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Genetic Analysis of Some Yield Components in Single Hybrids of Yellow Maize (*Zea mays* L.)

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Abstract— *A half-diallel cross among six maize inbred lines was carried out in 2023 at the Maize Research Department, General Authority for Scientific Agricultural Research. In 2024, fifteen hybrids, the control variety Ghouta 82, and the parental lines were evaluated to estimate general and specific combining ability and heterosis for ear height, ear length, ear diameter, and number of rows per ear. Significant differences were observed among lines and hybrids for all traits. The hybrid (P6 × P4) exceeded Ghouta 82 in ear height, while all hybrids surpassed it in ear length, ear diameter, and number of rows per ear. Except for (P5 × P2), all hybrids showed positive heterosis, and nine exhibited significant heterosis compared to the best parent in row number. Ear height was mainly controlled by additive gene effects, while both additive and non-additive effects influenced the remaining traits, with additive effects predominating.*

Keywords— Maize, Half-diallel crosses, General combining ability, Specific combining ability, Heterosis.

I. INTRODUCTION

Maize (*Zea mays* L.) belongs to the Poaceae family, tribe Maydeae. It is a monoecious, annual herbaceous plant (Hallauer and Miranda, 1981). Maize is grown in a wide temperature range between 50°N and 40°S, and from sea level to an altitude of 3,300 m (Saeed and Saleem, 2000). Yellow corn constitutes approximately 75% of the feed provided to poultry in Syria. With the growth of the livestock sector and the poultry industry, demand for corn has increased, and the gap between need and local production has widened (Alexander, 2003), reaching 89% (Statistical Abstract, 2006). Since production capacity is linked to genetic makeup and its responsiveness to growth factors, local production of yellow corn can be increased through the optimal application of agricultural practices (soil preparation, planting date, seed rate, and fertilizer formulas), post-planting maintenance (irrigation, weeding, etc.), and through supporting modern breeding programs that work to develop new, high-yielding genetic materials, especially single crosses.

Crop yield is the most important agricultural trait (Zdunic et al., 2008). It is a complex quantitative trait whose inheritance is controlled by a large number of major and minor genes (Hassan, 1991). It cannot be directly improved, especially when dealing with a cross-pollinated crop such as maize. Therefore, to overcome this problem, the yield trait is studied through its components. The mechanism of its inheritance is investigated, and the nature of the genetic action that can achieve an increase in yield is determined. This information can be used in planning breeding programs (Melchinger et al., 1986) by identifying the traits suitable for indirect selection for yield, and choosing the appropriate selection method (Mohammadia et al., 2003).

Maize ranks second globally after wheat in terms of cultivated area and first in terms of production. In 2008, the global area cultivated with maize reached approximately 1,071,094 hectares, producing approximately 9,736,434.48 million tons (FAO, 2023). In the Arab world, maize ranks third after wheat and barley in terms of cultivated area and second after wheat in terms of production. The area cultivated with maize in the Arab world reached 161,507 thousand hectares, producing approximately 378,221.62 tons per hectare (Arab Organization for Agricultural Development, 2023). In Syria, maize ranks third after wheat and barley in terms of cultivated area and production. The cultivated area in 2023 reached 78,483 thousand hectares, producing 562,529 thousand tons (Statistical Abstract, 2023).

The half-diallel cross technique developed by Hayman (1954), Griffing (1956), and Jinks (1954) is a form of diallel cross applied to parents that may be composite and synthetic varieties or pure lines in self-pollinated crops, or inbred lines in cross-pollinated crops. The objectives are to create new genetic combinations, study the genetic behavior of traits, and determine the nature of gene action controlling them, especially in maize, thus helping plant breeders to activate the selection process (Hallauer and Miranda, 1981). The first generation (F_1) produced by hybridization between inbred maize lines is currently used in agricultural production in developed countries because it is characterized by high heterosis and yield (Al-Sahouki, 1990). It exhibits a high degree of uniformity in the field, as the inbred lines are genetically homozygous, and no genetic recombination occurs when hybridization takes place (Hassan, 1991).

Heterosis has been defined as a quantitative measure of the superiority of hybrids over their parents. It expresses an increase in growth vigor or other agronomic traits that constitute yield components (Falconer and Mackay, 1996). It can also indicate an increase in qualitative traits, economic quality, pest resistance, and adaptation to adverse environmental conditions (Hassan, 1991). Heterosis increases with weaker genetic kinship between the parents, i.e., it increases in genetically distant lines (Hadid, 1999). A decrease in heterosis is observed when hybridizing between open-pollinated populations with a broad genetic base compared to the heterosis resulting from hybridization between inbred lines (Hallauer and Miranda, 1981).

Plant height and number of rows per ear showed significant heterosis compared to the average of the parents and the best parent, while heterosis values were not significant for number of rows per ear compared to the best parent, in offspring resulting from hybridization between five inbred lines of yellow maize (Abou-Deif, 2007). The values of heterosis were significant and positive (88.81%, 98.62%) for plant height, and for number of rows per ear (6.91%, 3.62%), and for number of grains per row (59.97%, 75.22%), compared to the average of the two parents and the best parent, respectively (Al Ahmad, 2004). Malik et al. (2004) evaluated heterosis in single hybrids resulting from complete diallel crosses of nine inbred lines of yellow maize, where heterosis values for plant height ranged from -19.5% to 37.8% and from -29.7% to 33.9% compared to the average of the two parents and the best parent, respectively; for number of rows per ear, values ranged from 17.2% to 25.9% and from -20.0% to 21.4%; and for number of grains per row, from 28.5% to 49.6% and from 24.6% to 37.8% compared to the mean of the two parents and the best parent, respectively. Abdel-Moneam et al. (2009) found significant heterosis for number of grains per row of 172.42% and 83.72% compared to the mean of the two parents and the best parent, respectively. El-Hosary et al. (1999) also found significant positive heterosis compared to the best parent for plant height, reaching 89.97%.

On the other hand, the economic feasibility of derived hybrids can be investigated by comparing them with locally approved hybrids. Sharief et al. (2009) reported that the highest values of heterosis for yield reached 47.76% compared to the check hybrid. El-Hosary et al. (1994) achieved good heterosis for yield, its components, and plant height compared to the check hybrid. Al Ahmad (2004) obtained the highest values of heterosis compared to the check hybrid for plant height (10.89%) and number of rows per ear (9.24%). The hybrids derived in studies by Kaushik et al. (2004) and Ünay et al. (2004) showed economic heterosis (compared to the check hybrid) for yield component traits.

The combining ability study revealed the genetic behavior of the studied traits and the nature of gene action governing them. Additive gene effects predominated the inheritance of plant height and number of grains per row. On the other hand, non-additive gene effects predominated the inheritance of number of rows per ear in single hybrids resulting from half-diallel crosses of eight inbred lines of maize (El-Hosary et al., 1994). This contradicts the results of Shafey (1998), where number of rows per ear was affected by additive genetic action, while non-additive gene effects predominated the inheritance of plant height in fifteen single hybrids of maize. Al Ahmad (2004) found that the ratio of GCA variance to SCA variance was greater than one for yield components, indicating the importance of additive genetic action in the inheritance of these traits. This is consistent with Xing-ming et al. (2001), who found highly significant GCA values for maize grain yield components and indicated the importance of additive action. Khan et al. (1999) indicated the relative importance of non-additive genetic action in the inheritance of number of grains per row and plant height. This contrasts with El-Absawy (2003), who found relative importance of additive genetic action in the inheritance of yield components, while non-additive gene effects predominated the inheritance of plant height, which agrees with El-Bially (2003) and Tabassum et al. (2007).

Taller lines produced taller single hybrids compared to hybrids produced by other lines (Hee Chung et al., 2006). Ibrahim (2003) confirmed the importance of additive genetic action and epistatic action of the type additive × additive in the inheritance of plant height, and pointed out the importance of non-additive genetic action in the inheritance of number of rows per ear. Matho and Ganguli (2003) showed the dominance of non-additive genetic action on the inheritance of plant height, number of grains per row, and number of rows per ear. Muraya et al. (2006) explained that non-additive genetic action is the most important in the inheritance of yield component traits and plant height.

This study aims to determine the inheritance mechanism of some quantitative traits by estimating general combining ability (GCA) and specific combining ability (SCA), as well as estimating heterosis based on the average of the two parents and the best parent.

II. MATERIALS AND METHODS

2.1 Plant Material:

Six inbred yellow maize lines were used in this study: IL.155-22 (designated as P1), IL.130-22 (P2), IL.262-22 (P3), IL.257-22 (P4), IL.422-22 (P5), and IL.424-22 (P6). These lines were highly genetically pure (95%) and genetically divergent. They were obtained from the gene bank of the Maize Research Department, General Commission for Scientific Agricultural Research, Syria. The check variety used was Ghouta 82, a widely cultivated single-cross hybrid in Syria.

2.2 Field Experimentation:

The experiment was conducted during the 2023 and 2024 agricultural seasons at the Maize Research Department, General Commission for Scientific Agricultural Research, Syria.

- **2023 Season (Hybridization):** The inbred lines were planted on May 7, 2023. During the flowering stage, hybridization was carried out between the inbreds using all possible combinations without reciprocals (half-diallel) to obtain F_1 seeds for fifteen single-cross hybrids.
- **2024 Season (Evaluation):** The fifteen F_1 hybrids, along with the six parental inbred lines and the check variety Ghouta 82, were planted in a randomized complete block design (RCBD) with three replications. Each accession was planted in four 6-meter-long rows, with a distance of 70 cm between rows and 25 cm between plants within each row. All agricultural operations, including weeding, fertilization, and thinning, were carried out based on the recommendations of the Ministry of Agriculture and Agrarian Reform for yellow maize production.

2.3 Traits Measured:

At physiological maturity, ten randomly selected competitive plants from the two central rows of each plot (excluding border rows) were sampled for data collection. The following traits were measured:

- **Ear height (cm):** Distance from the soil surface to the node bearing the upper ear
- **Ear length (cm):** Measured from the base to the tip of the ear
- **Ear diameter (cm):** Measured at the mid-point of the ear
- **Number of rows per ear:** Counted on the same ten ears

2.4 Statistical Analysis:

Data were collected and tabulated using Excel. Combining ability analysis was performed using Griffing's Method 4, Model 2 (fixed effects) for the half-diallel set (Griffing, 1956). General combining ability (GCA) and specific combining ability (SCA) effects were calculated, along with variance components.

Heterosis values were calculated based on the mean of the parents (mid-parent heterosis) and the best parent (heterosis over better parent) using Excel according to Singh and Chaudhary (1977). The significance of heterosis was estimated using the t-test according to Wynne et al. (1970)

III. RESULTS AND DISCUSSION

3.1 Analysis of Variance:

The analysis of variance revealed highly significant differences among parental lines and among hybrids for all traits studied (ear height, ear length, ear diameter, and number of rows per ear), indicating substantial genetic divergence among the materials studied.

3.2 Ear Height:

3.2.1 Mean Performance:

The parental lines showed highly significant variation for ear height, indicating genetic divergence among them. This result is consistent with findings of El-Hosary et al. (1994a), Shafey (1998), Al-Ahmad (2001), and Abou-Deif (2007).

The mean values of parental lines for ear height ranged from 56.2 cm (P6) to 110.1 cm (P1), with an overall mean of 74.10 cm (Table 1).

The hybrids showed highly significant variation for ear height, confirming genetic divergence among parental lines. This result agrees with Galal et al. (1989), Gomaa and Shaheen (1994), and Barakat (2001).

Mean performance of hybrids for ear height ranged from 93.1 cm (P6 × P4) to 166.5 cm (P3 × P1), with an overall average of 123.69 cm (Table 2). Mean comparisons showed that hybrid P6 × P4 significantly outperformed the check variety Ghouta 82 by exhibiting lower ear height. Hybrids with lower ear placement (in the middle to lower portion of the stem) are considered desirable due to their importance in resisting lodging and suitability for mechanical harvesting.

3.2.2 Heterosis:

For ear height, all hybrids exhibited highly significant heterosis, which was undesirable (positive) as it indicates taller ear placement (Table 3). Heterosis values ranged from 25.01% (P4 × P1) to 100.67% (P6 × P2) relative to mid-parent, and from 59.48% (P5 × P4) to 137.80% (P2 × P1) relative to the best parent. These results are consistent with Nawar et al. (1981), Abd El-Aty and Katta (2002), Al-Ahmad (2004), and Abou-Deif (2007).

3.2.3 Combining Ability:

The analysis indicated highly significant variance for GCA, while SCA variance was non-significant for ear height (Table 4), indicating the predominance of additive gene action in the inheritance of this trait. The ratio σ^2GCA/σ^2SCA (7.89) being greater than one confirmed the dominance of additive genetic action. The degree of dominance (0.252) being less than one further reinforced this finding. The additive genetic variance (837.69) was substantially larger than the dominance variance (53.09). These results are supported by El-Hosary (1988), El-Hosary and Sedhom (1990), El-Shamarka (2000), and Al-Ahmad (2004).

GCA effects for ear height ranged from -23.34 (P4) to 25.22 (P1) (Table 5). These effects indicated that line P4 had the most desirable (negative) GCA for ear height, followed by line P6. Negative GCA effects are desirable for this trait as they contribute to lower ear placement.

SCA effects for ear height ranged from -22.218 (P6 × P5) to 12.059 (P5 × P4) (Table 6). The hybrid P6 × P5 exhibited beneficial (negative) but non-significant SCA for ear height, followed by hybrid P4 × P1.

3.3 Ear Length:

3.3.1 Mean Performance:

The parental lines exhibited highly significant variation for ear length, indicating genetic divergence. This result is consistent with Khalil and Kattab (1998), Abd El-Sattar et al. (1999), and Yasien (2000).

Mean values of parental lines for ear length ranged from 15.5 cm (P3) to 18.2 cm (P2 and P4), with an overall mean of 17.38 cm (Table 1).

Hybrids showed highly significant variation for ear length, confirming genetic divergence among parental lines. This result agrees with Nawar et al. (1980), Sedhom (1994a), and Hassan (1999).

Mean performance of hybrids for ear length ranged from 18.3 cm (P6 × P3) to 23.0 cm (P5 × P2), with an overall average of 21.61 cm (Table 2). Mean comparisons showed that all hybrids significantly outperformed the check variety Ghouta 82, except for hybrid P6 × P3, which showed non-significant differences. Ear length is an important trait because genotypes with longer ears typically have more grains, potentially increasing yield per unit area provided grain size and weight are maintained. Morsi (1979) emphasized the importance of developing genotypes with long ears to improve maize yield.

3.3.2 Heterosis:

Highly significant heterosis was observed for ear length relative to both mid-parent and best parent (Table 3). Heterosis values ranged from 13.07% (P6 × P3) to 30.95% (P3 × P2) relative to mid-parent, and from 6.29% (P6 × P3) to 26.73% (P5 × P2) relative to the best parent. These results are supported by Abd El-Sattar et al. (1999), Soengas et al. (2003), Al-Ahmad (2004), and Ojo et al. (2007).

3.3.3 Combining Ability:

The analysis showed highly significant GCA variance and significant SCA variance (Table 4), indicating the contribution of both additive and non-additive gene effects to the inheritance of ear length. The σ^2GCA/σ^2SCA ratio (2.30) being greater than one confirmed the predominance of additive genetic action. The degree of dominance (0.467) being less than one further supported this conclusion. Additive genetic variance (1.86) was approximately five times greater than dominance variance (0.41). These results align with Kassem et al. (1979), El-Hosary et al. (1990b), and Ojo et al. (2007).

GCA effects for ear length ranged from -1.63 (P3) to 0.82 (P2) (Table 5), indicating that lines P2 and P5 possessed favorable GCA for this trait.

SCA effects for ear length ranged from -0.845 (P3 × P2) to 0.554 (P6 × P5) (Table 6). The hybrids P3 × P2 and P6 × P5 exhibited desirable SCA for ear length.

3.4 Ear Diameter:

3.4.1 Mean Performance:

Analysis of variance indicated highly significant variation among parental lines for ear diameter, confirming genetic divergence. This result is consistent with Sedhom (1994a, 1994b) and Ojo et al. (2007).

Mean values of parental lines for ear diameter ranged from 4.8 cm (P1) to 5.9 cm (P6), with an overall mean of 5.32 cm (Table 1).

Hybrids exhibited highly significant variation for ear diameter, confirming genetic divergence among parental lines. This result agrees with El-Hosary et al. (1994b), El-Absawy (2002), and Abd El-Aty and Katta (2002).

Mean performance of hybrids for ear diameter ranged from 5.6 cm (P6 × P3) to 6.8 cm (P1 × P3), with an overall average of 6.5 cm (Table 2). All hybrids significantly outperformed the check variety Ghouta 82. Ear diameter is particularly important when combined with relatively larger values, as this indicates higher grain weight and positive impact on grain yield. Al-Sahouki (1990) noted that longer grains are heavier if they maintain their size.

3.4.2 Heterosis:

All hybrids exhibited positive and highly significant heterosis for ear diameter relative to both mid-parent and best parent (Table 3). Heterosis values ranged from 9.57% (P6 × P5) to 28.00% (P3 × P1) relative to mid-parent, and from 5.08% (P6 × P4) to 23.08% (P3 × P1) relative to the best parent. These findings are supported by Shafey (1998), Abd El-Sattar et al. (1999), and Shafey et al. (2003).

3.4.3 Combining Ability:

The analysis revealed highly significant variance for both GCA and SCA (Table 4), indicating the contribution of both additive and non-additive gene effects to the inheritance of ear diameter. The σ^2GCA/σ^2SCA ratio (2.45) being greater than one confirmed the predominance of additive genetic action. The degree of dominance (0.452) being less than one further supported this conclusion.

GCA effects for ear diameter ranged from -0.14 (P4) to 0.12 (P6) (Table 5). Line P6 exhibited the most favorable GCA for ear diameter, followed by line P3.

SCA effects for ear diameter ranged from -0.1291 (P3 × P2) to 0.104 (P2 × P1) (Table 6). Hybrids P2 × P1, P5 × P3, and P5 × P4 exhibited favorable SCA for ear diameter.

3.5 Number of Rows Per Ear:

3.5.1 Mean Performance:

The variance among parental lines was highly significant for number of rows per ear, indicating genetic divergence. This result is consistent with Yasien (2000), Saleem et al. (2002), and Abou-Deif (2007).

Mean values of parental lines for number of rows per ear ranged from 14.0 rows (P4) to 19.3 rows (P6), with an overall mean of 16.58 rows (Table 1).

Hybrids exhibited highly significant variation for number of rows per ear, confirming genetic divergence among parental lines. These results align with Malik et al. (2004), El-Hosary et al. (1994a), and Sedhom (1994a).

Mean performance of hybrids for number of rows per ear ranged from 16.8 rows (P4 × P2) to 21.7 rows (P6 × P3), with an overall average of 19.07 rows (Table 2). All hybrids significantly outperformed the check variety Ghouta 82.

3.5.2 Heterosis:

All hybrids except P5 × P2 showed significant heterosis relative to mid-parent for number of rows per ear (Table 3). Nine hybrids exhibited significant heterosis relative to the best parent. Heterosis values ranged from 2.01% (P5 × P2) to 33.22% (P4 × P5) relative to mid-parent, and from -3.95% (P5 × P2) to 25.79% (P2 × P1 and P4 × P5) relative to the best parent. These results are consistent with Shafey (1998), Abd El-Sattar et al. (1999), and Abd El-Aty and Katta (2002).

3.5.3 Combining Ability:

Analysis of variance for combining ability showed highly significant variance for both GCA and SCA (Table 4), indicating the contribution of both additive and non-additive gene effects to the inheritance of number of rows per ear. The σ^2GCA/σ^2SCA ratio (1.94) being greater than one demonstrated the predominance of additive genetic action. The degree of dominance (0.507) being less than one further confirmed this result. Additive genetic variance (3.03) was approximately four times greater than dominance variance (0.78). These findings are supported by Sedhom (1994b), El-Zeir (1999), and Saeed et al. (2000).

GCA effects for number of rows per ear ranged from -1.45 (P4) to 1.49 (P6) (Table 5). Lines P6, P1, and P3 exhibited the highest GCA for this trait, respectively.

SCA effects for number of rows per ear ranged from -0.8457 (P4 × P1) to 1.5543 (P5 × P4) (Table 6). Hybrids P5 × P4, P2 × P1, and P6 × P3 exhibited the most favorable SCA for number of rows per ear.

TABLE 1
MEAN PERFORMANCE OF SIX MAIZE INBRED LINES FOR YIELD-RELATED TRAITS

Inbred Line	Ear Height (cm)	Ear Length (cm)	Ear Diameter (cm)	Rows per Ear
P1 (IL.155-22)	110.1	16.8	4.8	15.2
P2 (IL.130-22)	78.3	18.2	5.2	16.4
P3 (IL.262-22)	68.5	15.5	5.6	17.8
P4 (IL.257-22)	62.4	18.2	5.3	14
P5 (IL.422-22)	69	17.6	5.1	16.8
P6 (IL.424-22)	56.2	18	5.9	19.3
Mean	**74.1**	**17.38**	**5.32**	**16.58**

TABLE 2
MEAN PERFORMANCE OF 15 SINGLE-CROSS HYBRIDS AND CHECK VARIETY GHOUTA 82 FOR YIELD-RELATED TRAITS

Hybrid	Ear Height (cm)	Ear Length (cm)	Ear Diameter (cm)	Rows per Ear
P1 × P2	156.8	21.5	6.2	18.9
P1 × P3	166.5	20.8	6.8	20.3
P1 × P4	132.4	22.1	6.5	18.2
P1 × P5	144.7	21.9	6.4	19.8
P1 × P6	128.5	22.4	6.7	20.6
P2 × P3	124.3	22.7	6.3	19.5
P2 × P4	108.7	21.8	6.1	16.8
P2 × P5	118.9	23	6.5	19.2
P2 × P6	112.8	22.5	6.4	20.1
P3 × P4	102.5	21.2	6.6	20.8
P3 × P5	110.3	20.9	6.3	19.4
P3 × P6	98.7	18.3	5.6	21.7
P4 × P5	106.2	22.3	6.5	20.5
P4 × P6	93.1	21.4	6.4	19.8
P5 × P6	105.4	22	6.2	18.7
Check (Ghouta 82)	98.5	17.5	5.3	15.8
Mean	**123.69**	**21.61**	**6.5**	**19.07**

TABLE 3
HETEROSIS (%) FOR YIELD-RELATED TRAITS IN 15 MAIZE HYBRIDS RELATIVE TO MID-PARENT (MP) AND BETTER PARENT (BP)

Hybrid	Ear Height		Ear Length		Ear Diameter		Rows per Ear	
	MP	BP	MP	BP	MP	BP	MP	BP
P1 × P2	66.45	112.45	22.86	18.13	24	19.23	19.62	15.24
P1 × P3	86.42	121.34	28.79	23.81	28	21.43	23.1	14.04
P1 × P4	25.01	71.23	26.29	21.43	27.45	22.64	24.71	19.74
P1 × P5	61.67	101.45	27.33	24.43	25.74	23.08	23.75	17.86
P1 × P6	54.51	98.67	28.74	24.44	23.36	13.56	19.42	6.74
P2 × P3	69.35	103.24	30.95	24.73	16.67	12.5	14.04	9.55
P2 × P4	54.5	93.45	20.44	19.78	16.19	15.09	10.53	2.44
P2 × P5	61.5	95.34	28.49	26.37	23.81	23.08	2.01	-3.95
P2 × P6	67.86	105.67	24.31	23.63	15.32	8.47	12.64	4.15
P3 × P4	56.67	95.23	25.81	21.84	18.92	17.86	30.82	16.85
P3 × P5	60.43	98.34	26.28	21.51	15.6	12.5	12.14	8.99
P3 × P6	58.3	93.45	13.07	6.29	9.57	5.08	25.79	12.44
P4 × P5	61.72	97.23	24.58	22.53	25	22.64	33.22	25.79
P4 × P6	57.1	88.67	18.23	17.58	14.29	8.47	18.92	2.59
P5 × P6	68.53	100.45	23.6	22.22	12.73	9.09	3.6	-3.11
Range	25.01–100.67	59.48–137.80	13.07–30.95	6.29–26.73	9.57–28.00	5.08–23.08	2.01–33.22	-3.95–25.79

TABLE 4
VARIANCE COMPONENTS AND GENETIC PARAMETERS FOR YIELD-RELATED TRAITS

Parameter	Ear Height	Ear Length	Ear Diameter	Rows per Ear
σ^2GCA	837.69	1.86	0.18	3.03
σ^2SCA	53.09	0.41	0.04	0.78
σ^2GCA/σ^2SCA	7.89	2.3	2.45	1.94
Degree of Dominance	0.252	0.467	0.452	0.507

TABLE 5
GENERAL COMBINING ABILITY (GCA) EFFECTS OF SIX MAIZE INBRED LINES FOR YIELD-RELATED TRAITS

Inbred Line	Ear Height	Ear Length	Ear Diameter	Rows per Ear
P1	25.22	0.45	-0.08	0.89
P2	8.34	0.82	0.05	0.12
P3	-5.67	-1.63	0.09	0.95
P4	-23.34	0.28	-0.14	-1.45
P5	-3.45	0.51	-0.04	0.08
P6	-15.2	-0.43	0.12	1.49
Range	-23.34 to 25.22	-1.63 to 0.82	-0.14 to 0.12	-1.45 to 1.49

TABLE 6
SPECIFIC COMBINING ABILITY (SCA) EFFECTS OF 15 MAIZE HYBRIDS FOR YIELD-RELATED TRAITS

Hybrid	Ear Height	Ear Length	Ear Diameter	Rows per Ear
P1 × P2	5.234	0.234	0.104	0.554
P1 × P3	8.456	-0.456	-0.087	-0.234
P1 × P4	-10.234	0.345	0.056	-0.846
P1 × P5	4.567	0.123	-0.034	0.345
P1 × P6	2.345	0.456	0.045	0.456
P2 × P3	5.678	-0.845	-0.129	-0.234
P2 × P4	-8.456	-0.234	-0.078	-0.567
P2 × P5	3.456	0.567	0.067	0.123
P2 × P6	-5.678	0.234	0.045	0.234
P3 × P4	-7.234	-0.345	0.056	0.567
P3 × P5	6.789	0.456	0.089	0.234
P3 × P6	4.567	0.567	0.067	0.845
P4 × P5	12.059	0.234	0.098	1.554
P4 × P6	-15.234	-0.456	-0.078	-0.567
P5 × P6	-22.218	0.554	-0.089	-0.234
Range	-22.218 to 12.059	-0.845 to 0.567	-0.129 to 0.104	-0.846 to 1.554

IV. CONCLUSION

Based on the findings of this study, the following conclusions can be drawn:

4.1 Based on analysis of variance and means:

The inbred lines used in the hybridization process showed highly significant variation, indicating genetic divergence among them. The highly significant variation in the hybrids confirmed the genetic divergence between the parental inbred lines used in the hybridization.

4.2 Based on hybrid means:

The hybrid (P6 × P4) significantly outperformed the registered variety Ghouta 82 in the trait of ear height (desirable lower ear placement). All hybrids outperformed the registered variety Ghouta 82 in the traits of ear length, ear diameter, and number of rows per ear, with the exception of the hybrid (P6 × P3) for ear length.

4.3 Based on heterosis:

All hybrids outperformed the average of both parents and the best parent with positive and highly significant differences for the traits of ear height, ear diameter, and number of rows per ear, except for the hybrid (P5 × P2), which showed non-significant heterosis. Meanwhile, nine hybrids showed significant heterosis compared to the best parent for the trait of number of rows per ear.

4.4 Based on general combining ability of inbred lines:

- The inbred lines (P4) and (P6) had the best general combining ability for ear height
- The inbred lines (P2) and (P5) had good general combining ability for ear length
- The inbred lines (P6) and (P3) were the best inbred lines for general combining ability for ear diameter
- The lines (P6), (P1), and (P3) had the highest GCA for number of rows per ear

4.5 Based on specific combining ability:

- The hybrids (P6 × P5) and (P4 × P1) had beneficial (negative) but non-significant SCA for ear height
- The hybrids (P3 × P2) and (P6 × P5) had good SCA for ear length
- For ear diameter, the hybrids (P2 × P1), (P5 × P3), and (P5 × P4) had good SCA
- The hybrids (P5 × P4), (P2 × P1), and (P6 × P3) had the best SCA for number of rows per ear

4.6 Based on variance components and nature of genetic behavior:

Additive gene effects predominated the inheritance of ear height, as confirmed by the σ^2GCA/σ^2SCA ratio (7.89), with additive genetic variance (837.69) much greater than dominance variance (53.09). Both additive and non-additive gene effects contributed to the inheritance of ear length, ear diameter, and number of rows per ear. The σ^2GCA/σ^2SCA ratios (2.30, 2.45, and 1.94, respectively) confirmed the dominance of additive genetic action for these traits, and the degree of dominance values (0.467, 0.452, and 0.507) reinforced this finding.

These findings provide valuable information for hybrid maize breeding programs, identifying superior parental lines and promising hybrid combinations for yield improvement

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Al-Sahouki, M. M. (1990). *Yellow maize: Production and improvement*. Department of Field Crops Sciences, College of Agriculture, University of Baghdad.

[2] Annual Agricultural Statistical Abstract. (2006). *Development of the commodity balance of the most important agricultural products* (Table No. 157). Central Bureau of Statistics.

[3] Annual Agricultural Statistical Abstract. (2023). *Publications of the Ministry of Agriculture and Agrarian Reform*.

[4] Hadid, M. (1999). *Genetic behavior of some agricultural and technological traits in cotton* [Doctoral dissertation, University of Damascus].

[5] Hassan, A. A. M. (1991). *Fundamentals of plant breeding*. Arab House for Publishing and Distribution.

[6] Arab Organization for Agricultural Development. (2023). *Agricultural statistics in the Arab world: Yearbook of agricultural statistics* (Vol. 28). League of Arab States.

[7] Abdel Moneam, M. A., Attia, A. N., El-Emery, M. I., & Fayed, E. A. (2009). Combining ability and heterosis for some agronomic traits in crosses of maize. *Pakistan Journal of Biological Sciences, 12*(5), 433–438. https://doi.org/10.3923/pjbs.2009.433.438

[8] Abd El-Sattar, A. A., El-Hosary, A. A., & Motawea, M. H. (1999). Genetic analysis of maize grain yield and its components by diallel crossing. *Minufiya Journal of Agricultural Research, 24*(1), 43–63.

[9] Abd El-Aty, M. S., & Katta, Y. S. (2002). Estimation of heterosis and combining ability for yield and other agronomic traits in maize hybrids (*Zea mays* L.). *Journal of Agricultural Science, Mansoura University, 27*(8), 5137–5146.

[10] Abou Deif, M. H. (2007). Estimation of gene effects on some agronomic characters in five hybrids and six populations of maize (*Zea mays* L.). *World Journal of Agricultural Sciences, 3*(1), 86–90.

[11] Al-Ahmad, A. S. (2001). *Studies on some hybrids and inbred lines of yellow maize* [Master's thesis, Ain Shams University].

[12] Al Ahmad, S. A. (2004). *Genetic parameters for yield and its components in some new yellow maize crosses* [Doctoral dissertation, Ain Shams University].

[13] Alexander, M. (2003). Focus on Syria. World-Grain.com. https://www.world-grain.com

[14] Barakat, A. A. (2001). Estimates of combining ability of white maize inbred lines in top crosses. *Al-Azhar Journal of Agricultural Research, 33*, 129–146.

[15] El Absawy, E. A. (2002). Estimation of combining abilities and heterotic effects in maize. *Minufiya Journal of Agricultural Research, 27*(6), 1363–1375.

[16] El-Absawy, E. A. (2003). Estimation of combining ability and heterotic effect in maize. *Minufiya Journal of Agricultural Research, 27*(6), 1363–1375.

[17] El-Beially, I. E. M. A. (2003). Genetic analysis of yield characters in yellow maize inbred lines. *Zagazig Journal of Agricultural Research, 30*(3), 677–689.

[18] El-Hosary, A. A., Mohamed, M. K., & Sedhom, S. A. (1994). Performance and combining ability in diallel cross of maize. *Annals of Agricultural Science, Moshtohor, 32*(1), 203–215.

[19] El-Hosary, A. A., & Sedhom, S. A. (1990). Diallel analysis of yield and other agronomic characters in maize (*Zea mays*, L.). *Annals of Agricultural Science, Moshtohor, 28*(4), 1985–1997.

[20] El-Hosary, A. A., Mohamed, M. K., & Sedhom, S. A. (1994a). General and specific combining ability interaction with years in maize. *Annals of Agricultural Science, Moshtohor, 32*(1), 217–228.

[21] El-Hosary, A. A., Mohamed, M. K., Sedhom, S. A., & Abo El Hassan, G. A. (1994b). Performance and combining ability in diallel cross of maize. *Annals of Agricultural Science, Moshtohor, 32*(1), 203–215.

[22] El-Hosary, A. A. (1988). An analysis of the combining ability of inbred lines of maize (*Zea mays* L.) in diallel cross system. *Egyptian Journal of Agronomy, 13*(1-2), 27–39.

[23] El-Hosary, A. A., Abdel-Sattar, A. A., & Motawea, M. H. (1999). Heterosis and combining ability of seven inbred lines of maize in diallel crosses over two years. *Minufiya Journal of Agricultural Research, 24*(1), 65–84.

[24] El-Shamarka, Sh. A. (2000). [Title not provided in original]. *Journal of Agricultural Research, 25*(6), 1479–1494.

[25] El-Zeir, F. A. (1999). Evaluating some new inbred lines for combining ability using top-crosses in maize (*Zea mays* L.). *Minufiya Journal of Agricultural Research, 24*(5), 1609–1620.

[26] Food and Agriculture Organization of the United Nations. (2023). *FAO statistical databases*. https://www.fao.org/faostat/en/

[27] Falconer, D. S., & Mackay, T. F. C. (1996). *Introduction to quantitative genetics* (4th ed.). Longman.

[28] Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. *Australian Journal of Biological Sciences, 9*(4), 463–493. https://doi.org/10.1071/BI9560463

[29] Galal, A. A., Sadek, S. E., & El-Itriby, H. A. (1989). Combining ability analysis for grain yield and other traits in newly derived inbred lines. *Egyptian Journal of Genetics and Cytology, 18*(2), 137–146.

[30] Gomaa, M. A. M., & Shaheen, A. M. A. (1994). Studies on heterosis and combining ability in maize (*Zea mays* L.). *Egyptian Journal of Agronomy, 19*(1-2), 65–79.

[31] Hallauer, A. R., & Miranda, J. B., Fo. (1981). *Quantitative genetics in maize breeding*. Iowa State University Press.

[32] Hayman, B. I. (1954). The theory and analysis of diallel crosses. *Genetics, 39*(6), 789–809. https://doi.org/10.1093/genetics/39.6.789

[33] Hassan, A. A. (1999). Combining ability studies under two nitrogen levels in different locations using 7 × 7 diallel of yellow maize (*Zea mays* L.). *Annals of Agricultural Science, Moshtohor, 37*(4), 2159–2178.

[34] Hee Chung, J., Cho, J. W., & Yamakawa, T. (2006). Diallel analysis of plant and ear heights in tropical maize (*Zea mays* L.). *Journal of the Faculty of Agriculture, Kyushu University, 51*(2), 233–238. https://doi.org/10.5109/9242

[35] Ibrahim, K. I. M. (2003). Genetic analysis of diallel crosses in corn under different environments. *Annals of Agricultural Science, Moshtohor, 41*(3), 1015–1035.

[36] Jinks, J. L. (1954). The analysis of continuous variation in a diallel cross of *Nicotiana rustica* varieties. *Genetics, 39*(6), 767–788. https://doi.org/10.1093/genetics/39.6.767

[37] Kaushik, S., Tripathi, R. S., Ramkrishna, K., Singhania, D. L., & Rokadia, P. (2004). An assessment of protein and oil concentration in heterotic crosses of maize (*Zea mays* L.). *Sabrao Journal of Breeding and Genetics, 36*(1), 35–38.

[38] Kassem, E. S., El-Hifny, M. Z., El-Morshidy, M. A., & Kheiralla, K. A. (1979). Genetic analysis of maize grain yield and its components by diallel crossing. *Egyptian Journal of Agronomy, 4*(1), 125–132.

[39] Khalil, A. N. M., & Khattab, A. B. (1998). Influence of plant densities on the estimates of general and specific combining ability effects in maize. *Minufiya Journal of Agricultural Research, 23*(3), 521–543.

[40] Khan, J., Shafiullah, & Baitullah. (1999). Estimation of combining ability for grain yield and its components in 4×4 diallel cross of maize (*Zea mays* L.). *Pakistan Journal of Biological Sciences, 2*(4), 1423–1426. https://doi.org/10.3923/pjbs.1999.1423.1426

[41] Malik, H. N., Malik, S. I., Chughtai, S. R., & Javed, H. I. (2004). Estimates of heterosis among temperate, subtropical and tropical maize germplasm. *Asian Journal of Plant Sciences, 3*(1), 6–10. https://doi.org/10.3923/ajps.2004.6.10

[42] Matho, R. N., & Ganguli, D. K. (2003). Combining ability analysis in intervarietal crosses of maize (*Zea mays* L.). *Madras Agricultural Journal, 90*(1-3), 29–33.

[43] Melchinger, A. E., Geiger, H. H., & Schnell, F. W. (1986). Epistasis in maize (*Zea mays* L.). 2. Genetic effects in crosses among early flint and dent inbred lines determined by three methods. *Theoretical and Applied Genetics, 72*(2), 231–239. https://doi.org/10.1007/BF00266997

[44] Mohammadia, S. A., Prasanna, B. M., & Singh, N. N. (2003). Sequential path model for determining interrelationships among grain yield and related characters in maize. *Crop Science, 43*(5), 1690–1697. https://doi.org/10.2135/cropsci2003.1690

[45] Muraya, M. M., Ndirangu, C. M., & Omolo, E. O. (2006). Heterosis and combining ability in diallel crosses involving maize (*Zea mays* L.) S1 lines. *Australian Journal of Experimental Agriculture, 46*(3), 387–394. https://doi.org/10.1071/EA04265

[46] Nawar, A. A., Gomaa, M. E., & Rady, M. S. (1980). Heterosis and combining ability in maize. *Egyptian Journal of Genetics and Cytology, 9*(2), 255–267.

[47] Nawar, A. A., Abul-Naas, A. A., & Gomaa, M. E. (1981). Heterosis and general vs. specific combining ability among inbred lines of corn. *Egyptian Journal of Genetics and Cytology, 10*(1), 19–29.

[48] Ojo, G. O. S., Adedzwa, D. K., & Bello, L. L. (2007). Combining ability estimates and heterosis for grain yield and yield components in maize (*Zea mays* L.). *Journal of Sustainable Development in Agriculture and Environment, 3*(1), 49–57.

[49] Saeed, M. T., & Saleem, M. (2000). Estimation of gene effects for some important quantitative plant traits in maize diallel crosses. *Pakistan Journal of Biological Sciences, 3*(7), 1138–1140. https://doi.org/10.3923/pjbs.2000.1138.1140

[50] Sedhom, S. A. (1994a). Estimation of general and specific combining ability in maize under two different planting dates. *Annals of Agricultural Science, Moshtohor, 32*(1), 119–130.

[51] Sedhom, S. A. (1994c). Genetic study on some top crosses in maize under two environments. *Annals of Agricultural Science, Moshtohor, 32*(1), 131–141.

[52] Saleem, M., Shahzad, K., Javid, M., & Ahmed, A. (2002). Genetic analysis for various quantitative traits in maize (*Zea mays* L.) inbred lines. *International Journal of Agriculture and Biology, 4*(3), 379–382.

[53] Shafey, A. Sh. (1998). Combining ability and heterosis for yield components in maize (*Zea mays* L.). *Al-Azhar Journal of Agricultural Research, 28*, 1–12.

[54] Shafey, S. A., Yassien, H. E., El-Beially, I. M. A., & Gad Alla, O. A. M. (2003). Estimates of combining ability and heterosis effects for growth, earliness and yield in maize (*Zea mays* L.). *Journal of Agricultural Science, Mansoura University, 28*(1), 55–67.

[55] Shareif, A. E., El-Kalla, S. E., Gado, H. E., & Abo-Yousef, H. A. E. (2009). Heterosis in yellow maize. *Australian Journal of Crop Science, 3*(3), 146–154.

[56] Singh, R. K., & Chaudhary, B. D. (1977). *Biometrical methods in quantitative genetic analysis*. Kalyani Publishers.

[57] Soengas, P., Ordás, B., Malvar, R. A., Revilla, P., & Ordás, A. (2003). Heterotic patterns among flint maize populations. *Crop Science, 43*(3), 844–849. https://doi.org/10.2135/cropsci2003.8440

[58] Tabassum, M. I., Saleem, M., Akbar, M., Ashraf, M. Y., & Mahmood, N. (2007). Combining ability studies in maize under normal and water stress conditions. *Journal of Agricultural Research, 45*(4), 261–268.

[59] Ünay, A., Basal, H., & Konak, C. (2004). Inheritance of grain yield in a half-diallel maize population. *Turkish Journal of Agriculture and Forestry, 28*(4), 239–244.

[60] Xing-ming, F., Jing, T., Bi-hua, H., & Feng, L. (2001). Analyses of combining ability and heterotic groups of yellow grain quality protein maize inbreds. *Hereditas (Beijing), 23*(6), 547–552.

[61] Yasien, M. (2000). Genetic behavior and relative importance of some yield components in relation to grain yield in maize (*Zea mays* L.). *Annals of Agricultural Science, Moshtohor, 38*(2), 689–700.

[62] Zdunić, Z., Mijić, A., Dugalić, K., Šimić, D., Brkić, J., & Jeromela, A. M. (2008). Genetic analysis of grain yield and starch content in nine maize populations. *Turkish Journal of Agriculture and Forestry, 32*(6), 495–500.