A COMPARISON OF SIXTY *PANICUM* INTRODUCTIONS IN SOUTH-EASTERN QUEENSLAND

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ABSTRACT

Sixty introductions of seven Panicum *species were initially evaluated in grazed swards over three years at five sites in south-eastern Queensland. The accessions were scored for dry matter yield, palatability, winter greenness and spring greenness at most sites and ranked in order of mean score overall sites.*

Following the regional trials, twenty introductions of P. maximum *and* P. coloratum *were selected for comparison in two cutting experiments at Lawes. Eight attributes were recorded including mean dry matter yield (9 harvests over 4 years), standard deviation of the yield, first flowering, full flowering, seed yield, nitrogen content, acceptability to cattle and winter greenness. A numerical classification of the 8 attributes for each introduction was of no value in selecting potential cultivars but a system of continuous ranking for each attribute proved more successful in identifying superior introductions.*

P. maximum *CPI* 6563 *was superior to cv. Petrie in yield stability (a low standard deviation) and acceptability to cattle and was comparable in all other attributes. CPI* 6563 *was later released as cv. Gatton.*

INTRODUCTION

The genus *Panicum* contains valuable pasture grasses for a wide range of tropical and sub-tropical environments (Motta 1953; Bogdan 1959; Barnard 1972). In the post-1945 decade, C.S.I.R.O. introduced more than 90 accessions of 13 *Panicum* species and many of these were collected in Africa by the late J. F. Miles who was then attached to the C.S.I.R.O. Division of Plant Industry. The collection was initially screened by J. F. Miles in the old plant introduction nursery at Strathpine near Brisbane during 1954-55. Sixty introductions of 7 species were selected for regional evaluation in grazed swards at five sites in south-eastern Queensland. J. F. Miles undertook three experiments in coastal regions at Samford and Lawes while L. A. Edye completed two similar experiments near Taroom and Goondiwindi during 1955 to 1959. Subsequently, 20 introductions were selected by L. A. Edye for comparison in two cutting experiments at Lawes during 1959 to 1964.

This paper describes the results of this work which has not been previously published; but since it resulted in the release of the successful cultivar Gatton, it is felt that the evidence on which release was based should be placed on record. The results have been evaluated using classificatory and ranking procedures: the former method has been successfully used to evaluate *Stylosanthes* species (Edye *et. al.* 1975).

METHODS

Sites

The five regional sites were:

Samford, near Brisbane	(lat. 27.5°S., long. 153.0°E.),
Two at Lawes	(lat. 27.5°S., long. 152.3°E.),
"Nunbank" near Taroom	(lat. 25.7°S., long. 149.8°E.), and
"Tarewinnabar" near Goondiwindi	(lat. 28.5°S., long. 150.0°E.).

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The regional experiments commenced November to December 1955 and terminated September 1958, except at "Tarewinnabar" where the experiment commenced and terminated one year later. The two cutting experiments were conducted on an alluvial flat at Lawes during October 1959 to May 1964.

Introductions

The 60 introductions included in regional trials are listed in Table 1 and Appendix 1. The 20 accessions selected for the cutting experiments are indicated in Table 1.

There was marked variation both within and between the species included in the experiments. The *P. coloratum* introductions ranged from 17666 a fine-leaved erect type ("Bogdans") approaching *P. minus* in appearance, to 16790 which approached the "green panic" type of *P. maximum* (Bryant 1959). The *P. maximum* introductions similarly ranged from the tall coarse "colonial guinea" type 16062 to the fine-stemmed green panic type cv. Petrie. At the time the experiments were undertaken the only existing cultivar among the set was cv. Petrie. This was therefore included in the set as a control, since the primary purpose of the operation was to seek possible cultivars better than those already released.

Soils and fertilizer

The soil types at each site were: a red podzolic (Samford), a solodic (Lawes ridge), a clay loam alluvium (Lawes flat) and grey self-mulching cracking clays (Taroom and Goondiwindi). Basal fertilizer dressings of 377 kg ha^{-1} superphosphate were applied at Samford, Lawes ridge and Taroom before establishing the experiments: no basal fertilizer was required on the Lawes flat (Cartmill 1949) and at Goondiwindi. There were no maintenance fertilizer dressings except for the sward cutting experiment which received urea at 118 kg ha^{-1} of N after mowing in October and December 1960 and 1961.

Design and management

Regional trials—The introductions were randomised in unreplicated plots 80 m^2 at Samford, Lawes ridge and Lawes flat and established from clonal material. At Taroom and Goondiwindi the introductions were arranged in three randomised complete blocks in plots 40 m^2 or 20 m^2 depending on the amount of seed available to sow at a rate of 5 kg ha^{-1}. All plots were continuously but moderately grazed by cattle.

At the former three sites the attributes scored 1 to 10 max over three years (1956-58) were yield (5 to 7 occasions) palatability (5 to 8 occasions) winter greenness (1 to 4 occasions) and spring greenness (1 to 2 occasions). At Taroom, the dry matter yield was determined late April 1958 and expressed on a 1 to 10 scale. At Goondiwindi, the introductions were scored for dry matter yield in late April 1959 (1 to 10 max).

Cutting trial (rows)—The 20 introductions were arranged in randomised blocks with three replications. Establishment of rows 4 m long and 2 m apart resulted from planting clonal material spaced 25 cm apart within the rows, into cultivated soil during October 1959. Inter-row spaces were regularly cultivated and kept weed-free between supplementary spray irrigations. After flowering and seed maturation, inflorescences were hand harvested from the central 2 m of each row on two occasions, in March and April-May 1960. After harvesting, the inflorescences were air dried and the seed stripped and cleaned in a small hand winnower. The two harvests were then bulked to give a total seed yield for the season. No other measurements were made in this experiment.

Cutting trial (swards)—The 20 introductions were arranged in three randomised complete blocks; the plot size was 10 m × 4 m. The plots were planted into a prepared seedbed during October 1959 with clonal material from a previous experiment, spacing plants 25 cm apart on a square pattern. The period from then until January

TABLE 1

Panicum *accessions ranked for mean performance* (1 *to* 10 *max*) *over* 1 *to* 5 *sites.*

Rank Order	CPI† No.	Species	Type‡	Samford	Lawes Ridge	Lawes Flat	Taroom	Goondiwindi	Mean
1	16668	*P. coloratum*	Annual	6·57	—	—	—	—	6·57
*2	6563	*P. maximum* cv Gatton	—	—	—	6·40	—	—	6·40
*3	—	*P. maximum* cv Petrie	Green panic	—	3·49	5·74	7·35	9·00	6·40
4	7944	*P. minus*	—	—	3·16	6·01	10·00	—	6·39
5	16324	*P. coloratum*	Makarikari	6·38	—	—	—	5·00	5·69
6	16326	*P. coloratum*	Annual	5·68	—	—	—	—	5·68
*7	16790	*P. coloratum*	Intermediate	4·95	3·75	5·35	8·15	6·00	5·64
*8	14375	*P. coloratum*	Kabulabula	5·73	4·11	6·81	—	—	5·55
9	18022	*P. coloratum*	Kabulabula	4·85	4·18	6·58	—	—	5·20
*10	17078	*P. coloratum*	H'luti	3·75	3·75	5·92	5·35	7·00	5·15
*11	16725	*P. coloratum*	Kabulabula	5·75	3·46	5·39	5·00	6·00	5·12
12	14373	*P. coloratum*	Makarikari	5·08	—	—	—	—	5·08
13	16794	*P. coloratum*	Kabulabula	5·45	4·00	5·31	—	—	4·92
*14	16062	*P. maximum*	Colonial guinea	5·44	3·42	5·61	—	—	4·82
15	13371	*P. coloratum*	Bambatsi	5·35	5·00	—	5·40	3·33	4·77
*16	17666	*P. coloratum*	Bogdan's	5·15	3·54	5·21	0·90	8·33	4·63
17	17080	*P. coloratum*	H'luti	—	3·64	4·84	7·60	2·33	4·60
18	7940	*P. coloratum*	H'luti	—	3·27	6·01	7·65	1·33	4·57
19	17116	*P. spectabile*	Colonial guinea	3·96	—	5·15	—	—	4·56
*20	16327	*P. maximum*	—	4·74	3·89	5·93	6·00	1·67	4·45
*21	13372	*P. coloratum* cv Bambatsi	Bambatsi	5·08	4·87	6·55	1·95	3·67	4·42
*22	16003	*P. maximum*	—	3·63	3·72	5·64	—	—	4·33
23	17081	*P. coloratum*	—	—	—	—	5·25	3·33	4·29
*24	16793	*P. maximum*	Rhodesian	4·06	3·94	4·72	—	—	4·24
*25	16792	*P. maximum*	—	3·70	4·19	4·73	—	—	4·21
*26	16724	*P. maximum*	Rhodesian	3·42	3·65	5·39	—	—	4·15
*27	1o788	*P. coloratum*	Makarikari	4·72	4·56	6·76	4·00	0·67	4·14
28	15895	*P. maximum*	Colonial guinea	4·12	2·99	4·98	—	—	4·03
*29	16797	*P. coloratum*	Kabu'abula	—	4·40	5·10	3·90	2·67	4·02
*30	16723	*P. maximum*	Rhodesian	1·84	4·15	4·46	7·25	2·33	4·01
*33	16791	*P. maximum*	—	3·40	4·34	5·58	4·25	1·33	3·78
*34	15511	*P. maximum*	—	1·60	4·18	5·49	—	—	3·76
*40	8390	*P. maximum*	—	2·79	3·66	5·17	1·85	0·33	2·76

† Commonwealth Plant Introduction (CPI) No.
‡ *P. coloratum* types after Bryant (1959). *P. maximum* types after J. F. Miles.
* Selected for cutting trials.

1960 was allowed for establishment under supplementary irrigation. During this time missing plants were replaced, the grasses were mown twice to a height of 10 cm and the plots were hand-weeded. Weeding ceased when the experiment began.

After the final clearing cut on January 13, 1960, the experiment was harvested for dry matter yields of *Panicum* and volunteer species on nine occasions up until May 29, 1964; no yield harvests were taken during the 1962-63 season. At each harvest, one 1.0 m × 0.4 m quadrat in each plot was cut from pre-determined random positions with hand shears to a height of 10 cm. After harvesting, the plots were grazed by cattle at a high intensity for 6 or 7 days and then mown to a height of 10 cm. Although weed growth was substantial during the establishment phase and up until the first harvest, weed yields were negligible thereafter except where associated with a few low yielding introductions in the final year of the experiment. Weed yields are not presented.

Other measurements included days to first flowering and full flowering after December 1, 1962. Nitrogen content was determined on a sub-sample of the material harvested on March 28, 1960. The acceptability of the introductions to dairy cattle was scored (1 min to 10 max) during grazing on March 7, 1961 and February 24, 1964 by observing yield and residues for each introduction before, during and after grazing. Scores (1 min to 10 max) for winter greenness were available from the previous (regional) experiments at Lawes during August in each of the three years 1956-58. During 1962-63 when only flowering observations were taken, the plots were mown twice, on December 1, 1962 and June 6, 1963.

RESULTS

Regional trials

The average annual rainfall (mm) at Samford, Lawes, Taroom and Goondiwindi is 1034, 721, 654 and 572 respectively. The normal monthly distribution of the rainfall at each site has been published (Anon 1956) and is shown for Lawes in Table 2. During the three year experimental period the annual rainfall fluctuated above, below, then close to average at all sites except Gooniwindi where it was close to the average in all years.

TABLE 2

Monthly rainfall (mm) at Lawes

Month	1959–60	1960–61	1961–62	1962–63	1963–64	Average 1911–40
July	50	32	55	75	2	34
August	0	16	25	32	50	23
September	46	4	9	56	18	34
October	137	67	70	43	39	49
November	218	122	217	59	96	74
December	168	60	76	128	162	103
January	77	84	138	109	65	112
February	134	132	48	49	114	87
March	25	8	151	219	121	76
April	10	45	63	19	60	46
May	11	20	6	131	46	33
June	34	35	11	8	19	50
Total	910	625	869	928	792	721

Table 1 gives the overall mean and site mean score (1 to 10 max) for the top 30 accessions (plus 3 others) arranged in rank order: many accessions could not be grown at all sites due to insufficient seed or clonal material. At Samford cv. Petrie failed to persist soon after establishment and has been shown as missing. At Samford and Lawes the four attributes that were recorded were given equal weight in the site mean.

The first two introductions, 16668 and 6563 were only grown at one site. Although 16668 was described as an annual by Bryant (1959) it perennated at Samford and had the highest mean score. The cultivar Petrie was ranked third over four sites.

The 20 accessions selected (Table 1) for the cutting experiments did not correspond with the top 20 in rank order. In retrospect, there were some obvious ommissions such as 16668, 7944, 16324 and 16326. In other cases some of the accessions were similar to one another, for example the Kabulabula types 14375 and 18022 and the H'luti types 17078, 17080 and 7940 and it was desirable to sample a wider range of variation.

Cutting trials

Seasonal variation—The climate, and especially the rainfall of Lawes (Table 2) and south-eastern Queensland in general, is highly variable, so that seasonal differences can easily outweigh differences in yield potential between introductions (for a numerical demonstration of the magnitude of this effect, see Williams and Edye 1974). It is therefore necessary to establish the degree of stability of introduction performance over the period of the experiments. Table 3 shows the yield (over all replicates of all introductions) and the corresponding standard deviation for each harvest. The yield for harvest 6 is very high; this is presumably due to the high rainfall between October and December 1961 (Table 2). That for harvest 9 is very low; this is probably due to the fact that no nitrogenous fertilizer was applied during the 1963-64 growing season. When these two results are excluded, we note that both mean and standard deviation vary over an approximately 2/1 range; this suggests that introduction performance is sufficiently consistent to justify drawing conclusions as to relative performance from the results. The variance ratio due to introductions is given in the last column; it is significant for all except the first three harvests (when establishment was presumably incomplete), and the last (which was everywhere low). The analyses were also carried out as "split-plot" experiments, with the replicates taken out as blocks; there is clearly a significant effect due to micro-site heterogeneity.

TABLE 3

Characteristics of individual harvests of Panicum *introductions; (for explanation see text)*

Harvest		Yield kg ha^{-1}		Variance ratios	
No.	Date	Mean	standard deviation	Replicates	Introductions
1	28. iii.60	4170	1920	0·10 n.s.	1·25 n.s.
2	23. v.60	3300	1670	1·09 n.s.	1·55 n.s.
3	1.xii.60	4260	1240	0·29 n.s.	0·52 n.s.
4	1. iii.61	3950	1480	6·83 **	2·18 *
5	25. v.61	2050	910	20·94 ***	5·22***
6	21.xii.61	10730	2700	4·40 *	1·90 *
7	16. iv.62	3610	920	0·15 n.s.	2·10 *
8	17. ii.64	3960	1920	3·37 *	2·45 **
9	29. v.64	1150	480	3·96 *	0·82 n.s.

* $P < 0·05$ ** $P < 0·01$ *** $P < 0·001$ n.s. Not significant

Comparison of introductions

Altogether 8 attributes were recorded for each introduction and the attribute means are shown in Table 4. The mean dry matter yield over nine harvests differed significantly ($P < 0.05$) and ranged from 5.05 to 2.90 tonnes ha^{-1}.

There were significant differences between the introductions ($P < 0.01$) in the time of first flowering (range December 29 to January 22) and time of full flowering (range January 26 to February 7, excluding 16062 which never reached full flowering). Seed yields ranged from nil to 323 kg ha^{-1} (significant at $P < 0.001$) and

TABLE 4

Means for eight attributes of Panicum *introductions.*

Regional rank[A]	CPI No.	Yield D.M. Mean[B]	Yield D.M. SD	Flowering First	Flowering Full	Yield of seed	Nitrogen content	Acceptability	Winter-greenness
		tonnes ha^{-1}		*days from Dec. 1*		*kg ha*$^{-1}$	%	*Score* 1–10[C]	*Score* 1–10[C]
2	6563	4·27	2·70	55	85	264	1·14	8·0	4·5
3	cv. Petrie	4·51	3·50	48	69	283	1·19	6·6	4·5
7	16790	4·97	3·27	55	80	248	1·11	6·5	3·9
8	14375	3·48	2·01	58	86	52	1·15	5·8	5·8
10	17078	3·10	3·08	43	85	62	1·40	9·0	2·8
11	16725	5·05	3·42	53	84	72	0·86	5·5	3·8
14	16062	4·75	3·37	74	—	0	1·23	8·8	2·0
16	17666	4·73	2·17	55	83	19	1·12	7·3	3·1
20	16327	3·73	3·14	43	75	188	1·45	6·6	4·5
21	13372	2·91	1·90	53	80	63	1·09	7·3	5·0
22	16003	4·28	3·14	44	73	275	1·16	6·8	4·6
24	16793	4·73	4·45	48	73	156	1·16	6·1	2·5
25	16792	4·13	3·51	55	92	192	1·25	6·5	4·1
26	16724	4·95	4·40	59	75	255	0·83	7·0	3·4
27	16788	3·24	2·01	59	81	62	1·15	7·8	5·8
29	16797	2·90	3·35	44	74	129	1·49	7·6	5·2
30	16723	3·13	2·38	61	89	169	1·15	8·1	3·4
33	16791	3·46	4·42	55	75	202	1·36	7·5	3·6
34	15511	3·58	3·40	58	92	323	1·03	7·3	4·8
40	8390	3·70	2·92	48	79	147	1·14	6·6	3·5
Significant at		*	—	**	***	***	**	—	—
LSD ($P = 0·05$)		0·92	—	9·3	5·7	70·8	0·19	—	—

A Rank over all regional sites.
B Mean yield per harvest.
C Score 1 min.—10 max.
* $P < 0·05$ ** $P < 0·01$ *** $P < 0·001$

nitrogen content on March 28, 1960 ranged from 0.83 to 1.49 per cent (significant at $P < 0.01$). The remaining three attributes *viz* the standard deviation of the mean yield, acceptability to dairy cattle and winter greenness were not analysed for a significance test.

The eight pieces of information for each introduction were classified to the 5-group level by the conventional Euclidean model of Burr (1970). The results were disappointing: inspection of the attribute group-means disclosed no group with a combination of desirable attributes. This suggested that such attributes are largely uncorrelated and this was subsequently confirmed. It does not follow that there are no introductions possessing the desired combination of characters; but there can be only very few of them, or they would as a group be reflected in the structure of the population. Such introductions, if they exist within the population, can only be found by a search procedure.

The search procedure adopted was that of rank comparisons. If all introductions are ranked (1 max to 20 min) with respect to the desirable attributes, the population is searched to ascertain whether it contains one or more members whose ranks are everywhere, or almost everywhere, good.

In this experiment, the desirable attributes were considered to be, high dry matter yield, low standard deviation of yield, late flowering but still reaching full flowering before winter frosts, high seed yield to ensure seedling regeneration and to aid commercial development, high acceptability to cattle and the ability to retain green leaf during the winter months. However, it is unlikely that all agronomists will agree with this choice of attributes.

The eight sets of rankings and the overall mean are given in Table 5: the introductions have been re-arranged in order of mean rank. The ranks of 6563 are everywhere low except for nitrogen content; the mean rank is 6.9 and the rank variance only 7.9 compared with 10.6 and 28.7 respectively for cv. Petrie. It was on this basis that the senior author recommended commercial utilization of 6563 which was released by the Queensland Pasture Liaison Committee in 1964 as *P. maximum* cv. Gatton.

There are, however, several other points of interest in Table 5. Introduction 16062, the only colonial guinea type from Zaire, has a good dry-matter yield(in fact, for some harvests, the best of the set), and it is very acceptable; but it is clearly not frost-resistant. Its poor rank for seed yield is due to the fact that the first flower appeared very late, it never attained full flowering, and it completely failed to set seed.

This suggests that it is a promising guinea grass adapted to wet tropical environments, but not to the environment in which these experiments were conducted. Introduction 17666 shows a closely similar pattern. Introduction 16788 is interesting because of its very high winter greenness, and therefore frost resistance, and its high acceptability. In certain environments these qualities might be allowed to outweigh its poor yields of both dry matter and seeds; in fact the Makarikari-type cultivars Pollock and Burnett are very similar to 16788 and appear to be adapted to high-fertility clay soils in southern Queensland and northern New South Wales. Introduction 13372 later released as cv. Bambatsi, shows a similar pattern. Introduction 15511 which performed poorly in the regional trials was ranked equal third in the cutting experiments mainly because of its flowering characteristics and seed yield.

DISCUSSION

The 60 *Panicum* introductions included in the experiments were considered to be the most productive introductions of the genus that were available to C.S.I.R.O. in 1955. At that time, plant introduction activities were conducted without the aid of recently developed numerical methods which permit simultaneous processing of a large number of morphological and agronomic attributes and selection and evaluation was based on a relatively small number of desirable attributes. Promising introductions such as *P. minus* 7944 were sometimes overlooked due to inadequate data

TABLE 5

Ranks for criteria of success of Panicum *introductions.*

Regional rank	CPI No.	Yield D.M. Mean	Yield D.M. SD	Flowering First	Flowering Full	Yield of seed	Nitrogen content	Acceptability	Winter-greenness	Mean
2	6563	9	6	7	5	4	13	4	7	6·9
27	16788	16	2	3	9	16	10	5	1	7·8
30	16723	17	5	2	3	10	10	3	15	8·1
34	15511	13	14	5	1	1	18	8	5	8·1
8	14375	14	2	5	4	18	10	19	1	9·1
25	16792	10	17	7	1	8	5	16	10	9·2
7	16790	2	11	7	10	6	16	16	11	9·9
22	16003	8	9	17	17	3	8	12	6	10·0
16	17666	5	4	7	8	19	15	8	17	10·4
20	16327	11	9	19	13	9	2	13	7	10·4
3	cv. Petrie	7	16	14	19	2	7	13	7	10·6
33	16791	15	19	7	13	7	4	7	13	10·6
14	16062	4	13	1	20†	20	6	2	20	10·8
21	13372	19	1	12	10	15	17	8	4	10·8
10	17078	18	8	19	5	16	3	1	18	11·0
26	16724	3	18	3	13	5	20	11	15	11·0
29	16797	20	12	17	16	13	1	6	3	11·0
40	8390	12	7	14	12	12	13	13	14	12·1
11	16725	1	15	12	7	14	19	20	12	12·5
24	16793	5	20	14	17	11	8	18	19	14·0

† Accession 16062 did not attain full flowering so it was ranked 20.

processing facilities and methods. The new methods allow many additional attributes to be quickly and conveniently summarised such as seedling establishment, compatability with legumes, stolon and rhizome development, inflorescence characters concerned with seed retention and recovery in commercial seed production, chemical composition and digestibility.

Given a regionally selected collection of 20 introductions of *P. coloratum* and *P. maximum* and a limited data set of only eight attributes, a classificatory approach was of no value in evaluating the *Panicum* introductions. This contrasts strongly with the value of the method in evaluating *Stylosanthes* species (Edye *et. al.* 1975). The difference could be due to the larger number of species and greater diversity of agronomic performance which occurred in the *Stylosanthes* collection.

It is obvious that no one numerical approach will be suitable for comparing introductions in all agronomic experiments. In the *Panicum* experiment a system of continuous rankings proved the most suitable method. Introduction 6563 fulfilled all the requirements for success that were posed in selecting the eight attributes which were considered to be desirable. It showed considerable superiority to cv. Petrie in rankings for standard deviation of yield and acceptability to cattle and was comparable in all other attributes. No other introduction gave an overall superior performance. It is possible that some of the introductions were superior to cv. Petrie in other attributes that should have been recorded and that individual agronomists may wish to weight particular attributes for particular environments. However, the experiments have demonstrated some of the difficulties of evaluating grass introductions for commercial release as well as describing their agronomic performance over a range of sites.

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APPENDIX I

Panicum introductions that were included in the regional trial over 1 to 5 sites and whose rank order for mean performance was greater than 30 (see Table 1):

P. antidotale	Commercial blue panic, Q150, 17935, 18249.
P. coloratum	7937, 7940A, 16325, 16329, 16330, 16789, 16795, 16796, 17076, 17077, 17115, 17289.
P. deustum	16322.
P. maximum	8386, 8389, 8391, 14374, 15896, 16148, 16721, 16722, 18415.
P. meyeranianum	16737.

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