EVALUATION OF INTRODUCED GRASS SPECIES FOR PASTURES IN THE DRY TROPICS OF NORTH QUEENSLAND

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ABSTRACT

A range of introduced grasses was tested under cutting and grazing at five sites in the 1970's with fertilizer applied at sowing only. In sward experiments with 12 lines, the most persistent and productive were Brachiaria decumbens *and* Paspalum plicatulum. *Nitrogen levels in mature whole tops were below 1% in both sown and native grasses and ranged from 1.1 to 2.2% in associated legume.*

In row experiments using 86 lines under uncontrolled grazing, best spread occurred in the high yielding Andropogon gayanus *and* Hyparrhenia rufa *(by seedlings) and the moderate yielding* Bothriochloa insculpta, Brachiaria humidicola *and* Chloris gayana *(by stolons). Other persistent but slower colonizing grasses included* B. decumbens, Dichanthium aristatum, P. plicatulum, Urochloa mosambicensis, U. oligotricha *and* U. pullulans. *Accessions of* Cenchrus, Panicum *and* Setaria *failed to persist. Most of the persistent perennial grasses were readily accepted by stock and retained some greenness in the dry season when native grasses were dormant, with* A. gayanus *pre-eminent.* Stylosanthes hamata *cv. Verano persisted with the sown grasses.*

Sparse establishment of sown grasses occurred in these experiments and in commercial sowings. It is suggested that the ability of a sown grass to spread is most important in the dry tropics particularly if sown grasses are to be used in relatively low input pasture systems.

INTRODUCTION

A perennial grass is a highly desirable component of pastures in the dry tropics. It is important in relation to stability of pasture production, the energy value of the material on offer and the prevention of weed ingress (Norman 1967). In dry tropical areas receiving some winter rainfall perennial grasses can provide green feed when most legumes hay-off (Gardener 1980).

Native grass pastures of Cape York Peninsula are known to be of poor quality and more readily damaged by heavy grazing than *Themeda australis* and *Heteropogon contortus* pastures of the Mt. Garnet to Charters Towers area. Heavy grazing of the Peninsula pastures results in their replacement by thickets of dicotyledonous weeds including *Sida* spp., *Hyptis suaveolens, Urena lobata* and *Cassia occidentalis,* whereas in the more southern, drier areas a succession of grass would occur with *H. contortus* as a first stage. *H. contortus* is of limited occurrence in Cape York Peninsula (Isbell 1969).

The introduction of legumes into the native pastures of northern Queensland has resulted in an increase in stocking pressures and a decline in the better perennial native grasses (Ritson, Edye and Robinson 1971, Winks *et al.* 1974). The only published records of sown grass performance in the dry tropics of Queensland are from the north of Cape York Peninsula (Winter 1976) and from west of Townsville (Gillard 1971, Edye 1975).

This paper presents the results of a series of sward and row trials under cutting and grazing with a wide range of introduced grasses at five sites in far north Queensland. The aim of this series of experiments was to establish which species were potentially valuable as pasture plants in the region.

GENERAL MATERIALS AND METHODS

Details of the five sites are presented in Table 1. Merluna, Kalinga and Koolburra are typical of the slightly acid, infertile massive earths of the region (Galloway *et al.*

1970, Isbell and Smith 1975). Southedge and Boomerang are less acid with the former being P deficient (Gilbert and Shaw 1980) and the latter S deficient (Miller and Jones 1977). All sites were cleared and cultivated before sowing, except in experiment 4.

In experiments 1 and 2 yields were taken from a central 3 m^2 mower strip at the middle and end of each wet season, except in 1974 when a single end-of-wet-season cut was made. At each harvest sub-samples of separated species were analysed for N and P. Material was raked off at the end of the growing season after mowing.

Each site in experiments 3 and 4 was oversown with *S. hamata* cv. Verano at 5 kg ha^{-1} in January 1976 except for Merluna (November 22, 1977).

All experiments comprised three replicates in a randomized block design, but received different fertilizer treatments and included different groups of grasses. Details are given for each experiment in the results section.

TABLE 1

Details of sites used in the experiments

Site Number	1	2	3	4	5
Name	Merluna	Kalinga	Koolburra	Southedge	Boomerang
Location	142° 27E, 13° 4'S	143° 52'E, 15° 11'S	143° 15'E, 15° 14'S	145° 14'E, 16° 48'S	144° 49'E, 18° 11'S
Soil Type (Northcote)	Mottled Yellow earth Gn 2.61	Red Earth Gn 2.14	Grey leached earth Gn 2.94	Duplex Dy 3.43	Red friable earth Gn 3.12
Original Vegetation (dominant species)	*Eucalyptus leptophleba, E. nesophila*	*E. tetradonta, E. nesophila*	*E. leptophleba, Melaleuca viridiflora*	*E. leptophleba*	*E. crebra, E. polycarpa*
Average Rainfall (mm)	1380	1130	1130	1100	800
Altitude (m)	150	73	73	380	830
No. of Frosts $year^{-1}$	0	0	0	<1	5+
Soil Analysis (unfertilized)					
Extractable P (BSES) (ppm)	2	2	3	6	380
Extractable K (m.e. 100 g^{-1})	0.08	0.03	0.04	0.45	1.60
pH (H_2O)	5.3	5.6	5.4	6.2	6.1

Climate

Annual rainfall at Merluna, Kalinga and Koolburra was above average from 1970 to 1974 except at Kalinga in 1972 (860 mm). In the 1975 to 1979 period of experiments 3 and 4, rainfall was average to far above average in the first three years, but in 1978 total rainfall ranged from 56 to 76% at four sites, being average at Merluna only.

There were approximately five frosts per year at Boomerang while two mild frosts were noted at Southedge over the five year experimental period. Minimum temperatures in the three northern sites did not fall below 14°C.

RESULTS

Experiment 1

Seven grasses (Table 2) were sown in 6 x 5 m plots at Merluna and Kalinga on December 19 and December 21, 1970 respectively. Grass seed was broadcast at 5 kg ha^{-1} and raked in lightly. Superphosphate (Mo 12) was applied at 627 kg ha^{-1}, sulphate of ammonia at 125 kg ha^{-1}, KCl at 125 kg ha^{-1} and $ZnSO_4$ and $CuSO_4$ each at 11.2 kg ha^{-1}. *Stylosanthes guianensis* cv. Endeavour was oversown at Merluna on December 15, 1971 at 12 kg ha^{-1}. This site was accidentally grazed in January–February 1973.

At Kalinga only Basilisk, Nixon, Gayndah and American established, all of the order of 1 plant $plot^{-1}$. No thickening of the stand occurred and the trial was abandoned.

In the first year at Merluna, Basilisk and the two buffel grasses, Gayndah and American, had higher yields ($P>0.05$) than other sown grasses, followed by Rodd's Bay. In the following three years Rodd's Bay and Basilisk had highest yields (Table 2) while the buffel grasses weakened and died out. Burnett and Nixon did not give high yields and the stand of Petrie failed to thicken from a sparse establishment population.

Yield on offer in 1973 was lower than in 1972 and 1974 due to early wet season grazing. There was a tendency for the high yielding grasses to have lower yields of associated legume and native grass. This reached significance ($P = 0.05$) in 1973 with Rodd's Bay having lowest legume yield. Endeavour was killed by October fires in 1971 and 1972 but dense seedling regeneration occurred in the following wet season. Sown grasses survived burning, with Basilisk producing the most spring growth. There was some regrowth from *Heteropogon triticeus* but little from other native grasses (mainly *Pseudopogonantherum contortum*, *Sorghum plumosum* and *Eriachne* spp.).

TABLE 2

Annual dry matter yields of grasses sown in 1970 and 1973 at Merluna (experiment 1) and Kalinga and Koolburra (experiment 2) (kg ha^{-1})

Experiment	1				2		
Site	Merluna				Kalinga	Koolburra	
Year	71	72	73	74	73	73	74
Treatment							
Paspalum plicatulum Rodd's Bay	470	5417	2153	8560	4	600	1310
Brachiaria decumbens Basilisk	1583	5047	1080	3730	17	137	1090
Urochloa mosambicensis Nixon	67	403	507	160	0	303	0
Cenchrus ciliaris Gayndah	1267	290	43	0	12	107	0
Cenchrus ciliaris American	1137	743	17	0	0	213	0
Panicum coloratum Burnett	120	153	297	120	0	13	10
Panicum maximum Petrie	0	3	3	0	5	47	0
Panicum maximum Hamil					29	473	10
Panicum maximum Common guinea					169	420	10
Panicum maximum Q14734[a]					43	123	0
Cenchrus pilosus Q9142					30	207	0
Digitaria decumbens Pangola					0	0	0
Mean	774	1722	586	3140	26	240	486
SD	270	575	160	3990	47	158	656
LSD ($P = 0.05$)	851	1773	494	–		467	

[a] Queensland Department of Primary Industries Plant Introduction Number.

In 1978 Rodd's Bay and Basilisk were the only sown grasses persisting under grazing, the former as an almost monospecific sward and the latter sparsely scattered with Endeavour. Neither had colonized outside their original plots.

Yields of legume and native grass were variable and unrelated to treatment (Table 3).

Experiment 2

Twelve grasses (Table 2) were sown in 5 x 4 m plots at Kalinga and Koolburra on January 21, 1973. Fertilizer applied at sowing, was 500 kg ha^{-1} of superphosphate (Mo 12), 125 kg ha^{-1} of KCl, 11.2 kg ha^{-1} of each of $ZnSO_4$ and $CuSO_4$, and 125 kg ha^{-1} of ammonium sulphate. *S. scabra* CPI 34925 was sown at 12 kg ha^{-1} with the grass seed (5 kg ha^{-1}) followed by light raking.

Grass establishment averages 6 ± 4 plants m^{-2} at Kalinga compared to 20 ± 13 plants m^{-2} at Koolburra from identical seed sown on the same day. Establishment of *S. scabra* CPI 34925 was 4 ± 2 plants m^{-2} at both sites.

At Kalinga yields of both sown grass and legume were negligible in the first year while native grasses (mainly *Sorghum plumosum* and *Eriachne* spp.) yielded 1550 ± 350 kg ha^{-1}. In the following five years there was no increase in plant density of any sown

TABLE 3

Annual dry matter yields of sown legume and native grass at Merluna (experiment 1) and Kalinga and Koolburra (experiment 2) (kg ha^{-1}).

Experiment	1		2		2	
Site	Merluna		Kalinga		Koolburra	
Year	Legume	Native Grass	Legume	Native Grass	Legume	Native Grass
1	NS*	730 ± 320	3 ± 4	1550 ± 350	20 ± 8	1590 ± 200
2	1210 ± 740	1260 ± 510			1130 ± 660	2930 ± 550
3	860 ± 160	480 ± 130				
4	3240 ± 755	1540 ± 480				

* NS—Not sown

grass, although Rodd's Bay, Basilisk, Nixon, Gayndah, American and pangola persisted in small clumps. The annual *Cenchrus pilosus* did not regenerate in 1974. *S. scabra* maintained its plant density and constituted about half the dry matter yield.

At Koolburra all sown grasses were well represented in the first year but gave low yields relative to native grass (Tables 2 and 3). In December 1973 following a June fire regrowth was apparent on all treatments except *C. pilosus* with most from Basilisk, whereas *S. scabra* had many basal shoots. Rodd's Bay and Basilisk were the only grasses with yields above 10 kg ha^{-1} in the second year, both exceeding 1000 kg ha^{-1}. They were associated with legume yields of 250 and 430 kg ha^{-1} respectively compared to the mean legume yield of 1130 kg ha^{-1}. However, variability in the data resulted in no significant differences. Native grass yields were not affected by treatment.

Dry matter yield at Koolburra was not measured after 1974 but inspections each year up to 1979 revealed that Rodd's Bay, Basilisk and pangola remained vigorous and were high yielding under indifferent management (including fires and occasional overgrazing). Basilisk and pangola spread 2 to 3 m in this time but neither Rodd's Bay nor the other sparsely persistent grasses Nixon, Hamil and common guinea showed any spread. *S. scabra* CPI 34925 maintained its density and made up about half the total yield despite a severe occurrence of anthracnose disease.

Chemical Composition of tops in Experiments 1 and 2

Mean N level of whole tops of mature sown grass was generally below 1%, except in year 3 at Merluna when it was 1.2 ± 0.4% in March following grazing in January–February (Table 4). Native grass had similar N levels to those of sown grass at each harvest. Levels in associated legume ranged from 1.1 to 2.2%.

Levels of P in sown grass, native grass and legume were generally similar, usually below 0.15%.

TABLE 4

Mean N and P levels in mature whole tops of sown grass, sown legume and native grass at Merluna (experiment 1) and Kalinga and Koolburra (experiment 2).

Site	Merluna			Kalinga	Koolburra	
Year	2	3	4	1	1	2
N:						
Sown Grass	0.58 ± 0.09	1.24 ± 0.36	0.52 ± 0.14	1.06*	0.80 ± 0.08	0.41 ± 0.08
Native Grass	0.66	1.04	0.61	1.00	0.76	0.53
Legume	2.06	2.20	1.43	1.87	1.93	1.13
P:						
Sown Grass	0.10 ± 0.03	0.13 ± 0.02	0.06 ± 0.01	0.16*	0.16 ± 0.03	0.07 ± 0.02
Native Grass	0.11	0.15	0.08	0.10	0.19	0.09
Legume	0.18	0.20	0.08	0.09	0.12	0.07

* Level in Basilisk

TABLE 5

Mean number of sown grass plants per plot in each year in experiment 3.

Genus Species	*Site* *Year*	Merluna			southedge			Boomerang		
	CPI[a]/Q[b]/CV[c]	1975	1976	1977	1975	1976	1977	1975	1977	1979
Andropogon gayanus	43156	11.7	15.0	15.0	1.7	5	12	9.7	10	10
Andropogon gayanus	53580	2.3	3.0	5.0	0.7	0		3.3	2	
Andropogon gayanus	55606	5.3	10.3	10.3	7.3	12	20	7.1	8	8
Antephora acuminata	52995	0			0			4.0		
Antephora elongata	52191	0			1.3			0		
Antephora pubescens	43713	1.3			1.0	0.3		0	3	
Bothriochloa insculpta	Hatch	15.0	0.3	2.0	9.3	m	m	1.3	m	m
Bothriochloa sp.	52193	0.3	0.3		0			0.3		
Brachiaria decumbens	Basilisk	4.0	1.7	1.0	0.7	m	m	3.0	m	m
Brachiaria humidicola	Tully	3.7	m*	m	7.7	m	m	0.3	m	m
Brachiaria plantaginea	37227	0.3			0.7			0		
Cenchrus glaucus	52211	5.7			10.7	4	3	5.3	7	
Cenchrus ciliaris	American	7.0	0.3		7.7	5	6	3.7	10	7
Cenchrus ciliarus	Gayndah	3.0	0.3		5.3	5	3	3.7	8	2
Cenchrus pennisetiformis	Cloncurry	6.3	0.3	0.3	9.3	3	3	2.1	2	
Cenchrus pilosus	Q9142	0.7	0.3		1.0	0.3		1.0		
Cenchrus setigerus	Birdwood	0	0.7		2.0			0		
Chloris gayana	Callide	10.7	1.0	1.0	9.0	m	m	5.7	m	m
Chloris gayana	Pioneer	4.0	1.0	1.0	21.3	m	m	2.0	m	m
Dactyloctenium aegyptium	52222	0.3			3.0			2.0		
Dactyloctenium gigantium	Q10091	8.3			3.7			4.3		
Dactyloctenium sp.	Q9143	1.0			6.7			4.3		
Dactyloctenium sp.	52223	0.7			1.0			0		
Dactyloctenium sp.	43573	0			5.3			0.3		
Dichanthium aristatum	Angleton	0.3			4.7	m	m	4.0	m	m
Eragrostis superba	55250	1.0	0.3		6.3			0.3	0.3	
Hyparrhenia rufa	Q5108	3.0	3.0	10.0	2.0	10	25	7.0	5	23
Hyparrhenia rufa	52255	5.3	1.7	6.7	1.3	20	50+	3.0	20	50+
Hyparrhenia rufa	52256	8.0	3.7	16.7	7.0	20	50+	8.7	40	50+
Hyparrhenia rufa	52257	5.0	2.0	12.7	5.3	7	20	4.0	30	50+
Hyparrhenia variabilis	52258	1.3			0			1.3	3	
Melinis sp.	52264	4.7			1.0	1	2	5.3	5	
Panicum maximum	Gatton	6.3			0.7	0.7	0.3	2.0	5	0.3
Panicum maximum	Hamil	1.3	0.7	0.7	0.3	0.3	0.3	0		
Panicum maximum	Riversdale	12.3	2.3	0.7	2.7	2	1	5.7	6	
Panicum maximum	Petrie	4.0	0.7		1.0	0.6	0.3	1.3	4	3
Paspalum plicatulum	Bryan	4.3	6.7	7.3	3.7	5	6	6.7	9	10
Paspalum plicatulum	Rodd's Bay	8.0	12.3	13.0	1.3	2	4	2.3	7	9
Paspalum wettsteinii	Warrell	9.7	2.3		8.3	7		1.3	4	
Schmidtia bolbosa	43713	0			2.0			0		
Setaria sphacelata	Narok	11.7	0.3		1.3	0.7		7.0		
Setaria sphacelata	Kazungula	9.3	4.3	7.0	0.7	2		3.0		
Setaria sphacelata	15899	2.3	0.3		2.0			3.7	0.3	
Tricholena monachne	52313	0			0	2		11.3	0.7	
Urochloa mosambicensis	Nixon	6.0	4.3	0.3	4.0	m	m	2.3	m	m
Urochloa mosambicensis	46876	15.0	6.7	1.0	8.7	m	m	4.3	m	m
Urochloa mosambicensis	47162	8.7	5.7		7.0	m	m	5.3	m	m
Urochloa mosambicensis	47167	5.0	8.3		6.3	m	m	2.0	m	m
Urochloa mosambicensis	6559	0.3			0.7			0	m	
Urochloa oligotricha	43122	5.3	1.0		10.3	m	m	8.3	13	15
Urochloa oligotricha	45608	14.3	14.3	1.0	14.7	m	m	7.7	m	m
Urochloa oligotricha	47122	10.3	1.7	0.7	17.3	m	m	8.3	m	m
Urochloa oligotricha	47128	14.7	1.7		15.7	m	m	7.3	m	m
Urochloa oligotricha	52316	0.7			0			1.7	1	2
Urochloa pullulans	47037	14.3	10.0	0.3	9.0	m	m	4. 7	m	
Urochloa pullulans	LC3**	3.7	5.7	1.0	18.0	m	m	14.7	m	m
Urochloa stolonifera	47173	3.0	2.7	0.3	3.7	m	m	2.7	m	m
Mean		5.7	4.0	5.4	5.5			4.3		
SD		4.5	4.8	6.1	5.1			3.1		

No. of Treatments Persisting	51	39	25	52	41	33	49	43	29

a Commonwealth Plant Introduction Number.
b Queensland Department of Primary Industries Plant Introduction Number.
c Cultivar.
*m = Mat rather than separable stools.
** = Number assigned by R. L. Burt to line collected from near Townsville about 1970.

Experiment 3

At Merluna, Kalinga, Southedge and Boomerang 86 grass accessions from 22 genera were sown in November–December 1974. Each plot consisted of two 3 m long parallel rows 1 m apart, spaced at 1.5 m between plots. Sowing rate was 1 g seed plot^{-1} and superphosphate and ammonium nitrate were broadcast, each at 250 kg ha^{-1}.

Records of plant number (where separable), persistence, spread, flowering, yield (visually rated on a scale from 1 low to 5 high), greenness and new growth were made at all sites at least twice per year in the three years after sowing and once per year in the next two years.

At each site except Merluna the experiment was grazed from April to November in the first two years. Continuous access to grazing was allowed in subsequent years and grazing pressure was much higher than on adjacent native pasture. The Merluna site was burnt after winter in 1976 and 1977. None of the other sites was burnt.

Only 57 of the 86 treatments established at more than one site (Table 5). Only 10 treatments established at Kalinga with 1.9 $\pm$ 2.2 plants plot^{-1}, whereas seedling numbers per plot ranged from 4.3 to 5.7 at the other three sites. Verano establishment was adequate at Boomerang and Southedge ($>$ 1 plant m^{-2}), and the legume component was prominent throughout the trial. Poor establishment at Merluna produced sparse legume content at all stages.

The experiment was abandoned at Kalinga as very few sown grass plants were present in the second year. After three years at Merluna and five years at Southedge and Boomerang approximately half of the originally established grasses had failed. Representatives of nine genera persisted at all three sites, namely *Andropogon*, *Bothriochloa*, *Brachiaria*, *Cenchrus* (barely), *Chloris*, *Hyparrhenia*, *Panicum* (barely), *Paspalum* and *Urochloa*.

At all sites highest yield ratings were assigned to *Andropogon gayanus* and *Hyparrhenia rufa*. Moderate yield ratings were scored by *Bothriochloa insculpta*, *Brachiaria decumbens*, *B. humidicola*, *Chloris gayana*, *Dichanthium aristatum*, *Paspalum plicatulum*, *Urochloa oligotricha*, *U. mosambicensis*, *U. pullulans* and *U. stolonifera*. All other persistent sown grasses were rated low yielding, generally producing less dry matter than native grasses, and showing ill-thrift. Only the treatments with moderate and high yield ratings increased in plant density and spread away from their original rows (Table 6). Most consistent were *Andropogon gayanus* (2 to 10 m spread) and *Hyparrhenia rufa* (5 to 15 m) which colonized via wind-blown seed, and *Bothriochloa insculpta (3 to 10 m)*, *Brachiaria humidicola* (5 to 10 m) and *Chloris gayana* (3 to 10 m) which spread vegetatively. All of the other moderate yielding grasses showed some spread (0.1 to 7 m) over five years.

All of the persistent sown grasses retained some green leaf in the dry season when most native grasses had browned-off (with the notable exception of *Themeda australis*). Their green leaf production following storm rains was apparently greater than that of native grasses with most from *A. gayanus*. Within *Urochloa*, *U. oligotricha* had more green leaf than other species which tended to hay-off early in the dry season. Stock readily accepted most of the sown grasses. Exceptions included *Dichanthium aristatum* and both *Paspalum plicatulum* cultivars which were apparently less acceptable when mature. Most of the standing grass material was consumed by September regardless of its maturity. Grazing pressure in spring was generally very high (often about 5 beasts ha^{-1}), with stock congregating on the trial areas in preference to adjacent native pastures.

TABLE 6

Maximum spread of sown grass from the original rows in experiment 3 (m).

Genus Species	*Site* *Year* CPI/Q/CV	Merluna 1977	Southedge 1979	Boomerang 1979
Andropogon gayanus	43156	5	10	2
Andropogon gayanus	53580	3		
Andropogon gayanus	55606	5	5	1
Bothriochloa insculpta	Hatch	3	10+	10
Brachiaria decumbens	Basilisk		3	2
Brachiaria humidicola	Tully	5	10	5
Cenchrus ciliaris	American			1
Chloris gayana	Callide		8	5
Chloris gayana	Pioneer	3	10	5
Dichanthium aristatum	Angleton		5	3
Hyparrhenia rufa	Q5108	5	15	5
Hyparrhenia rufa	52255	5	15	6
Hyparrhenia rufa	52256	5	15	8
Hyparrhenia rufa	52257	5	10	6
Paspalum plicatulum	Bryan	2	0.1	
Paspalum plicatulum	Rodd's Bay	2	0.1	1
Setaria sphacelata	Kazungula	3		
Urochloa mosambicensis	Nixon		5	3
Urochloa mosambicensis	46876		7	5
Urochloa mosambicensis	47162		5	3
Urochloa mosambicensis	47167		5	2
Urochloa oligotricha	43122		3	5
Urochloa oligotricha	45608		3	2
Urochloa oligotricha	47122		5	2
Urochloa oligotricha	47128		2	2
Urochloa oligotricha	52316			2
Urochloa pullulans	47037		5	
Urochloa pullulans	LC3		7	6
Urochloa stolonifera	47173		5	5

TABLE 7

Plant density, spread away from original rows, leaf length and estimated yield of grass sown vegetatively at Kalinga (experiment 4).

Treatment	CPI/CV	No. of Plants $Plot^{-1}$				Spread (m) at May 23, 1979	Length of green leaf (cm) at Nov. 26, 1977	Estimated yield (g m^{-2}) at May 23, 1979
		At planting Jan. 6, 1976	Aug. 3, 1976	May 6, 1977	May 23, 1979			
Andropogon gayanus	43156	7	4	5	15	5	50	500
Bothriochloa insculpta	Hatch	10	8	2	2	1	10	50
Cenchrus ciliaris	American	10	8	2	0	0	20	–
Chloris gayana	Callide	10	7	0.3	3	0	5	20
Chloris gayana	Pioneer	10	3	0	0	0	–	–
Crysopogon sp.	52213	10	4	4	0	0	30	–
Digitaria milanjiana	7920	8	7	6	3	0	20	50
Digitaria smutsii	38869	10	9	4	2	0	20	50
Eragrostis superba	36643	10	5	0	0	0	–	–
Enteropogon macrostachyus	33114	10	2	2	1	0	30	20
Panicum antidotale	Blue Panic	10	0	0	0	0	–	–
Panicum maximum	Petrie	10	7	6	4	0	30	20
Paspalum plicatulum	Rodd's Bay	10	7	4	3	0	30	30
Urochloa oligotricha	47122	10	7	3	2	0	30	20
Urochloa pullulans	LC3	9	0	0	0	0	–	–

All of the persistent species produced seed. Both *A. gayanus* and *H. rufa* flowered latest, towards the end of the wet season (April–May), while *Urochloa mosambicensis* and *U. stolonifera* flowered in the first six weeks after the start of the wet season. Other persistent grasses flowered from late February to early April. Most intense flowering occurred in *A. gayanus* (except at Boomerang), *B. insculpta*, *C. gayana*, *H. rufa* and *Urochloa* spp. At no stage was a heavy seed crop recorded on *B. humidicola* or *Cenchrus* spp.

Experiment 4

At Kalinga fifteen grass treatments (Table 7) established in "Jiffy 7s" were planted vegetatively in an uncleared, uncultivated area on January 6, 1976. Each plot consisted of a pair of 2 m long parallel rows 1 m apart with 7 to 10 plants per plot. Fertilizer used was 400 kg ha^{-1} superphosphate, 100 kg ha^{-1} KCl and 10 kg ha^{-1} each of $ZnSO_4$ and $CuSO_4$.

Similar measurements and management were used to those in experiment 3.

First year survival in this vegetative sowing at site 2 ranged from 0 to 90% of original plants. By the fourth year *A. gayanus* with 15 plants replicate^{-1} was much more dense than other treatments (range 0 to 4 plants replicate^{-1}). Nine of the 15 treatments were still represented (Table 7).

A. gayanus (5 m) and *B. insculpta* (1 m) were the only grasses which spread. The former was most notable in both total yield and amount of green leaf in the dry season. Establishment of Verano was sparse and the legume content of the trial area was always small. All of the sown grasses had higher green leaf yields under the native leguminous tree (*Erythrophleum chlorostachys* (Cooktown ironwood) than under *Eucalyptus* spp.

DISCUSSION

The results indicate that successful establishment cannot be guaranteed in sowing grasses in the dry tropics of north Queensland. Therefore, it is essential to have species which can colonize from sparse establishment populations. *Andropogon gayanus*, *Hyparrhenia rufa*, *Bothriochloa insculpta*, *Brachiaria humidicola* and *Chloris gayana* satisfied this criterion at three sites, the first two lines via seedlings, the last three by stolons. Only *A. gayanus* exhibited spread at Kalinga.

It is likely that poor seed quality was responsible for many of the establishment failures: for example, the failures of 19 lines to establish at any of the four sites in experiment 3. However, the fact that three sowings at site 2 failed when successful results were achieved at other sites indicates that this sandy soil is generally unsuitable for grass establishment. Similar soils with rapid surface drying present establishment problems with legumes in the Northern Territory (Winkworth 1969) especially with removal of the grass cover (Mott, McKeon and Moore 1976).

Jones (1979) in reviewing *A. gayanus* noted that it was easily established and was an aggressive colonizer. Its reduced spread at Boomerang may be due to its much reduced seed production related to low night temperatures during flowering. A selection of *Andropogon gayanus* (gamba grass) has been registered for release as cultivar Kent by the Northern Territory Herbage Plant Liaison Committee (R. Wesley Smith, personal communication, 1979). Performance in recent studies in the Northern Territory (Reid and Miller 1970) and on infertile soils in the tropics of South America (CIAT 1979) indicate that this species warrants further testing to define its range of adaptation.

Bothriochloa insculpta cv. Hatch covers at least 2000 ha in central Queensland, showing adaptation to a wide range of soil types (but especially finer textured ones) and combining with Siratro and Townsville stylo (Bisset and Graham 1978). These studies are the first known attempts to grown *B. insculpta* in north Queensland's dry tropics. As it scored high ratings for persistence and spread at all sites, coupled with moderate yield and good acceptability to stock the grass is now recommended in this region. Its success on self mulching soils in central Queensland (Younger and Gilmore 1978) makes it a first choice for similar areas in north Queensland which are now carrying dense stands of *Themeda quadrivalvis* (P. J. McKeague, personal communication).

Strains of *Hyparrhenia rufa* (thatch grass) are naturalized along roadsides on the Atherton Tableland and in central Queensland. However, these do not persist under grazing (Bishop 1981) and thus are restricted to road and rail reserves from which stock are excluded. Thus the strong persistence and spread of *H. rufa* under heavy grazing at all three sites at which it established suggests that either the genotypes used in this trial were more tolerant of grazing pressure or that thatch grass is better adapted to lower latitudes. *H. rufa* is common in much of Colombia and Brazil (R. Madeiros, personal communication) being regarded as a moderately desirable plant which also fails to persist under intense grazing pressure. *H. rufa* CPI 52255, 52256, 52257 were introduced from Africa by I. B. Staples in 1970. They are much finer forms than *H. rufa* Q5108 which under heavy grazing closely resembles *Setaria sphacelata* cv. Kazungula. Although it has often been confused with the annual weed *Themeda quadrivalvis*, as *H. rufa* is a perennial with much more green leaf on offer in the dry season than most native grasses and high acceptability to stock, it does not warrant classifying as a weed in dry tropics pastures.

The line of *Dichanthium aristatum* used in experiment 3 was a tall type which rapidly became coarse and unacceptable to stock. There is a wide range of variation in *D. aristatum*. A low growing form which has colonized many overgrazed areas on basaltic soils in the upper Burdekin (Mt. Garnet) area is highly regarded by local graziers. This parallels the naturalization of the low growing *Bothriochioa pertusa* in the lower Burdekin region (Bisset 1981). These two grasses warrant adding to the list of colonizing grasses for use in animal production studies.

Brachiaria humidicola cv. Tully is being increasingly sown on north Queensland's wet tropical coast where it has a role as a weed free pasture which recovers quickly from heavy grazing pressure, particularly on soils too poorly drained for *Panicum maximum* and *Brachiaria decumbens* (C. H. Middleton, personal communication). It has performed well in the Solomon Islands (Gutteridge and Whiteman 1978), Samoa (Reynolds 1978) and Fiji (Partridge 1979). *B. humidicola* is now widely sown on infertile soils in high rainfall tropical areas of South America where *B. decumbens* has been damaged by spittle bug (Serrao *et al.* 1978). Results from experiment 3 indicate that *B. humidicola* may have value in the dry tropics. Although both *B. decumbens* and *B. humidicola* are incompatible with legumes in wet tropical situations, this did not apply in these experiments in the dry tropics.

Although *Brachiaria decumbens* and *Paspalum plicatulum* persisted, their spread was relatively small. Commercial and experimental (Anning 1977) experience with *P. plicatulum* in the region indicated that if left ungrazed it produced a dense stand which was of low acceptability to stock and too competitive for legumes. Heavy continuous grazing of sparse plants would overcome these two problems but not fulfill the roles of sown grasses.

Chloris gayana cultivars have been widely sown by land-holders in small areas of the dry tropics over many years. No evidence of these sowings now remains. At Swan's Lagoon cultivar Callide is persisting on a solodic soil after about 10 years of grazing, indicating that this cultivar may not follow the common pattern of most rhodes grass cultivars of rapid early colonization but lack of long term persistence.

Urochloa spp. did not perform well at the high-rainfall most northern site in both sward and row experiments but may be useful in drier areas. Although *U. mosambicensis* has been in Queensland's dry tropics for at least 25 years it has never colonized significant areas. Failure of *Cenchrus*, *Panicum* and *Setaria* lines is an indication of their intolerance of low fertility coupled with intense grazing pressure. Extensive sowings of *Cenchrus* cultivars in the region have resulted in short lived stands except on more fertile soils; for example, basaltic soils at Lakeland Downs. *Panicum maximum* and *Setaria sphacelata* cv. Kazungula have persisted at Weipa in heavily fertilized pastures and may have a role in high input systems in higher rainfall areas.

In the dry tropics total dry matter yield of sown grasses is of less importance than ability to supply some green leaf for most of the year. Mature whole tops of sown grasses were similar to native grasses in having below the 1% N level at which animal intake is restricted (Minson 1971). The green leaf present in sown grasses at most times of the year is an indication of the diet likely to be preferentially selected by stock (Mannetje 1974).

Management (grazing and burning) of the row experiments was severe after the first two years and no maintenance fertilizer was applied following modest initial levels. The species which persisted and spread are obviously quite resilient and may be useful in relatively low input pasture systems.

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