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FORAGE SPECIES ADAPTATION TO RED EARTH SOILS IN SOUTHERN QUEENSLAND

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ABSTRACT

The adaptation of 52 legume and 77 grass accessions to red earth soils at 6 sites in southern Queensland was investigated by recording their persistence, spread and dry matter yield in fertilized and unfertilized plots over several years.

The best adapted species over all sites were in the legume genera Cassia *and* Stylosanthes, *and the grass genera* Digitaria *and* Urochloa.

Although there was a large yield response to applied fertilizer in the first year, it declined in the second year and was not detectable thereafter. The application of fertilizer had no effect on establishment, persistence or spread.

INTRODUCTION

Although a large suite of commercially available grass cultivars and several legume cultivars are adapted to the wetter areas of southern Queensland (annual rainfall > 750 mm), very few of these are adapted to drier regions. Despite work by O'Donnell *et al.* (1973) which showed the pasture potential of several grass species and 2 *Stylosanthes* species at Charleville, cultivars of buffel grass (*Cenchrus ciliaris*) comprise the major sown species on the more fertile soils of drier regions.

The drier region of southern Queensland is characterised by variable rainfall, length of pastoral growing season (both summer and winter), frost and drought incidence, and soils differing widely in physical and chemical attributes. As a first step in evaluating species for this region, we investigated the 'climatic' adaptation of a range of grass and legume accessions from similar homoclimes by growing them on red earth soils near Roma (26°35′S, 148°48′E), Charleville (26°25′S, 146°17′E), Blackall (24°25′S, 145°28′E), Longreach (23°27′S, 144°08′E) and Duaringa (23°42′S, 149°42′E).

This paper documents the persistence, mean maximum yield and spread of 52 legume and 77 grass accessions grown at each site.

MATERIALS AND METHODS

Environments

The average length of pastoral growing season for these sites varies from 2 summer months and 1 winter month at Longreach (average annual rainfall 390 mm) to 4 summer and 3 winter months at Roma (average annual rainfall 520 mm) (Farmer *et al.* 1947). As this investigation was restricted to summer growing species, the rainfall data in Table 1 has been partitioned between the summer growing period (September to April), and the winter period (May to August) when growth is restricted by frost and low night temperatures. The data presented was obtained from the nearest town, as field records were generally incomplete.

Soils

The soils at 5 sites were loamy red earths (Gn 2.1) with a sixth site (Duaringa hill) on a heavier-textured, truncated red earth (Gn 2.1) at Duaringa characterised by a hard setting gravelly surface and the presence of *Calyptochloa gracilima*. Soils were sampled at 10 cm depths to 60 cm and analysed for N, P, K, Ca, Mg, Cl, pH, conductivity and organic carbon by Consolidated Fertilizers Ltd., Brisbane. Mean soil chemical values for 0-30 cm (representing the zone of maximum root density) are

TABLE 1

Mean summer (September – April) and winter (May – August) rainfall for the towns nearest to the experimental sites, and the actual rainfall received over the duration of observations

Site/season	Mean[1]	1977	1977/8	1978/9	1979/80	1980/1
			(mm)			
Roma summer	402	574	309	560	374	446
Roma winter	119	122	327	60	130	225
Charleville summer	367	349	154	290	197	323
Charleville winter	88	96	293	54	90	213
Blackall summer	405	340	193	358	366	282
Blackall winter	80	128	267	40	132	267
Longreach summer	342	410	162	396	507	283
Longreach winter	52	99	159	29	46	174
Duaringa summer	561	290	652	494	546	497
Duaringa winter	97	156	288	76	103	143

[1] Mean rainfalls from "Book of Normals No. 1 — Rainfall". Commonwealth of Australia Meteorological Branch.

given in Table 2. The Charleville and Duaringa hill sites were quite acid in the surface but neutral at depth, while the other sites were neutral to slightly acid throughout. Roma and Longreach sites were extremely low in organic carbon, and Roma was high in available phophorus. Charleville and Duaringa hill were high in nitrate N.

TABLE 2

Chemical composition of top 30 cm of soil at each site

	Roma	Charleville	Blackall	Longreach	Duaringa hill	Duaringa flat
Nitrate N (ppm)	3	39	7	1	17	2
Phosphorus BSES (ppm)	37	6	7	< 5	11	< 5
Phosphorus bicarb (ppm)	22	< 5	< 5	< 5	< 5	< 5
Potassium (ppm)	210	110	175	127	128	100
Magnesium (ppm)	90	67	147	118	98	104
Calcium (ppm)	460	427	910	573	330	543
Sodium (ppm)	5	28	25	7	16	10
Chloride (ppm)	5	13	17	5	27	7
pH (1.5 water)	6.6	4.5	6.8	6.4	4.7	6.3
Conductivity (mS/cm)	0.02	0.10	0.05	0.02	0.07	0.02
Organic carbon (%)	0.17	0.67	0.39	0.11	1.46	0.40

Plant material

The accessions used in this investigation came from areas of southern Africa and South America with similar annual rainfall and length of growing season to those experienced in the target area. The accessions which persisted for 1 or more years at each site are listed in Table 3, together with agronomic data from each site. An additional 23 legumes and 12 grasses either failed to germinate or did not establish at all sites. These species and their accession numbers (non-prefixed numbers are Commonwealth Plant Introduction (CPI) accessions; CQ numbers are CSIRO Queensland accessions; P numbers are New South Wales Department of Agriculture accessions) were *Aeschynomene indica* 26709, *A. villosa* 37235, *Alysicarpus procumbens* 60169, *Codariocalyx gyroides* 14343, *Desmodium canum* CQ 734, *D. heterocarpon* 57146, *Dolichos sericeus* 60218, *Glycine* spp. (native) P. 7876, P. 7881, P. 7882, P. 7874, P. 7912, P. 11812, *Indigofera nummulariifolia* 18420, *I. linnaei* CQ3011, *Neonotonia wightii* 60230, 60234, 60235, *Rhynchosia minima* 40226, *R. totta* 60342, *Stylosanthes guianensis* 40253, *S. viscosa* 51575, *Zornia pratensis* 60467, *Bothriochloa insculpta* cv. Hatch, *Cynodon nlemfuensis* 59659, *C. plectostachyus* 59673, *Digitaria eriantha* 41172, *D. gazensis* 59704, *D. milanjiana* 59733, *Enneapogon scoparius* 59846, *Enteropogon macrostachyus* 59848, *Fingerhuthia africans* 59860, *Paspalum* sp. 57977, *Schmidtia kalahariensis* 60080, and *Sporobolus consimilis* 60101.

Design and establishment

The experiment was established as a split plot design at each site with fertilizer treatment as main plots and accessions as subplots. There are 2 replicates of each fertilizer treatment, each fully randomised. The treatments were either nil fertilizer or 200 kg/ha of a mixture containing 78% superphosphate, 20% potassium chloride, 1% each of copper sulphate and zinc sulphate. Plots measured 2 × 1 m in stips rotary hoed into native vegetation and separated by 2 m within and between strips. Fertilizer was applied by hand and raked into the ground immediately before seeding. Legume seeds were mechanically scarified and inoculated with appropriate rhizobium. All accessions were broadcast onto the surface by hand at 2 kg/ha and lightly covered by raking. All sites were established in the first 2 weeks of December, 1976.

Management

The plot area at each site was fenced to exclude stock and vermin but kangaroos grazed plots from the outset at Blackall and Longreach. Domestic stock (cattle at Blackall and Duaringa; sheep at Charleville and Longreach; and both species at Roma) were allowed access to the plots during the winter of 1977 and continuously (with the exception of Charleville) from the winter of 1978 onwards. Sites were visited to record plant numbers, yield, greenness, and spread, in February, April and July 1977; April, July and October 1978; and February and June 1979. Follow up visits to check persistence were made in March/April of 1980 and 1981. As the number of established plants per plot varied with the species, all plots were rated for plant yield on a 1-5 scale. Quadrats (50 × 50 cm) were cut with hand shears 2.5 cm above ground level to provide an estimate of yield in kg/ha of oven dried material.

RESULTS

Establishment

There were no significant differences in establishment between fertilizer treatments over all sites or between treatments within sites. However there were significant accession differences between sites ($P < 0.01$) and significant site × accession interactions ($P < 0.05$). More plants established at Longreach, Charleville, and Blackall than at Duaringa flat, Roma and Duaringa hill, in that order.

TABLE 3

The accessions which established at each site, the number of seasons they persisted (P), mean maximum yield (Y in t/ha) for those years (calculated for first 3 years only), presence (+) or absence (–) of seedling regeneration (Sd), and occurrence (+) or failure (–) to spread (Sp) out of cultivated strip

Species	CPI[1]	Roma				Charleville				Blackall				Longreach				Duaringa hill				Duaringa flat			
		P	Y	Sd	Sp	P	Y	Sd	Sp	P	Y	Sd	Sp	P	Y	Sd	Sp	P	Y	Sd	Sp	P	Y	Sd	Sp
LEGUMES																									
Aeschynomene falcata	11500	–	–	–	–	–	–	–	–	1	0.1	–	–	–	–	–	–	4	0.5	–	–	4	0.9	+	+
Alysicarpus rugosus	60167	–	–	–	–	–	–	–	–	1	0.1	–	–	–	–	–	–	–	–	–	–	1	0.1	–	–
Cajanus cajan	60174	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	3.2	–	–
Cassia mimosoides	60177	1	0.6	–	–	1	1.3	–	–	1	0.8	–	–	1	0.4	–	–	1	1.0	–	–	3	1.7	+	–
Cassia falcinella	60179	1	0.4	–	–	2	1.7	+	+	1	0.8	–	–	1	2.3	–	–	1	1.0	–	–	3	1.3	+	+
Cassia rotundifolia	34719	2	1.4	+	+	2	0.8	+	+	4	0.9	–	–	2	0.4	–	–	2	0.8	–	–	5	3.9	+	+
Cassia rotundifolia	34721	2	2.0	+	+	2	0.6	+	–	5	1.0	+	+	4	1.5	+	+	3	0.4	–	–	5	3.1	+	+
Cassia pilosa	57503	2	2.3	+	+	2	0.9	+	+	4	1.2	+	+	3	0.4	–	–	2	0.8	–	–	3	1.8	+	+
Centrosema pascuorum	55697	1	1.0	–	–	1	0.8	–	–	1	1.3	–	–	1	1.8	–	–	1	0.1	–	–	1	4.3	–	–
Clitoria ternatea	37195	1	0.6	–	–	1	0.8	–	–	1	0.4	–	–	–	–	–	–	–	–	–	–	1	1.2	–	–
Crotalaria christantiflora	60186	1	0.1	–	–	1	0.5	–	–	3	0.5	+	+	–	–	–	–	3	0.4	–	–	3	1.2	–	–
Cyamopsis senegalensis	60225	2	3.5	+	+	1	2.5	–	–	1	4.1	–	–	1	3.0	–	–	1	0.4	–	–	1	1.9	–	–
Desmodium tortuosum	CQ762	–	–	–	–	–	–	–	–	4	0.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Galactia striata	49740	–	–	–	–	2	0.8	–	–	3	0.3	–	–	1	1.7	–	–	1	0.1	–	–	1	2.3	–	–
Lablab purpureus	16883	–	–	–	–	1	0.1	–	–	1	0.4	–	–	–	–	–	–	–	–	–	–	1	0.8	–	–
Listia heterophylla	18424	–	–	–	–	1	0.1	–	–	1	0.1	–	–	–	–	–	–	1	0.4	–	–	–	–	–	–
Lotononis bainesii cv. Miles		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	0.5	–	–	–	–	–	–
Lotononis bainesii	49182	1	0.4	–	–	1	0.1	–	–	3	0.1	–	–	–	–	–	–	1	0.1	–	–	3	0.5	–	+
Macroptilium atropurpureum cv. Siratro		–	–	–	–	2	0.6	+	–	1	0.1	–	–	2	0.6	+	–	4	0.6	–	–	4	2.8	+	+
Macroptilium bracteatum	27404	–	–	–	–	1	0.1	–	–	1	0.1	–	–	2	0.6	–	–	–	–	–	–	–	–	–	–
Macroptilium lathyroides	30229	1	2.1	–	–	1	1.7	–	–	1	0.1	–	–	2	2.1	–	–	1	0.6	–	–	1	1.7	–	–
Macroptilium martii	49780	–	–	–	–	1	0.4	–	–	1	1.3	–	–	–	–	–	–	–	–	–	–	1	1.4	–	–
Macrotyloma africanum	24972	1	0.8	–	–	–	–	–	–	1	0.4	–	–	1	0.4	–	–	–	–	–	–	1	1.2	–	–
Macrotyloma africanum	60207	1	0.4	–	–	1	0.1	–	–	1	0.4	–	–	1	0.1	–	–	1	0.3	–	–	–	–	–	–
Macrotyloma axillare cv. Archer		1	0.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1	–	–	–	–	–	–
Macrotyloma daltonii	60303	1	1.0	–	–	1	3.0	–	–	3	0.4	+	+	1	0.4	–	–	–	–	–	–	3	1.2	+	+
Neonotonia wightii cv. Cooper		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	1.3	–	–
Psoralea eriantha	CQ1601	2	0.7	–	–	1	0.1	–	–	4	1.4	–	–	4	0.1	–	–	1	0.1	–	–	1	0.1	–	–
Rhynchosia minima	33827	–	–	–	–	–	–	–	–	4	0.3	–	–	–	–	–	–	1	0.1	–	–	–	–	–	–
Stylosanthes guianensis	18750	–	–	–	–	1	1.0	–	–	1	0.1	–	–	2	0.4	–	–	1	0.8	–	–	3	1.5	–	–
Stylosanthes guianensis	40294	–	–	–	–	1	0.6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stylosanthes guianensis cv. Graham		–	–	–	–	1	0.8	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5	1.9	–	–
Stylosanthes fruticosa	40615	1	0.6	–	–	–	–	–	–	5	0.6	–	–	5	0.3	+	–	–	–	–	–	2	0.7	–	–
Stylosanthes fruticosa	41219	–	–	–	–	1	1.7	–	–	5	1.5	+	+	5	3.1	+	+	4	0.4	+	+	5	4.0	+	+
Stylosanthes hamata cv. Verano		1	0.6	+	–	2	1.1	+	–	4	1.5	+	+	5	1.6	+	–	5	1.0	–	–	5	3.0	+	+
Stylosanthes scabra	34925	–	–	–	–	–	–	–	–	5	1.6	+	–	5	1.5	+	+	5	2.1	+	–	5	3.6	+	+
Stylosanthes scabra	40289	–	–	–	–	1	0.1	–	–	5	0.7	+	–	4	1.2	+	–	5	1.5	+	–	5	3.2	+	+
Stylosanthes scabra	55868	1	1.0	–	–	1	5.6	–	–	5	2.7	+	+	5	3.9	+	+	5	2.8	+	+	5	5.2	+	+
Stylosanthes scabra	55870	–	–	–	–	1	2.7	–	–	5	3.1	+	+	5	3.7	+	+	5	3.7	+	+	5	6.7	+	+
Stylosanthes scabra	55872	–	–	–	–	4	0.9	–	–	5	2.7	+	+	5	6.1	+	+	5	2.1	+	+	5	5.8	+	+
Stylosanthes scabra cv. Fitzroy		–	–	–	–	1	0.5	+	–	5	2.0	+	+	5	1.3	+	+	5	1.3	+	–	5	3.9	+	+
Stylosanthes scabra cv. Seca		1	0.1	–	–	1	0.1	–	–	5	2.7	+	+	5	1.3	+	+	5	1.0	+	–	5	2.6	+	+
Stylosanthes viscosa	33941	–	–	–	–	1	0.1	–	–	5	0.3	–	–	5	1.2	+	+	4	1.3	+	–	4	1.4	+	–

Stylosanthes viscosa	34904	–	–	–	–	1	0.1	–	–	5	1.0	+	+	5	1.0	+	+	5	1.9	+	+	5	2.8	+	+
Teramnus labialis	60371	–	–	–	–	–	–	–	–	1	0.1	–	–	–	–	–	–	–	–	–	–	1	0.1	–	–
Teramnus labialis	60380	1	0.1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Vigna luteola	60428	–	–	–	–	–	–	–	–	–	–	–	–	1	0.1	–	–	–	–	–	–	–	–	–	–
Vigna unguiculata	60449	1	0.6	–	–	1	0.1	–	–	2	0.6	–	–	–	–	–	–	–	–	–	–	1	1.0	–	–
Vigna unguiculata	60451	–	–	–	–	–	–	–	–	2	0.5	–	–	1	0.4	–	–	2	0.4	–	–	3	1.2	+	+
Vigna unguiculata	60452	1	0.1	–	–	–	–	–	–	1	0.1	–	–	1	1.2	–	–	3	0.5	–	–	3	0.6	+	–
Vigna vexillata	60454	–	–	–	–	1	0.1	–	–	1	0.3	–	–	–	–	–	–	1	0.1	–	–	–	–	–	–
Zornia glochidiata	60465	–	–	–	–	1	0.5	–	–	1	0.1	–	–	1	0.1	–	–	1	0.1	–	–	–	–	–	–
GRASSES																									
Anthephora pubescens	43713	–	–	–	–	4	0.4	–	–	5	1.6	+	–	5	0.4	–	–	1	0.1	–	–	1	0.1	–	–
Bothriochloa insculpta	59584	–	–	–	–	2	0.6	–	–	5	1.3	+	+	4	1.0	–	–	–	–	–	–	–	–	–	–
Brachiaria brizantha	59591	1	0.6	–	–	1	0.4	–	–	1	0.5	–	–	1	0.1	–	–	–	–	–	–	5	1.4	+	+
Brachiaria brizantha	59592	–	–	–	–	2	0.5	+	+	1	0.3	–	–	1	0.1	–	–	–	–	–	–	5	1.4	+	–
Brachiaria brizantha	59593	–	–	–	–	2	1.1	–	–	4	1.2	+	+	1	0.1	–	–	3	0.4	–	–	5	1.2	+	–
Brachiaria brizantha	59602	2	0.1	+	–	–	–	–	–	1	0.1	+	+	–	–	–	–	–	–	–	–	2	0.8	–	–
Brachiaria decumbens	59614	–	–	–	–	1	0.6	–	–	–	–	–	–	4	0.7	–	–	5	1.0	+	–	5	0.6	–	–
Brachiaria decumbens	1694	2	0.5	–	–	2	2.4	–	–	3	0.3	–	–	2	1.2	–	–	–	–	–	–	5	2.3	+	+
Brachiaria decumbens cv. Basilisk		1	0.5	–	–	1	1.9	–	–	2	0.4	–	–	2	0.8	–	–	4	1.4	–	–	5	2.5	–	–
Brachiaria nigropedata	59616	4	0.9	–	–	3	2.2	+	–	–	–	–	–	5	1.4	–	–	3	0.3	–	–	5	0.5	–	–
Cenchrus ciliaris cv. American		–	–	–	–	–	–	–	–	5	1.2	–	–	5	0.6	+	–	–	–	–	–	1	0.6	–	–
Cenchrus ciliaris	59628	–	–	–	–	–	–	–	–	5	0.6	–	–	5	0.5	+	–	–	–	–	–	2	0.6	–	–
Cenchrus ciliaris	59629	–	–	–	–	–	–	–	–	1	0.8	–	–	5	0.8	–	–	3	0.6	–	–	3	0.4	–	–
Cenchrus ciliaris	59630	–	–	–	–	–	–	–	–	5	1.5	+	–	5	0.4	+	–	1	0.1	–	–	3	0.4	–	–
Cenchrus ciliaris	59631	–	–	–	–	–	–	–	–	1	0.6	–	–	5	1.5	–	–	–	–	–	–	3	0.6	–	–
Cenchrus ciliaris	59632	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	0.7	–	–
Cenchrus ciliaris	59636	–	–	–	–	–	–	–	–	5	0.4	–	–	5	0.5	–	–	–	–	–	–	2	0.4	–	–
Cenchrus ciliaris	59646	–	–	–	–	–	–	–	–	–	–	–	–	4	0.1	–	–	–	–	–	–	2	0.4	–	–
Cenchrus ciliaris	59894	–	–	–	–	1	0.6	–	–	5	1.0	–	–	5	0.7	–	–	2	0.3	–	–	2	0.6	–	–
Cenchrus ciliaris	60629	–	–	–	–	–	–	–	–	1	1.0	–	–	5	1.0	–	–	–	–	–	–	2	0.5	–	–
Cenchrus ciliaris	Q10077	–	–	–	–	–	–	–	–	1	0.6	–	–	5	0.9	–	–	–	–	–	–	2	0.3	–	–
Cenchrus ciliaris	Q10087	–	–	–	–	–	–	–	–	–	–	–	–	5	0.8	–	–	–	–	–	–	3	1.2	–	–
Chloris roxburghiana	59653	–	–	–	–	–	–	–	–	–	–	–	–	4	0.3	+	–	–	–	–	–	–	–	–	–
Digitaria endlichii	59817	1	0.4	–	–	–	–	–	–	3	1.3	–	+	–	–	–	–	–	–	–	–	1	0.1	–	–
Digitaria gazensis	59705	–	–	–	–	–	–	–	–	1	0.1	–	–	–	–	–	–	–	–	–	–	1	0.1	–	–
Digitaria gazensis	59707	2	0.4	–	–	–	–	–	–	–	–	–	–	2	0.3	–	–	3	0.3	–	–	3	0.4	–	–
Digitaria macroblephara	59722	–	–	–	–	1	0.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	0.4	–	–
Digitaria macroglossa	16267	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	0.8	–	–
Digitaria milanjiana	40700	4	1.5	–	–	4	1.8	+	+	5	3.2	+	+	5	1.3	–	+	5	1.5	–	–	5	2.7	+	+
Digitaria milanjiana	41192	4	1.1	–	–	4	2.6	+	+	5	3.0	+	+	5	1.0	–	–	4	1.0	+	–	5	1.4	+	–
Digitaria milanjiana	59761	4	1.8	+	+	4	2.2	+	+	5	2.6	+	+	–	–	–	–	5	1.7	+	+	4	0.1	–	–
Digitaria milanjiana	59830	4	1.7	–	–	4	2.6	+	+	5	1.8	+	+	5	0.9	+	+	3	0.1	–	–	3	1.0	–	–
Digitaria milanjiana	59765	–	–	–	–	–	–	–	–	5	1.1	+	+	5	0.8	–	+	4	0.8	–	+	5	1.0	–	+
Digitaria milanjiana	59770	1	0.4	–	–	1	1.0	–	–	4	0.2	–	–	4	0.6	–	+	5	1.2	–	+	5	1.7	+	+
Digitaria milanjiana	59774	4	0.6	–	–	4	0.6	–	+	5	0.9	–	+	4	0.3	+	+	5	0.9	–	+	5	1.4	+	+
Digitaria milanjiana	59766	–	–	–	–	2	0.4	–	–	5	0.3	+	–	4	0.8	–	–	3	0.5	–	–	5	1.9	–	+
Digitaria natalensis[2]	59689	1	0.8	–	–	2	1.8	+	+	5	1.5	+	+	4	0.5	–	–	3	0.6	–	–	3	1.7	+	–
Digitaria personii	59840	–	–	–	–	–	–	–	–	–	–	–	–	2	0.3	–	–	2	0.3	–	–	2	0.4	–	–
Digitaria pentzii	CQ997	–	–	–	–	4	0.9	–	–	–	–	–	–	4	0.7	–	–	2	0.4	–	–	1	0.8	–	–
Digitaria pentzii	23854	4	0.6	–	–	4	3.2	+	+	5	1.4	–	+	5	1.6	+	+	5	0.8	+	+	5	0.9	+	+
Digitaria pentzii	26836	–	–	–	–	3	0.6	+	+	5	1.1	–	+	4	0.6	–	–	–	–	–	–	5	0.4	–	–

TABLE 3 (continued)

The accessions which established at each site, the number of seasons they persisted (P), mean maximum yield (Y in t/ha) for those years (calculated for first 3 years only), presence (+) or absence (−) of seedling regeneration (Sd), and occurrence (+) or failure (−) to spread (Sp) out of cultivated strip

		Roma				Charleville				Blackall				Longreach				Duaringa hill				Duaringa flat			
Species	CPI[1]	P	Y	Sd	Sp	P	Y	Sd	Sp	P	Y	Sd	Sp	P	Y	Sd	Sp	P	Y	Sd	Sp	P	Y	Sd	Sp
Digitaria pentzii	41190	4	0.6	−	−	4	1.0	+	+	5	1.9	+	−	4	0.5	−	+	3	0.5	−	+	1	0.1	−	−
Digitaria polevansii	41183	−	−	−	−	4	1.5	+	+	5	0.9	+	−	4	0.6	−	+	5	0.3	−	−	5	1.5	−	−
Digitaria setivalva	26832	−	−	−	−	4	1.2	+	+	4	0.8	−	−	5	0.5	−	−	5	0.9	+	+	5	1.4	+	+
Digitaria setivalva	43908	−	−	−	−	4	1.7	+	+	1	0.1	−	−	5	1.3	+	+	−	−	−	−	5	0.5	−	−
Digitaria smutsii	38869	−	−	−	−	4	1.2	+	+	5	0.9	+	−	4	0.4	−	−	5	1.0	+	+	5	1.9	−	−
Digitaria swynnertonii	59715	2	0.6	+	+	2	0.6	−	−	5	1.2	+	+	4	0.6	−	−	1	0.4	−	−	5	2.5	+	+
Digitaria swynnertonii	59749	2	0.6	−	−	4	1.0	−	−	5	1.9	+	−	5	0.6	−	−	4	1.2	−	−	5	1.8	−	+
Digitaria valida	59790	−	−	−	−	3	0.5	−	−	3	0.4	−	−	3	0.1	−	−	−	−	−	−	−	−	−	−
Digitaria valida	59795	−	−	−	−	−	−	−	−	1	0.4	−	−	−	−	−	−	−	−	−	−	1	0.4	−	−
Eragrostis curvula	30374	−	−	−	−	4	1.5	+	−	−	−	−	−	3	0.1	−	−	−	−	−	−	−	−	−	−
Eragrostis curvula	30379	−	−	−	−	−	−	−	−	1	0.4	−	−	1	0.4	−	−	1	0.7	−	−	1	0.1	−	−
Eragrostis rigidior	59619	−	−	−	−	4	0.9	+	+	5	1.8	−	−	5	2.2	+	−	4	0.3	−	−	−	−	−	−
Panicum coloratum cv. Pollock		−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	2	0.3	−	−
Panicum coloratum	59876	−	−	−	−	4	1.2	+	+	−	−	−	−	4	0.7	−	−	−	−	−	−	5	1.0	−	−
Panicum maximum cv. Petrie		−	−	−	−	−	−	−	−	1	0.8	−	−	−	−	−	−	−	−	−	−	3	0.5	−	−
Panicum maximum	60022	−	−	−	−	2	0.9	−	−	4	0.9	+	−	−	−	−	−	4	0.8	−	−	−	−	−	−
Panicum maximum	60028	−	−	−	−	1	0.4	−	−	1	0.6	−	−	4	0.4	−	−	5	0.8	−	−	4	0.6	−	−
Panicum maximum	60035	−	−	−	−	−	−	−	−	4	1.0	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Schmidtia bulbosa	43716	4	2.1	+	+	4	2.5	+	−	5	3.7	+	+	5	2.9	+	+	2	0.4	−	−	1	0.6	−	−
Schmidtia bulbosa	Q10092	1	0.1	+	+	4	1.4	−	−	5	2.4	+	−	5	1.8	+	+	−	−	−	−	−	−	−	−
Urochloa mosambicensis cv. Nixon		4	2.9	+	+	4	1.3	+	+	5	2.5	+	+	5	1.2	+	+	5	1.7	+	+	5	3.4	+	+
Urochloa mosambicensis	60115	4	2.6	+	+	3	1.7	+	−	5	3.9	+	+	4	1.6	+	−	4	0.8	−	−	5	2.7	+	+
Urochloa mosambicensis	60117	4	1.9	+	+	4	1.9	+	+	5	2.2	+	+	5	1.2	+	−	4	1.4	+	−	5	2.6	+	+
Urochloa mosambicensis	60132	4	2.0	+	+	2	0.6	+	+	5	2.7	+	+	5	1.7	−	−	5	1.0	−	−	5	2.6	+	+
Urochloa mosambicensis	60134	4	2.5	+	+	2	0.8	+	+	5	4.0	+	+	5	2.0	+	−	5	1.9	+	+	5	2.8	+	+
Urochloa mosambicensis	60135	4	2.7	+	+	4	1.3	+	+	5	3.1	+	+	4	1.8	+	−	5	0.6	−	−	5	2.2	+	+
Urochloa mosambicensis	60136	4	1.8	+	+	4	1.9	+	+	4	2.8	+	+	4	1.6	+	+	5	2.1	+	+	5	2.7	+	+
Urochloa mosambicensis	60139	4	3.7	+	+	4	1.3	+	+	5	1.2	+	+	5	3.1	+	+	5	1.3	+	+	5	1.0	+	+
Urochloa mosambicensis	60149	4	3.0	+	+	4	2.5	+	+	5	2.7	+	+	4	1.3	−	−	5	0.5	+	+	5	1.3	+	+
Urochloa mosambicensis	60150	4	2.8	+	+	4	2.7	+	+	5	3.3	+	+	5	1.4	+	+	5	1.9	+	+	5	2.3	+	+
Urochloa mosambicensis	60151	4	0.9	+	+	4	1.7	+	+	5	1.6	+	+	5	1.8	+	+	5	1.3	+	−	4	0.8	−	−
Urochloa oligotricha	47122	4	1.4	+	+	4	1.2	+	+	5	2.9	+	+	5	2.7	+	+	5	1.2	−	−	5	2.1	+	+
Urochloa oligotricha	60122	4	0.8	+	+	3	0.6	+	+	5	2.5	+	+	5	0.9	−	−	5	1.3	+	+	5	1.9	+	+
Urochloa oligotricha	60126	4	2.8	+	+	2	1.4	+	+	5	3.2	+	+	5	1.2	−	−	5	0.9	+	−	5	2.6	+	+
Urochloa oligotricha	60127	4	1.8	+	+	4	2.1	+	+	5	3.1	+	+	5	1.7	+	−	5	1.5	+	+	5	2.6	+	+
Urochloa stolonifera	60128	−	−	−	−	2	0.3	−	−	5	2.1	+	+	4	0.8	−	+	2	0.1	−	−	4	0.6	+	+
No. of accessions persisting 3 or more years			24				35				70				71				55				75		
Mean yield of those accessions			1.8				1.5				1.6				1.2				1.1				1.8		
LSD for 3 yr. accession means $P < 0.05$			1.0				1.3				1.5				1.0				1.0				1.7		
$P < 0.01$			1.3				1.7				1.9				1.4				1.3				2.2		
$P < 0.001$			1.7				2.2				2.5				1.8				1.6				2.8		
LSD 3 yr. and general mean $P < 0.05$			0.7				0.9				1.0				0.7				0.7				1.2		
$P < 0.01$			0.9				1.2				1.4				1.0				0.9				1.6		
$P < 0.001$			1.2				1.5				1.8				1.2				1.2				2.0		

[1] CPI. Non-prefixed numbers are Commonwealth Plant Introduction (CPI) accessions; CQ numbers are CSIRO Queensland accessions; Q numbers are Queensland Department of Primary Industries accessions, and the N number is a Queensland University accession.

[2] *D. natalensis* ssp. *stentiana*.

Persistence

It can be seen in Table 3 that persistence (the number of seasons an accession persisted by perennation and/or seedling regeneration) varied markedly between sites, in the order Duaringa flat = Longreach = Blackall > Duaringa hill > Charleville > Roma. However analyses of plant numbers in 1978 (excluding seedlings) and 1979 (including seedlings) indicated no significant difference between fertilizer treatments over all sites or between treatments within sites. The Roma site was decimated by a locust plague (particularly the young legumes) in February and April 1977, and the Charleville site was heavily overgrazed at the start of the 1977/78 growing season.

Seedling regeneration

In 1977/78, a count of seedlings in and adjacent to plots revealed significant differences between accessions (P < 0.001) with a significant site × accession

TABLE 4

Mean yield (Y, t/ha) over sites and years and linear regression coefficient (b) for selected Cassia, Digitaria, Stylosanthes *and* Urochloa *accessions*

		Y[1]	b			Y	b
	CASSIA				*STYLOSANTHES*		
34719	*C. rotundifolia*	1.4	1.25	41219	*S. fruticosa*	2.0	0.46
34721	*C. rotundifolia*	1.5	0.96	Verano	*S. hamata*	1.8*	0.15
57503	*C. pilosa*	1.2	0.76	Fitzroy	*S. scabra*	2.1	1.47
				Seca	*S. scabra*	1.9	1.04
				34925	*S. scabra*	2.3	1.22
				40289	*S. scabra*	1.5**	0.85
				55868	*S. scabra*	3.7***	1.46
				55870	*S. scabra*	4.3***	1.67
				55872	*S. scabra*	4.2***	1.44
				33941	*S. viscosa*	1.1***	0.41
				34904	*S. viscosa*	1.7*	0.83
General mean		1.3	1.00			2.4	1.00
LSD accession means							
P < 0.05		*NS*				0.9	
P < 0.01		*NS*				1.2	
P < 0.001		*NS*				1.6	
	DIGITARIA				*UROCHLOA*		
40700	*D. milanjiana*	2.0***	1.82	Nixon	*U. mosambicensis*	2.2	0.85
41192	*D. milanjiana*	1.7***	1.66	60115	*U. mosambicensis*	2.2	1.70
59761	*D. milanjiana*	1.6**	0.61	60117	*U. mosambicensis*	1.9	0.85
59830	*D. milanjiana*	1.3	1.41	60132	*U. mosambicensis*	1.8	1.00
59765	*D. milanjiana*	0.9	0.95	60134	*U. mosambicensis*	2.3	1.27
59770	*D. milanjiana*	0.9	0.50	60135	*U. mosambicensis*	2.0	1.30
59774	*D. milanjiana*	0.8*	0.66	60136	*U. mosambicensis*	2.2	1.35
59766	*D. mombasana*	0.8*	0.43	60139	*U. mosambicensis*	1.8	0.37
59689	*D. natalensis*	1.2	1.60	60149	*U. mosambicensis*	1.9	1.03
CQ997	*D. pentzii*	0.7**	0.56	60150	*U. mosambicensis*	2.4*	1.00
23854	*D. pentzii*	1.5*	1.39	60151	*U. mosambicensis*	1.3*	0.60
23836	*D. pentzii*	0.6***	0.28	47122	*U. oligotricha*	1.9	0.89
41190	*D. pentzii*	0.9	1.15	60122	*U. oligotricha*	1.3*	0.65
41183	*D. polevansii*	1.0	1.21	60126	*U. oligotricha*	2.1	0.83
38869	*D. smutsii*	1.1	0.68	60127	*U. oligotricha*	2.1	0.94
26832	*D. setivalva*	0.9	0.89	60128	*U. stolonifera*	0.9***	0.42
59715	*D. swynnertonii*	1.1	1.11				
59749	*D. swynnertonii*	1.2	1.00				
General mean		1.2	1.00			1.9	1.00
LSD accession means							
P < 0.05		0.5				0.7	
P < 0.01		0.7				1.0	
P < 0.001		0.9				1.3	

[1] *, **, *** indicate different from general mean at P < 0.05, P < 0.01, P < 0.001 respectively.

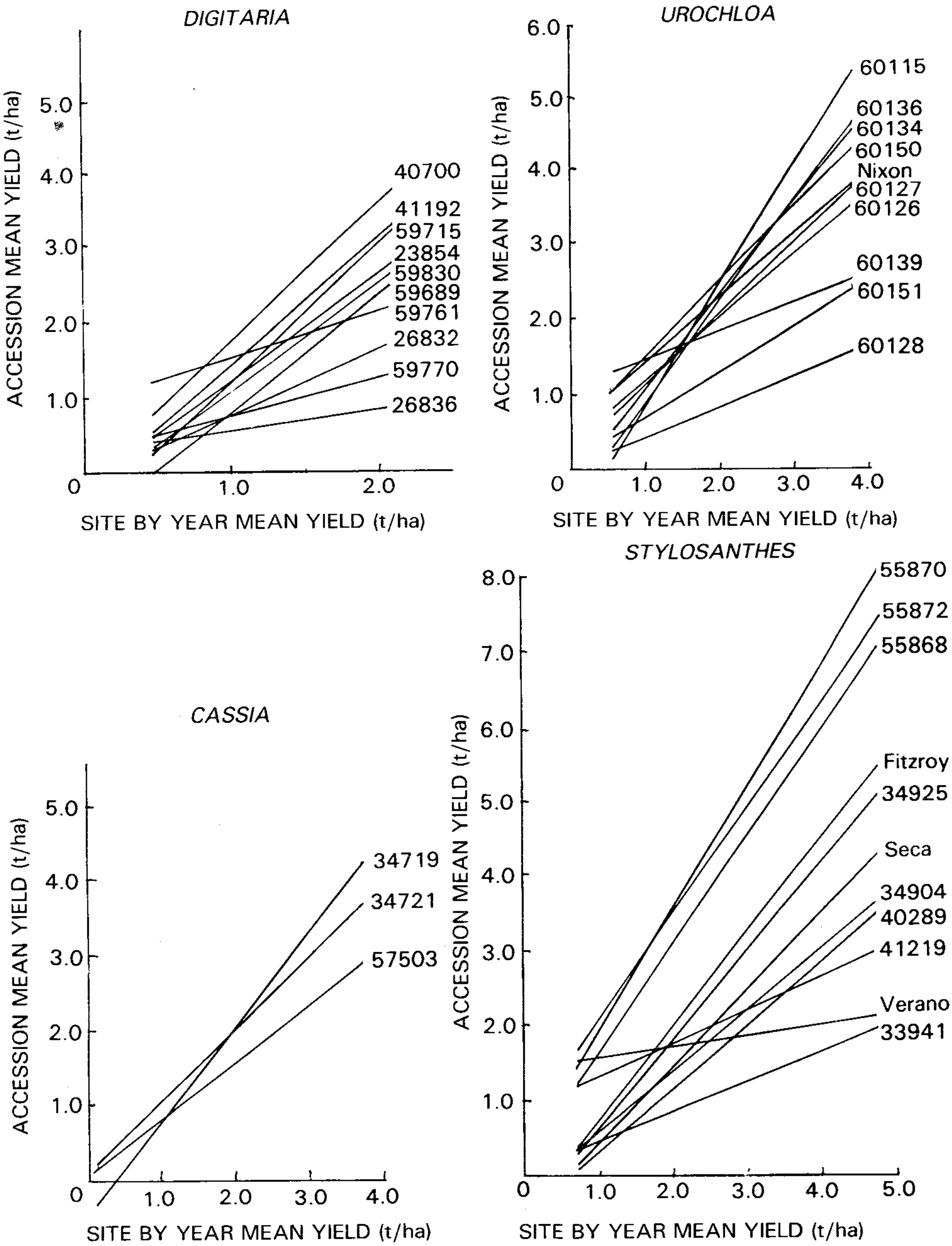

FIGURE 1
Regression lines for accession mean yields (t/ha) on site × year mean yields (t/ha) for the genera *Cassia, Digitaria, Stylosanthes* and *Urochloa*.

interaction ($P < 0.001$). There was more seedling regeneration ($P < 0.05$) at Blackall, Roma, and Charleville than at Duaringa flat, Duaringa hill and Longreach, in that order, but there was no significant difference between fertilizer treatments.

Spread

An analysis of the spread from each plot in April 1978 showed that there was no effect of fertilizer treatment either within or between sites. There was a significant difference between accessions ($P < 0.001$) and sites ($P < 0.05$) with accessions at Roma and Blackall spreading further out of their plots than at the other sites. The accessions which spread widely (2 m or more) since 1978 have been indicated in Table 3. Stoloniferous grasses like *D. milanjiana* 59774 have spread more by stolons than seed, whereas the *Urochloa* and *Stylosanthes* spp. have spread by seed.

Yield

Sites differed in their mean dry matter yield in each of the first 3 seasons growth ($P < 0.05$). Over all sites, fertilised plots yielded more than unfertilised plots, but only in the first 2 seasons ($P < 0.001$, $P < 0.05$ respectively). Within sites, fertilizer effects were apparent for all sites except Duaringa hill ($P < 0.05$) in the first season, and Roma and Duaringa hill ($P < 0.05$) in the second season. Table 3 contains mean yields for up to 3 years. The least significant differences given in Table 3 apply only to those accessions which persisted for the first 3 seasons. Yield data was not collected after the 1978/9 growing season.

The linear regressions of accession mean yields on site × year mean yields for the genera *Cassia, Digitaria, Stylosanthes* and *Urochloa* have been presented in Figure 1 to highlight differences in adaptation of accessions within those genera. The *Stylosanthes* regressions were derived from 4 sites (the stands at Roma and Charleville were decimated in the first year), while regressions for the other genera were derived from all sites. Linear regression coefficients and mean yields over sites and years for these genera are given in Table 4.

DISCUSSION

All sites had good establishment rains with the exception of Duaringa where most of the rain fell in March of that year. The poor establishment at Roma was undoubtedly due to the locust outbreak that occurred alongside the plots. All sites experienced below average rainfall — Duaringa in the summer of 1977 and all other sites in the summer of 1977/8 and winter of 1979.

The most persistent perennial legumes over all sites were in the genera *Cassia* and *Stylosanthes*. The *S. scabra* (55872) plot that did persist at Charleville was protected from grazing by a fallen tree. Seedling regeneration of the annual legumes was disappointing, particularly in regard to *Macroptilium lathyroides*. However *Cassia falcinella* and *Macrotyloma daltonii* did regenerate for up to 3 years depending on site. *Cyamopsis senegalensis* is a very short lived, hard seeded annual which matured within 2 months. Further investigation of this legume (Strickland and Ford 1984) showed that it has crop potential as a source of guaran. The most persistent grasses over all sites were in the genera *Digitaria* and *Urochloa*, but *Brachiaria nigropedata* (59616) and *Schmidtia bulbosa* (43716) also persisted well in most sites, the latter showing potential in grazing trials conducted by officers of the Queensland Department of Primary Industries at Charleville.

The ability to spread into native pasture is an important attribute for adaptation. Again, *Cassia* and *Stylosanthes* species were outstanding among the legumes. Apart from seedling spread in proximity to mother plots, these legumes became widely dispersed in cattle dung, particularly at Duaringa. *Urochloa* species spread several metres by seed at all sites and *Digitaria* species spread mainly by stolons, although some seedling regeneration did occur.

The variable (and often low) phosphate status of the soils suggested that there might be a response to applied phosphate in terms of establishment and persistence; however this was not detected. There was a large yield response in the first year, a small response in the second year, and no differences thereafter. This decline in response could be due to lack of available phosphate through utilisation, or through fixation in these red earths. The lower response to applied phosphate at Roma and Duaringa was presumably related to the higher initial soil phosphate status at those sites.

The maximum yields presented in Table 3 reflect not only growth in response to the environment, but also the effects of selective grazing. For example, the extremely high yields of some *Stylosanthes* accessions were recorded at a time when stock were ignoring them in preference to grass. They were certainly well grazed later in the season. Both stock and vermin had a preference for *Digitaria* and *Urochloa* plots but did not graze *Galactia striata*.

Within each of the better adapted genera, the most consistent high yields over all environments were produced by *Cassia rotundifolia* 34721, *Stylosanthes scabra* 55868, 55870 and 55872, *Digitaria milanjiana* 40700, and *Urochloa mosambicensis* 60150. Although the *Cassia* accession persisted for up to 5 years at Blackall and Longreach, it was not evident at those sites after that time. It persisted and spread widely at Duaringa over 10 years. The other high yielding accessions mentioned above are still persisting at all sites after 10 years and, in a more recent *Stylosanthes* evaluation on a red earth near Augathella (W. Queensland), cv. Fitzroy was as persistent and productive as the above accessions of *S. scabra*. The yield of *D. milanjiana* 41192 over all sites was not significantly different from that of 40700 but the latter had better spread at most sites. Although *D. milanjiana* 59761 had a high average yield (Table 4) it did not respond to better growing conditions. Its high rating in poor environments was due to stolon bulk rather than leafiness. It is a prostrate, very stoloniferous form that could have application for erosion control and in waterways. Although many of the *Urochloa* accessions had average yeilds as high as that of 60150, they responded quite differently to environmental change. For example 60139 yielded well in the worst environments but poorly in better environments, and 60115 behaved in the reverse manner. Accession 60150 was not significantly better than cv. Nixon at any site.

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