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Evaluation of the performance and heterosis in F_1 crosses of yellow and red maize

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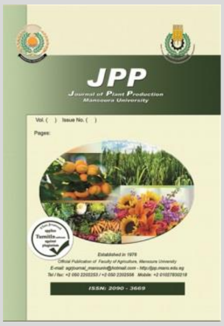

ABSTRACT

In season 2024, 24 genotypes of maize 6 inbred line, 15 cross and 3 check cultivars (S.C168, Gold and Yaqoyt5) were evaluated at the private Farm of the Department of Crops, Faculty of Agriculture, Mansoura University in RCBD with three replicates. The results showed that mean squares of genotypes, parents, crosses and parents versus crosses were significant or highly significant for flowering, vegetative, yield and yield components and quality traits. The data indicated highly significant differences for anthesis, silking dates and anthesis- silking interval (ASI) traits among the parental inbreds, their crosses and check cultivars. P_2(Red C) showed the earliest parent for anthesis, silking dates and ASI. All traits had significant heterosis over mid and pater parent except, grain yield per plant. Crosses P_1xP_4 and P_2xP_5 had negative and highly significant percentage of heterosis over mid (M.P) and better parent (B.P) for anthesis date and over mid parent for silking except ASI date. Cross P_1xP_6 (46.48 – 38.99%) had positive heterosis over mid parent and better parent respectively, for grain yield per plant. Positive significant heterosis over better and better parent were exhibited by 3 crosses P_1xP_2, P_1xP_5 and P_3xP_5 for shelling percentage. All crosses had positive significant heterosis over mid and better parent except, two crosses P_1xP_2 and P_3xP_4 for mid-parent and P_3xP_4 for better parent for oil percentage.

Keywords: Maize, mean performance, heterosis, grain yield, yield components

INTRODUCTION

In the world, maize is judged as one of the most significant crops. Due to its high yield and resistance to harsh conditions, it is also referred to as the "queen of cereals.". Its widespread use demonstrates the value of research in enhancing the functionality and development potential of maize cultivars (Matin *et al*., 2016). Humans consume corn as food. Additionally, it serves as a high-quality fundamental raw material for a variety of industrial products, including those made from oil, starch, protein, alcoholic drinks, food sweeteners, and animal feed. It is also used in preparation of gum, textiles, and the package and paper sectors. Additionally, maize has a high nutritious value.

Hybrid maize seed marketing is flourishing every year but limited commercial hybrids are suited to cultivation owing to existing diverse agro-ecological regime of the country. Since 250 years top innovations in modern agriculture has begun with heterosis discovery in plant crosses (Malik *et al*., 2004). Heterosis (hybrid vigor) is the enhancement in size, growth, fertility and yield in progeny compared to parents. Hallauer and Miranda (1988) manifested that heterosis depends on the genetic divergence of two parental varieties; also, genetic divergence of the parents is inferred from the heterotic patterns manifested in a series of cross combination. As compared to existing cultivars the new maize hybrid should be better for grain yield and other economic traits. The determination of heterosis is important for development of superior hybrids.

Therefore, this study was conducted to evaluate the performance and heterosis in 15 F_1 crosses of yellow and red maize.

MATERIALS AND METHODS

Experimental design and procedure:

The experiment was carried out at the Faculty of Agriculture, Mansoura University, Egypt, during the 2023 and 2024 growing seasons.

In 2023 growing season, the six parental inbred lines namely, (Red A, Red C, L.28, L.50, L.113 and L.143) and three cultivars' checks were planted on April 15th and May 22st, and each parental inbred lines was grown in three rows, to overcome the differences in flowering date and to secure enough hybrid seeds. During this season, all possible cross combinations, without reciprocals, by using a half-dialed to obtain a total of 15 F_1 hybrids.

In 2024 growing season, 24 entries (15 F_1's along their 6 parental inbred lines plus 3 cultivars checks) were evaluated.

A Randomized Complete Block Design (RCBD) was used for the experimental layout. The trial was replicated three times to ensure accuracy and reliability of the results. Each plot consisted of one ridge, each 5 meters long, with a row spacing 70 cm and a plant spacing of 25 cm. The seeds were planted at 2 seeds/hill, hills were thinned to maintain one plant per hill.

The studied characters

In each replication, data were registered on the following characters:

A- flowering and vegetative traits:

Days to anthesis, days to silking and anthesis-silking interval (ASI) for flowering traits, chlorophyll content (SPAD), ear leaf area (cm^2), plant height(cm), ear height (cm), ear position % and stay green for vegetative traits.

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B- Yield and yield components and quality traits

Number of ears/plant, ear diameter, cob diameter, kernel depth (cm^2), number of rows/ear, number of kernels/row, number of kernels/ear, 100-kernel weight (g) ear yield/plant, grain yield/plant and shelling percentage for yield and yield component and oil percentage for quality traits.

Analysis of variance:

The data were analyzed on plot mean basis. All obtained data were subjected to the statistical analysis of the Randomized Complete Block Design to test the differences among various genotypes, according to Snedecor and Cochran (1980). Treatments were compared using the least differences values (LSD) at 5% and 1% level of probability, according to Gomez and Gomez (1984).

Estimates of Heterosis:

Heterosis as proposed by (Mather and Jinks.,1982). was determined for individual cross as the percentage deviation of F_1 means from mid-parents (MP) and better-parent (BP) means and expressed as percentages.

Heterosis over the mid-parents % ($\bar{M}P$) =

$$[(\bar{F}1 - \bar{M}P)/ \bar{M}P] \times 100$$

Heterosis over the better-parent % ($\bar{B}P$) =

$$[(\bar{F}1 - \bar{B}P)/ \bar{B}P] \times 100$$

Where:

F_1: Mean value of the first generation.

$\bar{M}P$: Mean of the mid-parents calculated by using average mean of the two parents.

$\bar{B}P$: Mean of the better parent.

The significance of heterosis effect for F_1 values from the mid-parents and better-parent were tested according to the following formula:

LSD for mid-parents = t0.05 x $(3MSe/2r)^{1/2}$

LSD for better-parents = t0.05 x $(2MSe/r)^{1/2}$

RESULT AND DISCUSSION

A- Flowering and vegetative traits :-

Analysis of variance for flowering and vegetative traits are presented in Table 1 and 2. The results showed that mean squares of genotypes, parents, crosses and parents versus crosses were significant or highly significant for all flowering and vegetative traits. These results were garment with reported by Kamal *et al*. (2023) and Hajar *et al*. (2024).

Table 1. Mean squares of maize genotypes, parents, crosses, and parents versus crosses for all flowering traits during season 2024.

S.O.V	DF	Anthesis date (day)	Silking date (day)	ASI (day)
Replications	2	1.29	1.21	2.78
Genotypes	20	26.34**	10.61**	16.25**
Parents	5	6.49**	11.73**	2.36*
Crosses	14	27.99**	8.28**	21.24**
P V Cross	1	102.41**	37.64**	15.87**
Error	40	0.65	0.57	0.89
TOTAL	62	8.96	3.83	5.91

*and**significant at 5% and 1% probability levels, respectively

Table 2. Mean squares of maize genotypes, parents, crosses and parents versus crosses for all vegetative traits during season 2024.

S.O.V	DF	Chlorophyl content (SPAD)	Ear Leaf Area (cm²)	Plant height (cm)	Ear height (cm)	Ear position%	Stay green
Replications	2	3.47	2139.16	27.44	22.49	2.64	0.444
Genotypes	20	203.61**	72384.98**	4436.88**	588.35**	217.93**	10.687**
Parents	5	362.41**	59098.10**	6180.53**	605.30**	218.44**	5.156**
Crosses	14	134.14**	80496.11**	4059.23**	594.02**	219.42**	10.451**
P V Cross	1	382.20**	25263.67**	1005.74**	424.27**	194.67**	41.657**
Error	40	10.73	738.93	57.83	12.54	4.81	0.878
TOTAL	62	72.72	23895.73	1469.45	198.61	73.49	4.028

*and**significant at 5% and 1% probability levels, respectively

B- Yield and yield components and quality traits:

Analysis of variance for yield and yield components and quality traits are presented in Table3 and 4. The results showed that mean squares of genotypes, parents, crosses and parents versus crosses were significant or highly significant for yield and yield components and quality traits. These results were garment with reported by Abdel-Moneam *et al*. (2024) for number of kernels per row, kernels weight per plant, shelling percentage and oil percentage and Hajar *et al*. (2024).

Table 3. Mean squares of maize genotypes , parents , crosses , and parents versus crosses for number of ears/plant, ear diameter, cob diameter, kernel depth, number of rows/ear and number of grains/row during season 2024.

S.O.V	DF	Number of ears/plant	Ear diameter (cm)	Cob diameter (cm)	Kernel depth (cm)	Number of rows/ear	Number of grains/row
Replications	2	0.02	0.04	0.03	0.01	0.97	2.78
Genotypes	20	0.73**	0.86**	0.29**	0.15**	33.39**	88.29**
Parents	5	0.59**	2.32**	0.24**	0.12**	5.73**	81.96**
crosses	14	0.80**	0.36**	0.30**	0.11**	31.12**	78.90**
P V Cross	1	0.46**	0.53**	0.31**	0.72**	203.43**	251.43**
Error	40	0.02	0.02	0.02	0.01	0.47	2.78
TOTAL	62	0.25	0.29	0.10	0.05	11.10	30.36

*and**significant at 5% and 1% probability levels, respectively

Table 4. Mean squares of maize genotypes, parents, crosses, and parents versus crosses for number of kernels/ears, 100_kernel weight, Ear yield/plant, kernel yield/plant, shelling % and oil % during season 2024.

S.O.V	DF	Number of kernels/ ears	100_kernel weight(g)	Ear yield/plant (g)	kernel yield/plant (g)	Shelling %	Oil %
Replications	2	1434.11	0.65	7790.30	496.21	3.97	0.14
Genotypes	20	72366.26**	29.40**	79638.31**	58928.46**	222.45**	4.08**
Parents	5	50677.07**	37.64**	10285.56**	83085.92**	450.86**	4.34**
Crosses	14	72571.02**	18.53**	97192.40**	52019.28**	87.03**	3.55**
P V Cross	1	177945.63**	140.30**	180644.80**	34869.79**	976.24**	10.17**
Error	40	894.68	1.97	2498.37	1524.46	10.80	0.07
TOTAL	62	23967.43	10.78	27552.93	20008.71	78.86	1.36

*and**significant at 5% and 1% probability levels, respective

Mean Performance of Traits:

A- Flowering and vegetative traits :-

Table 5 showed that parent, P_2(Red C) showed the earliest parent for anthesis, silking dates 53 and 54 days respectively, and ASI (1 day). While P6 (L.143) showed the latest parent for anthesis, silking dates 57.3 and 60 days respectively, and P_1 (Red A) for ASI (3.67 day), with significant differences among them.

For hybrids, found that hybrids P_1xP_4, P_2xP_5, P_3xP_5, P_4xP_6 (47.7 days) and check cultivars SC168 (52.0 day) were earliest for anthesis date. While hybrids P_2xP_5 (53.7), P_2xP_6, P_4xP_6 and check cultivars SC168 (53.3) days were earliest for silking date. P_2xP_4, P_2xP_6, P_3xP_6, Gold 21, Yaqoot5 and SC 168 (1 days) were earliest for anthesis-silking interval, with significant differences among them.

Table 5. Mean of days to anthesis , silking dates and anthesis-silking interval for maize inbreds and their crosses as well as checks during 2024.

Genotypes	Anthesis date (day)	Silking date (day)	Anthesis-silking interval (day)
P1(Red A)	54.3	58.0	3.67
P2(Red C)	53.0	54.0	1.00
P3 (L.28)	54.7	57.7	3.00
P4 (L.50)	55.7	58.3	2.67
P5(L.113)	55.7	58.0	2.33
P6(L.143)	57.3	60.0	2.67
LSD 5%	0.34	0.32	0.40
LSD 1%	0.46	0.43	0.54
P1 X P2	53.0	57.0	4.00
P1 X P3	54.0	56.7	2.67
P1 X P4	47.7	56.3	8.67
P1 X P5	53.7	55.0	1.33
P1 X P6	54.0	58.3	4.33
P2 X P3	53.0	57.0	4.00
P2 X P4	54.3	55.3	1.00
P2 X P5	47.7	53.7	6.00
P2 X P6	52.3	53.3	1.00
P3 X P4	54.0	56.0	2.00
P3 X P5	47.7	56.7	9.00
P3 X P6	54.0	55.0	1.00
P4 X P5	57.0	58.7	1.67
P4 X P6	47.7	53.3	5.67
P5 X P6	54.3	57.0	2.67
LSD 5%	0.54	0.51	0.64
LSD 1%	0.73	0.68	0.85
Gold 21	58.0	59.0	1.00
Yaqout 5	58.0	53.0	1.00
SC 168	52.0	56.0	1.00
Average Parents	55.1	57.7	2.56
Average Crosses	52.3	56.0	3.67

Table 6 the data indicated highly significant differences for chlorophyll content, ear leaf area, plant height, ear height, ear position and stay green traits among the parental inbreds, their crosses and check cultivars. These results were garment with reported by Abdel-Moneam *et al.*(2024) and Hajar *et al.* (2024).

Results in Table 6 showed that chlorophyll content values ranged from 42.8 for P_2(L.50) to 71.9 for P_5(L.113) for parents. For crosses, it ranged from 43.4 for (P_2xP_5) to 66.2 for (P_3xP_4), with significant differences among them.

Ear leaf area values ranged from 936 cm^2 for P_4(L.50) to 1292 cm^2 for P_2(Red C) for parents. While for crosses, ear leaf area ranged from 710 cm^2 for (P_3xP_6) to 1305.3 cm^2 for (P_1xP_6). Check cultivars, (SC 168) 1376 cm^2 showed high value for ear leaf area, with significant differences among them.

Plant height values ranged from 155 to 290 cm for parents. The tallest parent was P_6(L.143). Meanwhile, parent P_5 (L.113) was the shortest parent. While crosses, ranged from 154 to 280.7 cm. The tallest cross was P_1xP_3, while cross P_3xP_4 was the shortest, with significant differences among them. check cultivars, SC168 showed 258 cm, which means it is the tallest than other checks.

Ear height values ranged from 79.7 to 119 cm for parents. the highest parent was P_1 (Red A). While P_5(L.113) was the lowest parent. For crosses, it ranged from 80 to 133 cm. The highest cross was P_4xP_5 while, P_1xP_3 was the lowest cross, with significant differences among them. While for check cultivars, gold 21 showed 102 cm, which mean that gold 21 was the highest check.

Ear position values ranged from 36.2% for P_6(L.143) to 58.6 % for P_3(L.28) for parents. While for crosses, it ranged from 31.8% for P_1xP_3 to 66.9% for P_3xP_4, with significant differences among them. Check cultivars, gold 21 showed 47 %.

Stay green values ranged from 1.67 for P_2(Red C) to 5.33 for P_4(L.50) for parent. While for crosses, it ranged from 2 for (P_2xP_6) to 8.67 for (P_2xP_5), with significant differences among them. check cultivars, yaqout5 showed 9.33 for stay green.

B- Yield and yield component and quality traits:-

From Table 7 the data indicated highly significant differences for number of ears/plant, ear diameter, cob diameter, kernel depth, number of rows/ear and number of grains/row traits among the parental inbreds, their crosses and check cultivars. The results were garment with reported by Abdel-Moneam *et al.* (2024) and Hajar *et al.*(2024).

Number of ears/ plant values ranged from 1 for P_6(L.143) to 2 for P_2(Red C), P_3(L.28), P_4(L.50) and P_5(L.113) for parents. While for crosses, it ranged from 1 ear/plant for P_1xP_2, P_1xP_3, P_1xP_4, P_1xP_5, P_1xP_6 and P_3xP_6 to 2 ears/plant for other crosses. Check cultivars, all checks showed 2 ear/plant.

Ear diameter values ranged from 2.50 cm for P_4(L.50) to 5.10 cm for P_6(L.143) for parents. For crosses, it ranged from 3.33 cm for (P_2xP_6) to 4.70 cm for (P_3xP_4). For checks, SC168 showed 5 cm.

Cob diameter values ranged from 1.83 cm for P_1(Red A) to 1.13 cm for P_4(L.50) for parents. For crosses, it ranged from 1.17 cm for (P_4xP_5) to 2.13 cm for (P_3xP_5). For checks, yaqout5 showed 2.07 cm.

Kernel depth values ranged from 0.67 cm for P_1(Red A) to 1.23 cm for P_2(Red C) for parents. For crosses, it ranged from 0.77 cm for (P_2xP_3) to 1.45 cm for (P_4xP_5). For checks, SC168 showed 1.48 cm.

Number of rows/ear showed that P_2(Red C) was the largest number of rows/ear (16), while P_6(L.143) was the least number of rows/ear (12.3) for parents. For crosses, cross (P_1xP_3) 24.3 was the largest number of rows/ear, while crosses (P_2xP_4) and (P_5xP_6) 14.3 were the least number of rows/ear. For checks, SC-168 showed 21 number of rows/ear.

Number of kernels/row showed that P_2(Red C) 39.3 was the largest number of kernels/row, while P_3(L.28) 24.7 was the least number of kernels/row. For crosses, ranged from 27.7 to 44 kernels/row. Crosses, (P_1xP_3) and (P_3xP_5) 44 were the largest number of kernels/row, while cross (P_2xP_3) 27.7 was the least number of kernels/row. For checks, yaqout5 showed 51.3 number of kernels/row.

Table 6. Means of chlorophyll content, ear leaf area, plant height, ear height, ear position and stay green for maize inbreds and their crosses as well as check cultivars during season 2024.

Genotypes	Chlorophyll (SPAD)	Ear leaf area (cm²)	Plant height (cm)	Ear height (cm)	Ear position (%)	Stay green
P1 (Red A)	69.2	1224.0	203.3	119.0	58.5	2.33
P2 (Red C)	54.6	1292.0	206.0	101.7	49.4	1.67
P3 (L.28)	52.8	987.0	186.0	109.0	58.6	2.67
P4 (L.50)	42.8	936.0	225.7	117.0	52.6	5.33
P5 (L.113)	71.9	1162.0	155.0	79.7	45.7	4.00
P6 (L.143)	62.7	1196.0	290.0	104.7	36.2	3.33
LSD 5%	1.40	11.58	3.24	1.51	0.93	0.40
LSD 1%	1.87	15.50	4.34	2.02	1.25	0.53
P1 X P2	56.3	1260.0	214.7	101.0	47.1	4.00
P1 X P3	45.9	975.0	280.7	80.0	31.8	5.33
P1 X P4	56.0	1036.0	260.7	98.3	37.7	5.33
P1 X P5	54.3	1208.0	190.7	87.7	46.0	5.67
P1 X P6	51.6	1305.3	225.0	83.0	36.9	3.33
P2 X P3	45.6	1207.5	216.0	104.0	48.2	2.67
P2 X P4	47.9	942.0	212.7	92.0	41.4	3.00
P2 X P5	43.4	910.3	211.7	97.7	46.2	8.67
P2 X P6	62.7	1076.0	165.0	96.7	58.5	2.00
P3 X P4	66.2	1120.0	154.0	103.0	66.9	6.67
P3 X P5	50.9	1134.0	224.3	99.3	44.3	4.67
P3 X P6	53.2	710.0	184.3	84.3	45.7	5.67
P4 X P5	49.3	1272.0	263.0	133.0	50.3	8.00
P4 X P6	60.5	1190.0	263.7	115.0	42.8	5.33
P5 X P6	59.5	981.5	231.3	116.3	50.4	5.00
LSD 5%	2.21	18.31	5.12	2.39	1.48	0.63
LSD 1%	2.95	24.51	6.86	3.19	1.98	0.84
Gold 21	54.4	1156.0	217.3	102.0	47.0	6.67
Yaqout 5	60.8	1284.0	221.7	89.0	40.1	9.33
SC 168	67.6	1376.0	258.0	100.7	38.9	6.00
Average Parents	59.0	1132.8	211.0	105.2	50.2	3.22
Average Crosses	53.5	1088.5	219.8	99.4	46.3	5.02

Table 7. Means of number of ears/plant, ear diameter, cob diameter, kernel depth, number of rows/ear and number of grains/row for maize inbreds and their crosses as well as checks during season 2024.

Genotypes	Number of ears/plant	Ear diameter (cm)	Cob diameter (cm)	Kernel depth (cm)	Number of rows/ear	Number of grains/row
P1 (Red A)	1.33	3.23	1.83	0.67	14.0	36.0
P2 (Red C)	2.00	4.07	1.60	1.23	16.0	39.3
P3 (L.28)	2.00	3.93	1.77	0.78	15.0	24.7
P4 (L.50)	2.00	2.50	1.13	0.91	12.7	33.7
P5 (L.113)	2.00	3.47	1.77	0.85	14.0	38.0
P6 (L.143)	1.00	5.10	1.33	1.07	12.3	33.0
LSD 5%	0.06	0.06	0.06	0.04	0.29	0.71
LSD 1%	0.08	0.08	0.08	0.06	0.39	0.95
P1 X P2	1.00	4.30	2.03	1.12	22.0	43.3
P1 X P3	1.00	4.03	1.80	1.12	24.3	44.0
P1 X P4	1.00	3.90	1.70	1.10	16.0	35.7
P1 X P5	1.00	3.40	1.60	1.32	18.7	39.3
P1 X P6	1.00	3.93	1.83	1.05	16.7	36.3
P2 X P3	1.00	3.93	1.80	0.77	19.0	27.7
P2 X P4	2.00	3.80	1.23	1.35	14.3	36.0
P2 X P5	2.00	4.03	1.87	0.97	16.0	41.0
P2 X P6	2.00	3.33	1.97	1.03	15.3	42.3
P3 X P4	2.00	4.70	1.20	1.42	23.0	29.0
P3 X P5	2.00	4.07	2.13	1.29	17.3	44.0
P3 X P6	1.00	4.07	1.53	1.20	16.0	41.3
P4 X P5	2.00	3.47	1.17	1.45	21.0	42.3
P4 X P6	2.00	3.80	2.03	1.24	15.7	35.3
P5 X P6	2.00	4.03	2.00	0.90	14.3	40.3
LSD 5%	0.10	0.10	0.10	0.07	0.46	1.12
LSD 1%	0.13	0.13	0.13	0.09	0.62	1.50
Gold 21	2.00	4.03	1.93	1.05	14.7	44.7
Yaqout 5	2.00	4.30	2.07	1.12	16.0	51.3
SC 168	2.00	5.00	2.03	1.48	21.0	42.0
Average Parents	1.72	3.72	1.57	0.92	14.0	34.1
Average Crosses	1.53	3.92	1.73	1.16	18.0	38.5

The data in Table 8 indicated highly significant differences for number of kernels/ear, 100-kernels weight, ear yield/plant, grains yield/plant, shelling % and oil % traits among the parental inbreds, their crosses and check cultivars. The results were compatible with reported by Abdel-Moneam *et al*. (2024) and Hajar *et al*. (2024).

In Table 8. Number of kernels/ear values indicated that P_6(L.143) 745.3 was the largest number of kernels/ear, while P_2(Red C) 346 was the least number of kernels/ear for parents. For crosses, (P_1xP_2) 953.3 was the largest number of kernels/ear, while cross (P_2xP_3) 370 was the least number of kernels/ear. For checks, SC168 showed 882 number of kernels/ear.

In Table 8. 100-kernels weight values ranged from 23g P_1(Red A) to 31.77g P_6(L.143) for parents. Which means that P_6(L.143) was the maximum weight, while P_1(Red A) was minimum weight. For crosses, ranged from 27.27g to 34.30g. Which means that cross (P_4xP_6) was the maximum weight, while cross (P_1xP_2) was the minimum weight. For checks, SC-168 showed the maximum weight 35.60g for 100_kernels weight.

In Table 8. Ear yield/plant values ranged from 566.7g for P_6(L.143) as minimum weight to 733.3 g for P_5(L.113) as maximum weight. While for crosses, it ranged from 583.3 g for (P_1xP_4) as minimum weight to 1100 g for (P_4xP_6) as maximum weight. Check cultivars, yaqout5 and SC168 showed maximum weight 1000 g for ear yield/plant.

In Table 8. Kernels yield/plant values ranged from 419 g for P_1(Red A) as minimum weight to 866.7 g for P_5(L.113) as maximum weight. While for crosses, it ranged from 466.7 g for (P3xP4) and (P3xP6) as minimum weight to 858 g for (P1xP5) as maximum weight. Check cultivars, yaqout5 and SC168 showed maximum weight 800 g for kernel yield/plant.

In Table 8. The highest percentages of shelling % were recorded by P_4(L 50) 83.33 % followed by P2 (Red C) 82.62% and P6 (L.143) 82.22%, with significant differences among them. Regarding to F_1 crosses the greatest values of shelling % was 93.67% for P_2xP_5 with significant differences among them and surpassed significantly over the three check cultivars Gold 21 (83.33%), Yaqout5 (80.00%) and SC 168 (70.33%).

In Table 8 the highest percentages of oil % were recorded by P_3 (L.28) 5.94% followed by P_4 (L.50) 5.41%, with significant differences among them. Regarding to F_1 crosses the greatest values of oil % were P_4 X P_5 (6.93%) followed by P_5 X P_6 (6.54%), with significant differences among them, and surpassed significantly over the three check cultivars Gold 21 (4.16%), Yaqout5 (3.75%) and SC 168 (4.11%).

Table 8. Means of number of kernels/ear, 100-kernels weight, ear yield/plant, grains yield/plant, shelling % and oil % for maize inbreds and their crosses as well as check cultivars during 2024.

Genotypes	Number of kernels/ear	100_kernels weight (g)	Ear yield/plant (g)	Grain yield/plant (g)	Shelling %	Oil %
P1 (Red A)	500.7	23.00	636.7	419.0	65.66	3.18
P2 (Red C)	346.0	23.33	603.3	446.0	82.62	3.26
P3 (L.28)	480.0	28.70	596.7	500.0	63.97	5.94
P4 (L.50)	475.7	26.87	600.0	500.0	83.33	5.41
P5 (L.113)	514.3	29.83	733.3	866.7	54.64	3.35
P6 (L.143)	745.3	31.77	566.7	466.7	82.22	3.88
LSD 5%	12.74	0.60	21.30	16.64	1.40	0.11
LSD 1%	17.05	0.80	28.50	22.26	1.87	0.15
P1 X P2	953.3	27.27	675.7	496.3	82.22	3.54
P1 X P3	856.0	29.03	650.0	560.3	76.92	4.19
P1 X P4	570.7	31.33	583.3	500.0	79.75	5.55
P1 X P5	733.3	30.50	1016.7	858.0	87.32	4.33
P1 X P6	578.7	28.43	600.0	648.7	83.33	3.77
P2 X P3	370.0	33.80	600.0	510.0	80.55	4.91
P2 X P4	479.3	34.23	680.0	483.3	71.07	4.36
P2 X P5	656.0	27.67	746.7	607.7	93.67	4.08
P2 X P6	740.0	29.20	604.0	529.3	83.73	4.86
P3 X P4	732.3	34.20	636.7	466.7	73.12	4.98
P3 X P5	661.3	29.53	1016.7	800.0	78.68	6.51
P3 X P6	465.7	28.33	593.3	466.7	82.22	6.39
P4 X P5	556.0	29.73	683.3	550.0	80.40	6.93
P4 X P6	551.3	34.30	1100.0	500.0	78.84	4.92
P5 X P6	515.7	30.73	933.3	800.0	80.00	6.54
LSD 5%	20.15	0.95	33.67	26.30	2.21	0.18
LSD 1%	26.96	1.27	45.06	35.20	2.96	0.24
Gold 21	655.3	32.73	600.0	500.0	83.33	4.16
Yaqout 5	821.3	33.93	1000.0	800.0	80.00	3.75
SC 168	882.0	35.60	1000.0	800.0	70.33	4.11
Average Parents	510.3	27.25	622.8	533.1	72.07	4.17
Average Crosses	628.0	30.55	741.3	585.1	80.79	5.06

Heterosis estimation: -

Heterosis that increase the performance of progeny compared with homozygous parents reach to the highest levels when the combining population was complementary and heterozygous (Mezmouk *et al*. 2014).

A- Flowering and vegetative traits:-

Table 9 results indicated that every cross under study had significant and negative heterosis over mid parent by all crosses except, one cross for mid parent namely, P_4xP_5.While, significant and negative heterosis over better parent were exhibited by five crosses P_1xP_4, P_2xP_5, P_3xP_5, P_4xP_6 and P_5xP_6 for anthesis date. For silking date, highest negative heterosis over mid parent were exhibited by all crosses except, two crosses for mid parents P_1xP_2 and P_2xP_3.While, highest negative heterosis over better parent were exhibited by all crosses except 3 crosses for better parent P_1xP_2, P_2xP_3 and P_2xP_4. Highest negative heterosis over mid parent were exhibited by seven crosses P_1xP_3,

P_1xP_5, P_2xP_4, P_2xP_6, P_3xP_4, P_3xP_6 and P_4xP_5.While, highest negative heterosis over better parent were exhibited by five crosses P_1xP_3, p_1xP_5, P_3xP_4, P_3xP_6, and P_4xP_5 for anthesis-silking interval. Youstina *et al.*(2016) and Prashanthi *et al.* (2024 a) they achieved similar findings.

Table 10 showed that highest positive heterosis over mid parent were exhibited by three crosses P_2xP_6, P_3xP_4 and P_4xP_6. While better parent cross P_3xP_4 showed positive and highly significant heterosis for chlorophyll content. For ear leaf area, three crosses P_1xP_6, P_3xP_4 and P_4xP_5 had positive over mid and better parent heterosis. Negative significant heterosis over mid and better parent were exhibited by three crosses P_2xP_6 and P_3xP_4 for plant height. Regarding ear height, two crosses P_4xP_5 and P_5xP_6 had highest positive heterosis over mid and better parent. Highest positive heterosis over mid and better parent were exhibited by three crosses P_2xP_6, P_3xP_4 and P_5xP_6 for ear position. All of crosses manifested positive and highly significant heterosis over mid and better parent except, two crosses P_2xP_4 and P_2xP_6 had negative for stay green. The results were compatible with reported by Attia *et al*. (2013) and Youstina *et al*. (2016)

Table 9. Percentage of heterosis over mid (M.P) and better parent (B.P) for F_1 crosses of studied maize flowering traits during season 2024.

Genotypes	Anthesis date (day)		Silking date (day)		ASI (day)	
	MP	BP	MP	BP	MP	BP
P1 X P2	-1.24*	0.00	1.79**	5.56**	71.43**	300.00**
P1 X P3	-0.92	-0.61	-2.02**	-1.73**	-20.00**	-11.11**
P1 X P4	-13.33**	-12.27**	-3.15**	-2.93**	173.68**	225.00**
P1 X P5	-2.42**	-1.23	-5.17**	-5.18**	-55.56**	-42.86**
P1 X P6	-3.28**	-0.61	-1.13*	0.52	36.84**	62.50**
P2 X P3	-1.55**	0.00	2.09**	5.56**	100.00**	300.00**
P2 X P4	0.00	2.52**	-1.48**	2.41**	-45.45**	0.00
P2 X P5	-12.27**	-10.06**	-4.17**	-0.56	260.00**	500.00**
P2 X P6	-5.14**	-1.26	-6.43**	-1.30*	-45.45**	0.00
P3 X P4	-2.11**	-1.22	-3.45**	-2.95**	-29.41**	-25.00**
P3 X P5	-13.60**	-12.80**	-2.02**	-1.73**	237.50**	285.71**
P3 X P6	-3.57**	-1.22	-6.52**	-4.68**	-64.71**	-62.50**
P4 X P5	2.40**	2.40**	0.86	-1.21	-33.33**	-28.57**
P4 X P6	-15.63**	-14.37**	-9.86**	-8.58**	112.50**	112.50**
P5 X P6	-3.83**	-2.40**	-3.39**	-1.73**	6.67**	14.29**
LSD 5%	1.15	1.33	1.08	1.25	1.35	1.56
LSD 1%	1.54	1.78	1.45	1.67	1.81	2.09

***and**significant at 5% and 1% probability levels, respectively.**

Table 10. Percentage of heterosis over mid (M.P) and better parent (B.P) for F_1 crosses of studied maize for Chlorophyll content , Ear Leaf Area, Plant height, Ear height, Ear position and stay green during season 2024.

Genotypes	Chlorophyll (SPAD)		Ear Leaf Area (cm²)		Plant height (cm)		Ear height (cm)		Ear position%		Stay green	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
P1 X P2	-9.08**	-18.69**	0.16	-2.48	4.89	5.57	-8.46**	-15.13**	-12.70**	-19.53**	100.00**	71.67**
P1 X P3	-24.72**	-33.62**	-11.80	-20.34	44.18**	50.90**	-29.82**	-32.77**	-45.66**	-45.71**	113.33**	99.63**
P1 X P4	-0.06	-19.12**	-4.07	15.36	21.52**	28.20**	-16.67**	-17.37**	-32.11**	-35.54**	39.13**	00.00
P1 X P5	-23.08**	-24.52**	1.26	-1.31	6.42	23.01**	-11.74**	-26.33**	-11.76**	-21.41**	78.95**	41.75**
P1 X P6	-21.69**	-25.39**	7.88	6.65	-8.78	10.66	-25.78**	-30.25**	-22.07**	-36.96**	17.65**	00.00
P2 X P3	-15.15**	-16.49**	5.97	-6.54	10.20	16.13*	-1.27	-4.59	-10.80**	-17.85**	23.08**	00.00
P2 X P4	-1.68	-12.28**	-15.44	-27.09	-1.47	3.24	-15.85**	-21.37**	-18.82**	-21.34**	-14.29**	-43.72**
P2 X P5	-31.31**	-39.59**	-25.81	-29.54	17.27**	36.56**	7.72**	-3.93	-2.91	-6.48**	205.88**	116.75**
P2 X P6	6.91**	0.00	-13.50	-16.72	-33.47**	-19.90**	-6.30*	-7.64*	36.87**	18.57**	-20.00**	-39.94**
P3 X P4	38.45**	25.30**	16.48	13.47	-25.18**	-17.20**	-8.85**	-11.97**	20.31**	14.16**	66.67**	66.75**
P3 X P5	-18.44**	-29.25**	5.54	-2.41	31.57**	44.73**	5.30*	-8.87**	-15.17**	-24.50**	40.00**	16.75**
P3 X P6	-7.94**	-15.16**	-34.95	-40.63	-22.55**	-0.90	-21.06**	-22.63**	-3.52*	-22.00**	88.89**	70.27**
P4 X P5	-14.04**	-31.43**	21.26	9.47	38.18**	69.68**	35.25**	13.68**	2.34	-4.37*	71.43**	50.09**
P4 X P6	14.66**	-3.51	11.63	-0.51	2.26	16.84**	3.76	-1.71	-3.53*	-18.62**	23.08**	00.00
P5 X P6	-11.52**	-17.20**	-16.75	-17.94	3.97	49.25**	26.22**	11.15**	23.00**	10.13**	36.36**	25.00**
LSD 5%	4.68	5.41	38.85	44.86	10.87	12.55	5.06	5.84	3.13	3.62	1.34	1.55
LSD 1%	6.26	7.23	51.98	60.03	14.54	16.79	6.77	7.82	4.19	4.84	1.79	2.07

***and**significant at 5% and 1% probability levels, respectively.**

Results given in Table 11 show crosses manifested positive and highly significant heterosis over mid-parent crosses P_2xP_6, P_4xP_6 and P_5xP_6 for number ears/plant. Regarding stem diameter, crosses P_1xP_2, P_1xP_3, P_1xP_4, P_1xP_5, P_2xP_4, P_2xP_5, P_3xP_4, P_3xP_5 and P_4xP_5 had significant and highly significant heterosis over mid and better parent**.** Crosses P_1xP_2, P_2xP_3, P_2xP_5, P_2xP_6, P_3xP_5, P_4xP_6 and P_5xP_6 showed highly and positive heterosis over mid and better parent for cob diameter. All crosses showed significant and positive heterosis over mid and better parent except four crosses P_2xP_3, P_2xP_5, P_2xP_6 and P_5xP_6 had negative and highly significant heterosis and P_1xP_2, P_1xP_6 for better parent of kernel depth. For number of rows/ear, all crosses showed significant and positive heterosis over mid and better parent except P_2xP_4 and P_2xP_6 had negative and significant better parent heterosis. Number of kernels/row, crosses P_1xP_2, P_1xP_3, P_1xP_5, P_2xP_5, P_2xP_6, P_3xP_5, P_3xP_6, P_4xP_5, P_4xP_6 and P_5xP_6 showed significant and positive heterosis over mid and better parent. Amanullah *et al*. (2011) , Youstina *et al*. (2016) and Prashanthi *et al*. (2024 a) they achieved similar findings.

Results given in Table 12 show significant and positive heterosis over mid and better parent by P_1xP_2, P_1xP_3 and P_3xP_4 for number kernels/ear. Crosses P_1xP_2, P_1xP_4, P_2xP_3, P_2xP_4, P_3xP_4 and P_4xP_6 had significant and highly significant heterosis over mid and better parent for 100-kernels weight**.** Positive significant heterosis over mid parent and better parent were exhibited by one cross P_4xP_6 for ear yield per plant. Cross P_1xP_6 (46.48 – 38.99%) had Positive heterosis over mid parent and better parent respectively, for grain yield per plant. Positive significant heterosis over better and better parent were exhibited by 4 crosses P_1xP_2, P_1xP_5 and P_3xP_5 for shelling percentage. All crosses had positive significant heterosis over better and better parent except, two crosses namely, P_1xP_2 and P_3xP_4 for mid-parent and P_3xP_4 for better parent for oil percentage. Abd El-Aty and Katta (2002), Appunu *et al*. (2007), Alam *et al*. (2008), Abdel-Moneam *et al*. (2009), Amiruzzaman *et al*. (2010), Abdel-Moneam *et al*. (2014) and Youstina *et al*., (2016) all achieved similar findings.

Table 11. Percentage of heterosis over mid-parent (M.P) and better-parent (B.P) for F_1 crosses of studied maize for number of ears/ plants, ear diameter, cob diameter, kernel depth, number of rows/ear and number of kernels/ears during season 2024.

Genotypes	Number of ears/plants		Ear diameter (Cm)		Cob diameter (cm)		Kernel depth (cm)		Number of rows/ear		Number of kernels/rows	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
P1 X P2	-40.00**	-50.00**	17.81**	5.74**	18.45**	10.91**	17.54**	-8.94**	46.67**	57.15**	15.04**	10.17**
P1 X P3	-40.00**	-50.00**	12.56**	2.54**	0.00	-1.82**	54.02**	43.59**	67.82**	62.00**	45.05**	22.22**
P1 X P4	-40.00**	-50.00**	36.05**	20.62**	14.61**	-7.27**	39.83**	20.88**	20.00**	14.58**	2.39*	-0.93
P1 X P5	-40.00**	-50.00**	1.49**	-1.92**	-11.11**	-12.73**	74.51**	55.30**	33.33**	33.58**	6.31**	3.51*
P1 X P6	-14.29**	-25.00**	-5.60**	-22.88**	15.79**	0.00	21.15**	-1.87**	26.58**	19.28**	5.31**	0.93
P2 X P3	-50.00**	-50.00**	-1.67**	-3.28**	6.93**	1.89**	-23.97**	-37.40**	22.58**	18.75**	-13.54**	-29.66**
P2 X P4	0.00	0.00	15.74**	-6.56**	-9.76**	-22.92**	26.17**	9.76**	0.00	-10.65**	-1.37	-8.47**
P2 X P5	0.00	0.00	7.08**	-0.82**	10.89**	5.66**	-7.20**	-21.14**	6.67**	00.00	6.03**	4.24**
P2 X P6	33.33**	0.00	-27.27**	-34.64**	34.09**	22.92**	-10.14**	-16.26*	8.24**	-4.37**	17.05**	7.63**
P3 X P4	0.00	0.00	46.11**	19.49**	-17.24**	-32.08**	67.65**	56.14**	66.27**	53.33**	-0.57	-13.86**
P3 X P5	0.00	0.00	9.91**	3.39**	20.75**	20.75**	58.37**	51.77**	19.54**	15.33**	40.43**	15.79**
P3 X P6	-33.33**	-50.00**	-9.96**	-20.26**	-1.08**	-13.21**	29.73**	12.15**	17.07**	6.67**	43.35**	25.25**
P4 X P5	0.00	0.00	16.20**	0.00	-19.54**	-33.96**	65.09**	59.34**	57.50**	50.00**	18.14**	11.40**
P4 X P6	33.33**	0.00	0.00	-25.49**	64.86**	52.50**	25.34**	15.88**	25.33**	23.63**	6.00**	4.95**
P5 X P6	33.33**	0.00	-5.84**	-20.92**	29.03**	13.21**	-6.09**	-15.88**	8.86**	2.15**	13.62**	6.14**
LSD 5%	0.18	0.21	0.19	0.22	0.18	0.21	0.13	0.15	0.98	1.13	2.38	2.75
LSD 1%	0.24	0.28	0.25	0.29	0.24	0.28	0.17	0.20	1.31	1.51	3.19	3.68

***and**significant at 5% and 1% probability levels, respectively.**

Table 12. Percentage of heterosis over mid-parent (M.P) and better-parent (B.P) for F_1 crosses of studied maize for number of ears/plants, ear diameter, cob diameter kernel depth, number of rows/ear and number of kernels/ears during season 2024.

Genotypes	Number of kernels/ears		100-kernels weight (g)		Ear yield/ plant (g)		Grain yield/ plant (g)		Shelling %		Oil %	
	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP
P1 X P2	125.20**	90.41**	17.70**	16.86**	8.98	6.13	14.76	11.28	10.90**	-0.48	9.94**	8.59**
P1 X P3	74.58**	70.97**	12.31**	1.16	5.41	2.09	21.94	12.06	18.68**	17.14**	-7.97**	-29.55**
P1 X P4	16.90	13.98	25.67**	16.63**	-5.66	-8.38	8.81	00.00	7.05**	-4.30	29.27**	2.67**
P1 X P5	44.50*	42.59	15.46**	2.23	48.42	38.64	33.47	-1.01	45.16**	32.98**	32.75**	29.25**
P1 X P6	-7.12	-22.35	3.83**	-10.49**	-0.28	-5.76	46.48	38.99	12.70**	1.35	6.94**	-2.83**
P2 X P3	-10.41	-22.92	29.92**	17.77**	0.00	-0.55	7.82	2.00	9.91**	-2.50	6.67**	-0.18
P2 X P4	16.67	0.76	36.39**	27.42**	13.02	12.71	2.18	-0.04	-14.35**	-14.72**	0.61**	-19.41**
P2 X P5	52.50*	27.56	4.08**	-7.26**	11.72	1.82	-7.41	-29.84	36.48**	13.38**	23.55**	21.80**
P2 X P6	35.61	-0.72	5.99**	-8.08**	3.25	0.11	16.00	13.42	1.59	1.34	36.07**	25.26**
P3 X P4	53.26*	52.57*	23.10**	19.16**	6.41	6.11	-6.67	-6.66	-0.72	-12.26**	-12.16**	-7.95**
P3 X P5	33.02	28.59	0.91	-1.01	52.88	38.64	17.07	-7.69	32.67**	23.00**	40.18**	9.60**
P3 X P6	-23.99	-37.52	-6.28**	-10.81**	2.01	-0.56	-3.45	-6.66	12.49**	0.00	30.25**	7.58**
P4 X P5	12.32	8.11	4.88**	-0.34	2.50	-6.82	-19.51	-36.54	16.54**	-3.52	58.20**	28.18**
P4 X P6	-9.69	-26.12	17.00**	7.97**	88.57*	83.33*	3.45	00.00	-4.75*	-5.39	5.92**	-9.05**
P5 X P6	-18.13	-30.81	-0.22	-3.25**	43.59	27.27	20.00	0.08	16.90**	-2.70	81.09**	68.56**
LSD 5%	42.75	49.36	2.01	2.32	71.43	82.48	55.80	64.43	4.70	5.42	0.37	0.42
LSD 1%	57.20	66.05	2.69	3.10	95.59	110.37	74.67	86.22	6.29	7.26	0.49	0.57

***and**significant at 5% and 1% probability levels, respectively**.

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تقييم السلوك الوراثى وقوة الهجين فى هجن الجيل الأول من الذرة الصفراء والحمراء

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الملخص

في موسم ٢٠٢٤، تم تقييم ٢٤ تركيب وراثي ٦ سلالات و١٥ هجينًا و ٣ هجن تجارية (S.C168, Gold and Yaqoyt5) في المزرعة الخاصة بقسم المحاصيل، كلية الزراعة، جامعة المنصورة في تصميم RCBD بثلاث مكررات. أظهرت النتائج أن متوسط مربعات التراكيب الوراثية والآباء والهجن والآباء مقابل الهجن كانت معنوية أو عالية المعنوية بالنسبة لصفات التزهير والنمو الخضري والمحصول ومكوناته وصفات الجودة. أشارت النتائج إلى اختلافات عالية المعنوية بالنسبة لصفات التزهير ومواعيد ظهور الحرير والفترة بين الإزهار و ظهور الحرير (ASI) بين الآباء والهجن والأصناف المقابلة. أظهر P_2 (Red C) أبكر الأباء بالنسبة للإزهار ومواعيد ظهور الحرير و ASI. كان لجميع الصفات قوة هجينة معنوية بالنسبة لمتوسط الأبوين وأفضل الأبوين باستثناء محصول الحبوب لكل نبات. أظهرت التهجينات P_1xP_4 وP_2xP_5 تأثيرا سالبا وعالية المعنوية لقوة الهجين بالنسبة لمتوسط الأبوين (M.P) وأفضل الأباء (B.P) لتاريخ الإزهار بالنسبة لمتوسط الأبوين لصفة ظهور الحريره باستثناء ASI. أظهر الهجين P_1xP_6 (٤٦,٤٨ - ٣٨,٩٩٪) قوة هجين موجبة بالنسبة لمتوسط الأبوين وأفضل الأبوين على التوالي، وذلك لمحصول الحبوب لكل نبات. أظهرت ٤ هجن P_1xP_2 وP_1xP_5 وP_2xP_5 وP_3xP_5 قوة هجين موجبة ومعنوية بالنسبة لمتوسط الأبوين وأفضل الأبوين لصفة نسبة التفريط. أظهرت جميع الهجن قوة هجين موجبة ومعنوية بالنسبة لأفضل الأبوين باستثناء هجنين هما P_1xP_3 وP_3xP_4 بالنسبة لمتوسط الأبوين وأفضل الأبوين لصفة نسبة الزيت.