

COMBINING ABILITY OF INBRED LINES DERIVED FROM A YELLOW FLINT MAIZE SYNTHETIC CMS 53

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ABSTRACT - The objectives were to study the combining ability of lines, derived from synthetic maize (*Zea mays* L.) CMS 53, in a diallel crosses, to identify lines for developing more stable and superior yielding hybrids combinations with a dent heterotic group. The 9 inbreds were crossed to form 36 single crosses, in 1999. Parental inbreds and crosses together with a single cross commercial hybrid were evaluated using a randomized complete block design with 2 replications in four locations during the 1999/00 summer season. Data were collected for several agronomic traits, but only ear yield (kg ha^{-1}) is discussed. For the analysis of this trait, Griffing's (1956) method 2, was used. The combining ability showed highly significant ($P < 0.01$) effects for locations, crosses, lines, general combining ability (GCA), and specific combining ability (SCA). Genotype x Locations was highly significant, but SCA x Location was ($P < 0.05$) significant. Means of the crosses over locations ranged from 6678 kg ha^{-1} to 11122 kg ha^{-1} . Results showed that additive and non-additive gene effects were important in this diallel study. There were specific superior crosses for each location indicating the importance of SCA effects over GCA effects at all locations. The selected lines should be useful to a breeding program in tropical conditions.

Key words: *Zea mays* L., diallel, inbred lines, combining ability, ear yield.

CAPACIDADE DE COMBINAÇÃO DE LINHAGENS DERIVADAS DO SINTÉTICO DURO DE MILHO CMS 53

RESUMO - Os objetivos deste trabalho foram estudar a capacidade de combinação e a identificação de linhagens promissoras derivadas de um sintético de milho (*Zea mays* L.) CMS 53, de grãos duros, em cruzamentos dialelo, como indicação para a formação de híbridos com maior estabilidade e maior potencial de produção quando em cruzamento com linhagens de um outro grupo heterótico dentado. Foram produzidos 36 híbridos simples dos cruzamentos entre nove linhagens-elites, em 1999. As linhagens parentais mais os híbridos simples e um híbrido simples comercial usado como testador foram avaliados usando-se blocos casualizados com duas repetições, em quatro locais, no ano agrícola de 1999/2000. Foram coletados dados para várias características de planta e espigas, mas foram usados somente os dados de produção de espigas (kg ha^{-1}) dos quatro locais, e que foram analisados utilizando-se o método 2, modelo 1 de Griffing (1956). Os resultados da análise da variância combinada mostraram efeitos altamente significativos ($P < 0.01$) para locais, cruzamentos, linhagens, CGC e CEC. A interação genótipos e locais foi altamente significativa; entretanto, a CEC e locais foi

significativa a $P < 0.05$. As médias dos cruzamentos nos quatro locais variaram de 6.678 kg ha^{-1} to $11.122 \text{ kg ha}^{-1}$. Os resultados mostraram que, tanto os efeitos aditivos como os não aditivos, foram importantes neste estudo. Foram identificados alguns cruzamentos específicos para cada local, indicando a importância superior da CEC sobre a CGC em todos locais de teste. As linhagens selecionadas podem ser de grande valia para programas de melhoramento nas condições tropicais.

Palavras chave: *Zea mays* L., diallelo, linhagem, capacidade de combinação, produção de espigas.

Maize inbred lines derived from different germplasm can exhibit varying response patterns when grown in different environments. Heterosis has been used in maize breeding programs since Shull (1909) described the concept of single cross hybrids. The yield of hybrids depends on the combining ability of the lines involved in their development. Therefore, breeders are interested in identifying lines that perform well in crosses.

The diallel cross methodology gives the opportunity to calculate GCA and SCA (Sprague & Tatum, 1942). The diallel crosses among lines have been utilized by plant breeders to better understand the nature of gene action controlling traits of agricultural importance and evolution (Kempthorne & Curnow, 1961), and to compare the relative magnitudes of the general combining ability of a group of lines (Hayes & Johnson, 1939).

Diallel analysis is applicable at an advanced breeding stage when a selected number of lines is to be tested (Yordanov, 1983). The limitation of this analysis is that a large number of crosses are required to test a small set of lines (Gonçalves, 1987; Hallauer & Miranda Filho, 1988; Martins & Miranda Filho, 1997).

Sprague & Tatum (1942) reported that GCA was relatively more important than SCA for unselected inbred lines, but the opposite was observed for selected lines. Inheritance studies have shown that grain yield is a quantitative trait under greater influence of SCA effects than GCA, indicating

the greater importance of non-additive gene action in controlling grain yield.

The majority of the research or measurements of GCA and SCA effects, has been with temperate inbred lines rather than tropical lines. Additional studies are needed to examine similar parameters with lines derived from tropical synthetic germplasm.

Information on inbred lines derived from a population is important in a breeding program. Lines with high GCA can be used to test self-progenies from a contrasting heterotic group to produce single cross hybrids. And single crosses can be used in the final double cross hybrids.

The objectives of this study were to use diallel crosses to evaluate the combining ability effects of nine lines selected from the tropical flint type synthetic CMS 53.

Material and Methods

Two hundred S_2 maize progenies, from a synthetic population (CMS 53) with flint kernel, developed by the National Center for Maize and Sorghum Research (EMBRAPA), were top-crossed with a contrasting heterotic dent type synthetic (CMS 61) and the hybrids were evaluated for yield and other characteristics, at five locations in the states of MG, PR, GO and SP, in 1997/98. Ten lines involved in the best crosses were selfed until S_6 and their seeds were increased.

Nine selected lines with high yield potential and good agronomic characteristics were chosen for

this study. These lines, with inbreeding coefficient (F) near one, were crossed in a 9 x 9 diallel scheme.

The 36 single crosses, the 9 inbred lines parents, and a commercial single-cross hybrid as a check (C 901) were evaluated using a randomized complete block design with two replications. The experiments were evaluated at four locations, at Sete Lagoas (MG), Janaúba (MG), Goiania (GO), and Londrina (PR), during the 1999/2000 summer season. Each plot consisted of two 4 m rows, spaced at 0,90 m x 0,20 m between and within rows, respectively. Data were collected for several traits, but only ear yield is presented in this study.

The analyses of variance were performed using an adaptation of Griffing's Method 2, Model I, diallel analyses (Griffing, 1956).

Results and Discussion

The mean ear yield of the single crosses over the four locations (Table 1) ranged from 11122 kg ha⁻¹ (L 5 x L 7) to 6678 kg ha⁻¹ (L 2 x L 8). The hybrid check out yielded the best single cross by 11,31%. The lower yielding inbred line (L8) produced 889 kg ha⁻¹, and the higher yielding line (L3) 3511 kg ha⁻¹. The individual analysis of variance (data not shown) showed highly significant differences among genotypes (P<0,01) at all locations.

For yield over locations, the CV of 13,15% was considered of acceptable magnitude (Scapim *et al.*, 1995).

Highly significant (P<0,01) differences for locations, genotypes (single-crosses and inbred lines) and genotype x locations were detected in the combined analysis of variance, (Table 2). Inbred lines and single crosses also showed highly significant differences (P<0,01). The single crosses yielded differently at tested locations, indicating genetic differences and behavior among them even though the inbreds were derived from a same heterotic population. These results agrees with Sprague & Eberhart (1977) and Gama *et al.* (1995), who found that single crosses with a narrow genetic base have a greater environmental interaction than germplasms from a broad genetic base.

Joint analysis of variance of diallel data across environments for GCA and SCA effects showed highly significant differences (P<0.01) for locations, GCA, SCA and SCA x locations, but GCA x environments interaction was (P <0.05) significant (Table 3).

There are instances in the literature where the relative sizes of mean squares have been used to

TABLE 1. Mean yield (kg ha⁻¹) for the 9 lines (diagonal) derived from the synthetic CMS 53 and the 36 single-crosses (above diagonal), and the commercial hybrid, evaluated over four locations.

Parents	1	2	3	4	5	6	7	8	9
1	3400	9777	9366	9277	9066	8922	10911	8255	8544
2		2288	8011	9522	9477	9466	9488	6677	9866
3			3511	8566	8988	7900	10422	9888	6922
4				2233	8133	8988	10722	7455	8600
5					2377	6833	11122	9277	8011
6						2966	9466	9733	8522
7							2777	9777	10122
8								888	10856
9									1355

Single cross hybrid-check: 12541 kg ha⁻¹.

TABLE 2. Mean squares for the combined analysis of variance for yield (kg ha⁻¹) of 36 crosses and 9 parents from the synthetic CMS 53.

Source of Variation	d.f.	Mean Square
Location (L)	3	193,851,028**
Genotype (G)	44	35,393,554**
Crosses	35	40,641,378**
Lines	8	14,982,417**
Groups(Lines vs Crosses)	1	15,008,794**
G x L	132	1,797,791**
Combined Error	144	1,303,468
Mean = 7424	CV % = 13	

** = Significant at 0.01 level of probability.

TABLE 3. Combined diallel analysis of variance for yield (kg ha⁻¹) of the 9 lines and 36 crosses derived from synthetic CMS 53.

Source of Variation	d.f.	Mean Square
Locations (L)	3	193,851,028**
GCA	8	5,874,225**
SCA	36	41,953,405**
GCA x L	24	1,664,752*
SCA x L	108	1,827,355**
Combined Error	144	1,303,468

*** = Significant at 0,05 and 0,01 levels of probability, respectively.

assess the relative importance of general and specific combining ability. Baker (1978) suggested an expression of the ration between GCA and SCA component of variance, to infer about the relative importance of general and specific combining abilities in determine progenies performance. The closer the ratios to unity, the greater the predictability based on general combining ability alone. In this study, the variation among the SCA effects had greater contribution to the total variation for ear yield than GCA effects indicating significant non-additive effects (Table 3). According to Hallauer & Miranda Filho (1988), dominance effects for grain yield are more relevant than for other maize traits. Different results were found by Paterniani *et al.* (2000), using a set of selected lines from CIMMYT, indicating greater

importance of additive effects than non-additive effects.

Lines L7 and L9 had the highest positive and negative GCA effects, respectively (Table 4). Four out of nine lines presented positive GCA effects. Similar results were obtained by Nass *et al.* (2000). The highest positive and negative SCA effects were found for the crosses L2 x L6 and L4 x L3, respectively. Vasal *et al* (1992) and Gama *et al.* (1995), reported that single crosses produced by crossing lines from different source populations had more positive SCA effects than those involving crossing lines from the same population.

The results of this study show that the lines likely to be useful in crosses in a breeding program are L7, L1 and L6, since they present high positive

TABLE 4. Estimates of GCA (diagonal), SCA effects (kg ha⁻¹)(above diagonal), of the 9 lines and 36 crosses from synthetic CMS 53, over the four locations.

Parent	1	2	3	4	5	6	7	8	9
1	71	1221	1014	1051	1333	508	1457	-64	483
2		-9	219	1395	665	2133	862	417	1856
3			-253	-250	1090	475	1962	1662	930
4				7	871	1457	1385	996	1462
5					-109	7	1383	1646	472
6						43	733	1327	-15
7							608	1205	662
8								-84	1419
9									-274

$SE \hat{g}_i \hat{g}_j$ 237 $SE \hat{S}_i \hat{S}_j$ 793

GCA for yield. Those lines can also be used as testers for lines derived from CMS 61 for single-cross productions. Some high yielding single crosses, e.g. L 2 x L 6 and L 3 x L 7, can be considered for hybrid productions.

Conclusions

Some of the single crosses presented good yields compared to the check hybrid over the four locations, indicating the good potential of the selected lines for hybrid development.

The line L 7 had the highest GCA effect, while lines L9 had lowest GCA effects for ear yield.

SCA mean square value was greater than GCA mean square, indicating the importance of non-additive effects for this set of lines.

The mean yield of the check was greater than the means of the single crosses produced with lines extracted from the same synthetic population, CMS 53.

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