# Combining ability in baby corn inbred lines (*Zea mays* L.)

**Luís Roberto Franco Rodrigues*[1] and Norberto da Silva[2]**

[1]Departamento de Genética, Instituto de Biociências, UNESP, Distrito de Rubião Júnior s/n, CEP 18618-000, Botucatu, SP, Brazil; [2] Departamento de Produção Vegetal, UNESP, Fazenda Experimental Lageado, Caixa Postal 237, CEP 18603-970, Botucatu, SP, Brazil. (* Corresponding Author. E-mail: luigues@bol.com.br)

## ABSTRACT

Seven baby corn inbreds were crossed in a complete diallel scheme. The single-cross hybrids obtained were assessed at the São Manuel Experimental Station, in São Paulo State, Brazil. The experiment was set up in a randomized complete block design with three replications, including one commercial control. The experimental plots consisted of a single row, 5 m long, with 25 plants. The traits assessed were: number of ears/plot, weight, length and diameter of husked and dehusked ears, plant height and ear height. General and specific combining ability effects (GCA and SCA) were determined. There was genetic variability among hybrids and the best hybrid (27Ax31B) was superior to the control for number of ears/plot and weight of ears dehusked. Inbreds 27 and 29 showed the best GCA effects for number of ears/plot, weight of husked and dehusked ears. The magnitude of GCA showed that the additive effects were dominant in most traits evaluated. The existence of dominance effects was also found.

**KEY WORDS:** Baby corn, *Zea mays* L., yield, combining ability.

## INTRODUCTION

Baby corn (*Zea mays* L.) is a young flowering corn ear harvested two days before silking and three days after silking, depending upon the developmental conditions of the plant and size of the ear shoot size ,denominated cob (Bar-Zur and Saadi, 1990). It is a new product that can be consumed fresh or in cans , as it is commonly distributed in the market.

In many countries, the baby-corn production is low or practically nonexistent due to the lack knowledge about the economic potential of the product, production cost, pre and post- harvesting practices, and the appropriate use of genetic material.

In Brazil, the production of baby corn is inexpressive and still needs financial investments from producers and processing industries. The majority of the industrialized baby-corn products is imported from Thailand (Pereira Filho et al., 1998). Sweet and popcorn cultivars have been used in the production of baby-corn due to their great acceptance by consumers (Pereira Filho et al., 1998). However, the disadvantage in using normal commercial sweet corn or prolific dent corn for baby corn production is the fast development of the ear shoots (Bar-Zur and Saadi, 1990). The development of cultivars suitable for grain maize (Thakur et al., 2000) is growing due to the lack of information on suitable cultivars for baby corn production.

Early ripening, low height, flowering uniformity and prolificity are considered the most important traits for the production of baby corn (Thakur et al., 2000). In addition, agronomic practices such population densities, nitrogen fertilization and detasseling have increased baby corn yield considerably. Prasanna et al. (1995) advocates that the regular and careful detasseling of plants prevent fertilization of ears for higher baby corn production. Thakur et al. (2000) observed that detasseling after emergence gave significantly higher marketable baby corn yield. In this case, the use male-sterile lines of baby corn is useful, since they do not need hybrid detasseling, production cost is reduced, breakage of fragile ears is prevented and there is an increase in marketable ears yield.

Little has been published on baby corn breeding procedures. The development of new hybrids for the exploration of heterosis depends on the combining ability of the lines or varieties involved in the production of these hybrids. Information on the populations "per se", as well as in hybrid combinations, is paramount for the development of basic populations improved to obtain different superior inbred lines by the heterosis presented in crosses (Delboni et al., 1989).

Knowledge of variances of general (GCA) and specific (SCA) combining ability defined initially by Sprague and Tatum (1942) and of their interactions with different environments is useful to plan corn breeding procedures (Matzinger et al., 1959). Griffing (1956) and other authors also proposed methods for assessing the genetic variation of lines based on the concepts of general and specific combining ability used extensively in the breeding of several economic crops.

Seven male-sterile lines of baby corn were crossed with their respective maintainer lines, in a complete diallel design, to estimate their general and specific combining ability to select superior inbreds for several traits.

## MATERIAL AND METHODS

From a segregating population, maintainers plants of indigenous popcorn, destined to the production of baby corn, were selected in the Department of Plant Science (Faculdade de Ciências Agronômicas) of São Paulo State University – Botucatu (UNESP). These plants generated two populations (A and B), after five selection cycles. After a new crossing of these populations with sweet corn grains, followed by a crossing between male-sterile plants and fertile male and the self-pollination of the fertile plants, seven male sterile lines, identified as 21A, 23A, 25A, 27A, 29A, 31A and 33A and its respective maintainer lines 21B, 23B, 25B, 27B, 29B, 31B and 33B (Silva and Ikuta, 1995), were observed in generation $S_2$. All those inbred lines were crossed in a 7x7 complete diallel design.

The resulting 21 single-cross hybrids were assessed at the São Manuel Experimental Station, located in São Manuel county, SP (22° 44' S latitude, 48° 34' W longitude, altitude 750 m) in the 2000/01 season. São Manuel county climate is characterized as subtropical humid (Espindola et al., 1974).

The experimental design used was a randomized complete block with three replications. The commercial cultivar AL-34 was used as control. The experimental plots included a single 5 m long row with 25 plants. Rows were spaced 0.9 m. Sample area were bordered by two rows of cutivar AL-34. Plots were over seeded on 28th August and, 22 days later were thinned to the desired final planting density of 55,000 plants/ha, at the seedling stage. Weeds, diseases and insect pests were controlled by using locally recommended practices.

The experiments were periodically irrigated.

Harvesting began 84 days after seeding, when the stylo-stigma presented a length varying from 1 a 2 cm. Eight manual harvests with intervals of one day were realized.

The following agronomic traits were assessed: plant height (PH), in meters from soil surface to the base of the flag averaged for 5 competitive plants in each plot; ear height (EH), in meters from the soil surface to the first ear node for 5 competitive plants in each plot; number of ears/plot (NE), weight of husked ears (WHE); weight of dehusked ears (WDE), both estimated in ton/ha; diameter of husked ears in centimeters (DHE), diameter of dehusked ears in centimeters (DDE), both obtained from the ratio between the total diameter ears/plot and the respective numbers of ears, length husked ears in centimeters (LHE) and length dehusked ears in centimeters (LDE), both obtained from the ratio between the total length of ears/plot and the respective numbers of ears. The number of ears/plot were transformed in square root according to Steel and Torrie (1960).

The analysis of variance was performed on all traits in the hybrids and check study, and the means were compared by the Tukey test. The general capacity (GCA) and the specific (SCA) combining abilities were estimate according to the Griffing (1956), Method 4, model I, (fixed):

$$Y_{ij} = m + g_i + g_j + s_{ij} + \varepsilon_{ij}$$

where:

$Y_{ij}$ is the mean of single cross ($i$x$j$); m is the overall mean; $g_i$, $g_j$ and $s_{ij}$ are general and specific combining ability effects; $\varepsilon_{ij}$ is the error term.

Analysis of variance and of the least significant differences by the Tukey test were performed using PROC ANOVA (SAS Institute, 1995). The GENES program (Cruz, 2001) was used for diallel analyses.

## RESULTS AND DISCUSSION

Hybrid means, coefficients of variation (CV%) and least significant differences by the Tukey test (LSD) are shown in the Table 1.

The best experimental precision was obtained for number of ears/plot (5.8%), followed by length of husked ears (6.2%), diameter of dehusked ears (6.3%) and diameter of husked ears (7.3%).

These traits were less affected by environmental uncontrolled variations. Other traits such as weight of husked ears and weight of dehusked ears, length of dehusked ears, plant height and ear height, CV% ranged from 10.2 to 20.0%.

All hybrids were comparable to check (AL-34) for number of ears/plot. Hybrids from 23Ax27B, 27Ax31B and 29Ax31B crosses were superior to the check in prolificity and did not show significant differences among them. It should be emphasized that the parental lines came from popcorn and the high prolificity is a common characteristic in popcorn populations (Gama et al., 1990). For weight of husked ear, only the 27Ax31B hybrid was different from check.

The average highest hybrid values for weight of dehusked ear were for 25Ax29B and 27Ax31B crosses. However, these hybrids did not differ significantly from check. Average productivity yield for the 27Ax31B hybrid was 1,97 kg/ha of dehusked ear (Table 1).

As for length of husked ears, none of the hybrids were superior to the AL-34. Hybrids from 21Ax29B, 21Ax33B and 27Ax33B crosses did not show significant differences among them (Table 1).

As for length of dehusked ear and diameter of husked and dehusked ears there were no significant difference among hybrids and between hybrids and check (Table 1). The average length of the dehusked ears ranged from 7.13 cm (29Ax33B) to 10.53 cm (23Ax25B)

**Table 1.** Means from number of ears/plot (NE), weight of husked ear (WHE), weight of dehusked ear (WDE), length of husked ears (LHE), length of dehusked ears (LDE), diameter of husked ear (DHE), diameter of dehusked ear (DDE), plant height (PH) and ear height (EH) obtained from 21 single-cross baby corn hybrids of a 7x7 diallel and one corn commercial cultivar. São Manuel, SP, 2000.

| Hybrids | NE (nº/plot) | WHE (ton/ha) | WDE (ton/ha) | LHE (cm) | LDE (cm) | DHE (cm) | DDE (cm) | PH (m) | EH (m) |
|---|---|---|---|---|---|---|---|---|---|
| 21Ax23B | 71.0ad[1/] | 8.22ac | 1.13ab | 21.13ad | 8.06a | 2.36a | 1.26a | 2.13ae | 1.09ad |
| 21Ax25B | 76.3ad | 9.50ac | 1.29ab | 23.46a | 8.86a | 2.60a | 1.33a | 2.26ac | 1.16ab |
| 21Ax27B | 62.3bd | 8.16ac | 1.25ab | 23.50a | 8.36a | 2.56a | 1.30a | 2.25ac | 1.20ab |
| 21Ax29B | 80.0ad | 7.56ac | 1.21ab | 20.16bd | 8.16a | 2.30a | 1.26a | 1.74f | 0.92bd |
| 21Ax31B | 80.0ad | 7.81ac | 1.22ab | 19.63cd | 7.66a | 2.33a | 1.26a | 1.83ef | 0.92bd |
| 21Ax33B | 61.7bd | 5.14c | 0.84b | 19.76cd | 7.70a | 2.23a | 1.20a | 2.04ae | 1.11ac |
| 23Ax25B | 76.3ad | 9.01ac | 1.28ab | 22.46ad | 10.00a | 2.56a | 1.33a | 2.30ab | 1.18ab |
| 23Ax27B | 92.7a | 10.81ab | 1.61ab | 23.63a | 10.53a | 2.43a | 1.33a | 2.20ad | 1.13ac |
| 23Ax29B | 84.3ad | 8.99ac | 1.31ab | 22.30ad | 7.46a | 2.43a | 1.30a | 2.00cf | 0.98bd |
| 23Ax31B | 70.3ad | 7.36ac | 1.02b | 21.56ad | 8.03a | 2.43a | 1.26a | 2.14ad | 1.06ad |
| 23Ax33B | 81.7ad | 7.30ac | 0.91b | 21.96ad | 7.36a | 2.23a | 1.20a | 2.05ae | 1.12ac |
| 25Ax27B | 70.0ad | 8.82ac | 1.25ab | 22.90ad | 8.90a | 2.43a | 1.30a | 2.26ac | 1.11ac |
| 25Ax29B | 86.0ad | 10.80ab | 1.77ab | 23.80a | 7.93a | 2.60a | 1.30a | 2.18ad | 1.00ad |
| 25Ax31B | 80.7ad | 8.89ac | 1.27ab | 22.00ad | 7.90a | 2.53a | 1.26a | 2.20ad | 1.16ab |
| 25Ax33B | 68.7ad | 7.75ac | 0.98b | 23.40a | 8.16a | 2.43a | 1.23a | 2.16ad | 1.10ac |
| 27Ax29B | 87.0ad | 10.86ab | 1.71ab | 22.40ad | 8.13a | 2.50a | 1.33a | 2.09ae | 1.04ad |
| 27Ax31B | 102.0a | 11.90a | 1.97a | 21.46ad | 8.06a | 2.16a | 1.33a | 2.08ae | 1.00ad |
| 27Ax33B | 77.0ad | 7.62ac | 1.14ab | 18.76d | 7.56a | 2.46a | 1.26a | 2.01cf | 0.96bd |
| 29Ax31B | 95.7a | 8.12ac | 1.25ab | 22.70ad | 8.06a | 2.46a | 1.33a | 1.77f | 0.76d |
| 29Ax33B | 89.0ad | 7.95ac | 1.26ab | 20.63ad | 7.13a | 2.33a | 1.23a | 1.95df | 0.98ad |
| 31Ax33B | 65.0d | 5.76bc | 0.90b | 21.96ad | 7.43a | 2.33a | 1.26a | 1.92df | 1.07ad |
| AL34 | 54.7d | 6.05bc | 1.14ab | 26.60a | 7.98a | 2.70a | 1.67a | 2.33a | 1.14ac |
| Mean | 77.8 | 8.38 | 1.26 | 23.10 | 8.16 | 2.4 | 1.3 | 2.09 | 1.04 |
| C.V% | 5.8 | 19.9 | 20.0 | 6.2 | 14.7 | 7.3 | 6.3 | 10.2 | 18.6 |
| L.S.D. | 28.8 | 5.25 | 0.95 | 4.07 | 3.65 | 0.52 | 0.30 | 0.29 | 0.31 |

[1/] Means followed by the same letters, in columns, are not significantly different at the 5% level according to Tukey test.

and the diameter of dehusked ears ranged from 1.20 cm (21Ax33B) to 1.33 cm (21Ax25B, 23Ax25B, 23Ax27B, 27Ax29B, 27Ax31B and 29Ax31B). Evaluation of length and diameter of dehusked ears is important for the canning food industry. Standardized measurements for length of dehusked ears used for canned food may vary from 4.5 to 10 cm and from 0.7 to 1.7 cm for diameter (Bar-Zur and Saadi, 1990). Therefore, all hybrids showed such traits among commercial values and will be available for use. It is important to emphasize that, in this study, the number of commercial baby corn ears/plot was not obtained. This trait is also important for the canning food industry and thus should be evaluated in future studies.

As for plant height, none hybrids showed higher height than the check (Table 1). Hybrids from 21Ax29B, 21Ax31B, 23Ax29B, 27Ax33B, 29Ax31B, 29Ax33B and 31Ax33B crosses were not higher than the check, and did not differ significantly among them. For ear height, only the 29Ax331B hybrid showed significant difference in relation to the check with shorter height. Optimum plant height for baby corn ranges from 2 to 2.5 m, and, and for the insertion of the first ear, 0.50 m and 1,98 m to highest insertion is recommended (Kumar and Singh, 1999). Hybrid heights ranged from 1.74 to 2.30 m and had an average of 2.07 m. First ear insertion height ranged from 0.76 to 1.20 m and had an average of 1.05 m (Table 1). Therefore, it is possible to select, among the evaluated hybrids, those which contribute to the decrease in ear height by indirect selection of smaller plants due to the positive correlation found among these traits (Haullauer and Miranda Filho, 1988; Merlo et al., 1988).

The sum of the general combining ability squares (GCC) and specific combining ability (SCA) are shown in the Table 2.

General combining ability was significant for all traits, except for length and diameter of dehusked ears. For these two traits, the parent lines did not show additive genetic value differences, therefore, the manifestation of the heterosis, or the genic complementation, is not expected among the parent lines for these traits. However, for specific combining ability, significant effect for number of ears/plot, length of husked ears and plant height and height ear was observed. For important traits such as weight of husked ears or weight of dehusked ears there was no significant effect of the specific combining ability, showing that the behavior of the best hybrids can be foreseen by using inbreds with high general combining ability.

The lack of specific combining ability indicates low genetic complementation among inbreds for alleles which show dominance (Cruz and Regazzi, 1997). In the present case, such fact could be explained if it were considered that tested inbreds have the same origin and are obtained from the self-pollination of one indigenous composite-cross of popcorn. On the other hand, high effects of general combining ability values show the presence of favorable genes in high frequency in some inbreds ,being them predominantly additive in their effects (Vencovsky and Barriga, 1992).

In relationship to the type of predominant genic action, the quadratic component of the general combining ability has been superior to the specific combining ability, evidencing predominance of the additive effects in the expression of the

**Table 2**. Mean squares of the analysis of variance of number of ears/plot (NE), weight of husked ears (WHE), weight of dehusked ears (WDE), length of husked ears (LHE), length of dehusked ears (LDE), diameter of husked ears (DHE), diameter of dehusked ears (DDE), plant height (PH) and ear height (EH) of 21 baby corn single-cross hybrids. São Manuel, SP, 2000.

| Source of variation | d.f. | NE (n$^o$/plot) | WHE (ton/ha) | WDE (ton/ha) | LHE (cm) | LDE (cm) | DHE (cm) | DDE (cm) | PH (m) | EH (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| Hybrids | 20 | 0.369[1/] | 0.572[1/] | 0.017[1/] | 2.079[1/] | 0.696 | 0.023[1/] | 0.002 | 0.025[1/] | 0.030[1/] |
| CGC | 6 | 0.627[1/] | 1.331[1/] | 0.038[1/] | 3.032[1/] | 1.374 | 0.041[1/] | 0.007 | 0.067[1/] | 0.023[1/] |
| CEC | 14 | 0.259[1/] | 0.246 | 0.008 | 1.671[1/] | 0.405 | 0.015 | 0.001 | 0.007[1/] | 0.006[1/] |
| Error | 40 | 0.09 | 0.193 | 0.01 | 0.61 | 0.59 | 0.01 | 0.003 | 0.003 | 0.003 |
| Quadratic components | | | | | | | | | | |
| CGC | | 0.107 | 0.228 | 0.006 | 0.484 | 0.157 | 0.006 | 0.004 | 0.013 | 0.004 |
| CEC | | 0.169 | 0.053 | 0.001 | 1.061 | -0.185 | 0.005 | -0.002 | 0.004 | 0.003 |

[1/] Significant at the 0.01 probability level.

characteristics: weight of ears husked and dehusked, length of dehusked ears, diameter of dehusked ears and plant height (Table 2). For the number of ears/ plot and length of husked ears, the dominance effects were more important, because the specific combining ability was predominant in relationship to the general combining ability. For the diameter of husked ears and ear height, the additive and dominance effects were almost equally important.

Estimates of general combining ability ($\hat{g}_i$) of each inbred of 7 evaluated traits are shown in the Table 3. Except for 21, 31 and 33 inbreds which showed negative effects of general combining ability for most of the traits, all the others showed mostly positive, although low in magnitude.

When important characteristics related to yield such as number of ears, weight of husked ears and weight dehusked ears were considered, 27 and 29 inbreds showed the highest positive effects and, in fact, produced the best hybrids when crossed among them or with others inbred lines (Table 1). It should be emphasized that, since this is a fixed model, estimates of ($\hat{g}_i$) are valid for this set of parental lines tested in this study and that in other diallelic combinations, the capacity of combination can be different depending on the genetic constitution of other parents (Vencovsky and Barriga, 1992).

Mean squares were not significant for specific combining ability for most traits (Table 2), indicating a similarity of such effect on different hybrid combinations, but not its lack. Therefore, estimates ($\hat{s}_{ij}$) from 21 hybrids are shown in the Table 4.

High positive estimate of ($\hat{s}_{ij}$) in absolute values indicates that hybrid performance is relatively superior or inferior to parent lines general combining ability, showing the importance of non-additive interactions resulting from the complementation degree among parent lines in relation to frequency of alleles in loci with some dominance, while low estimates of ($\hat{s}_{ij}$) in absolute value indicates that hybrids behave as expected in relation to general combining ability of parent lines (Vencovsky and Barriga, 1992). In the selection of parent lines used to produce hybrids, the effect of a specific combining ability analyzed in an isolated way has a limiting value. Thus, other parameters should be considered such as the average of hybrids and general combining ability of the respective parent lines (Oliveira et al., 1998). Therefore, superior hybrid combinations, which are important for breeding, are involved with at least one parental line which has the most favorable effect of general combining ability (Cruz and Regazzi, 1997). Thus, it is possible to analyze the two hybrids that showed the highest yields of husked and dehusked ears, such as the 27Ax29B and 27Ax31B (Table 1).

Husked ears yield, in the 27Ax29B hybrid, is associated with high effects of general combining ability of the 27 ($\hat{g}_i$ = 1.501 ton/ha) and 29 ($\hat{g}_j$ = 0.693 ton/ha) inbreds, with the low effect of the specific combining ability of two inbreds ($\hat{s}_{ij}$ = 0.188 ton/ha). Therefore, in this case, the high productivity is not due to dominant genetic effects of inbreds but to additive effects. In the 27Ax31B hybrid it is associated with the high effect of the general combining ability of the 27 ($\hat{g}_i$ = 1.501 ton/ha) inbred with one of the highest effects of the estimated specific combining ability ($\hat{s}_{ij}$ = 2.204 ton/

**Table 3.** General combining ability estimates ($\hat{g}_i$) from 7 baby corn inbred lines for number of ears/plot (NE), weight of husked ears (WHE), weight of dehusked ears (WDE), length of husked ears (LHE), length of dehusked ears (DDE), diameter of husked ears (DHE), diameter of dehusked ears (DDE), plant height (PH) and ear height (EH).

| Inbreds | ($\hat{g}_i$) | NE (n$^o$/plot) | WHE (ton/ha) | WDE (ton/ha) | LHE (cm) | LDE (cm) | DHE (cm) | DDE (cm) | PH (m) | EH (m) |
|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 01 | -0.471 | -0.941 | -0.130 | -0.731 | -0.024 | 0.004 | -0.013 | -0.048 | -0.026 |
| 23 | 02 | 0.043 | 0.139 | -0.066 | 0.350 | 0.482 | 0.012 | -0.001 | 0.078 | 0.061 |
| 25 | 03 | -0.165 | 0.741 | 0.050 | 1.335 | 0.556 | 0.158 | 0.011 | 0.184 | 0.075 |
| 27 | 04 | 0.179 | 1.501 | 0.268 | 0.278 | 0.500 | -0.043 | 0.009 | 0.080 | 0.039 |
| 29 | 05 | 0.545 | 0.693 | 0.182 | 0.135 | -0.424 | 0.044 | 0.011 | -0.140 | -0.131 |
| 31 | 06 | 0.216 | -0.123 | 0.008 | -0.396 | -0.355 | -0.039 | 0.012 | -0.093 | -0.063 |
| 33 | 07 | -0.347 | -1.913 | -0.314 | -0.972 | -0.735 | -0.135 | -0.061 | -0.063 | -0.001 |
| DP ($\hat{g}_i$) | | 0.24 | 0.25 | 0.21 | 0.50 | 0.43 | 0.09 | 0.04 | 0.05 | 0.03 |
| DP ($\hat{g}_i$ - $\hat{g}_j$) | | 0.37 | 0.36 | 0.33 | 0.77 | 0.90 | 0.18 | 0.06 | 0.07 | 0.05 |

**Table 4**. Specific combining ability estimates ($s_{ij}$) from 21 baby corn single-cross hybrids for number of ears/ plot (NE), weight of husked ears (WHE), weight of dehusked ears (WDE), length of husked ears (LHE), length of dehusked ears (LDE), diameter of husked ears (DHE), diameter of dehusked ears (DDE), plant height (PH) and ear (EH).

| Hybrids | NE (n$^o$/plot) | WHE (ton/ha) | WDE (ton/ha) | LHE (cm) | LDE (cm) | DHE (cm) | DDE (cm) | PH (m) | EH (m) |
|---|---|---|---|---|---|---|---|---|---|
| 21Ax23B | -0.006 | 0.504 | 0.061 | -0.401 | -0.574 | -0.085 | 0.001 | 0.025 | -0.043 |
| 21Ax25B | 0.512 | 1.192 | 0.105 | 0.995 | -0.192 | -0.039 | -0.048 | 0.047 | 0.013 |
| 21Ax27B | -0.612 | -0.918 | -0.153 | 1.093 | -0.266 | -0.141 | -0.010 | -0.091 | 0.089 |
| 21Ax29B | 0.012 | -0.71 | -0.107 | -1.123 | 0.440 | -0.127 | -0.012 | -0.141 | -0.021 |
| 21Ax31B | 0.340 | 0.456 | 0.077 | -1.135 | -0.076 | -0.013 | -0.016 | -0.095 | -0.091 |
| 21Ax33B | -0.186 | -0.524 | 0.019 | -0.429 | 0.284 | -0.057 | -0.010 | -0.075 | -0.051 |
| 23Ax25B | -0.002 | -0.368 | 0.031 | -1.105 | 0.796 | -0.009 | 0.036 | -0.037 | -0.003 |
| 23Ax27B | 0.524 | 0.742 | 0.143 | 1.123 | -0.358 | -0.063 | 0.008 | -0.033 | -0.007 |
| 23Ax29B | -0.262 | -0.360 | -0.071 | -0.063 | -0.766 | -0.045 | 0.006 | -0.005 | 0.003 |
| 23Ax31B | -0.734 | -1.074 | -0.187 | -0.275 | -0.232 | -0.081 | -0.029 | -0.097 | 0.013 |
| 23Ax33B | 0.480 | 0.556 | 0.025 | 0.711 | -0.582 | -0.005 | -0.022 | -0.039 | 0.035 |
| 25Ax27B | -0.508 | -1.940 | -0.333 | -0.593 | -0.326 | -0.083 | -0.034 | 0.071 | -0.041 |
| 25Ax29B | -0.014 | 0.848 | 0.273 | 0.437 | -0.360 | -0.001 | -0.006 | -0.057 | 0.009 |
| 25Ax31B | 0.074 | -0.146 | -0.053 | -0.851 | -0.486 | 0.033 | 0.040 | 0.043 | 0.120 |
| 25Ax33B | -0.062 | 0.414 | -0.021 | 1.125 | 0.184 | 0.019 | -0.004 | -0.037 | -0.079 |
| 27Ax29B | -0.278 | 0.188 | -0.005 | 0.093 | -0.128 | -0.101 | -0.004 | -0.081 | -0.095 |
| 27Ax31B | 0.850 | 2.204 | 0.431 | -0.283 | 0.264 | -0.265 | 0.032 | 0.017 | -0.025 |
| 27Ax33B | 0.084 | -0.476 | -0.079 | -1.433 | -0.374 | -0.059 | -0.008 | -0.083 | 0.113 |
| 29Ax31B | 0.164 | -0.818 | -0.205 | 1.091 | -0.692 | 0.027 | 0.020 | -0.165 | -0.105 |
| 29Ax33B | 0.378 | 0.652 | 0.117 | -0.423 | 0.122 | 0.003 | -0.004 | -0.075 | -0.073 |
| 31Ax33B | -0.694 | -0.622 | -0.059 | -1.455 | -0.600 | -0.297 | -0.052 | 0.011 | 0.097 |
| DP ($?_{ij}$) | 0.250 | 0.471 | 0.199 | 0.850 | 0.282 | 0.070 | 0.049 | 0.044 | 0.056 |
| DP ($?_{ij}$ - $?_{ik}$) | 0.659 | 0.730 | 0.340 | 0.900 | 0.531 | 0.143 | 0.089 | 0.078 | 0.082 |
| DP ($?_{ij}$ - $?_{kl}$) | 0.560 | 0.632 | 0.270 | 0.751 | 0.472 | 0.123 | 0.670 | 0.055 | 0.073 |

ha), since 31 inbred showed lower general combining ability ($\hat{g}_j$ = 0.123 ton/ha). In this case, the participation of a specific combining ability is significant for hybrid yield, contributing almost equally to the $g_i$ from both inbreds, regarding the dominance and epistasis effects (Gardner, 1963).

For weight of dehusked ears, the results were similar to those showed by the weight of husked ears. The general combining ability effect was more significant for the 27Ax29B hybrid, while the specific combining ability effect was more significant for the 27Ax31B hybrid.

The highest positive and negative general combining ability effects for the length of husked and dehusked ears, considering the two traits simultaneously, were shown by inbreds 25 and 33, respectively (Table 3). For the same traits, the highest positive and negative specific combining ability effects were observed for the 25Ax33B and 31Ax33B crosses, respectively (Table 4).

The highest positive and negative effects of the general combining ability for the diameter of husked ears and dehusked ears were observed in the 25 and 33 inbreds, respectively. For the same traits, the 25Ax31B and 31Ax33B crosses showed the highest positive and negative effects, respectively, for specific combining ability.

For plant height and ear height, most of the parents inbreds showed negative effects of general combining ability, indicating that, in average, these parents contributed to reduce the height of the plant and of the ear in crosses. For these traits, the 25 and 29 parental lines showed the highest positive and negative effects, respectively. For the specific combining ability the 25Ax31B hybrid showed the highest positive effect for plant height and ear height, while the 29Ax31B hybrid showed the highest negative effect for the same traits.

## ACKNOWLEDGMENTS

The first author thanks CAPES for the financial support.

## RESUMO

**Capacidade de Combinação de Linhagens de Minimilho (*Zea mays* L.)**

Cruzaram-se sete linhagens de minimilho em esquema dialélico completo. Os híbridos simples obtidos foram avaliados na Estação Experimental de São Manuel, SP, Brasil. O experimento foi instalado sob delineamento em blocos casualizados com três repetições, incluindo uma testemunha comercial. As parcelas consistiram de uma linha de 5 m com 25 plantas. Avaliaram-se os caracteres: o número de espigas por parcela, peso, comprimento e diâmetro de espigas com palha e sem palha, altura da planta e altura da espiga. Estimaram-se os efeitos da capacidade geral e específica de combinação. Houve variabilidade genética entre os híbridos e o cruzamento 27Ax31B foi superior à testemunha para as características: número de espigas por parcela e peso de espigas sem palha. As linhagens 27 e 29 apresentaram a maior capacidade geral de combinação para o número de espigas por parcela, peso de espigas com palha e sem palha. A magnitude da capacidade geral de combinação indicou a predominância de efeitos aditivos para a maioria das características avaliadas. A existência de efeitos de dominância também foi encontrada.

## REFERENCES

Bar-Zur, A. and Saadi, H. 1990. Profilic maize hybrids for baby corn. Journal Horticultural Science. 65:197-100.

Cruz, C.D. 2001. Programa Genes: Aplicativo computacional em genética e estatística. Imprensa Universitária, Viçosa.

Cruz, C.D., and Regazzi, A.J. 1997. Modelos biométricos aplicados ao melhoramento genético. Imprensa Universitária, Viçosa.

Delboni, J.S.; Silva, J.C.; Cruz, C.D. and Silva, C.H.O. 1989. Análise de Cruzamentos dialélicos entre variedades de milho braquítico-2, usando o método de Gardner e Eberhart. Revista Ceres.36:365-372.

Espindola, C.R.; Tosin, W.A.C. and Paccola, A.A. 1974. Levantamento pedológico da Fazenda Experimental São Manuel. p.650-651. In: Resumos do Congresso Brasileiro de Ciência do Solo, 14th, Santa Maria, 1974. SBCS, Rio Grande do Sul.

Gama, E.E.G.; Magnavaca A.R.; Silva, J.B.; Sana, L.M.; Viana, P.A.; Parentoni, S.N., Pacheco, C.A.P., Correa, L.A. and Fernandes, F.T. 1990. Milho pipoca. Informe Agropecuário. 14:8-12.

Gardner, C. O. 1963. Estimates of genetic parameters in cross fertilizating plants and their importance in plant breeding. p.225-252. In: Hanson, W. D. and Robinson, H. F. (Eds.) Statical genetics and plant breeding. Natl. Acad. Sci. - Natl. Res. Counc. Publ. 982. Washington.

Griffing, J.B. 1956. Concept of general and specific combining ability in relation to diallel systems. Australian Journal Biological Science. 9: 463-493.

Hallauer, A.R. and Miranda Filho; J.B. 1988. Quantitative genetics in maize breeding. University Press, Iowa.

Kumar, T.V. and Singh, V.S. 1999. Genetic variability studies for baby corn in maize (Zea mays L.). Agricultural Science Digest.19:67-71.

Matzinger, D.F.; Sprague, G.F and Cockerham, C.C. 1959. Diallel crosses of maize in experiments repeated over locations and years. Agronomy Journal. 51:346-350.

Merlo, E.; Fornasieri Filho, D. and Lan-Sánches, A. 1988. Avaliação de sete cultivares de milho pipoca (Zea mays, L.) em três densidades de semeadura. Científica. 16:245-251.

Oliveira, V.R.; Casali, V.W.D.; Cruz, C.D.; Pereira, P.R.G. and Scapim, C.A. 1998. Capacidade de combinação entre linhagens de pimentão diferindo na tolerância ao baixo teor de fósforo no solo. Bragantia. 57:203-214.

Pereira Filho, I.A.; Gama, E.E.G and Cruz, J.C.1998. Minimilho: efeito de densidades de plantio e cultivares na produção e em algumas características da planta de milho. Comunicado Técnico, 23. CNPMS/EMBRAPA, Sete Lagoas.

Prasanna, B.M.; Singh, N.N. and Sarkar, K.R. 1995. Babycorn. Indian Farming. 45:5-7.

SAS, 1995. SAS/STAT user's guide. v.1. SAS Institute Inc., Cary, North Carolina.

Sprague, G.F. and Tatum, L.A. 1942. Generals vs. specific combining ability in single crosses of corn. Journal American Society Agronomy. 34:923-932.

Steel, R.G.D. and Torrie, J.H. 1960. Principles and procedures of statistics. MacGraw-Hill, New York.

Silva, N. and Ikuta H. 1995. Obtenção de linhagens macho estéreis, Shrunken –2 de milho (Zea mays) para conserva (Baby-corn). Horticultura Brasileira. 13(1):115-116.

Takur, D.R.; Sharma, V. and Pathik, S.R. 2000. Evaluation of maize (Zea mays L.) cultivars for their suitablity babycorn under mid-hills of north-western Himalayas. Indian Journal Agricultural Science.70:146-148.

Vencovsky, R. and Barriga, P. 1992. Genética biométrica no fitomelhoramento. Sociedade Brasileira de Genética, Ribeirão Preto.

Received: May 10, 2002;

Accepted: October 25, 2002.