HETEROSIS AND COMBINING ABILITY IN MAIZE (*ZEA MAYS* L.)

El - Hosary * A.A.; A.M. Morsy*, M.K. Khlifa*; and M.A. Abd El-Khalik**

** Agronomy. Dep, Fac. of Agric, Moshtohor, Egypt*

*** Central administration for seed testing & certification*

ABSTRACT

Eight parental inbred line namely Moshtohor M110B, M.72, M70B, M.27, M.101H, M.105g, M.36 and M.106i, representing wide range of variability in most of the studied traits, were utilized. In 1994 all possible combinations were mad among them. In Both 1995and 1996 summer seasons, the eight inbred lines and their single crosses as well as three check varieties (SC.10 TWC. 310 and Giza2) were evaluated.

The results showed that significant genotypes mean squares were detected for all the studied traits. Significant genotypes by seasons interaction mean squares were detected for all traits except number of rows/ear. The two crosses M.110 B x M.101H and M.101H x M.106i had significant superiority of grain yield over the best check varieties. The three crosses M.110Bx M.101H, M.101H x 105g and M.101H x M.106i out yielded the best check SC.10 by 14.34%.

The variance associated with general(GCA) and specific (SCA) combining ability was significant for all traits except no of ears /plant, no of kernels/row and ear diameter which were insignificant GCA effects. With the exception of 100-kernel weight, silking date and stem diameter, the less ratio of GCA/SCA mean squares were detected, indicating that the large portion of the total genetic variability associated with these traits was due to non-additive gene action.

Estimated of GCA effects revealed that the parental lines M101H and 110B had considerable significantly positive g_i effects for grain yield/ plant and proved to be good combiners. Twenty parental combinations showed significantly positive S_{ij} effects for grain yield/plant.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereals in Egypt due to its vast area, total production and cash value. It is essential for human consumption livestocks. Moreover, it is also used for industrial purpose such as manufacturing starch and cooking oils. Much efforts are devoted nowadays to increase its productivity through genetical improvement. To carry out a successful breeding program, the breeder should have enough knowledge about they type and relative amount of genetic variance components and their interaction by environment for the attribute in questions. There for, the main objectives of this investigation were:

1- To estimate the amount of heterosis.

2- To evaluate the general (GCA) and specific (SCA) combining ability and their interaction by environment and (3) to compute the pridicted yield for the possible double crosses. It is hoped that the present study may help corn breeder to produce new hybrid varities of maize having higher yielding potentiality.

MATERIALS AND METHODS

The present study was carried out at the Research and Experimental Station of the Faculty of Agriculture at Moshtohor Zagzig University (Benha Branch) during the three summer growing seasons 1994, 1995 and 1996. Eight corn inbred lines were used as parents in this study. these are; M.110B, M.72, M.27, M.70B M.105g, M.106i and M.36. These inbreds were produced by Prof. Dr. A.A. El-Hosary in Moshtohor Experiment Station. During summer season of 1994, all possible combinations were handmade between the eight inbreds to produce 28 single crosses.

In 1995 and 1996 summer seasons, the eight inbred lines, 28 single crosses and three check varieties (Sc.10, TWC. 310 and Giza2) were sown in randomized complete block design with three replications.

In both seasons (1995 and 1996) each plot consisted of one ridge. Each ridge was 6m in length, 70cm in width and accommodated one plant/ hill. Hills were spaced 20 cm apart on one side of the ridge. The recommended agricultural practices for corn production were applied properly.

Data were collected on 10 plants from each plot to study; tasseling and silking dates (days), (cm), (degree), stem diameter, no. of ears/plant, ear husk (cm), ear length and ear diameter (cm), no. of kernels/row, no. of rows/ ear, weight of-100 kernel (g), and grain yield/plant (g).

The obtained data were analysed on individual plant basis. When the differences, between genotypes reached the significance level genetic analysis for GCA and SCA was carried out. Also, the obtained date were biometrically analyzed to estimate general combining ability (GCA)and specific combining ability (SCA) using method 2 model 1 of Griffing (1956).

RESULTS AND DISCUSSION

Analysis of variance, means and Heterosis:

The analysis of variance for the combined analysis for the studied traits is presented in Table (1). Significant genotypes mean squares were detected for all the studied traits indicating the wide diversity between the parental materials used in this study. Significant genotypes by seasons interaction mean squares were detected for all traits except number of rows per ear, indicating that the tested genotypes varied from each other, and ranked differently from season to another. For the number of rows per ear, insignificant genotypes by season interaction mean squars were detected, revealing that the genotypes responded to seasonal change by nearly similar magnitude.

Significant inbred lines mean squares were showed in all traits except number of ears per plant and 100-kernel weight. Insignificant mean squares of interaction between parental inbred lines and seasons were detected for all traits except silking date, stem diameter and ear husk. This result may revealed the high repeatability of the parental inbred lines under different seasons. The mean performance of tested eight inbred lines as an average over two seasons are presented in (Table2).

The parental lines M.105g and M.106I behaved as the latest for tasseling and silking dates. Meanwhile, the parental inbred lines M.27 and M.101H behaved as the earliest inbreds.

The parental line M72. Had the highest mean value for ear husk, but without significant superiority over those of inbred lines M.27, M.70B and M.105g. However, the parental inbred line M.101H had the lowest one for this trait.

The parental inbred lines M.110B and M.101H gave the highest number of rows /ear. However, the inbred line M.36 had the lowest one for this trait. While, the parental inbred lines M.72 and M.36 gave the highest mean values for number of kernels/ row. However, the inbred line M.27 and M.106I expressed the lowest ones for this trait.

The parental inbred lines M.110B, M.72 and M.36 recorded heavier 100-kernel weight. However, both inbred lines M.27 and M.106I showed the lowest ones. Also, the parental inbred lines M7.12 and M.36 had the heighest mean values for ear length.

The parental inbred line M110B was the first of grain yield/plant and the inbred line M101H was the second one.

Hybrid mean squares were significant for all traits except number of rows/ ear, number of ears/ plant Table (1), revelaing over all differences between these hybrids. Significant interaction between F_1 hybrids and seasons were detected for all traits except number of rows/ ear, indicating that these hybrids behaved some what differently from season to another. For the exceptional traits, insignificant mean squares for interaction between hybrids and season was detected, revealing that the hybrids were suspected to environmental change by nearly similar magnitude.

Mean performance of parental inbred lines, their F_1 hybrids and check varieties SC.10, TWC310 and Giza 2 at the combined over both seasons are presented in Table (2). The crosses were earlier in flowering than parents, a favourable situation only if the goal is to develop early maturity hybrids to avoid damage by borers or other environmental adverse conditions. The parental combinations that incorporated earliness in silking and tasseling dates are plants of these F_1 hybrids M.101 Hx M.72, M,72 x M.27 and M.27x M.101H.

The highest values for stem diameter were detected in crosses M.72 x M.27 and M.110 B x M.72. The high value for stem diameter is the most important trait for lodging resistance in maize. The two crosses M.110 Bx M105g, M.110Bx M36, M.101Hx 106I as well as TWC 310, sc10 and Giza2 gave the highest ear diameter. The two hybrids M.101 H x M.106I and M.105g x M.36 had the highest number of ears/plant.

Twenty five hybrids gave the high mean values for number of rows/ ear. The highest number of rows/ear was recorded by cross M.27x M.101H.

The cross M.110B x M.105g had the highest number of kernels/row. Also, the three crosses M.110B x M.72, M.110B x M.106I, M.72x M.70B as well as the TWC310 gave high number of kernels/row.

Both crosses M.110B x M.36 and M.70B x M.105g gave the highest mean values for 100-kernel weight. For grain yield/plant the two crosses M110 BX M101H and M101Hx 106I had significant superiority over the check (Table 2). The fluctuation of hybrids from season to another were detected for most traits. These results would be due to significant of interaction between hybrids and season (Table1).

Heterosis:

Mean squares for parents vs. hybrids was significant for all traits except 100-kernel weight (Table 1). F_1 mean values were significantly higher than parental means for all traits.

Insignificant interaction mean squares between parents vs. crosses and season were detected for all traits except for ear diameter, tasseling date, silking date, ear husk and grain yield/ plant. This result indicated that the heterotic effects were not affected by seasonal changes. For the exceptional traits, significant interaction mean squares were detected for parents vs. crosses by season, revealing that the heterotic effects were affected by seasonal changes.

Heterosis of grain yield per plant expressed as the percentage deviation of F_1 mean performance from Giza 2, TWC 310 and SC10 in the combined analysis are presented in (Table 3).

Twenty five crosses significantly out. Yielded (heterotic effects) Giza2 and seventeen crosses significantly outyielded TWC310. The other crosses exhibited insignificant heterotic effect relative TWC310.

The hybrids significantly outyielded SC.10 are M.110B x M.101 H, M.101H x 105g and M.101 H x M.106I, Meanwhile, seventeen crosses had insignificant effects relative to SC. 10 that hybrid program based on these materials would be useful after testing under different locations and years. The three crosses outyielded the check SC.10 by 14.34 % over two seasons. It could be concluded that these crosses offer possibility for improving grain yield of maize. Many investigators reported high heterosis for yield in maize (Borov, 1966; El-Rouby and Galal, 1972; El-Hosary *et. Al.*, 1990; Abd-Sattar, 1992 and Motawea, 1997) .

Prediction of double cross yield:

Prediction of double cross yield helps the plant breeder to choose the best double cross in hybrids maize program. Mohamed (1984) and others reported good correlation between the prediction and the actual double cross yield. Results indicated that the best ten double crosses from 210 double cross were : (110B x 101 H) (106I x 105g), (110Bx 70B) (101H x 105g), (101Hx110B) (105g x 106I), (101H x 110B) (106I x 105g), (70B x 101 H) (105g x 110 B), (101 H x 110B) (70B x 106I), (101H x 110B) (106I x 27), (110 B x 110 H) (27 x 105g), (27 x 70 B) (105g x 110B). and (110 B x 36) (105g x 101 H). These double crosses gave 169.1, 162.64, 162.63, 161,69, 161,24, 160.17, 159.52, 157.05, 156,36 and 152.56 (g) grain yield / plant. However, SC10 and TWC 310 gave 151.94 and Giza 122.61 (g) of grain yield per plant.

Hence, it could be concluded that these previous double crosses offer a possibility for increasing grain yield of maize. The single cross gave the highest grain yield when the best hybrid for using as females in production of double crosses.

Combining ability:

The observed mean squares for combined data for the studied traits are shown in Table (4). The mean squares associated with GCA were significant for all the studied traits except number of ears/plant, number of kernels/row and ear diameter. The SCA variances were significant for all characters under study.

It is evident that nonadditive type of gene action was the more important part of the total genetic variability for number of ears / plant, number of kernels / row and ear diameter. For the other studied traits, both additive and nonadditive types of gene action were involved in determining the performance of single cross progeny. Also, when GCA/SCA ratio was used , it was found that the grain yield / plant, no. of rows per ear, ear length, tasseling date and ear husk exhibited low GCA/SCA ratios of less than unity, indicating the predominance of non aditive of gene effects for these traits. For 100-kernel weight, silking date and stem diameter, high GCA/SCA rotios which exceeded the unity were detected indicating that additive and additive x additive types of gene action were more important than non additive effects in controlling these traits. The genetic variance was previously reported to be mostly due to additive types of gene action for earliness by (Mohamed, 1979; Mohamed, 1984; Nawar and EL-Hosary, 1985; El-Hosary, 1988 (b); El-Hosary *et. Al.*, 1990 ; Abdel-Sattar, 1992 and Nawar *et. Al.,* 1995 a and b); no.of ears / plant by (Mohamed, 1989; El-Hosary, *et. Al.*, 1990 and Motawea, 1997) ear length (El-Hosary *et. Al.*, 19990); No. of kernels / row by (Mohamed, 1989 and El-Hosary., 1990), and grain yield/plant by (Salem *et. Al.*, 1986, and El-Hosary *et. Al.*, 1990).

The non additive genetic variance was previously reported to be most prevalent for earliness (El-Hosary, 1988a, and Reddy and Agrowal, 1992), ear height (Mohamed, 1984 and El-Hosary, 1985 and 1988a), ear husk. (El-Hosary, 1985), ear length and ear diameter (Hajkham, 1970), No of f rows /. ear and No. of kernels / row (El-Absawy, 1990), 100-kernel weight and grain yield / plant (Mohamed, 1979 and Surinder *et. Al.*, 1992).

The mean squares of interaction between season and GCA were significant for ear diameter, silking date and grain yield per plant, revealing that the magnitude of additive and additive x additive types of gene action varied from one season to another. For other traits, non significant interaction between GCA and season were dectected indicating that additive and additive x additive types of gene action were not influenced by the seasonal conditions.

The mean squares of interaction between season and SCA were significant for all traits under study except stem diameter, No. of rows/ear, No. of kernels / row and 100-kernel weight. Such results indicated that non additive effects influenced by seasonal changes (El-Hosary, 1985 and 1988a).

Estimates of GCA effect gi for individual parental inbred lines in each trait in the combined analysis are presented in (Table 5).

The parental inbred line M.106I gave significant negative gi effect for silking and tasseling dates indicating that this inbred line could be considered as good combiner for developing early genotype.

The parental line M.27 showed significant negative gi effects for tasseling and silking dates, indicating that this inbred line could be considered as good combiner for developing early genotypes. This inbred could be candidates for early maturing corn. While, the parental line M105g gave positive and significant gi effects indicating a sheer tendency towards delayed tasseling and silking dates.

The parental line M.36 seems to be best combiner for ear length. While, the parental line M.101 seems to be good combiner for No. of rows/ear.

The parental lines M.101H and M.110B had considerable significantly positive gi effects for grain yield / plant, and proved to be good combiners in this respect. While, inbred line M.36 appeared to be the poorest combiner for grain yield / plant. Significant correlation coefficients between the parental performance and its gi effects were obtained for no. of rows per ear, tasseling and silking dates, grain yield, stem diameter and ear husk (Table 5). This finding indicates that intrinsic performance of parental inbred lines gave a good index of their gi effects. For other cases, insignificant correlation coefficients were obtained between the two variables. It could be concluded that the non-additive type of gene action had the greatest role in the expression of these traits which are in complete agreement with the findings reached above in (Table 5).

Specific combining ability effects were obtained (Table 6). For tasseling date, six crosses exhibited significantly negative S_{ij} effects in the combined analysis. Also, seven crosses expressed significant negative S_{ij} effects for silking date. Also, the two crosses M.110B x M.106I and M.101H x M.36 gave the hightest desirable S_{ij} effects for tasseling and silking dates. Eight crosses expressed significant S_{ij} effects for stem diameter. The cross M.36 x M.106 I had the highest desirable S_{ij} effects.

With respect to ear husk, five crosses showed significant positive S_{ij} effects in the combined analysis. The two crosses M.110B x M.36 and M.27 x M.72 B had the highest desirable Sij effects in the combined analysis.

Eight hybrids exhibited significant S_{ij} effects for ear length. The both crosses M.110B x M.27 and M.101 H x M.105g had the highest desirable S_{ij} effects for ear length .

For number of ears per plant, four crosses expressed significant positive S_{ij} effects in the combined analysis. The two crosses M.110 B x M.101 H and M.101 H x M.106I had significant S_{ij} effects for this traits.

Eleven hybrids exhibited significant S_{ij} effects for no. of rows / ear. The crosses M.72 x M.36, M.70B x M.105g, M.70 B x 36 and M.36x M.106I gave the highest S_{ij} effects for no. of rows/ear in the combined analysis.

Table (1): Mean squares from ordinary analysis of variance for growth and yield characteristics in the combined analysis in the F_1 generation.

S.O.V	d.f	Tasseling date	Silking date	Stem diameter (cm)	No.of ears/ plant	Ear husk (cm)	Ear length (cm)	Ear diameter (cm)	No. of kernels/ row	No. of rows/ ear	Weight of 100 kernel (g)	Grain yield/ plant (g)
Seasonc(s)	1	1.55**	173146.2**	206.18**	52.28**	429.59**	12391**	636.82**	5197.5*	6057.48**	23180.90**	644173**
Rep/ S	4	4.15	3.37	4.72	0.02	2.12	3.30	0.12	45.52	7.35	101.22	29.81
Genotype	35	31.22**	36.30**	0.20**	0.09**	1.83**	32.78**	1.72**	84.30**	29.68**	33.50**	8225.2**
Parents (P)	7	10.31**	23.31**	8.14**	0.01	0.96	17.43**	0.05	59.16**	22.96**	21.79	1057.49**
C ross (F_1)	27	12.90**	10.56**	0.27**	0.07	1.94**	6.76*	0.76**	27.14*	2.61	37.55**	1574.57**
Pvs F_1	1	672.07**	472.28**	0.46	1.20**	4.88**	842.80**	40.69**	1803.65**	807.63**	6.07	237968*
Gxs	35	15.53**	12.84**	0.14**	0.05*	2.03**	7.95**	2.12**	22.79*	1.89	32.45**	707.74**
Pxs	7	2.14	9.19**	0.21**	0.01	0.99*	8.16	0.04	17.28	3.47	28.98	21.49
F_1 xs	27	9.04**	6.83**	0.13**	0.06*	1.56**	8.19**	0.75**	23.41*	1.44	33.10**	840.54**
Pvs F_1 xs	1	284.55**	200.62**	0.01	0.01	22.05**	0.07	53.52**	51.94	3.14	39.01	1925.84**
Error	140	3.53	1.94	0.09	0.02	0.38	4.21	0.36	14.98	1.80	15.73	187.62

* and** significant at 0.05 and 0.01levels of probaility, respectively.

Table (2) : Genotypes meanperformance for growth and yield characteristics in combined analysis

Genotype	Tasseling date	Silking date	Setem diameter (cm)	No.of ears/plant	Ear husk (cm)	Ear length cm	Ear diameter (cm)	No. of kernels/row	No. of rows/ear	Weightof 100kernels (g)	Grain yield/ plant(g)
110B	64.67 b-g	69.67 bc	2.32 a	1.0 f	2.52 h-j	12.35 f	3.03 f	32.05 g-j	12.01 f	26.28 a-f	93.01 m
72	65.83 b-d	69.0 cd	2.31 a	1.0 f	3.31 b-h	17.11 c d	3.22 d-f	34.13 e-j	7.90 h-I	26.46 a-f	4.75 n o
27	64.83 b-f	66.67 e-i	2.08 a	1.0 f	3.18 b-i	12.25 f	3.25 d-f	26.64 k	9.63 g	21.06 e-f	59.16 n o
101H	65.17 b-f	66.50 e-I	2.20 a	1.0 f	2.23 j	13.67 e-f	3.30 e-f	30.18 j-k	12.31 d-f	22.57 c-f	74.88 n
70B	65.83 b-d	67.0 df	2.13 a	1.0 f	3.22 b-h	13.34 f	3.25 d-f	31.25 h-k	8.33 g-i	23.80 b-f	59.75 n o
1059	68.67 a	71.67 a	2.06 a	1.03 e-f	3.29 b-h	13.35 f	3.19 d-f	30.75 I-k	7.69 h-i	23.85 b-f	58.91 no
36	66.17 b-c	70.0 a-c	2.15 a	1.04 e-f	3.12 c-j	15.99 d-f	3.26 d-f	35.42 b-j	7.12 i	25.05 a-f	54.59 o
106I	67.0 ba	71.17 a-b	2.37 a	1.07 d-f	2.81 e-j	14.17 e-f	3.18 d-f	26.37 k	9.05 g-h	22.40 c-f	52.96 o
110Bx72	59.33 I-n	62.33 e-I	2.44 a	1.17 b-f	3.30 b-h	19.43 a-c	4.20 a b	40.73 a b	14.23 a-c	21.15 e-f	147.89 c-I
x 27	62.0 h-k	66.67 e-k	2.37 a	1.23 b-f	2.83 d-j	19.65 a-c	3.97 a-d	39.13 a-f	14.60 a-c	24.75 a-f	165.21 b c
x101h	63.17 e-j	66.0 e-k	2.12 a	1.33 b	2.35 I-j	19.73 a-c	4.48 a b	39.08 a-f	14.88 a-b	23.25 c-f	172.35a b
x70B	61.67 h-m	66.0 e-k	2.20 a	1.13 b-f	3.70 b-d	19.10 a-c	3.70 b-f	39.73 a-d	12.87 c-f	27.4 a-b	148.82 c-I
x150g	63.50 d-i	66.67 e-I	2.32 a	1.110 e-f	3.55 b-f	19.77 a-c	4.63 a	42.27 a	14.0 a-f	26.08 a-f	156.52 b-f
x36	63.50 d-I	66.0 e-k	2.24 a	1.0 f	3.23 b-h	18.73 a-d	4.57 a	35.06 b-i	13.2 a-f	29.58 a	132.67 h-l
x106i	61.17 I-n	64.83 I-m	2.40 a	1.2 b-f	5.07 a	18.21 a-d	3.98 a-d	40.48 a-c	13.03 b-f	23.90 b-f	146.45 d-i
72 x 27	57-17 mn	63.67 I-o	2.19 a	1.2 b-f	3.65 b-f	17.87 a-d	4.57 a	35.68 b-i	14.5 a-c	23. 0 c-f	139.81 f-j
x101H	62.0 h-k	65.83 f-k	2.50 a	1.03 e-f	3.22 b-h	16.93 c-d	4.40 a	35.22 b-j	14.10 a-d	24.43 a-f	119.32 k-l
x70B	61.00 I-n	64-67 j-m	2.20 a	1.2 b-f	2.93 d-j	19.40 a-c	4.40 a b	40.57 a-c	14.27 a-c	22.78 c-f	141.58 f-j
x105g	61.67 h-m	65.50 g-l	2.39 a	1.2 b-f	3.87 bc	17.74 a-d	4.25 a b	35.20 b-j	14.13 a-d	21.0 e-f	145.44 da-i
x36	61.33 I-n	64.83 I-m	2.35 a	1.23 b-f	3.67 b-f	19025a-c	4.52 a b	37.14 a-g	13.82 a-f	28.0 a-c	132.23 I-l
x106i	63.33 k-n	66.83 e-h	2.34 a	1.3 b c	3.18 b-i	18.53 a-d	4.43 a b	36.15 b-h	13.5 a-f	19.98 f	116.79 i
27 x101H	60.0 k-n	63.50 m-o	2.38 a	1.10 e-f	4.0 b	18.83 a-d	4.52 a b	39.75 a-d	15.0 a	22.72 c-f	142.69 f-j
x70b	60.50 k-n	65.0 h-m	2.06 a	1.27 b-d	3.60 b-f	18.40 a-d	4.52 a b	38.20 a-f	14.43 a-c	23.35 b-f	142.12 f-j
x105g	60.33 k-n	65.0 h-m	2.35 a	1.23 b-f	3.47 b-g	18.80 a-d	4.40 a b	37.0 a-g	13.93 a-f	23.95 b-f	151.39 c-h
x36	61.17 I-n	64.33 k-n	2.22 a	1.20 b-f	3.37 b-g	20.23 a-b	3.28 c-f	39.2 a-f	13.53 a-f	21.55 d-f	130.67 i-l
x106i	62.33 f-k	66.17 e-k	2.17 a	1.13 b-f	3.30 b-h	18.18 a-d	4.13 a-b	39.0 a-f	13.92 a-f	23.99 b-f	137.61 j-k

Table (2) cont.:

Genotype	Tasseling date	Silking date	Setem diameter (cm)	No.of ears/plant	Ear husk (cm)	Ear length cm	Ear diameter (cm)	No. of kernels/row	No. of rows/ear	Weightof 100kernels (g)	Grain yield/ plant(g)
101 Hx70B	61.67 h-m	65.33 g-m	S2.18 a	1.13 b-f	3.0 c-j	17.65 b d	4.14 a b	36.8 a-g	14.38 a-c	26.39 a f	161.65 b-d
x1059	63.50 d-I	66.67 e-I	2.34 a	1.10 c-f	2.52 h j	20.07 a-b	4.55 a	39.25 a-f	13.43 a-f	26.35 a-f	163.72 b-d
x36	59.00 n	62.83 n o	2.23 a	1.13 b-f	3.57 b-f	18.48 a-d	4.12 a b	34.59 d-j	13.28 a-f	24.95 a-f	125.24 j-l
x106i	60.83 j-n	64.67 j-m	2.34 a	1.50 a	3.70 b-d	19.73 a-c	4. 60 a	38.5 a-f	15.03 a	21.30 a-f	183.7 6 a
70B1059	63.33 d-j	66.67 e-I	2.35 a	1.28 b c	4.03 b	17.88 a-d	4.21 a b	36.99 a-g	13.68 a-f	28.90 e-f	160.03 b-f
x36	61.83 h-i	65.17 h-m	2.21 a	1.13 b-f	2.87 d-j	20.23 a b	4.17 a b	36.3 b-h	13.93 a-f	27.10 a b	126.52 j-l
x106i	64.28 c-h	67.83 d-f	2.20 a	1.27 b d	2.63 g-j	16.07 d-f	3.23 c-f	38.72 a-f	12.17 e-f	24.42 a-d	140.86 f-j
1059x36	62.17 g-k	66.83 e-h	2.33 a	1.32 a b	2.73 f-j	20.67 a	4.57 a	37.92 a-f	14.12 a-d	24.42 a-f	156.12 b-g
x106i	64.17 c-h	67.17 e-g	2.20 a	1.07 d-f	2.98 d-j	18.53 a-d	4.58 a b	37.0 a-g	13.40 a-f	24.94 a-f	131.16 I-l
36 x106I	61.83 h-I	66.0 e-k	2.15 a	1.30 b c	2.67 g-j	18.07 a-d	4.07 a-c	33.70 f-j	14.0 a-f	21.15 e-f	129.83 I-l
Twc310	60.66 j-n	69.16 j-m	2.13 a	1.04 e f	2.88 d-j	23.74 a-d	7.70 a	40.64 a-d	12.0 e-f	26.96 a-f	122.61j-l
Sc.10	63.66 d-I	62.16 e-I	2.06 a	1.24 b c	3.46 b-j	20.43 a b	4.79 a	39.95 a-f	12.0 e-f	25.96 a-f	151.94 c-h
G2	62.16 g-k	65.83 h-m	2.11 a	1.0 f	2.70 f-j	16.73 d-f	4.71 a	33.16 e-g	12.28 d-f	27.95 a b	107.61 I m

Table (3) : Percentage of heterosis over check varieties Giza 2, T.W.C. 310 and SC.10 for grain yield in the combined analysis.

Genotype		SC.10	TWC.310	Giza 2
110B	X72	2.26	20.62**	30.98**
	X27	9.07	34.74**	46.32**
	X101h	13.78*	40.57**	52.64**
	X 70b	-1.75	21.38**	31.81**
	X1059	-3.33	27.66**	38.62**
	X 36	-12.41*	8.21	17.50*
	X 106i	-3.31	19.44**	29.71**
72	X 27	-7.70	14.03*	23.82**
	X 101 h	-21.12**	-2.63	5.68
	X 70b	-6.53	15.47*	25.39**
	X 1059	-3.98	18.62	28.81**
	X 36	-12.70*	7.85	17.11*
	X 106i	-22.90**	4.75	3.44
27	X 101h	-5.80	16.38**	26.38**
	X 70 b	-6.17	15.91*	25.87**
	X 1059	-0.05	33.47**	34.08**
	X 36	-13.75	6.58	15.14**
	X 106i	-9.15*	12.23	21.88**
101H	X 70b	6.72	31.84**	43.17**
	X 1059	8.12**	33.57**	45.05**
	X 36	-17.32**	2.15	10.92
	X 106i	21.13**	49.87**	62.75**
70B	X 1059	5.65	30.52**	41.73**
	X 36	-16.47**	3.19	12.05*
	X 106i	-7.02	14.89*	24.75**
1059	X 30	3.08	27.34**	38.28**
	X 106i	-13.41	6.97	16.16
36	X 106i	-14.29**	5.89	14.99*
	$\overline{X}$	151.47	122.61	112.91

* and ** Significant at 0.05 and 0.01 levels of probability, respecively.

Table (4) : Observed mean squares for general and specific combining ability for F_1 generation in the combined analysis.

S.O.V	d.f	Tasseling date	Silking date	Stem diameter Cm	No. of ears / plant	Ear husk (cm)	Ear length (cm)	Ear diameter	No. of kernels / row	No. of rows / ear	Weight of 100-kernels (g)	Grain yield / plant (g)
G.C.A	7	9.14*	11.26**	0.077**	0.008	0.29*	3.51	0.22	9.94	5.23**	14.72**	1081.46*
S.C.A	27	10.72*	8.14**	0.061**	0.034*	0.69**	12.78**	0.68**	32.64**	11.06**	10.28**	3156.63**
G.C.Ax Year	7	2.34	3.43**	0.003	0.012	0.14	1.35	0.26*	14.55**	0.40	22.07**	322.99**
S.Ca x Year	27	5.89*	4.49**	0.001	0.017*	0.81**	2.98*	0.82**	5.86	0.60	8.0	241.15**
Error	140	1.17	0.65	0.03	0.007	0.13	1.40	0.12	4.99	0.69	5.24	62.54
G.C.A/ SCA		0.85	1.38	1.20	—	0.42	0.28	—	—	0.47	1.43	34

*and ** significant at 0.05 and 0.01 levels of probability, respectively.
GCA and SCA : general and specific combining ability, respectively.

Table (5) : Estimates of general combining ability effects for inbred lines in the combined analysis.

Tarits (F_1) parents		Tasseling date	Silking date	Stem diameter	Ear husk	Ear length	No. of rows / ear	Weight of 100-kernels (g)	Grain yield / plant (g)
110 B	$\hat{g}_i$	- 0.08	0.15	0.01	-0.009	-0.35	0.50*	1.04	11.34**
	Mean	64.67	69.67	2.32	2.52	12.35	12.01	26.28	93.01
72	$\hat{g}_i$	- 0.50	-0.46*	0.04**	0.130	0.38	-0.15	-0.50	-6.91**
	Mean	65.83	69.00	2.31	3.31	14.11	7.90	26.46	64.75
27	$\hat{g}_i$	-0.94**	-0.86**	-0.07**	0.140	-0.32	0.33	-1.29	-1.38
	Mean	64.83	66.67	2.08	3.18	12.25	9.63	21.06	59.16
101H	$\hat{g}_i$	-0.40	-0.85**	-0.01	-0.24*	-0.07	0.89**	0.02	7.69**
	Mean	65.17	66.50	2.20	2.23	13.76	12.13	22.57	74.88
70 B	$\hat{g}_i$	0.15	-0.06	-0.09**	0.003	-0.42	-0.35	0.65	-0.06
	Mean	65.83	67.50	2.13	3.22	13.34	8.33	23.80	59.75
1059	$\hat{g}_i$	1.15**	1.15**	-0.02	0.06	0.05	-0.38	-0.26	4.06
	Mean	68.67	71.67	2.06	3.29	13.35	7.69	23.85	58.91
36	$\hat{g}_i$	-0.13	-0.03	0.04**	-0.08	0.80*	-0.57*	1.07	-9.92**
	Mean	66.17	70.00	2.15	3.21	15.99	7.12	25.05	54.59
106I	$\hat{g}_i$	0.75*	-0.95**	0.09**	0.00	-0.40	-0.27	-0.73	-4.93*
	Mean	67.00	71.17	2.73	2.81	14.17	9.05	22.49	52.96
L.S.D	0.05 ($\hat{g}_i-\hat{g}_j$)	1.18	0.71	0.04	0.32	1.06	0.69	2.04	7.04
L.S.D	0.01 ($\hat{g}_i-\hat{g}_j$)	1.57	0.95	0.05	0.42	1.41	0.92	2.71	9.37
	r.	0.868**	0.912 **	0.74*	0.765*	0.638	0.941**	0.617	0.795*

*and** significant at 0.05 and 0.01 levels of probability, respectively.
r : Correlation coefficient between parental mean performance and its GCA effects.

Table (6) : Estimates of specific combining ability effects for F_1 generation.

Traits / crosses		Tasseling date	Silking date	Stem diameter	No. of ears / pant	Ear husk	Ear length	Ear diameter	No. of kernels / row	No. of rows / ear	Weight of 100-kernels (g)	Grain yield / plant
110B	x 72	-2.81**	-3.61**	0.09*	0.04	-0.06	1.35	0.14	2.81	1.01	-3.65*	16.52*
	x 27	0.29	1.12	0.14**	0.11	-0.54	2.26*	0.06	1.98	0.90	0.75	28.31**
	x101 H	0.93	0.44	-0.17**	0.21*	-0.65*	2.09*	0.40	1.70	0.63	-2.06	26.38**
	x 70B	-1,12	-0.35	-0.01	-0.00	0.47	1.82	-0.14	1.73	-0.16	1.46	10.60
	x 105g	-0.29	-0.90	0.04	-0.02	0.26	2.01*	0.53	4.53*	1.01	1.04	14.18*
	x36	0.99	-.038	-0.10*	-0.13*	0.08	0.22	0.67*	-2.44	0.40	3.21	4.31
	x 106i	-2.22*	-2.53**	0.01	0.02	1.84**	0.90	0.09	3.76*	-0.07*	-0.66	13.10*
72	x 27	-2.12*	-1.26*	-0.07*	0.06	0.14	0.08	0.39	-0.30	1.45*	0.53	21.25**
	x 101 H	0.18	.089	0.18**	-0.11	0.09	-1.11	0.31	-1.00	0.49	0.66	-8.31
	x 70B	-1.37	-1.06	-0.04	0.05	-0.44	1.71	0.39	3.72*	1.89**	-1.63	21.69**
	x105g	-1.71	-1.45	0.08*	0.05	0.44	-0.42	0.13	-1.38	1.79**	-2.47	21.44**
	x 36	-0.76	-0.93	-0.02	0.09	0.38	0.34	0.20	0.80	1.67**	3.23	22.21**
	x106i	0.37	0.09	-0.08*	0.10	-0.18	0.82	0.46	0.60	1.05	-3.05	1.78
27	x 101 H	-1.39	-1.05	0.17**	-0.04	0.86**	1.48	0.34	4.30*	0.91	-0.27	9.54
	x 70B	-1.44	-0.33	-0.06	0.11	0.22	1.40	0.66**	2.13	1.57*	-0.27	16.71**
	x105g	-2.61*	-1.55	0.15**	0.08	0.03	1.33	0.28	1.20	1.11	1.24	21.86**
	x 36	-0.49	-1.03	-0.05	0.05	0.07	2.01*	-0.62	3.64*	0.90	-2.49	15.12*
	x 106i	-0.20	-0.18	-0.014**	-0.07	-0.08	1.16	0.27	4.22*	0.98	1.75	17. 06**
101 H	x 70 B	-0.80	-0.01	-0.01	-0.02	-0.01	0.40	0.11	0.50	0.96	1.47	27.17**
	x 105g	0.03	0.10	0.09*	-0.05	-0.55	2.35*	0.25	3.22	0.05	2.33	25.17**
	x 36	-3.19**	-2.55**	-0.09**	-0.02	0.64**	0.01	0.04	-1.21	0.09	-0.09	0.62
	x 106I	-2.23*	-1.70**	-0.03	0.30**	0.70*	2.46*	0.52	3.49	1.55*	1.41	54.15**
70B	x 105g	-0.69	-0.68	0.17**	0.13*	0.73*	0.51	0.16	0.33	1.53*	-3.36	29.18**
	x 36	-0.90	-0.99	-0.03	-0.02	-0.30	2.11*	0.33	-0.13	1.98**	2.92	9.64
36	x106i	0.66	0.69	-0.09**	0.06	-0.61*	-0.85	-0.50	3.08	-0.09	2.93	18.99**
1059	x 36	-1.57	-0.55	0.02	0.18**	-0.48	2.08*	0.47	1.76	2.19**	-0.66	35.13**
	x 106i	-0.45	-1.20	-0.16**	-0.14	-0.31	1.14	0.43	1.64	1.18**	1.67	5.17
36	x106i	1.50	-1.18	0.72**	0.10	-0.49	-0.07	0.18	-1.43	1.97**	-3.44	17.83**
L.S.D 0.05 (sij-sik)		2.89	2.15	0.12	0.22	0.95	3.16	0.92	5.96	2.07	6.11	21.11
L.S.D 0.05 (sij-sik)		3.86	2.86	0.16	0.30	1.27	4.21	1.22	7.94	2.76	8.14	28.11
L.S.D. 0.01 (sij-sik)		2.73	2.02	0.11	0.21	0.90	2.98	0.87	5.62	1.95	5.76	19.91
L.S.D 0.01 (sij-sik)		3.64	2.69	0.15	0.28	1.20	3.97	1.15	7.49	2.60	7.67	26.51

Six crosses expressed significant positive S_{ij} effects for no. of kernels /row and the highest desirable S_{ij} effects in the combined analysis.

Regarding grain yield / plant, twenty parental combinations showed significantly positive S_{ij} effects. In conclusion, the best combinations were : M.110B x M.27, M.110B x M.101H, M.72 x M.27, M.27 x M.70 B, M.101 H x M.70 B, M.101 H x M.105g, M.101 H x M.106I, M.70B x M.105g, M.105g x M.36 and M.36 x M.106I, where, it had significant positive S_{ij} effects for grain yield / plant as well as most of the yield components.

In these crosses showing high SCA involving only one good combiner, such combinations would show with desirable transgressive segregates, providing that the additive genetic system present in the good combiner as well as the complementary and epistatic effect present in cross, act in the same direction to reduce undesirable plant characters and maximize the character in view. Therefore, the previous crosses might be of prime importance in breeding programe for traditional breeding procedures.

In most traits, the values of S_{ij} effect were mostly differed from season to another. This finding coincide with that reached above where significant SCA by season mean squares were detected (Table 4).

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