infertile, acidic, sandy red earth
Site N – grey, slightly alkaline clay loam with carbonate nodules at depth
Site U – slightly acidic, sandy red earth without subsoil constraints
Site W – hard-setting, grey, shallow duplex soil with impervious sodic subsoil
Site T – deep, friable red loam with fair organic carbon levels

Supplementary Table B. Critical aspects of the dryland field performance of each accession in the first 5 years, that limited or enhanced its potential agronomic value.

Accession	Genus species	Seed set	Palatability	Pests and diseases	Leafiness	Other features
Summer growers						
CPI 90727	*And.isc*	low	uncertain	seedhead ergot	fair	low leaf DMY
CPI 99868	*And.isc*	low	fair – low	ergot in heads	low	tight, low crown; very low DMY
CPI 99869	*And.isc*	low	fair – low	ergot in seedheads	low	tight, low crown; very low DMY
Q 20321	*Ant.pub*	fair – low	high	nil	very high	sturdy rhizomes
CPI 99572	*Bot.bar*	very low	uncertain	none seen	low	feeble growth
CPI 99867	*Bot.bar*	nil	uncertain	none seen	low	very erect; >1 m tall
TN 47	*Bot.ewa*	fair	fair	ergot in seeds	fair	prostrate winter tillers
CPI 11408	*Bot.gla*	good	good; heads eaten	leaf stripe	fair	prostrate spring tillers; good seeder
CPI 69517	*Bot.ins*	good	good	nil	good	good initially at site L
CPI 52193	*Bot.ins*	good	fair	nil	good; hairs at leaf base cf. cv. Medway	good nodal rooting; can look like Medway; did well at site N
Hatch	*Bot.ins*	fairly low	fair	nil	fair; thick stolons	poor nodal rooting; grew well at site N
Medway	*Bot.per*	good	fair/good	ergot in heads in wet years	good	tight sward; withstands gentle cultivation
CPI 60733	*Cen.cil*	fair	good	nil	fair	type D; erect; grew best at site L
CPI 71914	*Cen.cil*	good	good; hairy	nil	good	tight low crown; cv. Gayndah type
CPI 73390	*Cen.cil*	good	good	nil	fair	cv. Gayndah type
CPI 73393	*Cen.cil*	fair	fair	nil	fair	cv. Biloela type; erect, rhizomes
Q 10077	*Cen.cil*	good	fair	nil	fair – low	distinctive color and growth; tolerates gentle cultivation
Biloela	*Cen.cil*	fair	fair	nil	fair	short rhizomes; stemmy once mature
Gayndah	*Cen.cil*	good	good	nil	good	high drought tolerance; reliable
CPI 61135	*Cen.hyb*	good	good	nil	good	bristle-free seed
CPI 17655	*Cen.set*	good	good	nil	good	no seed bristles; frost-tender
Pioneer	*Chl.gay*	good	high, esp. to locusts	locusts	fair	long stolons
TN 45	*Chl.tru*	prolific	good	nil	good	aseasonal growth; good frost tolerance; prolific regeneration
Q 9143	*Dac.sp*	nil	uncertain	none seen	good	feeble growth
Q 10878	*Dac.sp*	nil	uncertain	none seen	good	flowered at 1 site

Continued

Accession	Genus species	Seed set	Palatability	Pests and diseases	Leafiness	Other features
TBA 1014	*Dic.ari*	very low	low	nil	fair	low crown; short runners
TBA 1024	*Dic.ari*	very low	uncertain	nil	fair	prostrate winter growth
CPI 89982	*Dig.aby*	very low	low	leaf rust; aphids	high	feeble growth in field, weedy at site T; long rhizomes
TN 57	*Dig.bro*	low	fair	nil	high	difficult to germinate; western form
CPI 26832	*Dig.eri*	fair	good	nil	fair	some long stolons and tufts
CPI 41192	*Dig.mil*	good	good	nil	good	grew well at sites L and M
CPI 59786	*Dig.mil*	fair	good	nil	fair; stolons	low frost tolerance; eaten by rabbits at site M
TBA 9	*Dig.smu*	low	high	nil	high	looks like cv. Premier
CPI 38869	*Dig.smu*	low	high	nil	good	long seed culms; pale color at sites M and U
TN 1	*Ent.aci*	fair	fair	nil	fair	deep crown
CPI 98920	*Era.bic*	good	low	nil	fair; red stem in winter	like cv. Consol
CPI 99872	*Era.hyb*	prolific	very low	nil	very low	dug out to remove weed risk; re-roots easily
CPI 98954	*Era.leh*	good	very low	nil	low	looks like CPI 98960; weed potential; dug out after 7 years
CPI 98960	*Era.leh*	good	very low	seedhead aphids	low	weed potential; dug out
CPI 99871	*Era.leh*	high	low; stalky	nil	low	dug out to remove weed risk
CPI 98952	*Era.obt*	prolific	low	none seen	low	looks like WA 80/1987
WA 80/1987	*Era.obt*	prolific	low	nil	low	weedy nature; spreads
CPI 59853	*Era.sup*	high	variable	nil	fair	pale leaf color
CPI 98987	*Era.tru*	nil	uncertain; very erect	none seen	fair	very low DMY; sturdy rhizomes
CPI 99865	*Lep.dub*	fair	good	nil	fair	easy to collect clean seed
CPI 99880	*Lep.fus*	high	fair – low	nil	fair; stalky	looks like annual Qld native one
TBA 1	*Pan.ant*	fair – low	good	leaf blotch	good	robust, short rhizomes
Bambatsi	*Pan.col*	low	good	nil	fair	not adapted to these soils
TN 8	*Pan.dec*	fair	good	nil	fair	
CPI 73576	*Pan.kal*	nil	uncertain	none seen	low	feeble growth; basal leaves
CPI 73577	*Pan.sta*	low	high	nil	good	robust crown; persistent
CPI 99877	*Pap.muc*	high	good	nil	fair	sturdy crown
CPI 43715	*Sch.pap*	good	good; stemmy	seedling damping-off	low	best at site M

Continued

Accession	Genus species	Seed set	Palatability	Pests and diseases	Leafiness	Other features
Inverell	*Set.inc*	fair	good when green	nil	fair	best at site W
Silk	*Sor.hyb*	low	high	leaf rust	good	poor performance
TN 9	*Spo.act*	good	fair	root aphids at site T	fair	erect habit
CPI 60781	*Spo.fim*	good	good	nil	good	tussocks
TN 35	*The.tri*	fair	good; seasonal; heads browsed	nil	fair	erect culms; typical tetraploid of the species
CPI 99561	*Tri.cal*	good	uncertain	nil	good	looks like native *Digitaria brownii*
CPI 99879	*Tri.cri*	high	low – fair	nil	good	looks like *Chloris virgata;* no stolons
CPI 60127	*Uro.oli*	fair	high	nil	good	N demanding; best at site L
CPI 60128	*Uro.sto*	good	fair	nil	fair; red when dry	may be glyphosate-tolerant
CPI 84971	*Aca.ang*	low	low	weevils seen	poor	root suckers; fair seedling frost tolerance
CPI 34721	*Cha.rot*	nil	uncertain	uncertain	good	baked by summer heat on bare soil
CPI 20733	*Cli.ter*	nil	uncertain	none seen	fair	feeble growth
CN 63	*Cul.pat*	fair; poor seed viability	fair; low for cattle	seed bruchids; some leaf yellows	good	frost- and rootknot nematode-tolerant
CPI 85178	*Des.vir*	fair	fair	nil	fair	lower yield than local native *Neptunia gracilis*
CPI 90751	*Des.vir*	low	fair	none seen	fair	very prostrate; relatively large flowers
CPI 78425	*Gal.sp.*	very low	low	weevils, leafspots	good	pale color; slight frost tolerance
WRI 3	*Gly.tom*	low	good	*Amnemus* weevil	good	can root at nodes
CPI 69495	*Ind.sch*	fair	low; uneaten by marsupials	nil	fair	weed potential; bushy
CPI 73608	*Ind.sch*	fair	low	nil	low	bushy
CPI 61815	*Leu.leu*	nil	high	nil	fair	poor growth; fair seedling frost tolerance
Cunningham	*Leu.leu*	nil	very high	nil seen	fair	very slow growth; frosted
CPI 62129	*Lys.wat*	nil	low	none seen	fair	feeble growth
CPI 90334	*Mac.atr*	very low	good	none seen	fair	non-climber; rel. thin leaves
CPI 90454	*Mac.atr*	very low	good; pilose leaf	cowpea aphids	good	very late flowering; root suckers
CPI 90455E	*Mac.atr*	very low	good	none seen	good	looks like cv. Siratro
CPI 90821	*Mac.atr*	low	good	red spider mite	fair	purple stems; thick taproot
Siratro	*Mac.atr*	low	high	leaf rust and virus	fair	low frost tolerance
CPI 38841	*Mac.lat*	fair	good	none seen	good	bushy habit; thin leaflets
CPI 60303	*Mac.dal*	nil	uncertain	leaf rust once	good	feeble growth

Continued

Accession	Genus species	Seed set	Palatability	Pests and diseases	Leafiness	Other features
CPI 85005	*Pha.fil*	nil in field; high at site T	high	*Botrytis* on pods	high	feeble growth except at site T; no hard seed
CPI 90752	*Pha.sp*	very low	low	nil	low	thin vine; tiny leaves; hypogeal emergence
CPI 52704	*Rhy.min*	nil in field	low at site T	none seen	low	thick stems, non-twining; non-hairy pods
TN 15	*Rhy.min*	low	fair/seasonal	leaf spots; mites	good; v. hairy	drops leaf in dry times
TN 24	*Rhy.min*	fair; very sticky pods	fair	leaf spots; legume little leaf	fair	good at sites L and N; hypogeal emergence
CPI 40615	*Sty.fru*	low	fair	collar rot at site T; looper caterpillars	fair	glandular leaves; erect; not suited to clays
CPI 41219	*Sty.fru*	low	uncertain	nil	poor	frost-tender
CPI 55872	*Sty.sca*	low	fair	none seen	fair	weak growth
TN 27	*Boe.dom*	low	good	hawkmoth grubs	fair	prostrate; frosted
TN 6	*Evo.als*	fair	fair – good	nil	fair	low DMY; frost-susceptible
CPI 84982	*Mer.aur*	nil	uncertain	none seen	low	feeble growth; tuber and vine
TN 7	*Sid.bra*	fair	low; seasonal	leaf beetles	good	prostrate stems
Aseasonal growers						
TN 36	*Dic.ser*	good	fair – good	*Dreschlera* leaf freckling	good	very hairy type; bluish leaf color
CPI 30374	*Era.cur*	high	fair; variable	nil	fair	winter green
CPI 98914	*Era.cur*	high	fair – good; better than CPI 30374	nil	fair	looks like cv. Consol
CPI 98926	*Era.cur*	good	fair	nil	fair	
SCS 4663	*Era.cur*	high	leaf fair; stem low	nil	good	looks like CPI 98926
CPI 99554	*Era.int*	good	uncertain	nil	fair	like *E. curvula* with wide leaves
TN 44	*Eri.pse*	fair	good	seedhead ergot	fair; lax habit	aseasonal growth
CPI 98990	*Fin.afr*	good	fair	nil	good	good frost tolerance
TN 22	*Thy.mit*	fair	good; seasonal	nil	fair; prostrate in winter tillers	aseasonal growth; some nodal rooting
TN 59	*Aca.ane*	nil	good	nil	fair	failed at site M where native
CPI 79501	*Cas.stu*	fair	low	nil	fair	slow to first flowering; bushy
TN 29	*Cul.pat*	low	fair; seasonal	caterpillars; leaf virus	good	prostrate; like CN 63
CN 55	*Cul.ten*	fair; high seedling regeneration	fair; low for cattle	*Botrytis* on stems at site T	low	frost-tolerant; best *C. tenax* line
TN 12	*Cul.ten*	fair	fair	caterpillars	fair	
WRI 19	*Cul.ten*	fair	fair – good	leaf grubs and weevils	good	ascendant habit; better than CN 55
Trifecta	*Med.sat*	very low	very high	none seen	good; drop in dry times	best at site L; nodules seen

Continued

Accession	Genus species	Seed set	Palatability	Pests and diseases	Leafiness	Other features
CPI 85166	*Atr.can*	nil	low	nil	fair	dioecious; best at site L
CPI 79496	*Atr.hal*	nil	good	nil seen	good	dioecious; never got a start
Q 22947	*San.min*	low	high	nil	high	earliest flowering line; best at site N
Winter growers						
Q 20701	*Agr.elo*	nil; good at site T	uncertain; high at site T	nil	good	feeble growth; erect at site T
Q 20704	*Agr.tri*	nil; fair at site T	uncertain; high at site T	stripe rust	high	feeble growth; short rhizomes
TN 10	*Aus.sca*	good	good	nil	good	sharp seeds; cool season growth
Q 20711	*Bro.ine*	nil; fair at site T	uncertain; high at site T	nil	high	feeble growth; good at site T
TN 49	*Ely.sca*	good	good; variable	mild leaf rust; coccids, root aphids	good	erect culms; short rhizomes
CPI 36101	*Ory.mil*	nil in field	uncertain; thick culms	none seen	low	feeble growth except at site T
Q 20715	*Sti.ten*	high	fair – low	nil	high; erect; rough	fine, wiry leaves; no sharp point on seeds
Q 22941	*Dor.hir*	low; OK at site T	low; unpalatable to locusts	nil	high; hairy	coarse, prostrate stems
TBA 7	*Med.lac*	good; burrs	high	powdery mildew	fair	good response to late spring rains
TBA 13	*Med.lac*	fair; burrs	fair	none seen; wrong *Rhizobium*?	fair	long pod spines; poor color
CD 64.11.1	*Med.mur*	fair	good	caterpillars at site U	fair	later flowering than WA 5320; spines on pod
WA 5320	*Med.mur*	good	high	nil	good	late flowering; spineless pods
Circle Valley	*Med.pol*	good	uncertain	downy mildew	good	no regrowth from late spring rains
Serena	*Med.pol*	good; v. early flowering	uncertain	none seen	good	no regrowth from late spring rains
CS 146	*Orn.com*	good	high; unpalatable to locusts	nil	excellent	like cv. Madeira

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