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NUMERICAL ANALYSIS OF TAXONOMIC AND PARENT-PROGENY RELATIONSHIPS AMONG AUSTRALIAN SELECTIONS OF PANICUM COLORATUM

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SUMMARY

Eighteen selections of *Panicum coloratum* L. and their 541 progeny derived from uncontrolled fertilization were examined morphologically. The data were analysed by numerical classification and ordination to clarify the varietal taxonomy of representatives of the species introduced into Australia, to provide information on the breeding behaviour of the parents and on segregation within their progeny.

Subgroups classified were identified with the *P. coloratum* varieties *makarikariense, coloratum* and *h'luti* and with *P. maximum*. Attributes distinguishing the subgroups of *P. coloratum* differed slightly from the descriptions of Bryant (1967). Habit form was not diagnostic in the classification and its significance with regard to Makarikari grass in Australia is discussed. To emphasize the agronomic difference between grasses representing different subgroups of the *P. coloratum* complex it is suggested that Kleingrass be identified as *P. coloratum* var. *coloratum*.

Parent-progeny relationships indicated cross fertilization as the main breeding system within *P. coloratum* var. *makarikariense*, and indicated some crossing between var. *coloratum* and var. *makarikariense* but not between those varieties and var. *h'luti*. The varieties *makarikariense* and *h'luti* can be regarded as extremes within the *P. coloratum* complex in Australia. Owing to the segregation of morphological characters in the progeny of the Makarikari grass lines, it is proposed that the maintenance of cultivar identity depends on the continued production of seed from mother seed areas grown in isolation. It is suggested, however, that because of the absence of agronomic variability between contemporary cultivars, the registration of more than one is not warranted.

I. INTRODUCTION

From within the *Panicum coloratum* L. grass complex, Makarikari grass (*P. coloratum* L. var. *makarikariense* Goosens) has been selected for commercial use in Australia. It is the best adapted grass species for sub-tropical, sub-humid environments with heavy soils (Lloyd and Scateni 1968) in the wheat belt of northern Australia. It is currently sown over a relatively small area which is likely to increase with enterprise diversification.

Wide variation in growth form and morphology of the *Panicum coloratum* complex is associated with its predominantly sexual (Hutchison and Bashaw 1964) and generally open pollinated (Pritchard and De Lacy 1974) reproductive behaviour. Within accessions introduced into Australia, Bryant (1959), Buckley (1959) and Cameron (1959) separately recognized up to 12 habit types. Bryant (1967) classified the genus *Panicum* on the variability in gross morphology and spikelet characteristics and described four varieties of *P.*

coloratum. (The descriptions of new species and varieties published by Bryant (1967) do not satisfy the requirements of the International Code of Botanical Nomenclature and therefore have no official botanical status. However for this agronomic paper it has been convenient to use the varietal epithets of Bryant.) Pritchard and De Lacy (1974) grouped accessions of *P. coloratum* in five categories according to gross morphology and chromosome number. Variability of associated characteristics separating varieties or types has not been conducive to confident varietal classification and diagnosis.

In this study, methods of numerical analysis have been used to clarify the classification among Australian selections of *P. coloratum*. Parent/progeny relationships have been investigated to provide information on the breeding behaviour of the parents and on the segregation occurring within their progeny.

II. MATERIALS AND METHODS

1. Plants

Eighteen accessions (table 1) were received from Australian sources as either seed or clonal material. A plant of each was clonally propagated to provide the parent selections for this study and these are identified subsequently by their accession numbers.

Approximately 30 plants of each selection were grown in an evaluation nursery where cross pollination between parents was possible. Seed was collected from each parent and a total of 541 individual progeny seedlings was sown at Toowoomba, Queensland.

TABLE 1

THE *P. coloratum* ACCESSIONS, VARIETAL DETAILS PROVIDED ON INTRODUCTION AND ORIGINAL ORIGIN OF SEED

*Accession Reference Number Used in This Paper	†Varietal Details on Introduction, and Other Reference Numbers	† Source of Seed Introduced into Australia
Bambatsi E₁ E₂ E₃ E₄ E₅	Similar to Makarikari Prinshoff strain 11/12	Commercial Line ex-Rhodesia All " E " lines were selected as clonal variants of Bambatsi (commercial) by Dr. J. K. Leslie in Toowoomba, Qld
C.P.I. 13371/72	Makarikari, Q.4380	Rhodesia
C.P.I. 16324	Makarikari, Q.4381, S.C.S. 328	South Africa
S.C.S. 429	" Klein " Coolah Grass, Q.4636, C.P.I. 23132	Texas, U.S.A. ex. South Africa
C.P.I. 16790	Makarikari, Q.4384, S.C.S. 327	South Africa
Q.4901	u/53/29, S.C.S. 374	Arizona, U.S.A. ex. South Africa
C.P.I. 16788	Makarikari B selection, Q.4379, S.C.S. 331	South Africa
Q.4902	Bambatsi, S.C.S. 390	Rhodesia
S.C.S. 383	Makarikari 2, Q.4633	South Africa
Q.4895	PR442 (Makarikari) ·C.P.I. 13372, S.C.S. 325	Rhodesia
S.C.S. 555	KX–20, Q.4638	South Africa
C.P.I. 17078	" Hammerskraal " Coolah Grass, Q.4899, S.C.S. 284	South Africa
C.P.I. 17666	*P. coloratum*, S.C.S. 285, Q.4403	Kenya

* Accession reference abbreviations

C.P.I. = Commonwealth Plant Introduction; S.C.S. = Soil Conservation Service of New South Wales Introduction; Q. = Queensland Department of Primary Industries Introduction.

† Information provided by W. Harding (personal communication).

2. Attributes

The plants were rated for a number of mainly morphological attributes in the second summer after planting. The 10 binary and 8 ordinal attributes used for numerical analyses are given in table 2.

3. Numerical analyses

The analyses were carried out to retain the separate identity of each of the 18 parents so that the inter-relationships between both parents and groups of progeny plants could be readily perceived. The 541 progeny plants were classified by the polythetic, divisive, classificatory program REMUL (Lance and Williams 1975), using 15 iterations during hierarchical and terminal reallocation into 32 groups. The 18 parents and the centroids of the 32 progeny groups were entered as 50 individuals to produce a similarity matrix with the program GROUPER (Lance, *et al.* 1968) using the Canberra metric (Lance and Williams 1967a) as similarity measure. With this similarity matrix, the parents and progeny group centroids were hierarchically classified in CLASS (Lance and Williams 1967b) by the flexible fusion strategy ($\beta = -0 \cdot 25$), and were ordinated by principal co-ordinate analysis (Gower 1966) with the program GOWER. GROUPER was used to diagnose the higher fusions of the hierarchical classification and GOWECOR (Lance, *et al.* 1968) was used to diagnose the vectors from the principal co-ordinate analysis. All attributes were treated as numerics for the GOWECOR diagnoses.

TABLE 2

List of the Attributes Used to Determine the Phenotypic Similarities among Plants of *P. coloratum* by Numerical Analysis

Attributes	States
BINARY	
1. Colour of leaf margins	Purpled; non-purpled
2. Colour of nodes	Purpled; non-purpled
3. Colour of leaf midribs	White; non-white
4. Pubescence of leaf blades	Hirsute; glabrous
5. Pubescence of leaf margins	Hirsute; glabrous
6. Pubescence of leaf sheaths	Hirsute; glabrous
7. Lowermost branch on panicles, single	Some single; none single
8. Lowermost branch on panicles, double	Some double; none double
9. Lowermost branch on panicles, multiple	Some multiple; none multiple
10. Plant waxiness	Glaucous; non-glaucous
ORDINAL	
11. Purpling of glumes	1) Nil 2) tips only 3) complete
12. Blueness of leaves	1) Nil 2) slight 3) definite 4) marked
13. Leaf blade length	1) Short, <20 cm 2) intermediate, 20–28 cm 3) long, >28 cm
14. Leaf blade width	1) Narrow, <8 mm 2) intermediate, 8–12 mm 3) broad, >12 mm
15. Leaf blade fold	1) Flat, >140° 2) intermediate, 90–140° 3) folded, <90°
16. Stem thickness	1) Thin, <2 mm 2) intermediate, 2–3 mm 3) thick, >3 mm
17. Habit	1) Upright, no nodal rooting 2) slightly stoloniferous, rooting from lowermost node 3) quite stoloniferous, rooting from lower 2–5 nodes 4) distinctly stoloniferous, creeping habit
18. Flowering time	1) Early 2) mid 3) late 4) very late

III. RESULTS

1. Classification of parents

Classification of parents and centroids of progeny groups based on hierarchical classification and principal co-ordinate analysis of both parents and progeny groups, reflects both the phenotypic similarities of the parents and their reproductive affinities. The hierarchical classification is given in figure 1 as a dendrogram truncated at the six group level. The distribution of each parent and its progeny within the six groups is given in table 3. The group-mean values of the 18 attributes are given for the six groups A to F and for group (A + B) in table 4 to indicate the group characteristics. The results of the principal co-ordinate analysis are presented in figures 2 and 3 as projections onto the largest three vectors and the diagnoses of these vectors are presented in table 5.

The results of the principal co-ordinate analysis support the groupings delimited in the hierarchical classification. These groups can be identified by their attributes (table 4) with taxa described by Bryant (1967).

Group F, containing one parent (C.P.I. 17666) was distinctly separated from all other groups (figures 1, 2, 3 and table 4). The group possesses morphological attributes (table 4) identifying it as *P. maximum* Jacq. *viz.* densely whorled lower panicle branches, wide green leaves and erect habit (Bryant 1967). Additional characteristics distinguishing this group from others are no purpling of nodes; leaf midrib not white; leaf blade, margin and sheath hirsute; plant non-glaucous; plant early flowering; and transverse ridging of the lemma (from observations subsequent to the numerical analysis).

TABLE 3

DISTRIBUTION OF THE PROGENY PLANTS IN RELATION TO THEIR MATERNAL PARENTS AND
THEIR CLASSIFICATION IN CLASS

Parent Line	Number of Progeny Plants	% Progeny Plants from Each Maternal Parent Occurring in the Following Groups from CLASS					
		A	B	C	D	E	F
Bambatsi	37	32·4*P	67·6	0	0	0	0
E1	34	38·2P	61·8	0	0	0	0
E2	40	37·5P	60·0	0	2·5	0	0
E3	46	43·5P	56·5	0	0	0	0
E4	37	48·6P	51·4	0	0	0	0
E5	50	32·0P	66·0	0	2·0	0	0
CPI 13371/72	50	34·0P	60·0	2·0	4·0	0	0
CPI 16324	17	82·4P	17·6	0	0	0	0
CPI 16788	11	54·5P	45·5	0	0	0	0
Q.4902	43	65·1P	30·3	2·3	2·3	0	0
Q.4895	41	43·9P	43·9	2·4	9·8	0	0
SCS 383	9	88·9P	11·1	0	0	0	0
SCS 555	40	47·5	45·0P	7·5	0	0	0
CPI 16790	6	0	66·7	33·3P	0	0	0
SCS 429	39	5·1	5·1	2·6	87·2P	0	0
Q.4901	35	25·7	22·9	20·0	22·9P	8·5	0
CPI 17078	1	0	0	0	0	100 P	0
CPI 17666	5	0	0	0	0	0	100 P

* " P " indicates that the parent line was classified in this group by CLASS

TABLE 4

GROUP-MEAN VALUES OF ATTRIBUTES FOR GROUPS A, B, A + B, C, D, E AND F IN THE HIERARCHICAL CLASSIFICATION (CLASS)

Groups	\<Attributes\> Leaf Margin Purple	Nodes Purple	Leaf Midrib White	Leaf Blade Hirsute	Leaf Margin Hirsute	Leaf Sheath Hirsute	Panicle Branch Single	Panicle Branch Double	Panicle Branch Multiple	Plant Glaucous	Glume Purpling Nil	Tips	Complete
A	0·198	0·923	1·000	0·000	0·537	0·004	0·991	0·150	0·045	0·996	0·000	0·195	0·805
B	0·028	0·672	1·000	0·000	0·267	0·012	1·000	0·111	0·020	0·996	0·045	0·430	0·525
A + B	0·109	0·792	1·000	0·000	0·395	0·008	0·996	0·129	0·032	0·996	0·024	0·318	0·658
C	0·071	0·929	0·786	0·000	1·000	0·214	0·929	0·143	0·000	1·000	0·071	0·143	0·786
D	0·196	1·000	0·982	0·000	0·929	0·036	0·982	0·927	0·727	1·000	0·000	0·491	0·509
E	0·000	1·000	0·200	0·400	1·000	0·800	1·000	1·000	1·000	0·600	0·000	0·000	1·000
F	0·000	0·000	0·167	1·000	1·000	1·000	0·833	0·000	1·000	0·000	0·000	0·000	1·000

	Blueness of Leaves Nil	Slight	Definite	Marked	Leaf Length Short	Int.	Long	Leaf Width Narrow	Int.	Broad	Leaf Fold Flat	Int.	Folded
A	0·022	0·031	0·247	0·700	0·093	0·242	0·665	0·013	0·740	0·247	0·256	0·471	0·273
B	0·028	0·052	0·478	0·442	0·060	0·637	0·303	0·068	0·665	0·267	0·183	0·594	0·223
A + B	0·025	0·042	0·368	0·565	0·075	0·450	0·475	0·042	0·701	0·257	0·218	0·536	0·247
C	0·071	0·143	0·000	0·786	0·714	0·286	0·000	0·929	0·071	0·000	0·214	0·429	0·357
D	0·179	0·339	0·214	0·268	0·536	0·357	0·107	0·232	0·768	0·000	0·054	0·589	0·357
E	0·000	0·800	0·000	0·200	0·400	0·600	0·000	0·200	0·800	0·000	0·200	0·200	0·600
F	0·000	1·000	0·000	0·000	0·000	1·000	0·000	0·000	0·000	1·000	0·000	1·000	0·000

	Stem Thickness Thin	Int.	Thick	Habit Erect	S. Stol.	Q. Stol.	V. Stol.	Flowering Time Early	Mid	Late	V. Late
A	0·009	0·203	0·789	0·449	0·344	0·181	0·026	0·004	0·199	0·648	0·229
B	0·040	0·382	0·578	0·506	0·363	0·108	0·024	0·028	0·375	0·347	0·251
A + B	0·025	0·297	0·678	0·479	0·354	0·142	0·025	0·017	0·253	0·490	0·241
C	0·571	0·357	0·071	0·643	0·143	0·214	0·000	0·000	0·000	0·500	0·500
D	0·089	0·732	0·179	0·232	0·429	0·321	0·018	0·125	0·839	0·000	0·036
E	1·000	0·000	0·000	0·200	0·800	0·000	0·000	0·400	0·600	0·000	0·000
F	0·000	1·000	0·000	1·000	0·000	0·000	0·000	1·000	0·000	0·000	0·000

TABLE 5

ATTRIBUTES THAT WERE HIGHLY CORRELATED (CORRELATION
COEFFICIENT > 0.5) WITH THE LARGEST THREE VECTORS
FROM THE PRINCIPAL CO-ORDINATE ANALYSIS. VECTORS
I, II AND III ACCOUNT FOR 31.7, 17.7 AND 14.8%
OF THE VARIANCE RESPECTIVELY

Attributes	Correlation Coefficient
WITH VECTOR I	
Lowermost branch on panicles, multiple ..	−0.813
Stem thickness ..	0.803
Pubescence of leaf sheaths	−0.757
Leaf midribs white	0.719
Pubescence of leaf margins	−0.705
Flowering time ..	0.663
Blueness of leaves	0.642
Pubescence of leaf blades	−0.608
Plant waxiness ..	0.605
Leaf length	0.584
Lowermost branch on panicles, double	−0.501
WITH VECTOR II	
Purpling of nodes	0.779
Lowermost branch on panicles, double	0.676
WITH VECTOR III	
Leaf width	−0.556
Leaf length	−0.535

The other groups belong to the *P. coloratum* complex. The major con-
trasting attributes contributing to their varietal separation (tables 4 and 5) are
hairiness of leaf margins and sheaths; panicle branching characteristics; leaf
colour, length and width; stem thickness; flowering time and midrib colour.
Habit form was not diagnostic in the separation (table 5). Bryant (1967)
diagnosed *P. coloratum* with a single lowermost panicle branch only. In this
study some parents and progeny of *P. coloratum* also had double and/or multiple
branching. In such instances the multiple branching was sparse in comparison
with the dense whorling of *P. maximum*.

Group D contained two parents; S.C.S. 429, a type specimen of *P. coloratum*
var. *coloratum* (*syn.* var. *typica*) (Bryant 1967), and Q.4901 (S.C.S. 374)
identified by Cameron (1959) as *P. coloratum* Arizona, a synonym of *P.
coloratum* var. *coloratum* (Bryant 1959, 1967). (These are not nomenclatural
types according to the International Code of Botanical Nomenclature, but type
specimens in the sense of Bryant (1967)). The attributes of this group (table
4) conform closely to the descriptions of *P. coloratum* given by Chippindall
(1955) and Bryant (1967).

Group A contained 12 parents (figure 1, table 3), including Q.4902 (S.C.S.
390) which was one of Bryant's (1967) specimens of *P. coloratum* var.
makarikariense. The other members of group A conformed to the description
of this variety and further subdivision was not according to habit. Group B
contained one parent, S.C.S. 555, which was one of Bryant's (1967) type
specimens of *P. coloratum* var. *intermedia*. Our analyses did not separate groups
A and B on extreme differences in any attributes (table 4) and many of the
progeny from maternal parents in group A were classified in group B. Group

(A + B) is thus regarded as *P. coloratum* var. *makarikariense,* with group B a less purpled variant (table 4). There was no distinct separation within this group on habit form. Foliar pubescence occurred on the leaf margins at the base of the blade, in agreement with the descriptions of Goosens (1934) and Bryant (1967) but was recorded for only approximately 40% of plants at the time of rating. In comparison with *P. coloratum* var. *coloratum* (group D), *P. coloratum* var. *makarikariense* (group A + B) had coarser stems, larger and bluer leaves, a smaller proportion of plants with hirsute leaf margins, and almost entirely single lower panicle branches. They also flowered later (table 4).

Group C, containing one parent (C.P.I. 16790), possesses culm characteristics like var. *coloratum* and flowering and colour characteristics like var. *makarikariense* (table 4). In the principal co-ordinate analysis (figures 2 and 3), group C occupied a position between group D (var. *coloratum*) and group (A + B) (var. *makarikariense*).

Group E, containing one parent (C.P.I. 17078) was distinctly separated from other *P. coloratum* groups (figures 1, 2 and 3) and has attributes identifying it as *P. coloratum* var. *h'luti* (Bryant 1967) *viz.* fine stem; small green leaves; pubescence on leaf blade, margin and sheath (table 4); and smaller seed than other varieties (observations subsequent to the numerical analyses). Additionally it has an indistinct midrib and sparsely whorled lower panicle branching.
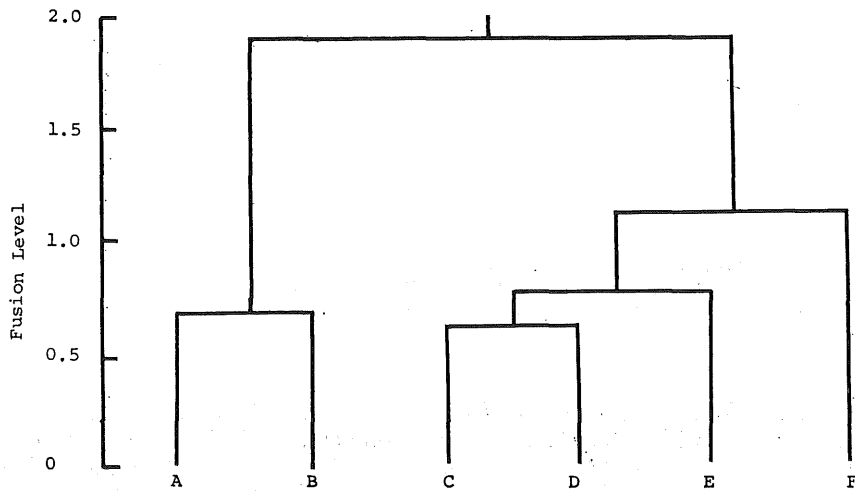
Composition
of groups

	A	B	C	D	E	F
N_1	12	1	1	2	1	1
N_2	8	13	2	6	2	1
N_3	215	250	13	54	4	5

Figure 1,—Truncated hierarchical classification (CLASS) of the parents of P. coloratum and the centroids of progeny groups from a prior classification (REMUL). N_1, number of parents; N_2, number of centroids of progeny groups from REMUL; N_3, number of individuals in the progeny groups.
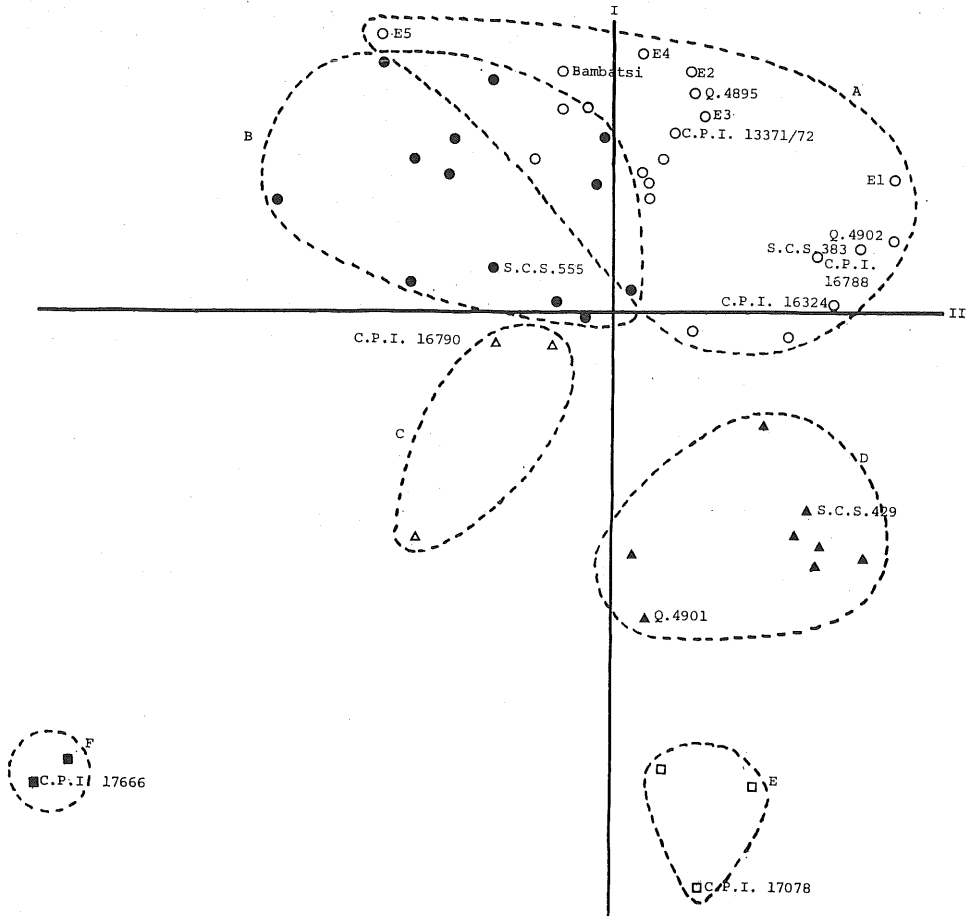
Figure 2.—*Projections of the parents and the centroids of the progeny groups from REMUL as points onto the plane of vectors I and II from the principal co-ordinate analysis. Groups A, B, C, D, E, F as classified in the hierarchical classification (figure 1).*

P. coloratum var. *makarikariense* and *P. coloratum* var. *h'luti* appear to be extremes within the *P. coloratum* complex. This is deduced from figures 2 and 3 where group (A + B) and group E are markedly separated along the largest vector. Attributes contributing to this separation along vector I are given in table 5.

2. Parent-progeny relationships

Although it is not possible to specify the breeding behaviour of each parent, it is possible to draw some conclusions on the degree of segregation after uncontrolled fertilization from table 3. At a lower level, more precise information is available from the unpublished similarity matrix produced in GROUPER and from homogeneity values obtained from REMUL on notional allocation of each parent to every progeny group.
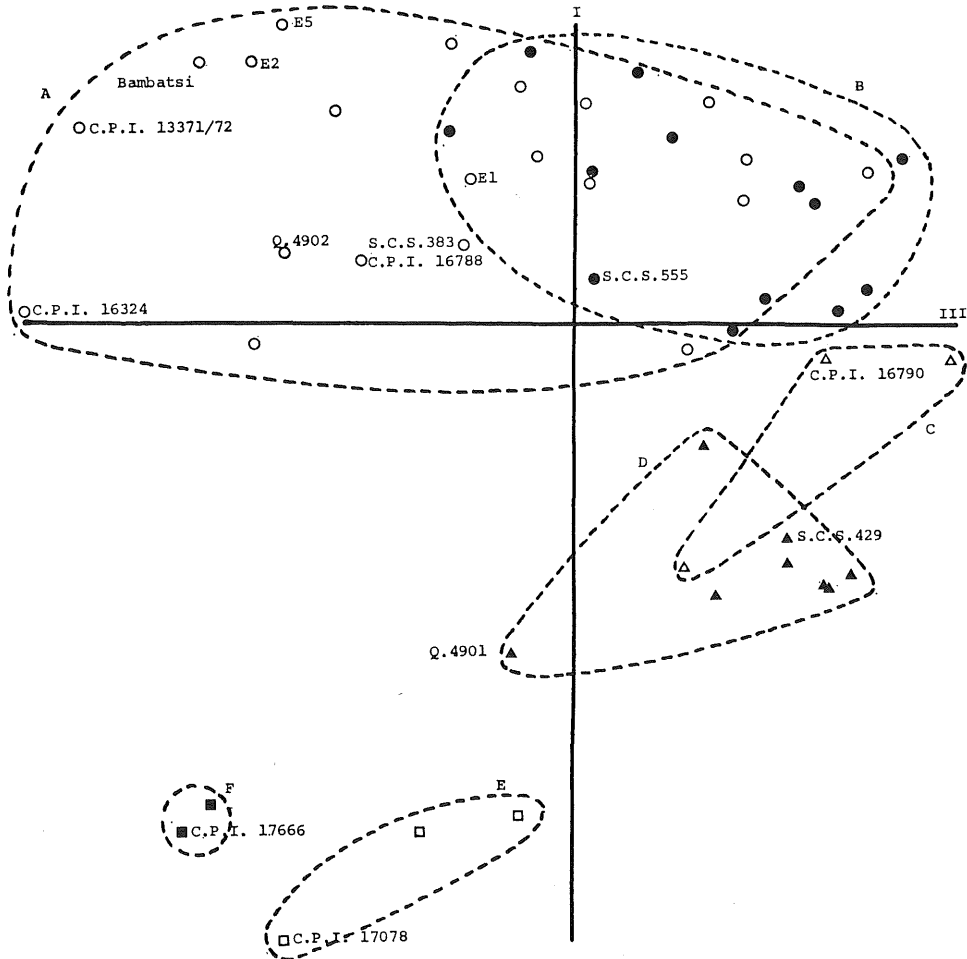
Figure 3.—*Projections of the parents and the centroids of the progeny groups from REMUL as points onto the plane of vectors I and III from the principal co-ordinate analysis. Groups A, B, C, D, E, F as classified in the hierarchical classification (figure 1).*

The var. *makarikariense* parents reproduced strongly to varietal "type", progeny being associated mainly with groups A and B (table 3). The distribution of progeny between these large groups, however, indicates that cross-fertilization between parents of that variety has been their main mode of reproduction. This general conclusion is supported by the cytogenetic findings of Pritchard and De Lacy (1974). More than 80% of the progeny of both C.P.I. 16324 and S.C.S. 383 were, however, associated in group A with their parents. Examination of REMUL homogeneity values less than 0.2 (0 = complete homogeneity; 1 = complete heterogeneity) showed that only 21% of the group A progeny of C.P.I. 16324 were closely similar to their maternal parent whereas 75% of the group A progeny of S.C.S. 383 were comparably similar. It is therefore unlikely that self-pollination was a significant breeding method of C.P.I. 16324. The dominance of expression of maternal characteristics in the progeny of S.C.S. 383 does not necessarily imply self-pollination. S.C.S. 383 is very similar to both Q.4902 and C.P.I. 16788 (respective similarity indices of 0.125 and 0.188,

where $0 =$ total similarity and $1 =$ total dissimilarity) and a moderate proportion of the individual progeny plants from these three parents fell together in one of the 32 REMUL progeny groups. There is morphological similarity not only among these parents but also among their progeny.

C.P.I. 16790 has demonstrated a reproductive affinity with var. *makarikariense* but not with var. *coloratum* (table 3).

Among the var. *coloratum* parents, a large proportion of the progeny of S.C.S. 429 were associated in group D with the parent (table 4), but only 24% of these were in REMUL groups closely similar to the parent (homogeneity values <0.2). It may be concluded that the progeny were produced mainly by out-crossing. The even distribution of the progeny of Q.4901 between groups A, B, C and D (table 3) indicates it is extremely promiscuous. The classification of some progeny of both var. *coloratum* parents in groups A and B suggest these accept pollen from some var. *makarikariense* lines, possibly those producing a small proportion of progeny in group D (table 3). The different proportions of progeny allocated to different groups is probably partly associated with the predominance of var. *makarikariense* accessions in the population.

The var. *h'luti* line (C.P.I. 17078) produced only one progeny, identical with the parent, probably due to the absence of a compatible co-parent.

The progeny of C.P.I. 17666 (*P. maximum*) were identical with the parent and were probably produced by apomixis, the main method of reproduction of that species (Brown and Emery 1958).

IV. DISCUSSION

Chippindall (1955) has described *P. coloratum* as a polymorphous species comprising several forms varying in habit, size, hairiness and colour. We have confined this investigation to forms of *P. coloratum* that have been considered of possible agronomic potential in Australia. The approach adopted of numerical classification on the attributes of both the parents and their progeny produced by uncontrolled fertilization has provided useful results. A similar numerical approach could be adopted to clarify the entire taxonomy of these and closely related *Panicum* species by extending the range of forms sampled from further African collections.

The analysis has separated the 18 parents and their progeny into groups corresponding mainly with the taxonomic divisions of Bryant (1967). The recognition of *P. coloratum* varieties *coloratum* (*syn. P. coloratum* L.), *makarikariense* Goosens and *h'luti* is strongly supported. Our Group C has a morphological affinity to both var. *makarikariense* and var. *coloratum* but its breeding behaviour is associated only with var. *makarikariense*. Pritchard and De Lacy (1974) have classified the one parent occurring in the group (C.P.I. 16790), and two other parents (C.P.I. 16788 and C.P.I. 16324) classified in this study as var. *makarikariense*, as morphologically typical members var. *makarikariense*.

The diagnoses of the separations vary from those of Bryant (1967) in rejecting habit form as a major contributing variable in all subgroups; in the recognition of multiple, though relatively sparse branching of the lower panicle branch in var. *coloratum* and var. *h'luti* in particular; and in the relative, though variable absence of hairs on the leaf margin of var. *makarikariense*. It is possible that these hairs are readily sloughed, since Hutchison and Bashaw (1964) found accessions, introduced as var. *makarikariense* without pubescent margins.

Most contemporary research with the species has been done in the U.S.A. with Kleingrass and in Australia with Makarikari grass. These are agronomically different subspecies of *P. coloratum* (J. K. Leslie, personal communication) and very little research data from the U.S.A. relating to the species are applicable in Australia. To emphasize this, it would be preferable to identify Kleingrass as *P. coloratum* var. *coloratum* and not simply *P. coloratum* as is present practice (E. C. Holt, personal communication). Makarikari grass is formally identified as *P. coloratum* var. *makarikariense* (Barnard 1972).

Habit form has been the pre-eminent characteristic in both the selection (Pole-Evans 1939; West 1952) and identification (Bryant 1959, 1967; Buckley 1959; Cameron 1959; Pritchard and De Lacy 1974) of *P. coloratum* lines, probably because it is the most recognizable form of variation between plants. The erect "Bambatsi strain" (West 1952) and the procumbent "Makarikari strain" (Pole-Evans 1939) of *P. coloratum* var. *makarikariense* were recognized as such in Australia (Anon. 1964) until the registration of cultivators in 1972. Bryant (1967) classified the habit forms as "forma erecta" and "forma stolonifera". This analysis, however, has shown habit to be almost non-diagnostic in the taxonomy of representatives of the species introduced into Australia, varying in a more random manner than other characteristics. This explains Bryant's (1966) observation that the very stoloniferous parental habit form of S.C.S. 555, agronomically desirable for soil stabilization, was not reproduced in open pollinated progeny. In this study only 10% of the progeny of S.C.S. 555 possessed the same habit form as the parent. Bryant's (1967) separation of *P. coloratum* var. *makarikariense* to "forma erecta" and "forma stolonifera" thus neglects the variability in other attributes occurring within these groups. Habit form should not, therefore, be used to diagnose varietal differences within the *P. coloratum* complex.

The generally sexual, open-pollinated breeding behaviour of the varietal groups of *P. coloratum* is endorsed by parent-progeny similarity data. The indication of cross-pollination between accessions classified as var. *makarikariense* and var. *coloratum* is supported by Pritchard and De Lacy's (1974) cytogenetic findings that corresponding ploidy levels are necessary for cross-fertilization between plants and of the predominance of tetraploids in both groups. Our classification of the non-hybridizing line C.P.I. 17078 as var. *h'luti* is also supported in their Type E lines (morphologically similar to our C.P.I. 17078 and Bryant's (1967) var. *h'luti*) being exclusively diploid, and therefore unable to hybridize with other varieties.

The open-pollinated breeding behaviour of *P. coloratum* var. *makarikariense* is of particular significance to the maintenance of morphological type in cultivars, two of which viz. cv. Pollock and cv. Bambatsi (described by Barnard (1972)) are commonly sown. Their maternal progenitors are S.C.S. 383 and C.P.I. 13371/72 respectively. Though variable, the cultivars have been subjected to selection pressure and are morphologically distinguishable in mother seed areas and in areas sown with first generation seed from mother seed plots grown in isolation. The segregation occurring within lines classified as var. *makarikariense* in this experiment, indicates that cultivar identity will be rapidly lost if seed is harvested from different cultivars grown in close proximity to each other, and even in successive generations of the one cultivar grown from an originally isolated seed source. Maternal seed areas grown in isolation are required to maintain cultivar identity. This may not, however, be agronomically necessary. Except for the higher seed set of cv. Bambatsi, the variation in agronomic characteristics between it and cv. Pollock documented by Barnard (1972) has been shown not to exist (Anderson 1972; D. L. Lloyd, unpublished data). The trend in practice has been to use mainly cv. Bambatsi and there is no demand for more than one of the contemporary cultivars of Makarikari grass.

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