PARTIAL DIALLEL CROSS BETWEEN EXOTIC AND ADAPTED MAIZE POPULATIONS EVALUATED IN ACID SOIL[1]

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ABSTRACT: In Brazil, acid soils represent a large portion of the agricultural area and the development of cultivars with tolerance to acidity has shown to be feasible. The identification of germoplasm potentially tolerant to acidity was the purpose of this work. Two distinct groups of maize (*Zea mays* L.) populations were crossed according to the partial diallel mating scheme: Group [1] with six adapted populations and Group [2] with seven exotic varieties. All varieties and crosses were evaluated under the condition of acid and low fertility soil. Traits analyzed were: EY- ear yield, PH- plant height and EH- ear height. Outstanding varieties *per se*, with yield higher than 3 t ha^{-1}, were SUWAN-2, TAITINGA, TAIÚBA and IUBATÃ in Group [1]; and CUPURICO DMR, TUXPEÑO AMARILLO, and AMARILLO DENTADO in Group [2]. Heterosis and its components showed no significant variation for PH and EH; and only average heterosis was significant for EY. The general combining ability effects (g_i and g_j) showed significant variation (P<0.01) for all traits and were due mainly to the variation of variety effects. The higher estimates g_i for EY were exhibited by WP 12 (0.178 t ha^{-1}), TAIÚBA (0.176) and TAITINGA (0.161) in Group [1]; and for g_j by CUPURICO DMR (0.300), TAITINGA TUXPEÑO AMARILLO (0.280) in Group [2], respectively. The variety cross TAITINGA x TUXPEÑO AMARILLO with mean yield of 4.34 t ha^{-1} and 25% of mid-parent heterosis may be indicated as an heterotic pattern. PH and EH were not considered as limiting to preclude the use of the outstanding populations. The varieties SUWAN 2, CUPURICO DMR, and TAITINGA were suggested to be used in maize breeding programs for acid soils.
Key words: *Zea mays,* partial diallel, heterosis, acid soil, aluminum tolerance

CRUZAMENTO DIALÉLICO PARCIAL ENTRE POPULAÇÕES EXÓTICAS E ADAPTADAS DE MILHO AVALIADO EM SOLO ÁCIDO

RESUMO: No Brasil os solos ácidos representam uma grande parte da área agricultável e o desenvolvimento de cultivares com tolerância à acidez tem-se mostrado exequível. A identificação de germoplasma potencialmente tolerante à acidez foi o propósito deste trabalho. Dois grupos distintos de populações de milho (*Zea mays* L.) foram cruzados segundo o esquema de dialelo parcial: Grupo [1] com seis populações adaptadas e Grupo [2] com sete exóticas. As populações e seus híbridos foram avaliados sob condição de solo ácido e de baixa fertilidade. Os caracteres analisados foram: EY- peso de espigas, PH- altura da planta e EH- altura da espiga. As populações que sobressaíram, com produtividade *per se* acima de 3 t ha^{-1} foram SUWAN-2, TAITINGA, TAIÚBA e IUBATÃ no Grupo [1]; e CUPURICO DMR, TUXPEÑO AMARILLO, e AMARILLO DENTADO no Grupo [2]. A heterose e seus componentes mostraram variação não significativa para PH e EH; e somente a heterose média foi significativa para EY. Os efeitos de capacidade geral de combinação (g_i e g_j) mostraram variação significativa (P<0,01) para todos os caracteres e foram devidos principalmente à variação dos efeitos de variedades. As maiores estimativas de g_i no Grupo [1] para EY (t ha^{-1}) foram exibidas por WP 12 (0,178 t ha^{-1}), TAIÚBA (0,176) and TAITINGA (0.161) no Grupo [1]; e para g_j por CUPURICO DMR (0.300), TAITINGA TUXPEÑO AMARILLO (0.280) no Grupo [2], respectivamente. O híbrido interpopulacional TAITINGA x TUXPEÑO AMARILLO com produção média de 4,34 t ha^{-1} e 25% de heterose pode ser indicado como um padrão heterótico. A altura da planta e da espiga não foram consideradas limitantes para impedir o uso das populações mais promissoras. As variedades SUWAN 2, CUPURICO DMR e TAITINGA foram as mais promissoras para programas de mehoramento visando adaptação às condições de solo ácidos.
Palavras chave: *Zea mays*, dialelo parcial, heterose, solo ácido, tolerância ao alumínio

INTRODUCTION

Acid soils represent about 1,660 million hectares of agricultural areas around the world (CIMMYT, 1997). In Brazil, soils under the vegetation known as “cerrado” in general show high acidity and low fertility and represent approximately 150 millions hectares (EMBRAPA, 1978). Maize production in such areas may turn to be feasible under the integration of agricultural practices, such as application of lime and phosphate, with the use of adapted cultivars. Therefore, the identification of germplasm with tolerance to the acid soil condition is a

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first action toward the development of varieties and hybrids with tolerance to this kind of stress.

For the development of base populations to be used in breeding programs, the combination of adapted germplasm with exotic germplasm is viewed as an interesting alternative because it allows the exploitation of heterosis and the introgression of alleles of interest that were not present in the local populations (Crossa et al., 1987; Hallauer & Miranda Filho, 1995). Under the Brazilian conditions, the introduction of exotic germplasm has greatly contributed for the enhancement of the yield potential of the local cultivars as well as for the incorporation of alleles for resistance to pest and diseases (Moro et al., 1981; Miranda Filho & Vencovsky, 1984; Miranda Filho, 1992; Regitano Neto et al., 1997).

The diallel cross mating schemes have been extensively used in breeding programs for the evaluation of the genetic potential of populations or genotypes (Vencovsky, 1970; Miranda Filho & Vencovsky, 1984; Gonçalves, 1987). When two distinct groups of varieties or populations (e.g., local vs exotic, dent type vs. flint type, late flowering vs. early flowering, etc) are available the intergroup partial diallel cross can be used (Miranda Filho & Geraldi, 1984; Geraldi & Miranda Filho, 1988). Those models allow the analysis of variance and estimation of effects for varieties within groups and heterosis and its components between groups. In this work, two groups of populations (adapted and exotic) were used and their genetic potentials were studied through the intergroup partial diallel scheme (Miranda Filho & Geraldi, 1984), aiming at the identification of new sources of genes for tolerance to the acid soil conditions.

MATERIAL AND METHODS

Two distinct groups of maize (*Zea mays* L.) varieties were used in this study: Group [1] with six syntetic varieties developed by Instituto Agronômico for São Paulo State, and Group [2] with seven exotic varieties (TABLE 1). Both groups came from the germplasm collection of the Instituto Agronômico de Campinas (IAC, Campinas, SP).

Crosses between varieties and sib-crosses within varieties were made in Piracicaba (Department of Genetics, ESALQ/USP), using paired line 10 m long. Minimums of 30 pollinated ears were obtained in each paired row. Crosses and parent varieties were evaluated in 1997/98 at the Anhembi Experimental Station (SP), Brazil. The experiment comprised 13 parent varieties, 42 variety crosses and two commercial double cross hybrids as checks, which were “a priori” considered as sensitive (AG 6601) and tolerant (AG 5011) to acid soil. Checks were intercalated as single rows after each sub-set of 14 plots within blocks. A completely randomized block design with four replications was used. Each plot was represented by a double-row 4.0 m long spaced 0.90 m apart with 40 plants after thinning. An experimental area characterized by acid soil and low fertility was used. The characteristics of the soil in the experimental area are shown in TABLE 2. Before planting, fertilization followed approximately the quantities (kg ha^{-1}): 16 kg N, 56 kg P_2O_5, and 32 kg K_2O. Other cultural practices and procedures followed technical recommendations for the maize crop.

Means (over four replications) of varieties and variety crosses were analyzed according to the model for the intergroup partial diallel cross, which is represented by (Miranda Filho & Geraldi, 1984)

$$Y_{ij} = \mu + \alpha d + \frac{1}{2}(v_i + v_j) + \theta(\bar{h} + h_i + h_j + sij) + \bar{e}_{ij})$$

In this model Y_{ij} is the observed mean of varieties (Y_{ii} in Group [1] or Y_{jj} in Group [2]; α = 1, and θ = 0) or hybrid crosses (i ≠ j; α = 0, and θ = 1); μ is the overall mean of varieties; d is a measure of the difference between groups; v_i and v_j are the variety effects for Group [1] or Y_{jj} in Group [2], respectively; $\bar{h}$ is the average heterosis of the ij variety crosses; h_i and h_j are the variety heterosis effects for Group [1] or Y_{jj} in Group [2], respectively; s_{ij} is the specific heterosis expressed in the i x j cross; $\bar{e}_{ij}$ is the error term associated with the respective mean. Definitions of the effects in the model are analogous to the model of Gardner & Eberhart (1966) for diallel cross involving only one group of varieties.

The effects of general combining ability (GCA) for varieties within groups were further included; estimates of effects and tests of hypothesis in the analysis of variance followed the model given by Geraldi & Miranda Filho (1988), that is a factorial analysis adapted from Method 4 of Griffing (1956).

The following traits were analyzed: PH- plant height (cm), EH- ear height (cm), and EY- ear yield (t ha^{-1}), after adjustment to stand variation; adjustment was for the expected stand (40 plants) through the analysis of covariance as suggested by Miranda Filho cited by Vencovsky & Barriga, 1992.

RESULTS AND DISCUSSION

Mean yields (ear yield) in the whole set of parent varieties were in the range of 3.31 t ha^{-1} to 3.86 t ha^{-1}. Varieties SUWAN 2, TAITINGA, CUPURICO DMR, TAIÚBA, IUBATÃ, TUXPEÑO AMARILLO and AMARILLO DENTADO, in this order, expressed the highest yield (over 3 t ha^{-1}). The average yield of parent varieties were close to 68% and 72% in relation to hybrid checks AG 6601 and AG 5011, respectively (TABLE 3). Means for plant height (PH) and ear height (EH) in the parent varieties were in the ranges of 155 cm to 218 cm and 79 cm to 136 cm, respectively. As the average height (PH) was 1.80m, it can be concluded that varieties from group 1 were medium to height, where CUPURICO and TUXPENO AMARILLO present the lowest size (TABLE 3).

TABLE 1 - Identification and characterization of 13 populations divided into two groups.[Ψ]

Group	Variety	Characteristics Cycle	Grain color	Endosperm
[1]	MOROTI	early	white	semi-flint
[1]	PORANGATU	early	orange	semi-flint
[1]	TAITINGA	early	white/orange	dent
[1]	IUBATÃ	early	yellow	semi-flint
[1]	TAIÚBA	early	yellow/orange	semi-dent
[1]	WP12	normal	yellow	semi-dent
[2]	PHILIPINE DMR2	---	white	semi-flint
[2]	SUWAN 2	early	yellow	flint
[2]	CARIPEÑO DMR	early	yellow/orange	semi-flint
[2]	AMARILLO DENTADO DMR	early	yellow	dent
[2]	CUPURICO DMR	early	orange	dent
[2]	TUXPEÑO CREMA I	---	light yellow	dent
[2]	TUXPEÑO AMARILLO	early	yellow	dent

[Ψ]Source: Lima et al. (1988); Gorgulho (1997).

TABLE 2 - Average chemical and physical composition of the soil at layers 0-20 cm and 20-40 cm at the Anhembi Experimental Station (SP).

Layer	pH $CaCl_2$	OM	P	K	Ca	Mg	Al	H+Al	SB[1]	T[2]	V[3]	m[4]
cm		$g\ dm^{-3}$	$mg\ dm^{-3}$	---------- $mmol_c\ dm^{-3}$						----------	------- %	-------
0-20	4.2	22	6	2.2	18	11	10	52	31.2	83.2	38	24
20-40	4.0	16	4	1.3	14	8	18	80	23.3	103.3	23	44

Micronutrients

Layer	B	Cu	Fe	Mn	Zn	Na
cm	----------	----------	---------- $mg\ dm^{-3}$	----------	----------	----------
0-20	0.33	0.9	174.0	6.5	0.5	4.6
20-40	0.36	0.8	91.6	3.3	0.4	4.6

[1]SB: sum of bases; [2]T: CEC, cation exchange capacity; [3]V: base saturation; [4]m: aluminum saturation

TABLE 3 - Parent variety means for plant height (PH), ear height (EH) and total ear yield (EY). Anhembi (SP), 1997/98.

Symbology	Variety	PH	EH	EY	EY CH 1	EY CH 2
		---------- cm	----------	$t\ ha^{-1}$	---------- %	----------
V_1	MOROTI	206	114	2.86	62.9	65.6
V_2	PORANGATU	186	104	3.00	65.9	68.8
V_3	TAITINGA	206	113	3.65	80.2	83.7
V_4	IUBATÃ	191	97	3.35	73.6	76.8
V_5	TAIÚBA	179	93	3.40	74.7	78.0
V_6	WP12	218	136	2.98	65.5	68.4
V_7	PHILIPINE DMR2	188	103	2.51	55.2	57.6
V_8	SUWAN 2	180	97	3.86	84.8	88.5
V_9	CARIPEÑO DMR	183	105	2.31	50.8	53.0
V_{10}	AMARILLO DENTADO DMR	188	98	3.01	66.2	69.0
V_{11}	CUPURICO DMR	172	87	3.52	77.4	80.7
V_{12}	TUXPEÑO CREMA I	183	101	3.00	65.9	68.8
V_{13}	TUXPEÑO AMARILLO	155	79	3.29	72.3	75.5
	Average	187	102	3.13	68.6	71.8
CHECK 1	*AG 6601	159	84	4.55	---	---
CHECK 2	*AG 5011	181	108	4.36	---	---

*Double cross hybrid

Variety crosses TAITINGA x TUXPEÑO AMARILLO, MOROTI x TUXPEÑO AMARILLO, TAITINGA x CARIPEÑO DMR, TAIÚBA x SUWAN 2, and TAIÚBA x CUPURICO DMR, exhibited the highest yields, over 4 t ha^{-1} (TABLE 4). Yields of variety crosses were also not higher than check yields, but some crosses reached relatively high yields, as for example, TAITINGA x TUXPEÑO AMARILLO that yielded 95.4% and 99.5% in relation to the hybrid checks AG 6601 and AG 5011, respectively (TABLE 4). Means for PH and EH in the variety crosses were in the ranges of 164 cm to 203 cm and 86 cm to 126 cm, respectively (TABLE 4).

In general, the relatively low yield of varieties, variety crosses and hybrid checks are attributed to the condition of acidity and low fertility of the soil in the experimental area. In corrected soil, in the same experiment area, Gorgulho (1997) evaluated the same set of varieties and variety crosses and observed average EY of 6.52 t ha^{-1}, with an increase of approximately 3.1 t ha^{-1} in relation to the results presented in this work. For PH and EH, there was a difference of approximately 20 cm for both traits. Difference between years of evaluation may be partly accounted for the explanation of those differences, but larger effect is attributed to differences in soil characteristics. In fact, high acidity and low cation exchange capacity (V%) (TABLE 2) may limit yield and plant development, as detected in other studies by Clark (1977), Gonzalez-Erico et al. (1979), Naspolini et al. (1981), Bennet et al. (1986), among others.

When comparing the condition of acid soil in the present study and the condition of corrected soil (Gorgulho, 1997), the outstanding varieties and variety crosses in both situations were TAITINGA, TAIÚBA, IUBATÃ, PORANGATU x PHILIPINE DMR2, PORANGATU x TUXPEÑO CREMA I, TAITINGA x CUPURICO DMR, and CUPURICO DMR x CARIPEÑO DMR for EY. For PH and EH, varieties TUXPEÑO AMARILLO and WP 12 also showed the lowest and highest means in both situations.

When focusing the parent varieties "per se", it was observed that yield above 3 t ha^{-1} under the conditions of acid soil was reached by three varieties of Group [1] (adapted) and by four varieties of Group [2] (exotic). A better performance of the adapted varieties should be expected, but the stressed condition may increase the genotype x environment interaction so that a less adapted variety for normal soil can express a relatively higher yield under the stress condition.

Some variety crosses showed mid-parent heterosis higher than 30% and the most heterotic crosses were, TAITINGA x CARIPEÑO DMR, WP 12 x CARIPEÑO and MOROTI x TUXPEÑO AMARILLO; these crosses also showed yield levels above 3.5 t ha^{-1} (TABLE 4). Some negative estimates of heterosis for EY did occur and the most negative values were for crosses IUBATÃ x SUWAN 2 and IUBATÃ x TUXPEÑO CREMA I. In both instances, yield was lower than the lower yield parent (IUBATÃ), probably as a consequence of a particular genetic combination that led to a less adapted genotype to the condition of acid soil.

The identification of heterotic combinations is important for the exploitation of genetic divergence between parents for the development of outstanding hybrids from inbred lines or for the synthesis of pairs of composites identified as heterotic groups (Hallauer & Miranda Filho, 1995). Heterosis in crosses between adapted and exotic germplasm have been reported by some authors (Miranda Filho & Vencovsky, 1984; Crossa et al., 1987; Santos et al., 1994).

The analysis of variance according to the diallel model (TABLE 5) showed significance for all traits in both groups and the difference between groups was non significant only for EY. Heterosis and its components showed no significant differences except average heterosis for EY. The effects of general combining ability (Method 4; Griffing, 1956) were significantly different for all traits in both groups, and the differences were attributed mainly to variety effects. The non-significance for heterosis and its components for PH and EH suggests that selection among varieties can be based only on the performance of varieties "per se". For EY, the non-significance for variety heterosis and specific heterosis indicates that the expression of the total heterosis shown no great variation among crosses around the average heterosis. In fact, the range for heterosis expression was from –0.86 to 1.09 t ha^{-1} averaging 0.29 t ha^{-1}; in percent of mid-parent, those values are –26.9 to 36.6%, averaging 9.8%. In percent of mid-parent, the range for heterosis seems to be large as compared with other reports. Nevertheless, when considering the absolute values 1 t ha^{-1} can not be considered a high heterosis expression despite the stressed condition of the acid soil. The precision of an experiment under stress tends to be substantially lower than in normal conditions and may difficult the detection of significant differences through the usual tests of hypothesis.

When choosing the two groups of varieties for this study, a superiority of the adapted group over the exotic group was expected. Nevertheless, the non significance for the contrast between group means for yield leads to the conclusion that their yield potential are very similar under the conditions of acid soil. When comparing our results with those reported by Gorgulho (1997), working with the same groups of varieties in corrected soil, the existence of the genotype x environment interaction is evident, because in normal conditions yield of the adapted group was significantly higher than the exotic group in two locations (Anhembi, SP; Rio Verde, GO); the contrasts were 5.54 vs 4.79 t ha^{-1} and 4.02 vs. 3.67 t ha^{-1}, respectively.

Estimates of effects in the model were used for the identification of outstanding varieties in each group. For population effects (v_i and v_j) the highest estimates were for varieties TAITINGA, TAIÚBA, and IUBATÃ in Group [1]; and SUWAN 2, CUPURICO and TUXPEÑO AMARILLO in Group [2] (TABLE 6). For PH and EH, estimates for variety effects were positive for TAITINGA and SUWAN 2, but low in magnitude. When comparing with estimates reported by Gorgulho (1997), varieties TAITINGA, SUWAN 2 and TUXPEÑO AMARILLO also exhibited good patterns of plant architecture under the condition of corrected soil (Gorgulho, 1997). Variety TAIÚBA has been mentioned by their adaptation to acid soils (Lima *et al*., 1992) and its germplasm represents 87.5% of the variety TAITINGA (Lima *et al*., 1988). Santos et al. (1994) detected variety effect estimate of SUWAN 2 as one of the largest (1.29 t ha^{-1}) in a diallel analysis of 28 varieties.

TABLE 4 - Means of variety crosses for plant height (PH), ear height (EH) and ear yield (EY) and estimates of mid-parent heterosis (h) and percentage of heterosis (h%).

Crosses$^{\Phi}$	PH	EH	EY	EY CH 1	EY CH 2	EY	EY
	cm		t ha^{-1}	%		h	h %
$V_1 \times V_7$	179	97	3.18	69.9	72.9	0.495	18.4
$V_1 \times V_8$	191	111	3.40	74.7	78.0	0.040	1.2
$V_1 \times V_9$	191	107	3.21	70.6	73.6	0.625	24.2
$V_1 \times V_{10}$	190	107	3.07	67.5	70.4	0.135	4.6
$V_1 \times V_{11}$	189	101	3.88	85.3	89.0	0.690	21.6
$V_1 \times V_{12}$	193	107	3.02	66.4	69.3	0.090	3.1
$V_1 \times V_{13}$	183	90	4.10	90.1	94.0	1.025	33.3
$V_2 \times V_7$	196	104	3.50	76.9	80.3	0.745	27.0
$V_2 \times V_8$	179	96	3.47	76.3	79.6	0.040	1.2
$V_2 \times V_9$	198	108	2.80	61.5	64.2	0.145	5.5
$V_2 \times V_{10}$	179	91	3.41	75.0	78.2	0.405	13.5
$V_2 \times V_{11}$	178	95	3.27	71.9	75.0	0.010	0.3
$V_2 \times V_{12}$	186	100	3.60	79.1	82.6	0.600	20.0
$V_2 \times V_{13}$	172	94	3.31	72.8	75.9	0.165	5.2
$V_3 \times V_7$	193	100	3.34	73.4	76.6	0.260	8.4
$V_3 \times V_8$	188	108	3.35	73.6	76.8	-0.405	-10.8
$V_3 \times V_9$	183	101	4.07	89.5	93.4	1.090	36.6
$V_3 \times V_{10}$	183	107	3.13	68.8	71.8	-0.200	-6.0
$V_3 \times V_{11}$	178	95	3.58	78.7	82.1	-0.005	-0.1
$V_3 \times V_{12}$	183	105	3.32	73.0	76.2	-0.005	-0.2
$V_3 \times V_{13}$	181	95	4.34	95.4	99.5	0.870	25.1
$V_4 \times V_7$	185	106	2.93	64.4	67.2	0.000	0.0
$V_4 \times V_8$	189	103	2.85	62.6	65.4	-0.755	-20.9
$V_4 \times V_9$	195	114	2.89	63.5	66.3	0.060	2.1
$V_4 \times V_{10}$	183	106	3.38	74.3	77.5	0.200	6.3
$V_4 \times V_{11}$	188	104	3.63	79.8	83.3	0.195	5.7
$V_4 \times V_{12}$	174	91	2.32	51.0	53.2	-0.855	-26.9
$V_4 \times V_{13}$	164	86	3.16	69.5	72.5	-0.160	-4.8
$V_5 \times V_7$	195	104	3.27	71.9	75.0	0.315	10.7
$V_5 \times V_8$	190	109	4.03	88.6	92.4	0.400	11.0
$V_5 \times V_9$	192	105	3.65	80.2	83.7	0.795	27.8
$V_5 \times V_{10}$	171	86	3.53	77.6	81.0	0.325	10.1
$V_5 \times V_{11}$	184	92	4.02	88.4	92.2	0.560	16.2
$V_5 \times V_{12}$	186	105	2.86	62.9	65.6	-0.340	-10.6
$V_5 \times V_{13}$	175	90	3.87	85.1	88.8	0.525	15.7
$V_6 \times V_7$	201	116	3.32	73.0	76.2	0.575	20.9
$V_6 \times V_8$	191	114	3.68	80.9	84.4	0.260	7.6
$V_6 \times V_9$	203	126	3.53	77.6	81.0	0.885	33.5
$V_6 \times V_{10}$	196	116	3.86	84.8	88.5	0.865	28.9
$V_6 \times V_{11}$	193	112	3.99	87.7	91.5	0.740	22.8
$V_6 \times V_{12}$	189	108	3.40	74.7	78.0	0.410	13.7
$V_6 \times V_{13}$	190	106	3.47	76.3	79.6	0.335	10.7
Average	186	102	3.42	75.2	78.4		
CHECK 1	159	84	4.55	--	--	--	--
CHECK 2	181	108	4.36	--	--	--	--

$^{\Phi}$Symbolism: see TABLE 3.

No significance was detected for variety heterosis effects in both groups; their ranges of variation were –0.477 to 0.292 t ha^{-1} and –0.359 to 0.310 t ha^{-1}, respectively (TABLE 6). For general combining ability (GCA), varieties WP12, TAIÚBA and TAITINGA in Group [1] and CUPURICO DMR and TUXPEÑO AMARILLO in Group [2] showed significant and positive estimates (TABLE 6). Variety WP12 in Group [1] also showed positive GCA estimates for PH and EH that can be seen as unfavorable traits if the objectives of the program is toward the development of short architecture cultivars. The outstanding varieties for GCA under the conditions of acid soil, as identified above, are not the same as those with better performance in corrected soil, which were PORANGATU and IUBATÃ in Group [1] and TUXPEÑO CREMA I and CARIPEÑO DMR in Group [2], as identified by Gorgulho (1997).

Following the objectives of this study, one can foresee wide possibilities for the use of the germplasm evaluated under the conditions of acid soil. The positive variety effects, mainly referring to varieties SUWAN 2, CUPURICO DMR and TAITINGA, may suggest their use as a base for intrapopulation recurrent selection under the specified conditions. On the other hand, outstanding varieties for yield with positive GCA effects may be used for the synthesis of pairs of composites, toward the exploitation of heterosis and reciprocal recurrent selection. Also, a specific variety cross can be identified as a heterotic group aiming at the exploitation of both general and specific combining ability through the extraction of inbred lines and the development of outstanding hybrids. This is the case of TAITINGA x TUXPEÑO AMARILLO, which yielded 4.34 t ha^{-1}, representing 95.4% and 99.5% of checks AG 6601 and AG 5011, respectively, including a mid-parent heterosis of 25%.

TABLE 5 - Mean squares[ℜ] in the analysis of variance for plant height (PH), ear height (EH) and ear yield (EY) following the model of intergroup parcial diallel cross (Miranda Filho & Geraldi, 1984).

Source	d.f.	PH	EH	EY
		---------- cm	----------	t ha^{-1}
Entries	54	110.729**	102.235**	188.803**
Varieties [1]	5	294.306**	439.333**	284.340*
Varieties [2]	6	265.533**	242.823**	471.111**
Groups	1	1176.450**	618.917**	92.990^{ns}
Heterosis	42	41.385^{ns}	29.719^{ns}	139.382^{ns}
Average heterosis	1	28.240^{ns}	0.404^{ns}	827.020**
Variety heterosis [1]	5	62.003^{ns}	31.633^{ns}	176.466^{ns}
Variety heterosis [2]	6	42.276^{ns}	14.549^{ns}	146.401^{ns}
Specific heterosis	30	38.209^{ns}	33.411^{ns}	108.876^{ns}
Error	162	46.303	36.970	104.297
General combining ability [1]	5	140.042**	232.266**	367.060**
General combining ability [2]	6	171.523**	169.134**	321.733**

[ℜ]Analysis with means over four replications.

TABLE 6 - Estimates of the effects of varieties (v_i and v_j), variety heterosis (h_i and h_j) and general combining ability (g_i and g_j) for plant height (PH), ear height (EH) and ear yield (EY) following the model of intergroup partial diallel (Miranda Filho & Geraldi, 1984; Geraldi & Miranda Filho, 1988).

	PH			EH			EY		
Group [1]	v_i	h_i	g_i	v_i	h_i	g_i	v_i	h_i	g_i
	----------	cm	----------	----------		----------	----------	t ha^{-1}	----------
MOROTI	8,3	-2,5	1,6	4,5	-2,2	0,0	-0,346	0,153	-0,019
PORANGATU	-11,7	3,5	-2,4	-5,5	-1,8	-4,5	-0,206	0,012	-0,091
TAITINGA	8,3	-6,4	-2,2	3,5	-3,0	-1,2	0,443	-0,06	0,161
IUBATÃ	-6,7	-0,5	-3,8	-12,5	4,9	-1,4	-0,226	-0,292	-0,405
TAIÚBA	-18,7	7,7	-1,6	-16,5	4,2	-4,1	0,193	0,079	0,176
WP12	20,3	-1,8	8,4	26,5	-2,1	11,2	0,143	0,107	0,178
Group [2]	v_j	h_j	g_j	v_j	h_j	g_j	v_j	h_j	g_j
PHILIPINE DMR2	9,6	0,4	5,1	7,3	-2,0	1,7	-0,561	0,109	-0,171
SUWAN 2	1,6	0,9	1,6	1,3	3,4	4,0	0,788	-0,359	0,035
CARIPEÑO DMR	4,6	5,0	7,3	9,3	2,7	7,4	-0,761	0,310	-0,070
AMARILLO DENTADO DMR	9,6	-7,5	-2,7	2,3	-1,8	-0,6	-0,061	-0,001	-0,031
CUPURICO DMR	-6,4	1,9	-1,4	-8,7	1,4	-3,0	0,448	0,075	0,300
TUXPEÑO CREMA I	4,6	-3,5	-1,2	5,3	-2,8	-0,1	-0,071	-0,306	-0,341
TUXPEÑO AMARILLO	-23,4	2,9	-8,9	-16,7	-1,0	-9,3	0,218	0,170	0,280
$\hat{\mu}$		188.0			102.6			3.129	
$\bar{h}$		-1.69			0.2			0.289	
d		9.6			6.9			0.067	

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