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SELECTION OF LOCAL LOWLAND RICE CULTIVARS BASED ON MULTIVARIATE GENETIC DIVERGENCE

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ABSTRACT

Seventy two local rice cultivars, adapted to lowland conditions, were evaluated, considering ten traits of agronomic importance. Their genetic divergence was evaluated through multivariate procedures, to orient the constitution of base populations for breeding purposes.

The clustering procedure proposed by Tocher was applied to Mahalanobis generalized distances; all cultivars could then be organized into four groups.

Special emphasis was given to the divergence within a group of 13 distinct cultivars identified as superior in relation to grain yield.

Measures of divergence permitted the recognition of two special groups within the set of 13, namely: group 1, with cultivars 49, 6, 35, 34, 38 and 13; group 2, with cultivars 59, 41, 37, 23, 3, 21 and 30. These groups seemed to be adequate for intercrossing in a factorial mating design (group 1 x group 2). Alternatively, cultivars of these groups could be used for intercrossings with introduced elite lines, already improved in terms of plant architecture.

Divergence was also detected among cultivars with the same denomination (Matão and Chorinho), but collected at different locations. It was inferred that these materials could have undergone a process of genetic divergence due to contrasting environmental conditions, maintained through decades of cultivation. The divergence detected in these cultivars with identical denomination was more pronounced for days to flowering than for other traits.

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INTRODUCTION

Breeding programs frequently require the effective identification of superior parental lines for intercrossing in order to exploit hybrid vigor for the constitution of base populations to be used for the extraction of new cultivars. Parental selection based on scientific evidence may prevent the possible early failure of a breeding program.

Breeders usually select parental lines for crossing on the basis of their performance both *per se* and in hybrid combinations. However, when selection is to be made among a relatively large number of parents or when the production of large numbers of hybrids is difficult, as is the case for autogamous and/or perennial plants, selection is performed on the basis of parental information only, with no *a priori* knowledge about the hybrids.

When parental lines are selected only on the basis of information regarding comparative trials for yield and yield components, two concepts of quantitative genetics are usually applied. The first takes into account the fact that the probability of obtaining superior lines is a function of gene frequency in the population, which means that superior lines are more easily obtained from already improved populations. This concept leads to recombination of elite material for the constitution of base populations. However, no safe information is available on the potential variability of the population to be formed.

The second concept refers to the need for considerable base population variability, which would permit selection and genetic gain. This variability is achieved through divergent parental crosses and is particularly interesting in cases in which hybrid exploitation is a viable alternative.

When decisions about the choice of parental lines are to be made on the basis of the above two concepts, a very useful statistical tool is the evaluation of genetic divergence through mutlivariate procedures such as clustering based on Mahalanobis D^2 generalized distances (Mahalanobis, 1936) and canonical variable analysis (Rao, 1952).

Genetic divergence has been studied in rice by Ram and Panwar (1970), Singh *et al.* (1979), Maurya and Singh (1977a) and Rao *et al.* (1981). These studies have been very useful for the constitution of cultivar groups with a high similarity pattern for comparison between genetic divergence and geographic diversity, for the evaluation of the evolutive level of *Oryza* species and for the choice of divergent parental lines for breeding programs.

The breeding program developed by the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)/Centro Nacional de Pesquisa de Arroz e Feijão (CNPAF) for rice cultivars adapted to lowland conditions is primarily based on the study and utilization of the wide genetic variability available in traditional cultivars. Thus, the objective of the present study was to evaluate the performance of 72 traditional rice cultivars with respect to ten traits of agronomic importance, and their genetic divergence through multivariate procedures in order to determine the constitution of base populations for breeding purposes. The degree of similarity between cultivars collected at different locations but with the same denomination was also investigated.

MATERIAL AND METHODS

A total of 72 rice cultivars from the germplasm collection program developed by EMBRAPA/CNPAF in the States of Minas Gerais and Maranhão were evaluated (Table I). The experimental design consisted of fully randomized blocks with two replications. The experimental plots consisted of 5.0-m long rows 0.4 m apart. The useful area of the plot was 1.6 m^2, corresponding to the center of the row, with 0.5 m eliminated at both ends.

Table I - Identification of traditional rice cultivars, adapted to lowland conditions, collected in the States of Minas Gerais (MG) and Maranhão (MA). 1980/81.

Cultivar No.	Cultivar name	CNPAF code	State of origin
1	Chorinho Americano	CGC-108	MG
2	Híbrido	CGA-76	MG
3	Poupa Preguiça	- *b/*	MG
4	Cana Roxa Palha Amarela	CGA-102	MG
5	Secretário	CGA-51	MG
6	De Abril	CGA-65	MG
7	Santa Catarina	CGA-2	MG
8	Bacaba	-	MA
9	Zebu	E043231	MA
10	Cutião Bico Preto	-	MA
11	Venez Branco	CGA-4	MG
12	Santa Catarina	CGA-1	MG
13	Chorinho Aliança	CGA-110	MG
14	- *a/*	CGA-66	MG
15	-	CGA-60	MG

Continued

Table I - Continued.

Cultivar No.	Cultivar name	CNPAF code	State of origin
16	Uberabinha	CGA-80	MG
17	-	CGA-74	MG
18	Matão	CGA-43	MG
19	-	CGA-105	MG
20	Arroz de Leite	-	MA
21	Quebra Cacho	CGA-91	MG
22	Santa Catarina	CGA-9	MG
23	Cuchilão	E043281	MA
24	Buriti	E043788	MA
25	Híbrido	CGA-19	MG
26	Santa Catarina	CGA-6	MG
27	-	E043346	MA
28	Palha Murcha	-	MA
29	Honduras	CGA-71	MG
30	Brejeiro	CGA-115	MG
31	Nenezinho	-	MA
32	Escrivimangote	CGA-126	MG
33	Bico de Ouro	CGA-93	MG
34	Coqueiro Casca Branco	CGA-111	MG
35	Brejeiro	CGA-81	MG
36	Matão	CGA-120	MG
37	Maraba	E043796	MA
38	Paga Dívida	CGA-7	MG
39	Bico Preto Roxo	E044059	MA
40	De Abril	CGA-48	MG
41	Catetinho	CGA-107	MG
42	Lageado	E043966	MA
43	Bacaba Branco	-	MA
44	Prata	CGA-123	MG
45	Desempenho Amarelinho	CGA-29	MG
46	Chorinho	CGA-114	MG
47	Chorinho com Apiculo	CGA-118	MG
48	Japones de Várzea	CGA-122	MG

Continued

Table I - Continued.

Cultivar No.	Cultivar name	CNPAF code	State of origin
49	-	CGA-63	MG
50	Cacho de Ouro	CGA-77	MG
51	Barriga Branca	CGA-53	MG
52	Come Cru Vermelho	-	MA
53	Canela de Aço	-	MA
54	Macanco	CGA-11	MG
55	Cana Roxa	-	MA
56	Santa Catarina	CGA-8	MG
57	-	CGA-54	MG
58	Amarelão	CGA-68	MG
59	-	E043699	MA
60	Matão	-	MA
61	Nanico	CGA-124	MG
62	Mundicera	CGA-49	MG
63	Americana	-	-
64	Matão	E044172	MA
65	Cutião Vermelho	-	MA
66	Santa Catarina	CGA-17	MG
67	CICA 8c/	-	GO
68	Santa Catarina	CGA-21	MG
69	Come Cru Branco	-	MA
70	IAC25c/	-	SP
71	Mucuim	-	MA
72	IAC 47c/	-	SP

[a] Unknown or not identified.

[b] Not coded at CNPAF.

[c] Checks.

The following traits were evaluated: plant height (PH) and leaf area (LA) in a sample of five plants; panicle length (PL), number of spikelets/panicle (NSP), pecent filled grains/panicle (%GP) and 100 weight of grains (G100) in a sample of 20 panicles; number of tillers (NT) and of panicles (NP)/m^2; days to flowering (DF) and grain yield/plot (GY).

In addition to univariate analysis of variance and cluster analysis for grouping means by the criteria of Scott and Knott (1974), the following analyses were performed:

a) Estimates of generalized D^2 Mahalanobis distances.

b) Cultivar grouping according to the clustering procedure proposed by Tocher (cited by Rao, 1952). A detailed example of the application of this method has been described by Singh and Chaudhary (1979).

c) Graphic divergence analysis using canonical variables. This procedure is used to obtain information about genetic distance by plotting the dispersal of the scores for each cultivar in graphs in which the first canonical variable and the second canonical variable on the y axis (Rao, 1952).

The trial was conducted in Goiânia, State of Goiás (GO), at EMBRAPA/CNPAF in 1981/82.

RESULTS AND DISCUSSION

Table II shows the existence of significant differences ($P < 0.01$) among cultivar means for all traits evaluated, as well as high (above 70%) genotype determination coefficients (b) for most traits, except for NT and NP, whose values were 42.77% and 47.40%, respectively. These data indicate a highly favorable situation for breeding, suggesting the possibility of effective discrimination of genotypically superior cultivars among the 72 materials tested.

NT and NP were considerably affected by environment and presented a relatively low experimental precision, with CV's of 25.38% and 23.50%, respectively. Although the F test showed the presence of significant differences (Table III), the Scott and Knott test was not sensitive for the identification of significant differences among cultivar means (Table III) for the two traits. The experimental precision for the remaining traits was good, with CV's ranging from 15.54% (grain yield) to 1.53% (days to flowering).

The clustering procedure proposed by Tocher (cited by Rao, 1952) was applied to Mahalanobis generalized distances (Table III) and permitted the division of the 72 cultivars into four groups. Group I consisted of 66.7% of the cultivars, group II of 29.2%, group III of 2.8%, and group IV of 1.4%. The cultivars did not cluster by geographic origin, showing that there is a relationship between cultivars collected in Maranhão and in Minas Gerais.

Table II - Summary of analyses of variance for ten traits of rice cultivars adapted to lowland conditions, with the respective means and coefficients of variation (CV) and of genotypic determination (b).

Source of variation	d.f.	Means squares									
		Days to flowering	PH (cm)	NT	NP	PL (cm)	NSP	%GP	G100 (g)	LA (cm^2)	GY (g/plot)
Blocks	1	7.650	191.0000	398.0000	8566.0000	0.2656	227.2500	61.8125	0.0030	25.5312	127216.0000
Cultivars (Total)	71	383.2870*	396.3908*	11186.2700*	9419.4650*	7.9617*	1417.9720*	334.0361*	0.2395*	222.8196*	100089.0000*
Selected cultivars[a]		75.5703*	140.0677*	24312.6200*	16653.1880	2.8708	1253.0704*	29.2578	0.1138*	98.5788*	(14530.0000)
Residue	71	2.7588	73.3873	6402.2680	4954.5070	2.3327	358.5060	24.3195	0.0277	45.5792	12482.1400
Mean		108.59	137.12	315.23	299.47	22.11	141.67	76.44	2.78	48.04	768.32
CV (%)		1.53	6.25	25.38	23.50	6.91	13.36	6.45	5.98	14.36	14.54
b (%)		99.28	81.49	42.77	47.40	70.70	74.72	92.12	88.44	78.65	87.53

Abbreviations used are: PH, plant height; NT, number of tillers; NP, number of panicles; PL, panicle length; NSP, number of spikelets/panicle; % GP, percent filled grains/panicle, G100, 100 grains weight; LA, leaf area; GY, grain yield.

* Significant at the 1% level of probability by the F test.

[a] Group of 13 cultivars selected for yield at 18% selection intensity.

Table III - Groups of rice cultivars adapted to lowland conditions, established by the clustering method of Tocher applied to Mahalanobis generalized distances.

Group	Cultivars
I	1, 3, 4, 6, 8, 9, 10, 11, 13, 16, 19, 20, 21, 23, 24, 28, 29, 30, 31, 32, 33, 34, 35, 37, 38, 39, 40, 41, 43, 44, 47, 48, 49, 50, 52, 53, 54, 55, 57, 58, 59, 60, 64, 65, 67, 69, 71, 72
II	2, 5, 7, 12, 14, 15, 18, 22, 25, 26, 27, 36, 42, 45, 46, 51, 56, 61, 62, 66, 68
III	63, 70
IV	17

Maximum distance = 2071.4 between cultivars 42 and 63.
Minimum distance = 1.6 between cultivars 10 and 39.

On the basis of the traits analyzed, Cutião Bico Preto (No. 10) and Bico Preto Roxo (No. 39) were the cultivars showing the closest genetic relationship, with a minimal distance from each other ($D^2 = 1.6$). In contrast, Lageado (No. 42) and Americana (No. 63) were the cultivars showing the greatest genetic divergence, with maximal distance from each other ($D^2 = 2071.4$).

The use of parental lines with maximal genetic divergence has been recommended by several investigators, to maximize hybrid heterosis and to increase the probability of the occurrence of superior segregants in advanced generations. Thus, the information presented in Table III could be used to orient intercrossing. Since cultivars belonging to the same group present a high level of genetic similarity, according to multivariate analysis, crosses with in the same group should be avoided, whereas crosses involving parental lines belonging to different groups should be encouraged. Since heterosis is a relative measure (F_1 compared to parents) the identification of parental lines for crossing based only on genetic divergence and ignoring *per se* performance may not be a good breeding strategy. On this basis, it can be seen from Table III that, even though Lageado (No. 42) and Americana (No. 63) are the cultivars with the greatest genetic divergence, their respective mean grain yields per plot were only 623.5 and 923.5 g (Table IV), i.e., significantly lower values than those obtained for the most productive cultivars. If cultivar Paga Dívida (No. 38), the most productive one with 1254.50 g/plot (Table IV), is taken as reference, it would be highly unlikely that the yield of the F_1 hybrid between cultivars Bico Roxo

(No. 39) and Americana (No. 63) would match that of Paga Dívida (No. 38) since high heterosis (approximately 62%) would be needed for this to occur.

Thus, in terms of breeding programs, it seems more rational to recommend crosses between genetically divergent cultivars that also exhibit a superior performance in terms of the traits of major agronomic importance. Table IV lists the means obtained for each cultivar for the ten traits evaluated. When considering grain yield in particular, nine cultivars (Paga Dívida, No. 38, De Abril, No. 6, Cuchilão, No. 23, Quebra Cacho, No. 21, Marabá, No. 37, Coqueiro Casca Branca, No. 34, Brejeiro, No. 35, Unknown, No. 49, and Poupa Preguiça, No. 31) were found to be statistically superior to the others. In addition to these, four other cultivars (Catetinho, No. 41, Brejeiro, No. 30, Unknown, No. 59, and Chorinho Aliança, No. 13) were also outstanding, with yields of approximately 1000 g/plot. Despite the relative similarity in terms of grain yield per plot, there still was a considerable genotypic variability among the 13 cultivars for most of the traits evaluated (Table II). Thus, additional genetic gain is possible by selecting populations derived from crosses between these parental lines.

Table IV - Comparison of mean data concerning traits of agronomical importance obtained for 72 rice cultivars adapted to lowland conditions.

Cultivar	Days to flowering	PH (cm)	NT	NP	PL (cm)	NSP	%GP	G100 (g)	LA (cm^2)	GY (g/plot)
1	99.00I	135.30B	212.50A	195.00A	24.28A	171.00B	87.29A	2.60C	49.30A	597.00C
2	127.00C	138.50B	302.00A	296.00A	23.60A	127.58C	66.85C	2.30D	33.10B	478.50D
3	99.00I	142.50A	287.50A	283.50A	19.35B	156.50B	77.21B	3.50A	54.35A	1056.00A
4	92.00J	147.20A	308.50A	291.00A	21.60B	134.50C	89.37A	2.80C	52.50A	843.00B
5	129.00B	139.98B	355.00A	348.50A	23.65A	115.00D	60.25C	2.50D	37.90B	456.00D
6	105.00G	158.30A	652.50A	556.00A	20.40B	99.00D	83.50B	2.85C	42.05B	1099.00A
7	125.00C	50.00A	355.00A	342.00A	24.90A	125.50C	55.57D	2.50D	41.95B	687.00C
8	102.00H	134.10B	226.00A	214.50A	22.40A	183.00A	86.91A	2.70C	58.90A	684.00C
9	104.00G	152.90A	178.50A	173.50A	23.65A	185.50A	80.23B	2.90B	63.20A	829.00B
10	101.50H	136.50B	247.00A	242.50A	21.90B	137.00C	83.56B	3.45A	45.40B	569.50C
11	92.00J	158.10A	348.50A	337.50A	22.70A	143.00C	79.90B	3.20B	56.60A	705.50C
12	129.00B	144.90A	391.00A	387.50A	23.10A	121.50B	51.78B	2.48B	42.25B	459.50D
13	115.00E	139.00B	246.00A	242.50A	22.35A	170.00B	87.97A	2.60C	53.95A	1001.00B

Continued

Table I - Continued.

Cultivar	Days to flowering	PH (cm)	NT	NP	PL (cm)	NSP	%GP	G100 (g)	LA (cm^2)	GY (g/plot)
14	129.00B	131.90B	300.00A	292.00A	24.35A	130.00C	62.63C	2.40D	40.20B	468.00B
15	127.00C	135.00B	351.00A	343.50A	23.20A	117.00D	55.19D	2.50D	40.20B	498.00D
16	97.50I	144.40A	308.50A	281.00A	18.05B	162.00B	86.11A	2.65C	47.95A	950.50B
17	115.00E	65.10D	387.00A	285.00A	19.30B	70.50D	75.84B	2.70C	19.30B	505.00B
18	125.00C	143.68A	351.00A	328.50A	24.70A	143.50C	63.06C	2.50D	45.85B	595.00C
19	91.00J	154.80A	338.50A	326.00A	23.95A	153.00B	75.94B	2.80C	56.50A	571.00C
20	103.00G	134.60B	415.00A	403.50A	19.00B	136.50C	89.27A	3.20B	51.95A	884.00B
21	95.50J	145.50A	392.50A	323.50A	22.15A	135.00C	85.54A	3.05B	58.20A	1169.50A
22	129.00B	131.00B	289.50A	282.00A	24.55A	130.50C	51.57D	2.55D	41.05D	481.50D
23	95.00J	158.10A	378.50A	359.50A	20.40B	130.00C	83.85A	3.25A	56.20A	1174.00A
24	103.50G	139.90B	273.50A	266.00A	24.20A	182.50A	86.16A	2.70C	66.95A	917.50B
25	115.00E	138.70B	358.50A	352.50A	22.90A	126.50C	61.82C	2.45D	34.65B	596.00C
26	125.00C	128.40B	210.00A	203.50A	23.40A	137.50C	65.20C	2.55D	36.30B	610.50C
27	138.00A	118.40B	346.00A	340.00A	25.60A	145.00C	61.99C	2.40B	38.15D	647.50C
28	99.00I	128.70B	248.50A	209.50A	21.15B	149.50C	85.75A	2.80C	50.35A	668.50C
29	98.00I	152.80A	338.50A	287.00A	21.50B	129.50C	90.58A	3.40A	54.20A	895.00B
30	94.00J	136.70B	292.50A	277.50A	22.10A	145.50C	87.89A	2.80C	51.15A	1006.00B
31	105.00G	135.30B	233.50A	232.50A	16.26B	172.50B	77.41B	2.65C	76.05A	746.00C
32	114.00E	131.30B	465.00A	460.00A	19.30B	102.40B	80.33B	2.55D	31.35B	904.50B
33	95.00J	148.80A	266.00A	262.00A	23.35A	169.50B	87.49A	2.55B	53.05A	917.50B
34	107.00F	157.70A	311.00A	303.50A	23.30A	136.50C	88.10A	2.90B	58.90A	1146.00A
35	104.50G	152.70A	369.50A	362.00A	23.25A	168.00B	82.29B	3.00B	56.35A	1145.50A
36	127.00C	137.20B	281.00A	277.50A	24.25A	128.00C	55.32D	2.55D	41.90B	481.50D
37	99.00I	142.60A	275.00A	267.50A	20.65B	156.50D	83.21B	3.20B	53.15A	1167.00A
38	109.00F	157.30A	363.50A	354.50A	21.95B	142.50C	88.71A	3.00B	53.45A	1254.50A
39	102.00H	132.20B	268.50A	258.50A	21.50B	134.50C	87.53A	3.50A	45.20B	622.00C
40	108.00F	129.40B	366.00A	357.00A	22.60A	103.00B	76.43B	2.75C	36.50B	885.50B
41	99.00I	138.30B	314.50A	281.00A	22.00A	143.00C	89.89A	3.25A	50.50A	1017.00B
42	138.00A	129.20B	362.50A	352.50A	26.10A	161.50B	44.01D	2.35D	42.95B	623.50B

Continued

Table I - Continued.

Cultivar	Days to flowering	PH (cm)	NT	NP	PL (cm)	NSP	%GP	G100 (g)	LA (cm^2)	GY (g/plot)
43	182.00H	136.30B	330.00A	325.00A	20.10B	153.50B	81.95B	2.35D	57.10A	742.50C
44	103.50G	148.10A	264.50A	254.50A	20.50B	140.00C	90.47A	2.95B	63.40A	637.50C
45	229.00B	121.40B	282.00A	274.50A	24.40A	113.50B	61.66C	2.60D	32.90B	571.50C
46	118.00B	131.70B	183.50A	181.00A	21.70B	147.50C	91.00A	2.55D	46.70B	750.50C
47	115.00E	141.40B	319.50A	316.00A	23.25A	145.50C	86.49A	2.55D	45.30B	841.00B
48	100.00I	143.10A	345.00A	335.00A	19.60B	134.50C	83.14B	3.10B	43.75B	854.00B
49	104.00G	139.90B	508.50A	486.00A	20.70B	90.50D	81.22B	2.85C	33.75B	1109.50A
50	100.50H	155.90A	329.50A	317.00A	20.90B	140.50C	89.38A	3.10B	56.60A	888.00B
51	125.00C	138.70B	407.50A	402.50A	23.65A	135.00C	59.09C	20.40D	45.45D	698.50C
52	100.00I	134.90B	283.50A	280.00A	20.80B	146.50C	60.84C	2.85C	53.90A	639.00C
53	103.50G	137.70D	173.50A	171.00A	22.55A	191.00A	76.35B	3.15B	64.10A	766.50C
54	99.00I	138.90B	308.50A	288.50A	20.70B	208.00A	83.06B	2.20D	55.35A	924.00B
55	115.00E	135.10B	326.00A	315.00A	18.10B	108.50D	90.02A	2.75C	62.60A	707.50C
56	125.00C	135.00B	313.50A	305.00A	22.95A	126.00C	63.03C	2.35D	42.55B	609.50C
57	93.50J	139.50B	372.00A	322.50A	24.48A	117.00D	84.49A	3.45A	36.85B	833.50B
58	103.00G	128.20B	257.50A	237.50A	21.15B	161.50B	88.53A	2.95B	50.45A	787.50B
59	99.00E	148.90A	312.00A	276.00A	22.35A	172.00B	80.99B	3.15B	56.65A	106.50B
60	102.00H	139.90B	158.50A	253.50A	20.80B	151.50B	86.19A	3.35A	62.95A	474.50D
61	129.00B	89.89C	352.50A	341.00A	20.10B	113.50D	49.53D	2.55D	27.20B	317.50D
62	120.00D	137.00B	342.00A	336.00A	23.20A	132.00C	62.81C	2.50D	35.80B	711.50C
63	76.00K	122.90B	401.00A	293.50A	26.55A	207.00A	69.67C	1.85D	41.60B	923.50B
64	102.00H	128.10B	288.50A	275.00A	19.80B	136.00C	72.17B	3.15B	56.95A	924.50B
65	100.00E	127.00B	268.50A	226.00A	21.60B	140.00C	78.70B	3.00B	45.05B	671.50C
66	127.00C	138.60B	374.50A	367.50A	23.70A	120.00D	51.39D	2.55D	40.55B	403.00D
67	113.00E	119.60B	332.50A	327.00A	18.90B	95.00D	90.35A	2.55D	32.80B	923.00B
68	129.00B	126.70B	294.50A	292.50A	23.15A	114.50D	59.29C	2.60D	39.00B	503.50D
69	104.50G	137.30B	222.00A	214.50A	23.30A	200.00A	82.03B	2.80C	60.45A	638.00B
70	78.00K	136.90B	239.50A	216.00A	21.30B	143.50C	78.09B	2.95B	37.85B	509.00D
71	103.50G	129.50B	252.50A	247.50A	21.40B	157.00B	85.86A	2.70C	59.70A	742.50C
72	93.00J	138.80B	288.50A	246.00A	21.50B	148.50C	85.33A	3.15B	48.85A	902.00B

Means followed by the same letter did not differ significantly by the Scott and Knott test at the 5% level of probability.

For abbreviations, see Table II.

The genetic divergence among the cultivars evaluated is presented in Figure 1, with emphasis on the 13 cultivars cited above. In this figure, dispersal is presented in relation to the first two canonical variables which retained approximately 88.1% of the total available variability. Thus, its use for the objectives of the present study is satisfactory.

It can be seen that some of the 13 cultivars identified present satisfactory genetic divergence, as is the case between cultivar 38 (the most productive) and cultivar 30, between 49 and 21, or even between 13 and 23. Thus, the use of these parental lines for hybrid derivation or for constituting base populations for the extraction of superior lines is recommended.

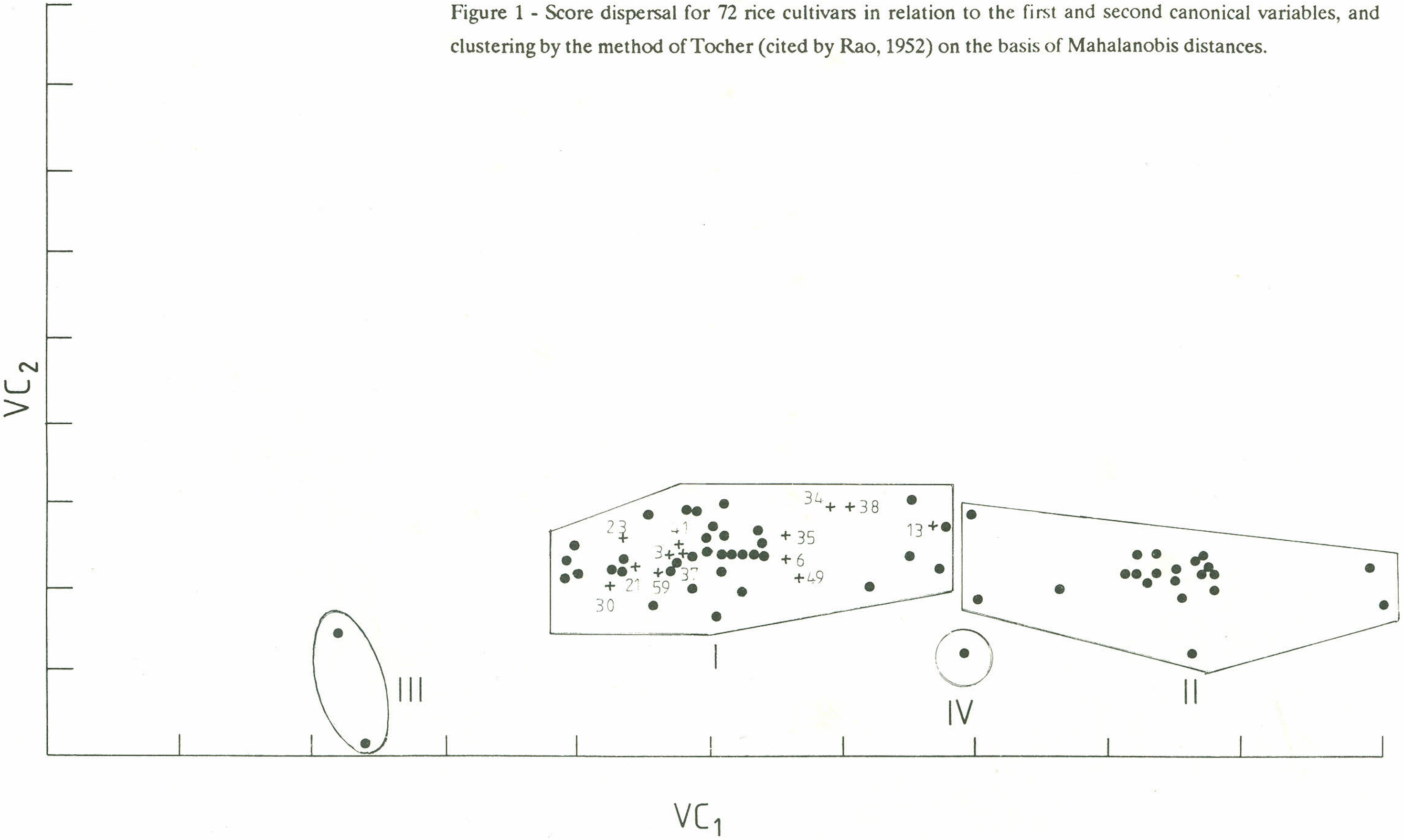
Figure 1 also shows that certain crosses between the selected cultivars may not produce superior descendants since they represent homogeneous groups, at least in terms of the ten traits analyzed. A high degree of similarity is observed among cultivars 6, 35, 49, 34 and 38 (subgroup I), among cultivars 41, 3, 37 and 59 (subgroup III), and among cultivars 21, 30 and 23 (subgroup III). Thus, even though these subgroups are highly productive, crosses between cultivars within them are not recommended since the probability of extracting lines derived from segregant generations that would be superior to the original cultivars is low.

In allogamous cultures, the evaluation of a relatively large number of lines is usually done in two steps. The first generally consists of a top cross in which each line is crossed with a common male parent (tester) and the best genotypes are recognized in comparative trials. The second consists of the evaluation of hybrid combinations of the group selected in diallel crosses, which provide information on the general and specific combining ability of the parents.

Knowing the combining ability of the materials in a hybridation program is very useful for the selection of parental lines that may produce additional desirable recombinants. Studies of this type have been conducted on rice by several investigators (Mohanty and Mohapatra, 1973; Singh and Nanda, 1976; Singh, 1977; Maurya and Singh, 1977b; Shrivastava and Seshu, 1983; Lopes, 1984; Kaw, 1988).

A procedure similar to that used for allogamous species could be recommended for autogamous species, and for rice cultivation in particular, with the following modifications: during an initial stage, comparative trials for grain yield and for its components would be carried out together with studies of genetic divergence, as presented here. The parental lines with superior agronomic performance and satisfactory genetic divergence would thus be identified. In a second stage, diallel crosses would be performed, with preference given to partial crosses (or factorial mating designs), to establish similar groups, thus permitting crosses between divergent parents only. Several investigators have provided detailed information about the

Figure 1 - Score dispersal for 72 rice cultivars in relation to the first and second canonical variables, and clustering by the method of Tocher (cited by Rao, 1952) on the basis of Mahalanobis distances.



use of partial diallels (Miranda-Filho and Geraldi, 1984; Vencovsky, 1987; Geraldi and Miranda-Filho, 1988).

Within this strategy, we recommend the establishment of a diallel from crosses among parents 49, 6, 35, 38 and 13 (forming group 1) and among parents 59, 41, 37, 23, 3, 21 and 30 (forming group 2). This recommendation is of a technical nature, since it would avoid 46% of the crosses among the 13 parents, in relation to the complete diallel.

Another alternative is the establishment of diallels from crosses between groups 1 and 2 and elite introduced lines presenting the same type of modern plant. This would lead to an increased probability of obtaining lines with better plant architecture and the maintenance of a certain level of rusticity in traditional cultivars, an important characteristic for lowland cultures. Of the 72 cultivars analyzed (Table I), seven have the Santa Catarina denomination, four have the Chorinho denomination, and four the Matão denomination. Two hypotheses may be proposed with respect to these cultivars having the same denomination and collected at different locations: a) they represent the same genetic material, and b) they are divergent materials because of the differentiated selection pressure to which they were submitted over decades of cultivation, and/or because of mechanical seed mixture, and/or because of the occurrence of mutations.

Multivariate analysis of genetic divergence has been very useful to recognize clusters of cultivars with a high similarity pattern, permitting inferences about the possible similarity of cultivars with the same denomination. Figure 2 shows the relative position of cultivars with the Santa Catarina, Matão and Chorinho denominations.

Cultivars with the Santa Catarina denomination occupied close relative positions in the score dispersal plot constructed as a function of the first two canonical variables (Figure 2) and did not differ statistically from each other with respect to NT, NP, PL, G100 and LA. This suggests that these cultivars may represent the same genetic material.

For the cultivars of the Matão denomination, considerable divergence was detected between those collected in Minas Gerais (18 and 36) and those collected in Maranhão (60 and 64). The two Maranhão cultivars were mainly characterized by a smaller number of days to flowering (20 days less), higher 100 grain weight and superior filled grain percent when compared to the Minas Gerais cultivars. Since the divergence of these materials is related to geographic diversity, environmental factors are believed to have induced differentiated selective pressures, leading to the variability observed.

Among the cultivars of the Chorinho denomination (1, 13, 46 and 47), only one was divergent in relation to the others, mainly owing to its low grain yield and considerably reduced number of days to flowering. Although divergent, cultivar 1 did

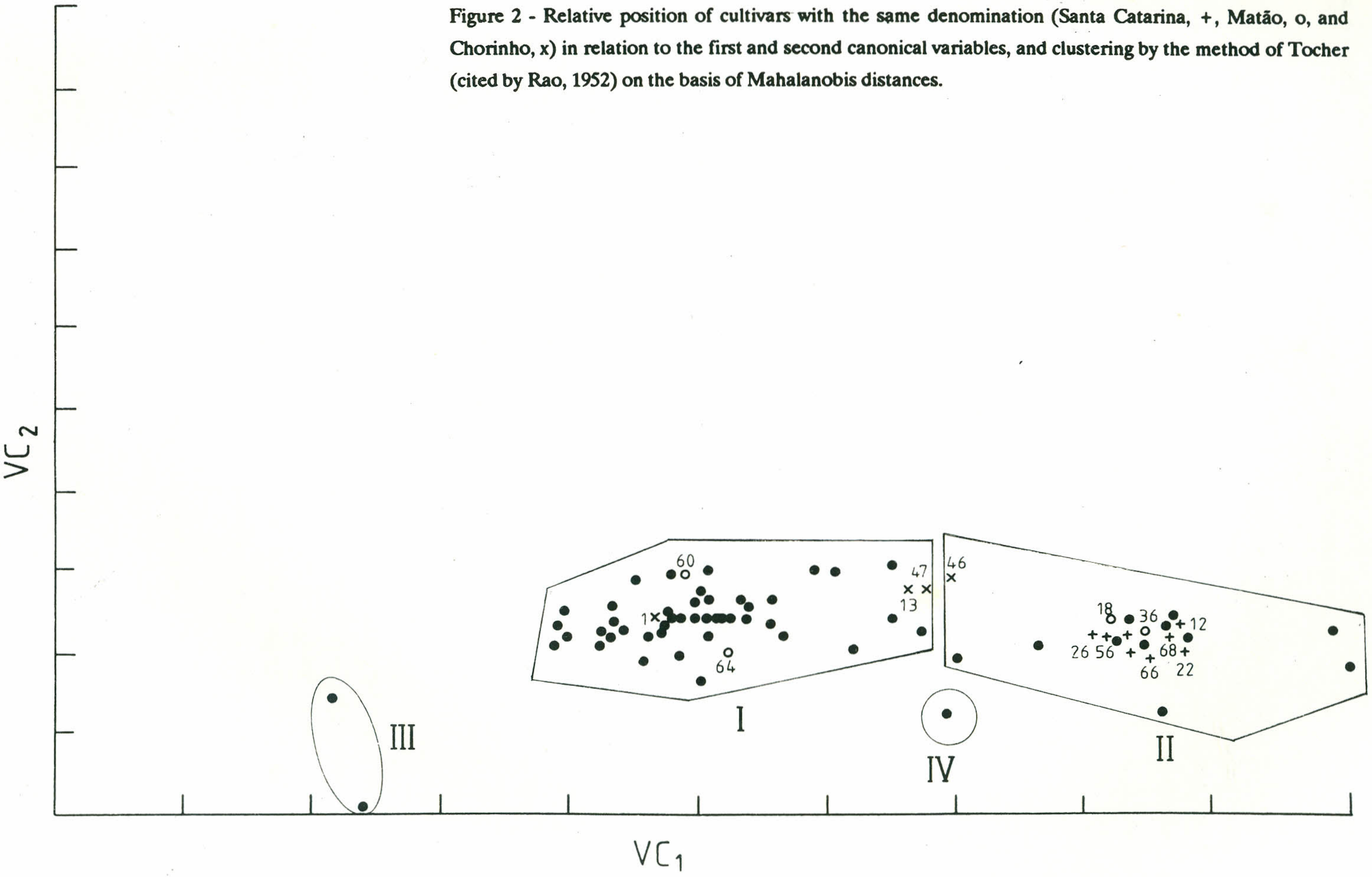


Figure 2 - Relative position of cultivars with the same denomination (Santa Catarina, +, Matão, o, and Chorinho, x) in relation to the first and second canonical variables, and clustering by the method of Tocher (cited by Rao, 1952) on the basis of Mahalanobis distances.

not differ statistically from cultivar 13 in any traits except for days to flowering and grain yield (Table IV). This fact shows that diversity induced by selective forces may have occurred and that days to flowering appears to have been the trait most vulnerable to selection pressure.

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RESUMO

Setenta e dois cultivares tradicionais de arroz de várzea úmida foram avaliados em relação a dez caracteres agronômicos. Estimaram-se suas divergências genéticas através de técnicas multivariadas, visando orientar o estabelecimento de populações básicas para o melhoramento.

O agrupamento pelo método de Tocher a partir das distâncias generalizadas de Mahalanobis, possibilitou a divisão dos 72 cultivares em quatro grupos.

Deu-se ênfase ao estudo da divergência genética entre 13 cultivares cujo desempenho em relação a rendimento de grãos/parcela foi superior. Baseando-se na divergência genética foi recomendada a formação de dois grupos entre os 13 progenitores (grupo 1: cultivares 49, 6, 35, 34, 38 e 13 e grupo 2: cultivares 59, 41, 37, 23, 3, 21 e 30) para o estabelecimento de cruzamentos fatoriais entre os dois grupos, ou entre os grupos 1 e 2 com linhagens elites introduzidas que apresentem tipo de planta moderna.

Constatou-se a existência de divergência entre cultivares coletados em diferentes locais, mas que mantinham a mesma denominação de Matão e Chorinho. Há evidências de que a diversidade ambiental durante décadas de cultivo tenha contribuído para a diferenciação genotípica e que o controle genético do ciclo parece ter sido o mais vulnerável às pressões seletivas.

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