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Heterosis and Combining Abilities for Certain Maize Inbreds and their F_1 Crosses Relating to Quality Traits, Yield, and Its Components

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Cross Mark

ABSTRACT

A half-diallel cross among five yellow maize inbred lines was made in 2019 summer season, at the Experimental Farm of Agronomy Department, Faculty of Agriculture, Mansoura University, El-Dakahlia Governorate, to investigate heterosis and combining ability to choose the best parental inbred lines for developing high yielding new yellow single crosses and producing better hybrids. In most cases, the mean squares of the genotypes, parents, crosses, and parents' vs crosses were significant or very significant for the quality attributes, yield components, and yield. The variances in grain yield/plant between the parents and their crosses were very considerable. For every analyzed grain yield, yield component, and quality attribute, the GCA and SCA mean squares were significant or extremely significant, demonstrating that both additive and non-additive types of gene effects were involved in the inheritance of these traits. The ratio of GCA/SCA was less than unity for all studied traits, flashing that the non-additive genetic effects were more important and played the major role in the inheritance of all studied traits. The most excellent general combiners were P3 (Inb. 69) and P5 (Inb. 309) for Kernels No./row and grain yield/plant. The greatest cross combinations were eight crosses for grain yield/plant. Nine single crosses manifested positive and highly significant heterosis over mid and better parents (ranged from 193.95% for cross P_4 X P_5 to 865.36% for cross P_1 X P_4 over mid parent and from 115.70% for cross P_4 x P_5 to 686.13% for cross P_2 x P_4 over better parent) for grain yield/plant.

Keywords: Maize, diallel, combining ability, heterosis, grain yield, yield components.

INTRODUCTION

Among the grains, maize holds a unique position in human nutrition, animal husbandry, and industrial applications (Keskin *et al.*, 2005). The most expensive and time-consuming stage in the production of maize hybrids is identifying parental inbred lines that produce better hybrids. Grain yield performance of maize hybrids is not predicted by the performance of inbred lines of maize (Hallauer and Miranda, 1981). Combining ability analyses are commonly employed in maize breeding programs to provide GCA and SCA information from maize populations for genetic diversity evaluation, inbred line selection, heterotic pattern classification, heterosis calculation, and hybrid production (Fan *et al.*, 2002; Melani and Carena, 2005; Barata and Carena, 2006). Heterosis was first used in the United States in 1933, when heterosis maize hybrids were planted on only 1% of all agricultural land. By 1953, however, the percentage of heterosis maize hybrids had increased to 96% (Sprague, 1962). Based on the aforementioned data, the most effective breeding programme may be selected (Liao 1989, Pal and Prodham 1994). Important markers of potential usefulness for inbred lines in hybrid combinations are the impacts of general combing ability (GCA) and specific combing ability (SCA). While non-additive genetic variation has been linked to differences in SCA effects, additive, additive x additive, and higher-order interactions of additive genetic effects in the base population have been implicated in differences in GCA effects (Falconer, 1981). In genetic research, parallel crossings have been used to find superior parents for hybrid or cultivar production as well as to determine the inheritance of a characteristic among a range of genotypes (Yan and Kang, 2003). According to Kanchao *et al.* (2020), compared to GCA, heterosis had a stronger and more positive correlation with SCA, indicating that SCA can be utilized to predict heterosis and produce possible hybrids in commercial maize breeding. Large collections of parental lines with genotypic data available can be shared and used in hybrid breeding programs worldwide by employing an open-source breeding method. Based on their analysis, Habiba *et al.* (2022) determined that the majority of the lines under study had very general combiners, and those superior crosses resulted from having an excellent × good combiner for the majority of yield component characteristics. According to Kamal *et al.* (2023), while SCA variations were greater than GCA variants for grain yield, plant height, cob height, number of grains per row, cob girth, and cob length, additive gene action was found to be more significant for the number of days to 50% silking and tasseling. These findings highlight the significant role of non-additive genes in the inheritance of these traits. In order to find superior single-cross hybrids that were created from the new maize inbred lines under investigation, our research's main objectives were to ascertain the heterosis and combining ability for yield and its components as well as grain quality characteristics in maize inbred lines and their F1 crosses.

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MATERIALS AND METHODS

The current study examines the differences in performance between a few experimental inbred lines of maize and their F1 single crosses, which were created by crossing various inbred lines developed by ARC. It also looks at the variability between five inbred lines of maize (*Zea mays*, L.) and their crosses, estimates the effects of combining ability for five inbred lines, identifies the type of gene action controlling the inheritance for studied traits, and identifies superior crosses and its parental inbred lines.

Five inbred strains of maize with varying genetic backgrounds were employed as genetic resources in this investigation. Table 1 lists the paternal inbred lineages' sources.

Table 1. Parental inbred lines for maize, along with their names and origins.

NO.	Names	Color of grains	Sources
P1	Inb. 27	Yellow	Regionally advanced, ARC, Egypt
P2	Inb. 48	Yellow	Regionally advanced, ARC, Egypt
P3	Inb. 69	Yellow	Regionally advanced, ARC, Egypt
P4	Inb. 103	Yellow	Regionally advanced, ARC, Egypt
P5	Inb. 309	Yellow	Regionally advanced, ARC, Egypt

Using a half-diallel crosses mating design, 10 single crosses were produced by crossing the five parental inbred lines of maize in all feasible combinations, with the exception of reciprocals, during the 2019 growing season.

Through the 2020 growing season, the parents, ten F1 single crossings, and three checks (SC 168, SC 3084, and SC 3444) were assessed. Three replications were included in the Randomised Complete Blocks Design (RCBD) experiment setup. The area measured three meters in length and seventy centimeters in width. The Experimental Farm of the Agronomy Department, Faculty of Agriculture, Mansoura University, El-Dakahlia Governorate was the site of the 2019 and 2020 growing season experiments.

In the 2019 and 2020 growing seasons, maize seed was manually seeded on May 15 and June 1, respectively. Each hill had two grains sowed with a distance of 25 cm. Following seedling emergence, hills were trimmed to ensure one plant per hill. The experiment was twice hoed before to the initial and subsequent watering. When preparing the seedbed, 200 kg/feddan of phosphorus in the form of calcium superphosphate (15.5% P_2O_5) was added to the soil. After thinning, 50 kg/fed of potassium sulphate (48% K_2O) was applied. Additionally, before the 1st and 2nd irrigations, nitrogen was given in the form of urea (46.5% N) at a rate of 120 kg N/fed in two equal split doses. It is suggested that other approaches be implemented in agriculture.

The measures that were taken included ear length (cm), ear diameter (cm), cob diameter (cm), kernel depth (cm), number of rows/ear, number of kernels/row, 100-kernel weight (g), grain yield per plant (g), cob weight/plant (g), shelling percentage, crude protein percentage, and oil percentage.

Statistical analyses:

Analysis of variance:

Plot mean analysis was used to analyse the data. In accordance with Snedecor and Cochran (1980), all collected data were statistically analysed using the randomised complete block design to look for differences across different genotypes. According to Gomez and Gomez (1984), treatments were compared using the least differences values (LSD) at the 5% and 1% level of probability.

Diallel analysis:

1-Estimation of combining ability:

In order to evaluate the general (GCA) and specific (SCA) combining abilities of the data, Griffing (1956) method 2 model 1 was employed for analysis. There was a firm belief about the parents. This is how the relative weights of GCA and SCA were expressed:

$$K^2_{GCA} / k^2_{SCA} = \frac{MS_{GCA} - MS_e / P + 2}{MS_{SCA} - MS_e}$$

Where:

MS: Mean squares, P: No. of parents, and K^2 = is the average squares of the effects

The analysis of variance for each trait is presented in Table 2.

Table 2. Analysis of variance for combining ability.

S.O.V	D.F.	SS	M.S	E.M.S
GCA	(p-1)	Sg	Mg	$\sigma^2 e + (P+2)/(1/P-1)\sum gi^2$
SCA	p(p-1) / 2	Ss	Ms	$\sigma^2 e + 2/(P/P-1)\sum i \sum j\ S^2 ij$
Error	(c-1)(r-1)	Se	Me	$\sigma^2 e$

Where, Me: The error mean squares of the main randomized complete block design divided by number of replications (Me = Me/r).
p: Number of parents

2-Estimation of Heterosis:

According to Mather and Jinks (1982), heterosis was calculated for each cross as the percentage divergence of the F1 means from the means of the check variety, mid-parents (MP), and better parent (BP). The results were reported as percentages as follows:

1-Heterosis over the mid-parents % ($\overline{MP}$) = [($\bar{F}_1$ – $\overline{MP}$)/ $\overline{MP}$] x 100

2-Heterosis over the better-parent % ($\overline{BP}$) = [($\bar{F}_1$ – $\overline{BP}$) / $\overline{BP}$]x 100

3- Heterosis over the check-variety % ($\overline{CV}$) = [($\bar{F}_1$ – $\overline{CV}$) / $\overline{CV}$] x 100

Where:

F1 is the first generation's mean value, $\overline{MP}$ is the mid parent's mean determined by averaging the means of the two parents, $\overline{BP}$ is the better parent's mean value, and $\overline{CV}$ is the better check variety's mean value.

Using the following formula, the importance of the heterosis effect for F1 values from the better and mid-parents was examined:

$$\textbf{LSD for mid-parents heterosis} = t_{0.05} \times (3MS_e/2r)^{1/2}$$

$$\textbf{LSD for better parent or check variety heterosis} = t_{0.05} \times (2MS_e/r)^{1/2}$$

Where:

t: Tabulated (t) value at a stated level of probability for the experimental error degree of freedom,

MS_e: Mean squares of the experimental error from the analysis of variance, and r: Number of replicates

RESULTS AND DISCUSSION

1-Analysis of variance:

Table 3 displays the analysis of variances for grain-yield, yield-attributes, and quality traits. The findings made it abundantly evident that, for every analyzed yield, yield components, and quality characteristic, the variances of genotypes, parents, crosses, and parents vs crosses were significant or extremely significant, except each of; genotypes for rows No./ear trait, parents for ear length, rows No./ear and protein % traits, crosses for ear length, ear diameter, cob diameter, kernel depth and rows No./ear traits, and parents and crosses for rows No./ear trait. These results are in accordance with those reported by Chaudhary *et al.* (2000), Abd El-Aty and Katta (2002), Nawar *et al.* (2002), Barakat *et al.* (2003), Gautam (2003), Singh (2005) and Machado *et al.* (2009), Habiba *et al.* (2022) and Kamal *et al.* (2023).

Table 3. Mean squares for the examined yield, yield components, and grain quality variables for the 2020 season for maize genotypes, parents, crossings, and parents vs crosses.

S.O.V	DF	Ear length, cm	Ear dimeter, cm	Cob diameter, cm	Kernel depth, cm	Rows No./ear	Kernels No./row
Replications	2	8.02*	0.14	0.05	0.01	2.76	27.02
Genotypes	14	25.84**	0.99**	0.25**	0.11**	5.28	243.71**
Parents	4	2.73	0.33*	0.27**	0.11*	3.90	123.33**
Crosses	9	4.55	0.18	0.05	0.02	6.46	76.50**
P V Cross	1	309.88**	10.99**	2.04**	0.89**	0.18	2230.04**
Error	28	2.33	0.11	0.05	0.03	2.92	16.83
TOTAL	44	10.07	0.39	0.12	0.06	3.66	89.48

Table 3. Continued

S.O.V	DF	Grain yield/plant, g	Cob weight, g	Shelling %	Oil %	Protein %
Replications	2	7.62**	8.867	2.22	0.00	0.05
Genotypes	14	109204.50**	1850.476**	896.03**	5.67**	0.88**
Parents	4	1512.00**	765.500**	103.78**	1.70**	0.09
Crosses	9	72594.61**	1698.019**	883.56**	7.62**	0.95**
P V Cross	1	869463.51**	7562.500**	4177.26**	4.10**	3.40**
Error	28	1.07	20.557	2.98	0.03	0.06
TOTAL	44	34747.92	602.273	287.10	1.82	0.32

2. Parental mean performance and its F1 crosses:

Results in Table 4 showed that the highest values of ear length were recorded by P1 (17.00 cm) followed by P5 (16.00 cm), and the highest values of ear length for crosses were recorded by P3 x P4 (23.00 cm), P2 x P3 (22.67 cm) and P1 x P4 (22.00 cm) without significant differences among them.

For ear diameter, the highest values were recorded by P5 (3.95 cm) followed by P4 (3.79 cm), without significant differences between them, and the highest values for crosses were recorded by P3 x P5 (4.93 cm), followed by P2 x P4 (4.85 cm), and P1 x P5 (4.77 cm), without any notable distinctions between them. The highest values of cob diameter were recorded by P1 (2.42 cm) followed by P4 (2.28 cm) and P5 (2.18 cm), having notable variations between them. Regarding to crosses, the greatest values of cob diameter were documented by P1 x P4 (2.71 cm), P2 x P4 (2.69 cm) and P3 x P5 (2.66 cm) without significant differences among them, as shown in Table 4.

Kernel depth ranged between 0.46 cm for inbred parent P1 (Inb. 27) to 0.92 cm for P3 (Inb. 69). The maximum values of Kernel depth were recorded by P3 (0.92 cm) followed by P5 (0.88 cm), without significant differences between them. Regarding to crosses, kernel depth ranged between 0.88 cm to 1.14 cm. The greatest values of kernel depth were 1.14, 1.09, 1.08 and 1.07 cm and documented by P3 x P5, P1 x P5, P2 x P4 and P2 x P5, respectively, without significant differences among them, as shown in Table 4.

Data in Table 4 shows that the differences between rows No./ear for parents and crosses were highly significant. For inbred parents, rows No./ear ranged between 14.00 rows/ear for inbred parent P2 (Inb. 48) to 17.00 rows/ear for P3 (Inb. 69). The maximum values of rows No./ear were recorded by P3 (17.00 rows/ear) followed by P1 (16.00 rows/ear) and P5 (16.00 rows/ear), with significant differences between them. Regarding to F1 crosses, rows No./ear ranged between 13.33 to 18.00 rows/ear. The greatest values of rows No./ear were 18.00 and 17.33 rows/ear and documented by P1 x P2 and P2 x P5, correspondingly, with no appreciable variations amongst them.

Kernels No./row ranged between 20.67 kernels/row for inbred parent P4 (Inb. 103) to 36.00 kernels/row for P5 (Inb. 309). The maximum values of kernels No./row were recorded by P5 (36.00 kernels/row) followed by P1 (26.67 kernels/row), with significant differences between them. Regarding to F1 crosses, kernels No./row ranged between 36.00 to 50.67 kernels/row. The greatest values of kernels No./row were 50.67, 47.33 and 42.67 kernels/row and documented by P2 x P3, P3 x P4 and P1 x P3, respectively, with significant differences among them (Table 4).

There were notable differences in the grain yield per plant between the parents' and their crosses' yields. For inbred parents, grain yield/plant ranged between 43.67 g for inbred parent P2 (Inb. 48) to 97.67 g for P5 (Inb. 309). The maximum values of grain yield/plant were recorded by P5 (97.67 g/plant) followed by P1 (73.67 g/plant) and P3 (72.67 g/pant), with significant differences among them. Regarding to F1 crosses, grain yield/plant ranged between 44.67 and 576.00 g/plant, and the greatest values of grain yield/plant were 576.00, 526.00 and 447.33 g/plant for crosses P1 x P4, P2 x P5 and P3 x P5, respectively, with significant differences among them, and surpassed significantly over the two commercial chick cultivars SC. 3084 (384.00 g/plant) and SC. 3444 (383.00 g/plant), as presented in Table 4.

The maximum values of cob weight were recorded by P_5 (67.67 g) followed by P_3 (57.67 g) and P2 (41.33 g/pant), with significant differences among them. Also, the greatest values of cob weight were 116.67 and 100.67 g for crosses P_1 x P_4 and P_1 x P_2, respectively, with significant differences between them, and surpassed significantly over the three commercial chick cultivars SC. 168 (95.67 g), SC. 3084 (77.67 g), and SC. 3444 (73.33 g). The highest percentages of shelling % were recorded by P1 (66.97 %) followed by P4 (61.44 %) and P5 (59.52 %), with significant differences among them. Regarding to F_1 crosses the greatest values of shelling % were 86.93, 85.85, 85.82, 85.32 and 85.12 % for crosses P_2 x P_4, P_2 x P_5, P_2 x P_3, P_3 x P_4 and P1 x P5, respectively, with significant differences among them, and surpassed significantly over the two commercial chick cultivars SC. 3084 (83.18 %) and SC. 3444 (83.93 %), as shown in Table 4.

For inbred parents, data in Table 4 showed that the maximum values of oil % were recorded by P2 (6.97 %) followed by P3 (5.60 %) and P4 (5.43 %), with significant differences among them. Regarding to F_1 crosses, the greatest values of oil % were 9.83, 7.00 and 6.83 % for crosses P_2 x P_3, P_2 x P_5 and P_1 x P_5, respectively, with significant distinctions amongst them, and surpassed significantly over the two commercial chick cultivars SC. 168 (6.00 %) and SC. 3444 (6.40 %).

For inbred parents, results in Table 4 showed that protein % ranged between 11.64 % for inbred parent P2 (Inb. 48) and 12.07 % for P3 (Inb. 69). Regarding to F1 crosses, protein % ranged between 11.53 % and 13.61 %. The greatest values of protein % were 13.61, 12.83, 12.65 and 12.63 % for crosses P4 x P5, P2 x P4, P1 x P5 and P2 x P5, respectively, with significant variations including them, and surpassed significantly over the three commercial chick cultivars SC. 168 (10.66 %) and SC. 3444 (10.80 %) and SC. 3084 (11.24 %).

Table 4. Mean performance of five parental maize inbred lines and their F_1 crosses and three commercial single crosses for all studied yield and yield components and quality traits.

Trait Genotype	Ear length, cm	Ear diameter, cm	Cob diameter, cm	Kernel depth, cm	Rows No./ear	Kernels No./row
P1 (Inb. 27)	17.00	3.34	2.42	0.46	16.00	26.67
P2 (Inb. 48)	14.33	3.13	1.92	0.61	14.00	21.33
P3 (Inb. 69)	15.67	3.50	1.67	0.92	17.00	22.00
P4 (Inb. 103)	15.67	3.79	2.28	0.75	15.00	20.67
P5 (Inb. 309)	16.00	3.95	2.18	0.88	16.00	36.00
LSD 5%	0.81	0.18	0.12	0.09	0.90	2.17
LSD 1%	1.09	0.24	0.16	0.12	1.22	2.93
P1 x P2	21.33	4.44	2.46	0.99	18.00	38.00
P1 x P3	21.67	4.34	2.33	1.00	13.33	42.67
P1 x P4	22.00	4.69	2.71	0.99	16.00	39.33
P1 x P5	19.67	4.77	2.60	1.09	16.00	36.00
P2 x P3	22.67	4.17	2.40	0.88	14.00	50.67
P2 x P4	19.67	4.85	2.69	1.08	14.67	38.00
P2 x P5	19.67	4.67	2.54	1.07	17.33	36.00
P3 x P4	23.00	4.39	2.46	0.97	14.67	47.33
P3 x P5	21.67	4.93	2.66	1.14	14.67	36.67
P4 x P5	21.67	4.65	2.61	1.02	16.00	38.00
LSD 5%	1.14	0.25	0.17	0.13	1.28	3.07
LSD 1%	1.54	0.33	0.23	0.17	1.72	4.14
SC. 168	23.67	5.06	2.88	1.09	18.00	47.33
SC. 3084	24.67	4.86	2.49	1.19	15.33	44.00
SC. 3444	22.33	4.82	2.46	1.18	14.67	40.00

Table 4. continued

Trait Genotype	Grain yield/ plant, g	Cob weight, g	Shelling %	Oil %	Protein %
P1 (Inb. 27)	73.67	36.33	66.97	5.40	11.86
P2 (Inb. 48)	43.67	41.33	51.38	6.97	11.64
P3 (Inb. 69)	72.67	57.67	55.75	5.60	12.07
P4 (Inb. 103)	45.67	28.67	61.44	5.43	11.72
P5 (Inb. 309)	97.67	67.67	59.52	5.00	11.95
LSD 5%	0.55	2.40	0.91	0.09	0.13
LSD 1%	0.74	3.23	1.23	0.12	0.17
P1 x P2	44.67	100.67	30.73	4.60	12.19
P1 x P3	430.67	80.67	84.22	6.00	11.53
P1 x P4	576.00	116.67	83.16	6.40	11.97
P1 x P5	301.33	52.67	85.12	6.83	12.65
P2 x P3	413.67	68.33	85.82	9.83	12.08
P2 x P4	359.00	54.00	86.93	6.87	12.83
P2 x P5	526.00	86.67	85.85	7.00	12.63
P3 x P4	306.00	52.67	85.32	6.50	12.32
P3 x P5	447.33	82.67	84.40	5.00	12.52
P4 x P5	210.67	43.33	82.94	4.17	13.61
LSD 5%	0.77	3.39	1.29	0.13	0.18
LSD 1%	1.04	4.57	1.74	0.17	0.25
SC. 168	739.67	95.67	88.55	6.00	10.66
SC. 3084	384.00	77.67	83.18	7.33	11.24
SC. 3444	383.00	73.33	83.93	6.40	10.80

Combining ability analysis:

Both general and specific combining abilities are long-standing concepts. For an extended period, general combining ability has been identified as the comparative effectiveness of individuals within a comparable set of organisms when they are crossed with a heterogeneous tester. When the phrase "specific combining ability" first appeared in the context of plant breeding, it meant how well the progeny of a given cross performed in comparison to other comparable crossings. It was stated that the excellence or inferiority of the cross resulted from strong or low specific combining capacity, and that a particular parental combination was particularly desired or undesirable.

Table 5's results demonstrated that for every grain yield, yield components, and quality characteristics under study, variances in combining abilities, both general (GCA) and specialized (SCA), were either extremely substantial or considerable. These findings suggested that the inheritance of these qualities was influenced by both additive and non-additive forms of gene effects.

For all analysed maize grain yield, yield component, and quality attribute, the ratio of GCA/SCA (baker ratio) was less than unity. These findings suggest that non-additive genetic influences were more significant and were primarily responsible for the inheritance of all characteristics under investigation. Similar results were obtained by Singh (2005), Machado *et al.* (2009), Habiba *et al.* (2022) and Kamal *et al.* (2023)

Table 5. The mean squares of the combining abilities, both general and particular (GCA and SCA), as well as the GCA/SCA ratio, for all investigated maize grain yield, yield components, and quality parameters

S.O.V	DF	Ear length	Ear dimeter cm	Cob diameter	Kernel depth cm	Rows no./ear	Kernels no./row
gca	4	1.58	0.16**	0.09**	0.03	0.84	8.81
sca	10	11.43**	0.40**	0.08**	0.04**	2.13	110.21**
Error	28	0.78	0.04	0.02	0.01	0.97	5.61
GCA/SCA	-	0.22	0.44	0.68	0.59	0.44	0.14

Table 5. Continued

S.O.V	Df	Grain yield/plant g	Cob weight g	Shelling %	Oil %	Protein %
gca	4	2384.67**	202.13**	128.82**	1.98**	0.24**
sca	10	50008.23**	782.70**	366.62**	1.85**	0.31**
Error	28	0.36	6.85	0.99	0.01	0.02
GCA/SCA	-	0.09	0.34	0.41	0.68	0.61

Effects of general combining abilities (gi):

High positive GCA impacts would be beneficial from a breeder's perspective and of interest for all qualities tested. Table 6's GCA impacts results for the anthesis date demonstrate that the best general combiners were: inbred lines P3 (Inb. 69), P1 (Inb. 27) and P4 (Inb. 103) for ear length; P5 (Inb. 309) for thickness of ears; P4 (Inb. 103) for thickness of cobs; P5 (Inb. 309) for kernel depth; P5 (Inb. 309) and P1 (Inb. 27) for rows number per ear; P3 (Inb. 69) and P5 (Inb. 309) for kernels No./row and grain yield/plant; P1 (Inb. 27) for cob weight; P3 (Inb. 69), P4 (Inb. 103) and P5 (Inb. 309) for shelling %; P2 (Inb. 48) and P3 (Inb. 69) for oil %; and P5 (Inb. 309) and P4 (Inb. 103) for protein %, wherever they exhibited substantial or extremely meaningful and positively GCA impacts for these traits. Comparable findings were reporting by Sadek *et al.* (2000); Gautam (2003); Surya and Ganguli (2004); Singh (2005); Rakesh *et al.* (2006); EL-Shenawy *et al.* (2009); Sultan (2010); Sultan *et al.* (2011); Habiba *et al.* (2022) and Kamal *et al.* (2023).

Table 6. General combining ability (gca) effects of all the parental maize inbred lines for yield, yield components and quality traits.

Trait Parent	Ear length	Ear diameter, cm	Cob diameter, cm	Kernel depth, cm	Rows No./ear	Kernels No./row
P1 (Inb. 27)	0.29	-0.08	0.08	-0.08*	0.32	-0.34
P2 (Inb. 48)	-0.67*	-0.15*	-0.06	-0.04	-0.15	-0.91
P3 (Inb. 69)	0.52	-0.09	-0.17**	0.04	-0.34	1.37
P4 (Inb. 103)	0.14	0.10	0.09*	0.00	-0.25	-1.10
P5 (Inb. 309)	-0.29	0.21**	0.06	0.08*	0.42	0.99
LSD gi 5%	0.61	0.13	0.09	0.07	0.68	1.64
LSD gi 1%	0.82	0.18	0.12	0.10	0.92	2.21
LSD gi-gj 5%	1.58	0.34	0.23	0.19	1.76	4.24
LSD gi-gj 1%	2.13	0.46	0.31	0.25	2.38	5.71

Table 6. Continued.

Trait Parent	Grain yield/ plant, g	Cob weight, g	Shelling %	Oil %	Protein %
P1 (Inb. 27)	-11.35**	5.05**	-2.66**	-0.29**	-0.19**
P2 (Inb. 48)	-21.26**	0.62	-6.25**	0.80**	-0.06
P3 (Inb. 69)	23.36**	1.67	2.21**	0.27**	-0.12*
P4 (Inb. 103)	-5.21**	-9.14**	3.63**	-0.26**	0.11*
P5 (Inb. 309)	14.46**	1.81	3.08**	-0.52**	0.27**
LSD gi 5%	0.41	1.81	0.69	0.07	0.10
LSD gi 1%	0.56	2.45	0.93	0.09	0.13
LSD gi-gj 5%	1.07	4.68	1.78	0.18	0.25
LSD gi-gj 1%	1.44	6.31	2.40	0.24	0.33

The effects of specific combining ability (S_{ij}):

For every characteristic under study, the crosses with the highest positive SCA effects were the most desired. Results in Table 7 showed that the best cross combinations - out of 10 studied crosses- were: seven crosses for ear length; six crosses namely P1 X P2, P1 X P4, P1 X P5, P2 X P4, P2 X P5 and P3 X P5 for ear diameter; three crosses namely P2 X P3, P2 X P4 and P3 X P5 for cob diameter; three crosses namely P1 X P2, P1 X P5 and P2 X P4 for kernel depth; two crosses namely P1 X P2 and P2 X P5 for rows No./ear; six crosses, namely P1 X P2, P1 X P3, P1 X P4, P2 X P3, P2 X P4 and P3 X P4 for kernels No./row; all studied crosses, except two crosses (P1 x P2 and P4 x P5), for grain yield/plant; five crosses namely P1 X P2, P1 X P3, P1 X P4, P2 X P5 and P3 X P5 for cob weight; all studied crosses, except the first cross P1 x P2, for shelling %; six crosses namely P1 X P4, P1 X P5, P2 X P3, P2 X P4, P2 X P5 and P3 X P4 for oil %; and four crosses namely P1 X P2, P1 X P5, P2 X P4 and P4 X P5 for protein %. Welcker *et al.* (2005), Muraya *et al*. (2006), Amaregouda and Kajidoni (2007), Aliu (2008), Fan *et al.* (2009), Sultan (2010), Sultan *et al.* (2011), Habiba *et al*. (2022) and Kamal *et al*. (2023) all achieved similar findings.

Table 7. The effects of specific combining ability (sca) for all the studied maize F_1 crosses for yield, yield components and quality traits.

Trait Cross	Ear length	Ear dimeter, cm	Cob diameter, cm	Kernel depth, cm	Rows No./ear	Kernels No./row
P1 X P2	2.27**	0.43**	0.05	0.19*	2.32**	3.97*
P1 X P3	1.41*	0.26	0.02	0.12	-2.16**	6.35**
P1 X P4	2.13**	0.42**	0.14	0.14	0.41	5.49**
P1 X P5	0.22	0.39**	0.06	0.16*	-0.25	0.06
P2 X P3	3.37**	0.16	0.24*	-0.04	-1.02	14.92**
P2 X P4	0.75	0.66**	0.27**	0.20*	-0.44	4.73**
P2 X P5	1.17	0.37**	0.15	0.11	1.56*	0.63
P3 X P4	2.89**	0.14	0.14	0.00	-0.25	11.78**
P3 X P5	1.98**	0.57**	0.37**	0.10	-0.92	-0.98
P4 X P5	2.37**	0.10	0.07	0.02	0.32	2.83
LSD Sij 5%	1.25	0.27	0.18	0.15	1.40	3.35
LSD Sij 1%	1.68	0.37	0.25	0.20	1.88	4.52
LSD sij-sik 5%	2.36	0.51	0.35	0.28	2.65	6.35
LSD sij-sik 1%	3.19	0.69	0.47	0.38	3.57	8.57
LSD sij-skl 5%	2.16	0.47	0.32	0.26	2.42	5.80
LSD sij-skl 1%	2.91	0.63	0.43	0.35	3.26	7.82

Table 7. Continued.

Trait Cross	Grain yield/ plant, g	Cob weight, g	Shelling %	Oil %	Protein %
P1 X P2	-185.97**	30.33**	-32.99**	-2.02**	0.21*
P1 X P3	155.41**	9.29**	12.04**	-0.09	-0.39**
P1 X P4	329.32**	56.10**	9.56**	0.84**	-0.18
P1 X P5	34.98**	-18.86**	12.07**	1.53**	0.34**
P2 X P3	148.32**	1.38	17.23**	2.66**	0.02
P2 X P4	122.22**	-2.14	16.91**	0.22**	0.54**
P2 X P5	269.56**	19.57**	16.39**	0.61**	0.18
P3 X P4	24.60**	-4.52*	6.84**	0.39**	0.09
P3 X P5	146.27**	14.52**	6.48**	-0.86**	0.13
P4 X P5	-61.83**	-14.00**	3.60**	-1.16**	1.00**
LSD Sij 5%	0.85	3.70	1.41	0.14	0.20
LSD Sij 1%	1.14	4.99	1.90	0.19	0.26
LSD sij-sik 5%	1.61	7.02	2.67	0.27	0.37
LSD sij-sik 1%	2.17	9.47	3.61	0.36	0.50
LSD sij-skl 5%	1.47	6.41	2.44	0.24	0.34
LSD sij-skl 1%	1.98	8.65	3.29	0.33	0.46

Heterosis estimation: -

The success of breeding programs in many other crops, including the commercial maize sector, can be attributed in large part to heterosis. Scientists started planning tests to figure out the mechanism of heterosis in the early 1900s. The scientific community has generally linked heterosis to dominance or over-dominance over the years, but more recently, researchers have revealed that linkage and epistasis play significant roles. Throughout the past century, a recurring theme has been that not every experiment or organism can be explained by a single theory of heterosis (Leyla Cesurer *et al.*, 2002).

Table 8's results showed that every cross under study had positive and extremely significant heterosis over mid-parents and better parent (ranged from 19.19% to 51.11% over mid parents, and from 15.69% to 46.81% over better parent) for ear length. Also, all studied crosses manifested positive and highly significant heterosis over mid parents and better parent (ranged from 20.31% to 40.23% over mid parents, and from 16.02% to 28.12% over better parent) for ear diameter. Similar results were obtained by Abd El -Aty and Katta (2002); Reddy and Ahuja (2004); Pilar *et al.* (2006) and Shalim *et al.* (2006).

All examined crossings showed positive and extremely significant heterosis over mid parents, as shown by the results shown in Table 8 (which varied from 12.92% for cross P1 X P5 to 37.89% for cross P3 X P5), nine crosses over better parent (ranged from 1.86% to 24.91%), and no crosses had desirable positive significant heterosis over check variety for cob diameter. Also, all studied crosses manifested positively and extremely substantial heterosis over mid-parents (ranged from 15.93% for cross P2 X P3 to 85.93% for cross P1 X P2), nine crosses over better-parent (ranged from 5.68% to 63.84%), and no crosses had desirable positive significant heterosis over check variety for kernel depth.

As shown in Table 8, four crosses out of studied crosses manifested positively and significant or extremely significant heterosis over mid-parents (ranged from 3.23% for crosses P1 X P4 and P4 x P5 to 20.00% for cross P1 X P2), two crosses namely; P1 x P2 and P2 x P5, recorded exceedingly significant and positively heterobeltiosis (12.50% and 8.33%), and no crosses had desirable positive significant heterosis over check variety for rows no./ear. For kernels no./row, all studied crosses manifested positively and very significant heterosis over mid-parents (ranged from 14.89% for cross P1 X P5 to 133.85% for cross P2 X P3), 6 crosses recorded highly-significant and positive heterobeltiosis (ranged from 42.50% for cross P1 xP2 to 130.30% for cross P2 x P3), and one cross (P2 x P3) had desirable positive and significant heterosis over check variety for kernels no./row. The results agreement with Abd El -Aty and Katta, (2002); Reddy and Ahuja (2004); Pilar *et al.* (2006), Shalim *et al.* (2006) and Abdel-Moneam *et al.* (2014)

Table 8. Percentage of heterosis over mid (MP), better parent (BP) and the best commercial variety (CV) in F1 crosses of maize for the studied yield, yield components and quality traits.

Trait	Ear length			Ear diameter			Cob diameter		
Cross	**MP**	**BP**	**CV**	**MP**	**BP**	**CV**	**MP**	**BP**	**CV**
P1 X P2	36.17**	25.49**	-13.53	37.32**	33.09**	-12.33	13.44**	1.86**	-14.48
P1 X P3	32.65**	27.45**	-12.15	26.76**	23.79**	-14.30	14.08**	-3.59**	-19.00
P1 X P4	34.69**	29.41**	-10.81	31.48**	23.70**	-7.39	15.58**	12.28**	-5.79
P1 X P5	19.19**	15.69**	-20.26	30.80**	20.70**	-5.81	12.92**	7.45**	-9.62
P2 X P3	51.11**	44.68**	-8.09	25.59**	18.96**	-17.66	33.78**	24.91**	-16.57
P2 X P4	31.11**	25.53**	-20.26	40.23**	28.12**	-4.23	28.24**	18.25**	-6.49
P2 X P5	29.67**	22.92**	-20.26	31.97**	18.34**	-7.78	23.60**	16.27**	-11.70
P3 X P4	46.81**	46.81**	-6.76	20.54**	16.02**	-13.31	24.41**	7.75**	-14.48
P3 X P5	36.84**	35.42**	-12.15	32.39**	24.92**	-2.65	37.89**	21.65**	-7.53
P4 X P5	36.84**	35.42**	-12.15	20.31**	17.85**	-8.18	17.13**	14.67**	-9.27
LSD 5%	2.21	2.55	2.55	0.48	0.55	0.55	0.33	0.38	0.38
LSD 1%	2.98	3.45	3.45	0.65	0.75	0.75	0.44	0.51	0.51

Table 8.Continued.

Trait	Kernel depth cm			Rows No./ear			Kernels No./row		
Cross	**MP**	**BP**	**CV**	**MP**	**BP**	**CV**	**MP**	**BP**	**CV**
P1 X P2	85.93**	63.84**	-16.60	20.00**	12.50**	0.00	58.33**	42.50**	-19.72
P1 X P3	45.54**	9.36**	-15.76	-19.19**	-21.57**	-25.94	75.34**	60.00**	-9.85
P1 X P4	62.17**	30.65**	-16.60	3.23*	0.00	-11.11	66.20**	47.50**	-16.91
P1 X P5	61.39**	22.83**	-8.18	0.00	0.00	-11.11	14.89**	0.00	-23.94
P2 X P3	15.93**	-3.81**	-25.87	-9.68**	-17.65**	-22.22	133.85**	130.30**	7.05*
P2 X P4	58.75**	43.01**	-9.02	1.15	-2.22	-18.50	80.95**	78.13**	-19.72
P2 X P5	43.51**	20.90**	-9.86	15.56**	8.33**	-3.72	25.58**	0.00	-23.94
P3 X P4	15.97**	5.68**	-18.29	-8.33**	-13.73**	-18.50	121.88**	115.15**	-0.01
P3 X P5	26.52**	24.16**	-3.97	-11.11**	-13.73**	-18.50	26.44**	1.85	-22.53
P4 X P5	24.65**	15.57**	-14.08	3.23*	0.00	-11.11	34.12**	5.56	-19.72
LSD 5%	0.26	0.30	0.30	2.48	2.86	2.86	5.94	6.86	6.86
LSD 1%	0.36	0.41	0.41	3.34	3.86	3.86	8.02	9.26	9.26

Table 8. Continued.

Trait	Grain yield/plant			Cob weight g			Shelling %		
Cross	**MP**	**BP**	**CV**	**MP**	**BP**	**CV**	**MP**	**BP**	**CV**
P1 X P2	-23.86**	-39.37**	-93.96	159.23**	143.55**	5.23	-48.06**	-54.11**	-65.30**
P1 X P3	488.61**	484.62**	-41.78	71.63**	39.88**	-15.68**	37.26**	25.76**	-4.89**
P1 X P4	865.36**	681.90**	-22.13	258.97**	221.10**	21.95**	29.52**	24.17**	-6.08**
P1 X P5	251.75**	208.53**	-59.26	1.28	-22.17**	-44.94**	34.59**	27.10**	-3.87*
P2 X P3	611.17**	469.27**	-44.07	38.05**	18.50**	-28.57**	60.22**	53.93**	-3.08*
P2 X P4	703.73**	686.13**	-51.46	54.29**	30.65**	-43.55**	54.10**	41.49**	-1.83
P2 X P5	644.34**	438.57**	-28.89	59.02**	28.08**	-9.40*	54.84**	44.25**	-3.05*
P3 X P4	417.18**	321.10**	-58.63	22.01**	-8.67*	-44.94**	45.60**	38.87**	-3.64*
P3 X P5	425.24**	358.02**	-39.52	31.91**	22.17**	-13.59**	46.44**	41.81**	-4.68**
P4 X P5	193.95**	115.70**	-71.52	-10.03**	-35.96**	-54.71**	37.14**	35.00**	-6.33**
LSD 5%	1.50	1.73	1.73	6.57	7.58	7.58	2.50	2.89	2.89
LSD 1%	2.03	2.34	2.34	8.86	10.23	10.23	3.37	3.89	3.89

Table 8. Continued.

Trait	Oil %			Protein %		
Cross	**MP**	**BP**	**CV**	**MP**	**BP**	**CV**
P1 X P2	-25.61**	-33.97**	-37.27**	3.75**	2.75**	8.45**
P1 X P3	9.09**	7.14**	-18.18**	-3.66**	-4.50**	2.58**
P1 X P4	18.15**	17.79**	-12.73**	1.51**	0.90**	6.49**
P1 X P5	31.41**	26.54**	-6.86**	6.27**	5.89**	12.54**
P2 X P3	56.50**	41.15**	34.05**	1.91**	0.06	7.47**
P2 X P4	10.75**	-1.44**	-6.32**	9.83**	9.43**	14.15**
P2 X P5	16.99**	0.48**	-4.55**	7.06**	5.65**	12.37**
P3 X P4	17.82**	16.07**	-11.36**	3.52**	2.00**	9.61**
P3 X P5	-5.66**	-10.71**	-31.82**	4.19**	3.66**	11.39**
P4 X P5	-20.13**	-23.31**	-43.14**	15.00**	13.89**	21.09**
LSD 5%	0.25	0.29	0.29	0.35	0.40	0.40
LSD 1%	0.34	0.39	0.39	0.47	0.54	0.54

Table 8 results indicate that, with regard to grain yield/plant, nine of the ten crosses that were studied showed positive and highly significant heterosis over mid and better parents (ranging from 193.95% for the cross P4 X P5 to 865.36% for the cross P1 X P4 over mid parent and from 115.70% for the cross P4 x P5 to 686.13% for the cross P2 x P4 over better parent). No crosses, however, showed desirable positive and significant heterosis over check variety pertaining to grain yield/plant.

For cob weight/plant, (Table 8) 8 crosses out of 10 studied crosses manifested positively and highly-significant heterosis over mid-parents (ranged from 22.01% for cross P3 X P4 to 258.97% for cross P1 X P4 over mid parent), and one cross (P4 X P5) recorded desirable negatively and highly-significant heterosis over mid-parents (-10.03%). Regarding better parent heterosis, 7 crosses manifested positive and highly significant heterosis (ranged from 18.50% for cross P2 x P3 to 143.55% for cross P1 x P2), and three crosses manifested desirable negative and significant of highly-significant heterosis over better parent for cob weight/plant. With respect to heterosis over the best check variety, one cross had desirable positively and highly-significant heterosis over the best check variety for cob weight/plant.

Table 8's results regarding shelling percentage revealed that no crosses exhibited the desired positive and significant heterosis over check variety for shelling %, with 9 out of 10 studied crosses displaying positive and highly-significant heterosis over mid and better parents (ranging from 29.52% for cross P1 X P4 to 60.22% for cross P2 X P3 over mid parent and from 24.17% for cross P1 x P4 to 44.25% for cross P2 x P5 over better parent). Abd El-Aty and Katta, (2002); Abdel-Moneam *et al.*, (2009); Weidong and Tollenaar (2009); Amanullah *et al.*, (2011); and Abdel-Moneam *et al.* (2014) all achieved similar findings.

The findings presented in Table 8 demonstrated that seven of the ten crosses that were studied showed positive and highly significant heterosis over mid parents (ranging from 9.09% for cross P1 X P3 to 56.50% for cross P2 X P3), six crosses showed positive and highly significant heterosis over better parent (ranging from 0.48% for cross P2 x P5 to 41.15% for cross P2 x P3 over better parent), and one cross, P2 x P3, had desirable positive and highly significant heterosis (34.05%) over check variety for Oil %.

The findings presented in Table 8 for protein percentage indicate that nine of the ten studied crosses showed positive and highly-significant heterosis over mid-parents (ranging from 1.51% for cross P1 X P4 to 15.00% for cross P4 X P5), eight crosses showed positive and highly-significant heterosis over better parent (ranging from 0.90% for cross P1 x P4 to 13.89% for cross P4 x P4 over better parent), and all of the studied crosses showed desirable positive and highly-significant heterosis over check variety for protein percentage.

REFERENCES

Abd El-Aty, M.S. and Y.S.Katta (2002). Estimation of heterosis and combining ability for yield and other agronomic traits in maize hybrids (*Zea mays* L.). J. Agric. Sci. Mansoura Univ., 27(8): 5137-5146.

Abdel-Moneam M. A.; M.S. Sultan; S.E. Sadek and M.S. Shalof (2014). Estimation of heterosis and genetic parameters for some flowering and vegetative traits in maize using the diallel cross method. Journal of Advances in Natural Sciences, Vol. 2, No. 2, 157-166.

Abdel-Moneam M.A.; A.N. Attia; M. I. EL-Emery and E.A. Fayed (2009). Combining abilities and heterosis for some agronomic traits in cross of maize. Egypt Pakistan J. of Biol. Sciences 12 (5) 433-438.

Aliu S.., Fetahu Sh. and Salillari A. (2008). Estimation of heterosis and combining ability in maize (*Zea mays* L.) for ear weight (ew) using the diallel crossing method. Agronomijas Vēstis (Latvian Journal of Agronomy), No.11, 7-11

Amanullah, S.; M. Mansoor and M. Anwar khan (2011). Heterosis studies in diallel crosses of maize. Sarhad J. Agric., 27 (2):207-211, (C.F. Computer Search).

Amaregouda H.M. and S.T. Kajidoni (2007). Combining ability analysis of S2 lines derived from yellow pool population in Rabi maize. Karnataka J. Agric. Sci., 20(4): 904- 918.

Barakat,A.A.; M.A.Abd EI-moula and A.A.Ahmed, (2003). Combining ability for maize grain yield and its attributes under different environments. J Agric. Sci. Assiut. Univ. 34: 15-25.

Barata C. and M. Carena (2006). Classification of North Dakota maize inbred lines into heterotic groups based on molecular and testcross data. Euphytica 151: 339-349.

Chaudhary, A. K. ; L.B. Chaudhary and K.C. Sharnia. (2000) Combining ability estimates of early generation inbred lines derived from two maize populations. Ind. J. Genet. 60: 55-61.

EL-Shenawy, A. A.; H. E. Mosa and A. A. Motawei (2009). Combining ability of nine white maize (*Zea mays* L.) inbred lines in diallel crosses and stability parameters of their single crosses J. Agric. Res. Kafrelsheikh Univ., 35 (4) .

Falconer, D.C. (1981) An introduction to quantitative genetics. /2nd edition, Longman, New York , 67-68.

Fan X.M.; J. Tan; J.Y. Yang; F. Liu; B.H. Huang and Y.X. Huang (2002). Study on combining ability for yield and genetic relationship between exotic tropical, subtropical maize inbreeds and domestic temperate maize inbreeds. (In Chinese, with English abstract.) Sci. Agric. Sinica35:743-749.

Fan X.M.; Y.M. Zhang; W.H. Yao; H.M. Chen; J. Tan; X.L. Han; L.M. Luo and M.S. Kang (2009). Classifying maize inbred lines into heterotic groups using a factorial mating design. Agron. J., 101: 106-112.

Gautam, A. S.(2003) Combining ability studies for grain yield and other agronomic characters in inbred lines of maize (*Zea mays* L.). Crop Research (Hisar). 2003. 26 (3), 482-485.

Gomez, K. M. and A. A. Gomez (1984). Statistical procedures for agricultural research. John Wily and Sons, New York, 2nd ed., 68P.

Griffing B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. Australian J. Bi-ol. Sci. 9: 463-493.

Habiba, Rehab Mohamed Mohamed, Mohamed Zakaria El-Diasty and Rizk Salah Hassanin Aly(2022). Combining abilities and genetic parameters for grain yield and some agronomic traits in maize (*Zea mays* L.). Beni-Suef Univ J Basic Appl Sci (2022) 11:108 https://doi.org/10.1186/s43088-022-00289-x

Kamal, N., S. Khanum, M. Siddique, M. Saeed, M. F. Ahmed, M. T. A. Kalyar, S. Ur-Rehman and B. Mahmood (2023). Heterosis and Combining Ability Studies in A 5x5 Diallel Crosses of Maize Inbred Lines. J. Appl. Res Plant Sci. Vol. 4(1), 419-424, 2023, https://doi.org/10.38211/joarps.2023.04.01.50

Kanchao Yu, Hui Wang, Xiaogang Liu, Cheng Xu, Zhiwei Li, Xiaojie Xu, Jiacheng Liu, Zhenhua Wang and Yunbi Xu (2020). Large-Scale Analysis of Combining Ability and Heterosis for Development of Hybrid Maize Breeding Strategies Using Diverse Germplasm Resources. Front. Plant Sci., 01 June 2020. Volume 11 - 2020 | https://doi.org/10.3389/fpls.2020.00660

Keskin B.; I.H. Yilmaz and O. Arvas (2005). Determination of some yield characters of grain corn in eastern Anatolia region of Turkey. J. Agro., 4(1): 14-17.

Leyla Cesurer ; T.Dokuyucu and A. Akkaya (2002) Understanding of Heterosis, University of Nebraska - Lincoln , Dep. of Agronomy/Horticulture KSU. Agriculture of Faculty, Department of Field Crops, Kahramanmaraş

Liao,S.S.,(1989)Analysis of combining ability for major character in maize inbred lines .abstract .(C.F. Computer Search).

Machado, J. C.; J. C. Souza; M. A. P.Ramalho and J. L.Lima, (2009) Stability of combining ability effects in maize hybrids. Scientia Agricola. 2009. 66: 4, 494-498.

Mather, K. and J.L. Jinks (1982). Biometrical genetics. 3rd Ed. Chapman and Hall, London, 382 Pp.

Melani M.D. and M.J. Carena (2005). Alternative maize heterotic pattern for the Northern Corn Belt. Crop Sci.45:2186-2194.

Muraya M.M.; C.M. Ndirangu and E.O. Omolo (2006). Heterosis and combining ability in diallel crosses involving maize (*Zea mays* L.) S1 lines. Australian J. Exp. Agri., 46(3): 387-394.

Nawar, A.A. ; S.A. EL-Shamarka and E.A. EL-Absawy (2002). Diallel analysis of some agronomic traits of maize. J. Agric. Sci. Mansoura Univ., 27 (11): 7203-7213.

Pal, A.K and Prodham (1994) Combining ability analysis of grain yield and oil content along with some other attributes in maize(*Zea mays* L .)Indian J.Genetisc .54:376-380.

Pilar, S.; B. Ordàs ; R.A. Malvar ; P. Revilla, and A. Ordàs (2006). Combining abilities and heterosis for adaptation in flint maize populations. Crop Sci., 46 : 2666-2669.

Rakesh Kumar ; S. Mohinder and M. S.Narwal, (2006) Combining ability analysis for grain yield and its contributing traits in maize (*Zea mays* L.). National J. of Plant Improvement. 8: (1), 62-66.

Reddy, D. M. and V. P. Ahuja (2004). Heterosis studies over environments for grain yield and its components in maize (*Zea mays* L.). National J. of Plant Improvement. , 6(1) :26-28.

Sadek, S.E.; H.E. Gado and M.S. Soliman (2000). Combining ability and type of gene action for maize grain yield and other attributes. J. Agric. Sci., Mansoura Univ. 25(5): 2491- 2502.

Shalim Uddin, M.; Firoza Khatun; S. Ahmed; M. R. Ali and Shamim Ara Bagum (2006). Heterosis and combining ability in corn (*Zea mays* L.). Bangladesh J. Bot., 35(2): 109-116.

Singh, P. K. (2005). Components of genetic variation in yield traits of maize. Journal of Research, Birsa Agric. Univ. 17 (2): 257-262.

Snedecor G. W. and Cochran W G. (1977). Statistical methods applied to experiments in agriculture and biology. 5th ed. Ames, Iowa: Iowa State University Press, 1956. Number 19 May 9. (C.f. Computer Search).

Sprague. (1962). Corn and corn improvement, Third edition, Madison, Wisconsin, USA, 234-289.

Sultan, M. S.; A. A. EI-Hosary ; A. A. Lelah ; M. A. Abdel-Moneam and M. A. Hamouda (2011). Combining ability for some important traits in red maize using Griffing's method 2 and 4. Dept. of Agron., J. Agric. Sci., Mansoura Univ., Egypt. ,2(6):811-822.

Sultan, M.S.; M.A. Abdel-Monaem and Soad H. Haffez (2010) combining ability and heterosis estimates for yield, yield components and quality traits in maize under two plant densities Fac. Agric., Mansoura Univ., Egypt. Vol .1(10):1419-1430

Surya Prakash and D. K.Ganguli, (2004) Combining ability for various yield component characters in maize (*Zea mays* L.). Journal of Research, Birsa Agricultural University. 2004. 16: 1, 55-60.

Weidong, L and M. Tollenaar (2009). Response of yield heterosis to increasing plant density in maize. Crop Sci., 49: 1807-1816.

Welcker C.C.; B. C. Andréau; S.N. Parentoni; J. Bernal and W.J. Horst (2005). Heterosis and combining ability for maize adaptation to tropical acid soils. Crop Sci., 45: 2405-2413.

Yan, W. and M. Kang (2003). GGE Biplot Analysis ,207-228, New York.

قوة الهجين والقدرة على الائتلاف لبعض سلالات الذرة الشامية الصفراء وهجنها لصفات المحصول ومكوناته وصفات جودة الحبوب

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الملخص

تم إجراء تهجين نصف دائري بين خمس سلالات من الذرة الشامية الصفراء في موسم صيف 2019. ثم تم تقييم السلالات الأبوية وهجن الجيل الأول مع ثلاثة هجن تجارية صفراء، SC 168، SC 3084 وSC 3444، في تص ميم القطاعات الكاملة العشوائية بثلاثة مكررات في المزرعة التجريبية بقسم المحاصيل، كلية الزراعة، جامعة المنصورة، مصر. محافظة الدقهلية، وذلك بهدف دراسة قوة الهجين والقدرة على الائتلاف لاختيار أفضل سلالات الأبوية لتطوير هجن صفراء فردية جديدة عالية الإنتاجية، وأشارت النتائج في معظم الحالات إلى أن متوسط مربعات التراكيب الوراثية والآباء والهجن والآباء مقابل الهجن كان معنويًا أو معنوي جدًا لصفات المحصول ومكوناته وصفات جودة الحبوب. وكانت الفروق في محصول الحبوب/النبات بين الآباء والهجن الناتجة منها عالية جداً. وكانت متوسطات مربعات كل من القدرة العامة والخاصة على الائتلاف GCA وSCA معنوية أو معنوية جدا لمعظم الصفات المدروسة، مما يدل على أهمية كلا من الفعل الجيني المضيف وغير المضيف (السيادي) في وراثة هذه الصفات. وكانت نسبة GCA/SCA أقل من الوحدة لجميع الصفات المدروسة، مما يشير إلى أن الجينات غير المضيفة كانت أكثر أهمية ولعبت الدور الأكبر في توريث جميع الصفات المدروسة. وكانت أفضل السلالات قدرة عامة على التآلف هي P3 (Inb. 69) و P5 (Inb. 309) لصفتي عدد الحبوب/صف ومحصول الحبوب/نبات. وكانت أفضل التوليفات الهجينية قدرة خاصة على التآلف: ثمانية هجن لصفة محصول الحبوب/النبات. أظهرت تسعة هجن قوة هجين موجبة وعالية المعنوية بالنسبة لمتوسط الأبوين وأفضل الأبوين (تراوحت من 193.95% للهجين P4 X P5 إلى 865.36% للهجين P1 X P4 تفوقا على متوسط الأبوين، ومن 115.70% للهجين P4 x P5 إلى 686.13% للهجين P2 x P4 تفوقا على الأب الأفضل) في صفة محصول الحبوب/النبات.