# ESTIMATION OF SOME PARAMETERS, HETEROSIS AND HERITABILITY FOR YEILD AND MORPHOLOGICAL TRAITS IN INBRED LINE OF MAIZE (*Zea mays L*) USING LINE X TESTER METHOD

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## Abstract

**The study was conducted at field experiment - College of Agriculture– in Dohuk University during spring and autumn season (2007). Fourteen inbred lines (genotypes) of corn were used for this study, ten genotypes namely (ZP-204, Zp-301, ZP-595, ZP-670, ZP-430, ZP-505, UN- 44652, ZP –735, OH 40, and DK-17) were used as line males and four genotypes (ZP- 197, ZP-607, ZP-707, UN-44052) were used as testers (females), every genotype was planted in row with 400 cm along, 75cm between rows and 25cm between plants. A line x tester method was used which was suggested by (Kempthorne, 1957), for estimation the general combining ability of parent and specific combining ability of their F1 hybrids. Genetic components resulting from additive and non-additive type of gene action were also estimated. Heterosis was measured as a deviation of from the mid-parents. The proportional contribution of lines, testers and line x tester interaction, average degree of dominance, heritability in broad and narrow sense and expected genetic advance were determined. In spring season crossing was done, and in autumn season assessment (54) genotypes (40 F1 + 10Lines + 4 Testers).**

**The result shows: Significant positive heterosis in F1 generation over mid-parent values in favorable direction was obtained for most studied characters of hybrids also significant negative heterosis in desirable direction was recorded for days to 50% tasseling and days to 50% silking. Heritability in broad sense was high for all studied characters while heritability in narrow sense was high for days to 50% tasseling, plant height and ear height. The value of additive gene effects was more than the value of dominance gene for days to 50% tasseling, plant height, ear height and leaf area, while the value of dominance gene effects was higher than the value of additive gene effects for days to 50% silking and chlorophyll. The average degree of dominance was greater than one for days to 50% tasseling days to 50% silking and chlorophyll.**

## Introduction

**Corn is one of the most important summer economic cereal crops of the world. It ranks the third after wheat and rice. Corn contributes highly percent of poultry ration; it also entered in more industrial products. It possesses one of the most well studied genetic systems among cereals which have motivated a rich history of research into the genetics of various traits in maize. In fact maize has been subjected to extensive genetic studies than any other crop (Hallauer and Miranda, 1988). The production of high productivity hybrids is one of the objectives of plant breeder to evaluate the lines according to the general and specific combining ability and selecting the best of them to be entered in hybrid and synthetic cultivars production to reach the highest yield.**

**As a result of high costs of exported hybrid seeds, the breeding programs and hybridization with region varieties, must achieve required improvements for local**

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varieties both in quality and quantity which represented in grain yield (Lyerly, 1942 and Sprague, 1977), therefore, the hybridization is considered one of the most important programs which is used for obtaining hybrids that selected in next stages, the superior hybrids in suitable local environment. Such programs need testing the ability of inbred lines that are use us a parent according to there general combining ability and then selecting the effective specific combining ability on the yield hybrids (Ahmed and Ali 2003). Line xTester method is considered one of the effective ways for estimating the general and specific combining ability, hybrid vigor and gene action to select the inbred lines for the late generation (Kempthorne, 1957 and Ceranka *et. al.* 1998).

Line x tester was studied by Al-Barodi (1999) ; Al-Azawi (2002); Gauntam (2003) , Rezaei *et al.* (2004); Ali *et al.* (2006), Mohammed and Al- Juobori (2007). The aims of the research are: Estimation Heterosis and Heritability for same morphological traits in inbred line of maize.

## Materials and Methods

The study was carried out at field experiment College of Agriculture/ Dohuk University during the growing season 2007. Fourteen inbred lines (genotypes) of corn were used for this study, ten genotypes namely ((1) ZP-204, (2) Zp-301, (3) ZP-595, (4) ZP-670, (5) ZP-430, (5) ZP-505, (6) UN- 44652, (7) ZP –735, (8) OH 40, and (9) DK-17) were used as line males and four genotypes ( A ZP- 197, B ZP-607, C ZP-707, D UN-44052) were used as testers (females). The genotypes were sown during spring on April,11,2007, each genotype was planted in rows with 400 cm length , 75cm between rows and 25cm between plants (Al-Falahi, 2000), 600 Kg/ ha of compound fertilizer (N.P.K) ( 27-27-0) was applied during land preparing, also 200 kg/ ha urea fertilizer 46% N was added in two dates, the first rate was added after 30 days from planting, and the second

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rate added at before anthesis starting stage, plants were thined in hills to one plant. Weeds were controlled by hand, Sesamia criteca (corn borer) was controlled by using diazinon 10% insecticide (Al-Falahi, 2000).

Hybridization among the genotypes has been done by line x tester method (Kempthorne, 1957), during anthesis as the tassels of male parent and the silks of females appeared, they were isolated and covered with special papers bag for this purpose to avoid self-pollination among them, self pollination was done for all the genotypic materials (14 parents) the seeds of each hybrid and parent were harvested and dried to be used in autumn season (July, 2007), forty hybrids and by using fourteen parents were planted. By using randomized Complete Block Design (R.C.B.D) with three replications was applied. All recommended cultural practices and operations (planting, irrigation, Thinning, fertilization, weeds and insect controls) were done as the same spring season.The data were recorded from ten plants taken randomly from each row and then the average of one plant was calculated. The characters was studied: days to 50% tasseling and silking, plant height (cm), ear height (cm) , leaf area ($cm^2$): leaf width x length x 0.75 (Johnson, 1973) and Chlorophyll estimation from plant leaves (mg) (Ranganna, 1977). And total chlorophyll was estimated using Spectrophotometer apparatus.

General and specific combining ability was estimated as follows:

**A- Estimation (G.C.A) general combining ability effect for the parent L (lines)**

$\hat{g}i = \overline{Yi..} - \overline{y..}$

**B) Effect of (G.C.A) for the j parent i (tester)**

$\hat{g}i = \overline{Y.j.} - \overline{y..}$

**Specific combining ability for hybrids was calculated from the below formula**

$\hat{S}ij = yij. - \overline{yi..} - \overline{y.j.} + \overline{y...}$

**Mean of genotypic were compared according to Duncan multiple range test (Duncan, 1955). The data were analyzed using S.A.S Program analyzing**

**Proportional contribution and also determine from the formula:**

**Contribution of line = ssLx100/ Ss cross**

**Contribution of tester = ss t x 100/ Ss cross**

**Contributions of line x tester= ssL x sst x100/ Ss cross**

**The phenotype variance was estimated, which involved both genotypic and environment variance by using expected**

**variance mean E.M.S for the fixed sample (Kehel, 1967) according to the following formula:**

**Environment variance $\sigma^2 e$ = Mse / r = M s$\bar{e}$ singh and chaudhary (1979)**

**$\sigma^2 l$ = [ Ms (L) – Mse ] / rt = ½ $\sigma^2 A$ $\sigma^2 A = 2 \sigma^2 L$**

**$\sigma^2 t$ = [ Ms (t) – Mse ] / rL = ½ $\sigma^2 A$ $\sigma^2 A = 2 \sigma^2 t$**

**Additive variance**

**$\sigma^2 A = [2 \sigma^2 L + 2 \sigma^2 t ] / 2 = \sigma^2 l + \sigma^2 t$**

**Dominance variance**

**$\sigma^2 Lt$ = [ Ms (Lx t) – Mse ] / r = $\sigma^2 D$**

**Phenotype variance**

**$\sigma^2 p = \sigma^2 L + \sigma^2 t + \sigma^2 (L \times t) + \sigma^2 e$**

**$= \sigma^2 A + \sigma^2 D + \sigma^2 E = \sigma^2 G + \sigma^2 E$**

**Variance of general and specific combing ability was estimated according to (Singh and Chaudhary, 1979)**

**The heterosis was estimated according to the following formula:**

**Heterosis (H ) = F1- [P i + Pj ] / 2 (Falconer, 1989)**

**F1 = mean of first generation**

**Pi = mean of first parent (line)**

**Pj = mean of second parent (tester)**

**Then the significant of heterosis was determined.**

**t (H)** $= \frac{O - H}{\sqrt{V(H)}}$

**t (H)** $= \dfrac{O-H}{\sqrt{3\ /\ 2\sigma^2 e}}$

**The genetic advance of the characteristics was calculated according to the following formula:**

**$\Delta$ G = h$^2$ n.s.σ p**

**Where:**

**$\Delta$G = Genetic improvement**

**I = selection intensity 10% = 1.76**

**σ P = standard deviation of phenotype**

**After that the expected genetic advance t as percent % calculated according to the following equation**

**Where:**

**$\Delta$ G =** $\dfrac{\Delta G}{\bar{y}...}$ **x 100**

$\bar{y}$... **= General mean**

**The value of the expected genetic advance is considered higher when, it was more than 30%, medium where the result is between 10-30% and is considered lower when it is less than 10%. (Agrawal, V. and Z. Ahmed. 1982).**

**The heritability in Broad and Narrow was determined depending on variance of general and specific combining abilities.**

**Heritability (H$^2$ n.s and H$^2$ b.s) are measured as follows:**

**H$^2$ n.s it is considered high when it is more than 50%, it is medium where the result is between 20-50% and it is considered low when it is less than 20% (Al-Adari, 1987).**

**H$^2$ b.s it is considered high when it is more than 60%, it is medium when the result is between 40-60% and it is considered low when it is less than 40% (Ali, 1999). And as follows:**

$$H^2 b.s = \frac{\sigma^2 G}{\sigma^2 P}$$

$$H^2 n.s = \frac{\sigma^2 A}{\sigma^2 P}$$

**Where:**

**H$^2$ b.s = Heritability broad sense**

**H$^2$ n.s = Heritability in narrow sense**

**σ$^2$ G = genetic variance only** $\sigma D + \sigma A$

**σ$^2$ A = additive gene variance**

**σ$^2$ P = phenotypic variance (genetic and environment variance).**

**Average degree of dominance (ā) was calculated according to the following equation:**

$$\bar{a} = \sqrt{\frac{2\sigma^2 D}{\sigma^2 A}}$$

**if ā = 0 no dominance**
**if ā = <1> 0 partial dominance**
**if ā = 1 complete dominance**
**if ā > 1 over dominance**

## Results and discussion

**Table (1) referred to the significant differences between parents, lines, testers and line x tester for studies Character at levels %.**

**Table (1): Analysis of variance for line x tester method (Kempthorne, 1957)**

| S.O.V | d.f | Days to 50% tasseling | Days to 50% silking | plant height cm | Ear height cm | Leaf area $cm^2$ | Chlorophyll gm. | Grain yield/plant gm. |
|---|---|---|---|---|---|---|---|---|
| Replications | 2 | 15.50 | 20.72 | 75.25 | 148.43 | 20325.42 | 9471.63 | 0.11 |
| Genotypes | 53 | 79.81** | 82.11** | 1274.10** | 660.61** | 23034.82** | 23852.74** | 9.79** |
| Parents | 13 | 58.48** | 67.12** | 820.11** | 581.26** | 23123.49** | 12297.73** | 4.69** |
| Par.vas. cro. | 1 | 1842.86** | 1985.78** | 35291.22** | 14036.74** | 47470.48** | 110698.22** | 305.84** |
| Crosses | 39 | 41.72** | 38.30** | 553.19** | 344.09** | 8859.94** | 25477.60** | 3.90** |
| Lines | 9 | 70.20** | 47.40** | 1091.32** | 852.70** | 19743.84** | 20511.36** | 4.21** |
| Testers | 3 | 138.47** | 119.47** | 1497.57** | 480.68** | 141446.13** | 5766176** | 24.07** |
| Lin. X test. | 27 | 21.47** | 26.25** | 268.88** | 159.37** | 4544.61** | 23556.00** | 1.55** |
| Error | 106 | 1.59 | 1.47 | 19.66 | 15.70 | 1223.85 | 1855.81 | 0.16 |

**1-The mean of genotypes**

**The data in table (2) shows significant differences among genotypes means for all studied characters. Inbred lines (10) was earlier for days to 50% tasseling which tasseled during (59.00) days, whereas late days of 50% tasseling were recorded by lines (6) and (8) that was (70.00) days for each of them. No significant difference found between (B) and (C) testers for 50% tasseling but it was significant between other testers, the earlier tester for this trait was (11) which tasseled during (58.00) days .The earlier inbred lines for days to 50% silking were (3) and (10) which silked during (63.00) days for each of them, while the late inbred line was (8) which silked**

during (74.00) day. There were no significant differences among testers (A), (B) and (C) with (D) days to 50% silking .The highest plant height observed in an inbred lines (4) and (8) the value scored (172.14) cm and (172.00) cm respectively, while the inbred lines (6) reached (115.56) cm was less for plant height. No significant differences between testers (A) and (B), the tester (A) gave the lowest plant height and reached (154.16) cm .The inbred line (7) scored a high ear height reaching (92.07cm), while the inbred line (6) gave the lowest ear height (35.45 cm). The tester (C) was superior for ear height and the value reached (78.26 cm) while (B) tester scored the lowest ear height (60.74cm).

The largest mean for leaf area was found in inbred lines (2) and reached (559.16 $cm^2$), whereas the less leaf area was inbred line (8) (326.83 $cm^2$), the tester (C) gave the largest leaf area and reached (525.90 $cm^2$), while the less leaf area was observed in tester (A) (350.83 $cm^2$).

The large quantity of chlorophyll was found in inbred line (10) (337.39), whereas the less quantity of chlorophyll was obtained in inbred line (9) (109.77). The tester (A) gave the largest quantity of chlorophyll and reached (384.07), the fewer amounts for this trait was observed in tester (B) (260.00). the highest of grain was observed in line 10 and was 80.09 while the low weight of grain was recorded in line (4) (52.26). the tester A give a highly grain weight and the value was (77.90). the highly grain was observed in hybrid (D×5) and reached 85.85 whereas the low value of this trait was observed in hybrid (B×9).

Table (2): Means for studied characters (lines and testers)

| Genotypes | Days to 50% tasseling | Days to 50% silking | plant height (cm) | Ear height (cm) | Leaf area ($cm^2$) | Chlorophyll (gm) | Grain yield/ plant (gm) |
|---|---|---|---|---|---|---|---|
| 1 | 62.00 d | 65.00 c | 134.00 b | 61.83g | 440.06c | 255.31c | 63.12d |
| 2 | 66.00c | 69.00 b | 152.40d | 73.06d | 559.16a | 250.23c | 55.46f |
| 3 | 60.00e | 63.00c | 151.00d | 59.82g | 435.42c | 238.23c | 57.65e |
| 4 | 68.00b | 71.00 a | 172.14g | 87.62 b | 554.33a | 255.18c | 52.26f |
| 5 | 61.00d | 64.00c | 142.28c | 62.01 f | 367.84d | 231.99c | 64.28d |
| 6 | 70.00a | 73.00 a | 115.56a | 35.45h | 328.49e | 240.84c | 58.88e |
| 7 | 68.00b | 72.00 a | 171.56g | 92.07a | 522.23b | 133.75d | 72.73b |
| 8 | 70.00a | 74.00 a | 172.00g | 58.29g | 326.83e | 109.77e | 62.94d |
| 9 | 68.00b | 71.00 a | 153.20e | 64.44 f | 329.71e | 337.39a | 58.33e |
| 10 | 59.00e | 63.00c | 154.42e | 70.05e | 424.74c | 255.31c | 80.09a |
| A | 58.00e | 62.00d | 154.16e | 70.02e | 350.83d | 384.07a | 77.90a |
| B | 62.00b | 61.00d | 155.30e | 60.7g | 443.20c | 260.00b | 69.74b |
| C | 62.00b | 65.00c | 166.48f | 78.26 c | 525.90b | 275.95b | 67.53c |
| D | 70.00a | 64.00c | 175.21h | 75.60d | 525.44b | 298.45b | 63.44d |

1-10 = lines

A-D = testers

**2- Genetic parameters**

**Table (3) indicates the value of additive gene effects was more than the value of dominance gene for days to 50% tasseling, plant height, ear eight and leaf area and grain yield (10.28), (138.36) (85.24) and (1974.07) (1.13) respectively, while the value of dominance gene effects was higher than the value of additive gene effects for days to 50% silking and chlorophyll and scoring (8.25) and (7233.72) respectively. The average degree of dominance was more than one days to 50% tasseling (1.13), days to 50% silking(1.45) and chlorophyll (2.05) indicating this trait under control of the over dominance gene effect, whereas plant height, ear eight and leaf area were under control of complete dominance and the value scoring (1.09), (1.06) and(1.07) respectively and partial dominance for growing yield (0.9). heritability of broad sense was found for all studied characters and high heritability of narrow sense obtained for days to 50% tasseling, plant height ear height scoring and grain yield (55.57), ( 57.42), (57.87) and (65.34) respective, whereas medium heritability of narrow sense was observed for days to 50% silking (44.36) and leaf area (45.5) and low for Chlorophyll (27.31)**

**Table (3): Genetic parameters values for studied characters**

| Characters | $\sigma^2$A | $\sigma^2$ D | ā | $H^2$.b.s | $H^2$.n.s |
|---|---|---|---|---|---|
| Days to 50%tasseling | 10.28 | 6.62 | 1.13 | 91.38 | 55.57 |
| Days to 50% silking | 7.76 | 8.25 | 1.45 | 91.56 | 44.36 |
| Plant height (cm) | 138.36 | 83.07 | 1.09 | 91.85 | 57.42 |
| Ear height (cm) | 85.24 | 47.89 | 1.06 | 89.45 | 57.87 |
| Leaf area (cm2) | 1974. 07 | 1140.25 | 1.07 | 71.79 | 45.50 |
| Chlorophyll (gm.) | 3414. 83 | 7233. 72 | 2.05 | 85.16 | 27.31 |
| Grain yield (gm.) | 1.13 | 0.46 | 0.90 | 90.72 | 65.34 |

**3- Heterosis**

**Table (4) reveals to estimation of heterosis for studied characters. Most hybrids gives negative values of heterosis in desirable direction for earlier tasseling and depending on over mid parents, with the excepting of hybrids (Dx9) and (Cx9) gives positive heterosis which was reached (1.00) and (2.00) respectively. Similar results in maize have been reported by Echandi and Hallauer (1996); Al-Jamili, Abd (1996) and Yousif (1997).**

**Significantly different at level (1%) and negative values heterosis in favorable direction were found for earlier of silking except hybrids (Cx9) and (Dx9) which obtained positive heterosis and reached (1.50) and ( 0.50) respectively, a highly negative significant heterosis for earlier direction of silking was found in hybrids (Ax3), (Bx8), (Cx3), (Dx2) and (Ax10) and the value were reached (- 12.00),( - 12.00),( -**

**11.00),( - 11.50) and ( - 10.50) respectively. The results are in agreement with reports of Sanvicenta *et al.* (1998) and Al-Azawi (2002).**

**All hybrids have significant positive heterosis in desirable direction at level 1% for plant height, the hybrids (Cx6) and (Ax3) superior at significant positive heterosis for plant height were reached (66.60) and (58.32) respectively, but the hybrids (Bx7) and (Bx5) obtained the lowest positive heterosis and reached (2.400) and (11.19) respectively. Thirty five (35) hybrids were superior in heterosis for plant height and their heterosis was ranged between (21.00 - 66.60). Similar results have been reported in maize for plant height trait by El- Shamarka (1995); Echandi and Hallauer (1996) and Mohammed (2005).**

**Most hybrids were scored significant positive heterosis in favorable direction at level 1% for ear height over deviation F1 from mid parent, the hybrids (Cx6) and (Cx3) superiors at significantly positive heterosis in high direction for ear height and reached (49.52) and (43.53) respectively. The results are in agreement with studies of Monteagudo and Sinoba (1996) and Mohammed (2005)**

**for leaf area most hybrids which obtained significant positive heterosis in desirable direction for leaf area over mid parent except the hybrids (Ax7), (Bx1), (Bx4), (Bx7), (Bx9) and (Bx10) although they have positive heterosis but did not reach significant level. The (Dx5) and (Cx1) were identified the better hybrids significantly at 1% for positive heterosis in desirable direction for leaf area and reached (299.54) and (252.49) respectively. Similar results in maize were reported by Rehman *et al.* (1992); Ali (1999), and Muraya *et al*. (2006).**

**(13) hybrids obtained significant positive heterosis in desirable direction for chlorophyll in plant leaves at 1% with (2) genotypes at level 5%, which computed over mid parent, among them the hybrid (Cx4) (428.72) was the best hybrid for chlorophyll estimated in positive desirable heterosis, while less quantity of chlorophyll for positive desirable direction at 1% was obtained in hybrid (Bx9) (84.04). Significant and not significant negative values of heterosis of chlorophyll in plant leaves were also found. Hybrid (Dx9) obtained high negative heterosis scoring (- 106.70) at level1%.**

**For grain yield, (Cx6) the best hybrid in desirable direction at level 1% for grain yield was (5.89). Similar results in maize were reported by Revilla *et al*. (2000), and Rezaei *et al.* (2004).**

**Table (4): Heterosis for studied characters**

| Hybrids | Days to 50% tasseling | Days to 50% silking | Plant height (cm) | Ear height (cm) | Leaf area (cm) | Chlorophyll (gm.) | Grain yield (gm.) |
|---|---|---|---|---|---|---|---|
| Ax1 | - 7.00** | - 7.00** | 47.58** | 29.68** | 194.09** | 55.05 | 5.12** |
| Ax2 | - 5.50** | - 5.50** | 54.98** | 31.73** | 229.18** | 44.24 | 3.98** |
| Ax3 | - 11.00** | - 12.00** | 58.32** | 39.28** | 156.66** | - 25.29 | 2.88** |
| Ax4 | - 7.00** | - 8.50** | 52.88** | 20.27** | 120.37** | 25.74 | 4.06** |
| Ax5 | - 9.00** | - 10.50** | 41.44** | 33.89** | 184.61** | 184.98** | 4.80** |
| Ax6 | - 5.00** | - 5.00** | 49.90** | 39.58** | 208.57** | 60.81* | 3.19** |
| Ax7 | - 7.50** | - 8.50** | 32.59** | 16.97** | 37.02 | 40.48 | 3.58** |
| Ax8 | - 14.00** | - 4.00** | 16.19** | 12.54** | 67.06** | 79.49* | 2.14** |
| Ax9 | - 8.00** | -8.00 | 36.15** | 14.60** | 97.19** | 130.69** | 3.28** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Ax10 | - 10.00** | - 10.50** | 25.97** | 22.99** | 62.21* | 112.13** | 3.78** |
| Bx1 | - 7.00** | - 8.00** | 43.03** | 14.33** | 33.17 | 122.70** | 2.71** |
| Bx2 | - 2.50** | - 3.50** | 33.83** | 11.73** | 109.76** | 109.63** | 2.24** |
| Bx3 | - 7.00** | - 7.00** | 21.68** | 4.08* | 67.07** | - 25.60 | 1.40** |
| Bx4 | - 6.00** | - 7.50** | 39.03** | 20.61** | 43.39 | 5.349 | 2.86** |
| Bx5 | - 7.00** | - 7.50** | 11.19** | 21.49** | 114.03** | 85.64** | 3.82** |
| Bx6 | - 7.00** | - 7.00** | 33.50** | 9.60** | 53.43* | 49.73 | 3.59** |
| Bx7 | - 1.500 | - 1.50 | 2.40* | 9.40** | 28.26 | 8.72 | 2.71** |
| Bx8 | - 11.00** | - 12.00** | 28.59** | 24.33** | 62.74* | 55.80 | 2.01** |
| Bx9 | - 4.00** | - 3.50** | 32.63** | 37.65** | 17.28 | 84.04** | 2.02** |
| Bx10 | - 7.00** | - 7.50** | 40.09** | 22.99** | 28.70 | - 10.98 | 2.67** |
| Cx1 | - 4.00** | - 4.00** | 43.03** | 21.04** | 252.49** | 18.49 | 4.53** |
| Cx2 | - 2.50** | - 3.50** | 50.49** | 29.08** | 189.68** | 17.60 | 4.27** |
| Cx3 | - 11.00** | - 11.00** | 50.27** | 43.53** | 161.06** | - 17.34 | 3.11** |
| Cx4 | - 10.00** | - 10.50** | 45.79** | 26.00** | 140.66** | 428.72** | 4.53** |
| Cx5 | - 8.00** | - 8.50** | 42.36** | 40.90** | 140.52** | 219.01** | 3.75** |
| Cx6 | - 8.00** | - 9.00** | 66.60** | 49.52** | 240.78** | 378.08** | 5.89** |
| Cx7 | - 6.50** | - 7.50** | 37.24** | 20.39** | 144.43** | - 18.19 | 4.14** |
| Cx8 | - 8.00** | - 8.00** | 42.76** | 16.24** | 181.26** | 135.24** | 2.42** |
| Cx9 | 2.00* | 1.50 | 21.00** | 16.75** | 131.4** | 82.26** | 0.63* |
| Cx10 | - 4.00** | - 3.50** | 43.78** | 22.82** | 107.62** | 26.63 | 3.16** |
| Dx1 | - 4.00** | - 5.00** | 14.38** | 8.28** | 168.87** | - 59.83 | 2.45** |
| Dx2 | - 10.50** | - 11.50** | 31.09** | 15.75** | 207.28** | 21.11 | 2.68** |
| Dx3 | - 5.00** | - 6.00** | 37.75** | 23.26** | 187.39** | - 71.62* | 2.17** |
| Dx4 | - 9.00** | - 9.50** | 30.80** | 11.09** | 209.5** | - 2.78 | 3.56** |
| Dx5 | - 8.00** | - 8.50** | 25.48** | 25.41** | 299.54** | 49.52 | 3.82** |
| Dx6 | - 9.00** | - 9.00** | 36.07** | 20.78** | 181.93** | - 12.11 | 3.22** |
| Dx7 | - 7.50** | - 8.50** | 16.76** | 7.04** | 150.30** | - 20.65 | 1.86** |
| Dx8 | - 8.00** | - 8.00** | 15.33** | 4.20* | 109.25** | - 29.92 | 1.32** |
| Dx9 | 1.00 | 0.50 | 29.37** | 4.04* | 119.82** | - 106.70** | 0.75* |
| Dx10 | - 7.00** | - 6.50 | 26.72** | 24.73** | 102.61** | 2.58 | 3.37** |

*Significant at level 5%
** Significant at level 1 %

**4-Proportional contribution**

Table (5): referred to contribution of proportion for studied characters. The line contributed by highly proportion for appearing days to 50% tasseling, plant height,

**ear eight and leaf area reaching (38.83),( 45.52),(٥٧ . 18) and (51.42) respectively, whereas the lines x testers interaction had the great contribution for affecting days to 50% silking (47.44) and chlorophyll (64.01). Value of expected genetic advance were high for chlorophyll and leaf area and the value reaching (62.90) and (61.74) respectively, while the expected genetic advance were medium for plant height (18.38) and ear eight(14.39), whereas it was low for days to 50% tasseling and days to 50% silking and grain yield scoring (3.82), (3.82) and (1.76) respectively. This mean the some tester and inbred line was appearing highlu specific combining ability so that you can used this tester or inbred lines to produce the superior hybrid.**

**Table (5): proportional contribution for lines, testers, line x testers interaction and average degree of dominance for studied characters.**

| Characters | Contrib. of lines (%) | Contrib. of testers (%) | Contrib. of L x T (%) | Expect genetic advance |
|---|---|---|---|---|
| Days to 50% tasseling | 38.83 | 25.53 | 35.63 | 3.82 |
| Days to 50% silking | 28.56 | 23.99 | 47.44 | 3.82 |
| Plant height (cm) | 45.52 | 20.82 | 33.65 | 18.38 |
| Ear height (cm) | 57. 18 | 10.74 | 32.06 | 14.39 |
| Leaf area (cm2) | 51.42 | 12.28 | 36.29 | 61.74 |
| Chlorophyll (gm) | 18.57 | 17.40 | 64.01 | 62.90 |
| Grain yield | 24.93 | 47.41 | 27.56 | 1.76 |

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**الخلاصة**

**تقدير قوة الهجين والتوريث وبعض المعالم الوراثية للحاصل وبعض الصفات المورفولوجية في سلالات من الذرة الصفراء باستعمال طريقة السلالة × الفاحص.**

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**الدراسة طبقت في حقل التجارب/ كلية الزراعة جامعة دهوك خلال الموسم الربيعي والخريفي لعام 2007 . استعمل اربعة عشرة سلالة من الذرة الصفراء ، عشرة منها وهي (zp-204 , zp-301 , zp-595 , zp-670 , zp-430 , zp-505 , un-44652 , zp-735 , OH40 , DK17) كامهات واربعة منها (zp-197 , zp-607 , zp-707 , un-44052) استعملت كفواحص (اباء) . جميع التراكيب الوراثية زرعت في مروز طول المرز (4) متر والمسافة بين مرز واخر (75) سم وبين نبات واخر (25) سم . استعملت طريقة Kempthorne 1957 (فاحص×سلالة) لتقدير قابلية الائتلاف العامة للاباء وقابلية الائتلاف الخاصة للهجن . تم تقدير التباين الاضافي وغير الاضافي والفعل الجيني وقوة الهجين على اساس معدل الابوين ودرجة مساهمة السلالات والفاحص والسلالة×الفاحص ونسبة التوريث والتحسين الوراثي المتوقع . في الموسم الخريفي جرى تقييم (54) تركيب وراثي (40 هجين + 10 سلالة + 4 فاحص).**

**اظهرت النتائج قوة هجين موجبة على اساس معدل الابوين لاغلب الصفات المدروسة وبالاتجاه السالب لعدد الايام الى 50% تزهير ذكري وانثوي . نسبة التوريث بالمعنى الواسع كانت عالية لكل الصفات في حين كانت نسبة التوريث بالمعنى الضيق عالي لعدد ايام الى 50% تزهير ذكري وارتفاع النبات والعرنوص . كانت التأثير الاضافي اكبر من التأثير السيادي لعدد الايام الى 50% تزهير ذكري وارتفاع النبات والعرنوص والمساحة الورقية في حين كان التأثير السيادي اكبر من التأثير الاضافي في عدد الايام الى 50% تزهير انثوي والمحتوى الورقي من الكلورفيل وكان معدل درجة السيادة اكثر من واحد لعدد الايام الى 50% تزهير ذكري وانثوي والمحتوى الورقي من الكلورفيل.**

## Results and discussion

### 1- Ear length (cm)

**Table (6) indicates a significant difference among the means of lines, testers and line x testers for ear length. The inbred line (2) obtained a high ear length scoring (20.73cm), while the lowest ear length was observed in line (10), i.e., (16.06cm). The tester (C) was superior for this trait and the value was (21.86cm), the low ear length was found in tester (A) (17.63 cm), no significant differences between tester (C) and (D). The hybrids (Bx4) and (Bx10) gave the highly ear length were reached (23.96cm) and (23.06cm) respectively, and the lowest ear length was recorded in hybrids (Dx8) (18.50cm).**

**Table (6): Means ear length for parents and hybrids of maize.**

| Lines | Testers A | B | C | D | Mean of Lines |
|---|---|---|---|---|---|
| 1 | 21.83 | 20.53 | 21.90 | 21.06 | 16.63c |
| 2 | 21.06 | 21.03 | 20.90 | 18.66 | 20.73a |
| 3 | 20.46 | 21.66 | 20.03 | 17.00 | 18.20b |
| 4 | 19.63 | 23.96 | 20.70 | 20.73 | 20.66a |
| 5 | 20.86 | 22.10 | 20.43 | 18.66 | 16.63c |
| 6 | 20.60 | 21.53 | 20.16 | 19.43 | 15.76d |
| 7 | 19.16 | 21.36 | 19.86 | 19.23 | 18.20b |
| 8 | 20.26 | 22.76 | 20.76 | 18.50 | 15.43d |
| 9 | 20.33 | 20.60 | 19.40 | 22.56 | 16.26c |
| 10 | 19.30 | 23.06 | 19.90 | 20.73 | 16.06c |
| Mean of Testers | 17.63c | 19.66b | 21.03a | 20.10a | |

**Table (7) demonstrates that most of hybrids obtained significant positive heterosis in favorable direction at level 1% for ear length over mid parent except the hybrid (Ax9) which has significant positive heterosis at level 5%, and the hybrid (Dx3) appeared not significant in positive heterosis (0.30). The hybrids (Ax5) and (Bx4) were superior significantly at level 1% of positive heterosis in desirable direction for ear length scoring (4.83) and (4.50) respectively. Hybrid (Bx9) gave a high negative heterosis in non desirable direction for this and reached (- 0.28). The results are in agreement with reports of Al-Jamili (1996) and Al-Barodi (1999).**

**Table (7): Heterosis of hybrids for ear length of maize.**

| Testers / Lines | Heterosis A | B | C | D |
|---|---|---|---|---|
| 1 | 3.18** | - 0.16 | 2.46** | 1.91** |
| 2 | 4.43** | 2.35** | 3.48** | 1.53* |
| 3 | 4.26** | 3.41** | 3.05** | 0.30 |
| 4 | 2.21** | 4.50** | 2.50** | 2.81** |
| 5 | 4.83** | 4.01** | 3.61** | 2.13** |
| 6 | 4.15** | 3.03** | 2.93** | 2.48** |
| 7 | 2.81** | 2.96** | 2.73** | 2.38** |
| 8 | 2.11** | 2.56** | 1.83** | - 0.15 |
| 9 | 1.50* | - 0.28 | - 0.21 | 3.23** |
| 10 | 0.93 | 2.65** | 0.75 | 1.86** |

*Significant at level 5%
** Significant at level 1 %

**Table (8) includes the estimation of general, specific combining ability and genetic parameters of genotypes of ear length. The inbred line (1) obtained a high positive G.C.A for ear length scoring (0.76), while the highly negative G.C.A for this trait was observed in line (7) reaching (- 0.66). The tester (B) obtained the high positive G.C.A (1.29) which can be entered for hybridization breeding program to improved and increasing ear length, and the tester (A) gave the low negative G.C.A effect for ear length (- 0.21). The high positive S.C.A effect was recorded in hybrid (Dx9) (2.75), but a high negative S.C.A effect was appeared in hybrid (B x1) (- 2.09). Similar results in maize were reported by Ahmed *et al.* (2003).**

**Table (8): Estimation of the general combining ability G.C.A effect for lines and testers, specific combining ability effect for hybrids and genotypic parameters for ear length of maize.**

| | S.C.A | | | | G.C.A for Lines |
|---|---|---|---|---|---|
| Testers / Lines | A | B | C | D | |
| 1 | 0.71 | - 2.09 | 0.73 | 0.64 | 0.76 |
| 2 | 0.86 | - 0.67 | 0.64 | - 0.83 | - 0.15 |
| 3 | 0.89 | 0.58 | 0.40 | - 1.88 | - 0.77 |
| 4 | - 1.40 | 1.41 | - 0.39 | 0.38 | 0.68 |
| 5 | 0.56 | 0.29 | 0.08 | - 0.93 | - 0.05 |
| 6 | 0.38 | - 0.19 | - 0.10 | - 0.08 | - 0.13 |
| 7 | - 0.52 | 0.16 | 0.12 | 0.23 | - 0.66 |
| 8 | - 0.09 | 0.89 | 0.35 | - 1.16 | 0.004 |
| 9 | - 0.17 | - 1.41 | - 1.16 | 2.75 | 0.15 |
| 10 | - 1.23 | 1.02 | - 0.68 | 0.89 | 0.17 |
| G.C.A for Testers | - 0.21 | 1.29 | - 0.16 | - 0.91 | |

| | Lines | | Testers | Hybrids | |
|---|---|---|---|---|---|
| S.E | 0.23 | | 0.15 | 0.47 | |
| $\sigma^2$ gca/$\sigma^2$ sca | $\sigma^2$ A | $\sigma^2$ D | ā | $H^2$ b.s. | $H^2$ n.s. |
| 0.45 | 1.02 ± 0.64 | 1.11 ± 0.35 | 1.47 | 75.84 | 36.27 |

**$\sigma^2$ g.c.a/$\sigma^2$ s.c.a was less than one (0.45) which confirm that the effect of non-additive genetic variance for the inheritance of ear length, the variancc**

componenets results differed from zero for ear length. The value of dominance gene effects was higher than the value of additive gene effects and reached (1.11). The average degree of dominance was more than one (1.47) indicating ear length under control of the over dominance gene. A high propotion of broad sense heritability was recorded (75.84) wherease, narrow sense heritability was observed in medium value (36.27). Malvar *et al.* (1996); Ali (1999); Dawood and Mohammed (2000) and Ahmad and Ali (2002) also reported that the medium value of narrow sense heritabilityof maize. Appendix (2) shows that the contribution of proportion for ear length was higher for lines x testers interaction scoring (51.21%), while lines and testers were contributed (١٢.43 %%) and (36.34 %) respectively for showing this trait.Value of the expected genetic improvement was low (1.25) for ear length.

**2- Number of rows/ear**

Significant differences were present among genotypes for means of number of rows per ear table (9). The largest mean for number of rows/ear was found in line (4) (17.56), whereas the less number of rows/ ear was obtained in line (8) (14.66). The tester (B) gave the largest number of rows per ear scoring (16.86), and the less number for this trait was observed in tester (A) (12.66). For hybrids, the hybrid (Cx4) gave the maximum number of rows per ear, i.e., (21.76), the hybrids (Dx5) and (Dx8) gave the minimum number for this trait scoring (13.76) for each of them.

Table (9): Means number of rows/ ear for parents and hybrids of maize.

| Lines | Testers | | | | Mean of Lines |
|---|---|---|---|---|---|
| | A | B | C | D | |
| 1 | 16.46 | 17.10 | 18.00 | 18.56 | 15.53b |
| 2 | 17.33 | 16.00 | 19.80 | 16.90 | 16.53a |
| 3 | 17.66 | 17.76 | 18.00 | 15.06 | 17.10a |
| 4 | 18.43 | 18.23 | 21.76 | 18.43 | 17.56a |
| 5 | 15.76 | 15.10 | 17.30 | 13.76 | 15.33b |
| 6 | 16.46 | 16.86 | 19.56 | 15.76 | 15.63b |
| 7 | 15.96 | 15.53 | 19.10 | 15.00 | 16.46a |
| 8 | 16.46 | 16.13 | 18.10 | 13.76 | 14.66b |
| 9 | 17.13 | 20.23 | 16.23 | 15.10 | 16.20a |
| 10 | 15.53 | 18.53 | 20.43 | 14.60 | 16.23a |
| Mean of Testers | 12.66c | 16.86a | 15.76b | 15.63b | |

**Table (10) shows that (16) hybrids significantly gave positive heterosis in favorable direction at 1% for number of rows/ear. Among them the (Bx9) (4.08) was the best hybrid which computed over mid parent. A highly negative heterosis for this trait in non desirable direction was observed in hybrid (Bx7) (- 0.85) while the lowest negative heterosis was found in hybrid (Cx9) (- 0.20). Similar results in maize were reported by Al-Falahi (2003) and Mohammed (2005).**

**Table (10): Heterosis of hybrids for number of rows/ear of maize.**

| | Heterosis | | | |
|---|---|---|---|---|
| Testers / Lines | A | B | C | D |
| 1 | - 0.08 | 0.05 | 0.66 | 3.45** |
| 2 | 1.90** | 0.06 | 3.58** | 2.90** |
| 3 | 2.08** | 1.68** | 1.63** | 0.91 |
| 4 | 2.43** | 1.73** | 4.98** | 3.86** |
| 5 | 0.66 | - 0.50 | 1.41* | 0.10 |
| 6 | 0.60 | 0.50 | 2.91** | 1.33* |
| 7 | 0.08 | - 0.85 | 2.43** | 0.55 |
| 8 | 0.26 | - 0.56 | 1.11* | - 1.10 |
| 9 | 1.48* | 4.08** | - 0.20 | 0.88 |
| 10 | - 0.05 | 2.45** | 4.06** | 0.45 |

***Significant at level 5%**
**** Significant at level 1 %**

**The data in table (11) reveals the estimation of general, specific combining ability and genetic parameters for genotypes of number of rows /ear. The inbred line (4) obtained the highly positive G.C.A for number of rows /ear scoring (2.11, while a high negative G.C.A for this trait was observed in inbred line (5) that is (- 1.61). The tester (C) obtained the highly positive G.C.A (1.73), the tester (D) gave the low negative G.C.A for number of rows per ear (- 1.41), the hybrids (Bx9) and (Dx1) were superior in positive S.C.A effect for this trait, i.e., (3.00) and (2.44) respectively. The hybrids (Cx9) and (Bx2) have obtained the low negative S.C.A, i.e., (- 2.67) and (- 1.56) respectively. Similar results in maize were reported by Ahmed *et al.* (2003).**

**Table (11): Estimation of the general combining ability G.C.A effect for lines, testers, specific combining ability effect for hybrids and genotypic parameters for number of row / ear of maize.**

| | S.C.A | | | | G.C.A for Lines |
|---|---|---|---|---|---|
| Testers / Lines | A | B | C | D | |
| 1 | - 0.69 | - 0.48 | - 1.26 | 2.44 | 0.43 |
| 2 | 0.19 | - 1.56 | 0.55 | 0.80 | 0.41 |
| 3 | 0.91 | 0.58 | - 0.85 | - 0.64 | 0.02 |
| 4 | - 0.40 | - 1.03 | 0.81 | 0.62 | 2.11 |
| 5 | 0.65 | - 0.43 | 0.08 | - 0.30 | - 1.61 |
| 6 | - 0.32 | - 0.35 | 0.66 | 0.01 | 0.06 |
| 7 | - 0.05 | - 0.91 | 0.96 | 0.01 | - 0.69 |
| 8 | 0.74 | - 0.01 | 0.27 | - 1.01 | - 1.006 |
| 9 | 0.33 | 3.00 | - 2.67 | - 0.66 | 0.07 |
| 10 | - 1.36 | 1.20 | 1.42 | - 1.26 | 0.17 |
| G.C.A for Testers | - 0.37 | 0.05 | 1.73 | - 1.41 | |
| | Lines | | Testers | | Hybrids |
| S.E | 0.22 | | 0.14 | | 0.45 |
| $\sigma^2$ gca/$\sigma^2$ sca | $\Sigma^2$ A | $\sigma^2$D | ā | $H^2$ b.s. | $H^2$ n.s. |
| 0.90 | 2.63 ± 1.50 | 1.45 ± 0.43 | 1.04 | 86.67 | 55.88 |

$\sigma^2$ g.c.a/$\sigma^2$ s.c.a was less than one (0.90) indicating that the inheritance of number of rows/ear under controlling of non-additive genetic variance. The additive gene effects were higher than the dominance gene effects for number of rows/ ear was reached (2.63). The average degree of dominance was (1.04) which emphasized numbers of rows/ear under control of the complete dominance, the heritability of broad and narrow sense were higher for ear height scoring (86.67) and (55.88) respectively, that can improve number of rows/ ear by selection program. The results are in agreement with reports of Mousa (1997); Al-Dilemi (2004) and Rezaei *et al.* (2004). The testers contributed by high propotion for showing this trait which reached (38.82%), while lines and line x tester interaction contributed (٢٧.21 %) and (33.95%) respectively for inheritance rows /ear. The value of the expected genetic improvement was low (2.50) for number of rows/ear appendix (2).

**3-Number of grains/row**

**The data in table (12) shows that there were significant differences among genotypes for means of number of grains/row. High number of this trait was found in inbred line (3) (43.78), the inbred line (9) obtained the lowest mean of number of grains/row (27.67). The tester (A) was superior in this trait and gave the mean (46.82) grains/ear. The hybrids (Cx6) and (Cx1) obtained the highest number of this trait scoring (52.81) and (52.39) respectively, whereas the lowest number of grains/row was observed in hybrids (Dx5) and (Dx8), i.e., (40.26) and (39.79) respectively.**

**Table (12): Means of number of grains /row for parents and hybrids of maize**

| | Testers | | | | Mean |
|---|---|---|---|---|---|
| Lines | A | B | C | D | of Lines |
| 1 | 49.12 | 47.32 | 52.39 | 41.28 | 34.43d |
| 2 | 46.62 | 45.91 | 44.67 | 43.68 | 42.25a |
| 3 | 47.08 | 45.52 | 47.37 | 43.20 | 43.78a |
| 4 | 40.19 | 41.09 | 42.76 | 46.15 | 42.33a |
| 5 | 48.65 | 49.96 | 44.23 | 40.26 | 35.00c |
| 6 | 43.72 | 44.73 | 52.81 | 45.51 | 30.08e |
| 7 | 44.27 | 46.76 | 44.70 | 43.46 | 33.00d |
| 8 | 43.81 | 46.33 | 47.92 | 39.79 | 31.31e |
| 9 | 47.03 | 41.35 | 46.54 | 49.32 | 27.67f |
| 10 | 46.82 | 41.77 | 45.57 | 45.72 | 33.69d |
| Mean of Testers | 39.20b | 44.09a | 40.50b | 36.03c | |

**Table (13) demonstrates that most of hybrids positively gave significant heterosis in desirable direction at level 1% for number of grains /row over mid parent. Among them the (Ax5) was the best hybrid valued (15.77). The two hybrids (Dx8) and (Bx9) were observed negative heterosis (- 1.85) and (- 0.02) respectively. Similar results in maize were reported by Al-Jamili (1996) and Al-Falahi (2003).**

Table (13): Heterosis of hybrids for number of grains/ row of maize.

| Testers / Lines | Heterosis A | B | C | D |
|---|---|---|---|---|
| 1 | 10.73** | 5.02** | 9.33** | 0.51 |
| 2 | 11.90** | 7.29** | 5.28** | 6.58** |
| 3 | 14.82** | 9.35** | 10.44** | 8.86** |
| 4 | 6.47** | 3.46 | 4.37* | 10.04** |
| 5 | 15.77** | 13.17** | 6.68** | 5.003** |
| 6 | 12.66** | 9.77** | 17.08** | 12.07** |
| 7 | 10.20** | 8.79** | 5.96** | 7.01** |
| 8 | 4.54* | 3.16 | 3.99* | - 1.85 |
| 9 | 9.56** | - 0.02 | 4.39* | 9.47** |
| 10 | 11.58** | 2.63 | 5.66** | 8.10** |

*Significant at level 5%
** Significant at level 1 %

Table (14) demonstrates that there were differences general and specific combining for number of grains/ row of maize. The inbred line (1) gave a highly G.C.A in an increasing direction for number of grains /row and reached (2.14) while the inbred line (2) gave the lowest value of G.C.A in negative direction (- 0.16). The tester (C) had the positive general combining ability scoring (1.51), (B) tester obtained low negative G.C.A, i.e., (- 0.31). (Dx4) hybrid gave a highly positive S.C.A (5.14) while high negative S.C.A was observed in hybrid (Dx1) (- 4.69).

Table (14): Estimation of the general combining ability G.C.A for lines, testers and specific combining ability for hybrids and genotypic parameters for number of grains/ row.

| Testers / Lines | S.C.A A | B | C | D | G.C.A for Lines |
|---|---|---|---|---|---|
| 1 | 1.24 | 0.10 | 3.34 | - 4.69 | 2.14 |
| 2 | 1.05 | 1.006 | - 2.06 | 0.009 | - 0.16 |
| 3 | 0.94 | 0.03 | 0.06 | - 1.04 | 0.41 |
| 4 | - 2.70 | - 1.15 | - 1.29 | 5.14 | - 2.83 |
| 5 | 2.52 | 4.49 | - 3.05 | - 3.96 | 0.38 |

| | | | | | |
|---|---|---|---|---|---|
| 6 | - 3.32 | - 1.65 | 4.60 | 0.36 | 1.30 |
| 7 | - 0.87 | 2.27 | - 1.61 | 0.21 | - 0.58 |
| 8 | - 0.99 | 2.18 | 1.94 | - 3.13 | - 0.92 |
| 9 | 0.62 | - 4.39 | - 1.03 | 4.81 | 0.67 |
| 10 | 1.50 | - 2.88 | - 0.91 | 2.29 | - 0.41 |
| G.C.A for Testers | 0.34 | - 0.31 | 1.51 | - 1.54 | |
| | Tines | | Testers | | Hybrids |
| S.E | 0.71 | | 0.45 | | 1.42 |
| $\sigma^2$ gca/$\sigma^2$ sca | $\Sigma^2$A | $\sigma^2$ D | ā | $H^2$ b.s. | $H^2$ n.s. |
| 0.18 | 2.75 ± 1.81 | 7.41 ± 2.49 | 2.32 | 62.41 | 16.90 |

**The ratio of $\sigma^2$ g.c.a/$\sigma^2$ s.c.a was less than one (0.18). This indicates that non-additive genetic variance was the major source of genetic variation for the inheritance of number of grains/row of maize. The dominance gene effects were higher than that additive gene effects for grains/row and reached (7.41) Similar results in maize were reported by Al-Dilemi (2004). The average degree of dominance was more than one (2.32) indicating number of grains/row was under control of the over dominance gene. High heritability of broad sense with low heritability of narrow sense was found for number of grains/row scoring (62.41%) and (16.90%) respectively. The number of grains/row can be improved by hybridization program. Similar results in maize were reported by Al-Aswedi (2002). Appendix (2) shows that the testers had the great contribution for the number of grains/row (52.24%), while lines and lines x testers interaction contributed (16.63%) and (31.12 %) respectively for inheritance of this trait. The value of expected genetic improvement was low (1.40) for number of grains/row.**

**4- Grain weight ( gram).**

**The results in table (15) illustrate that there were significant differences among genotypes for grain weight. The highest weight of grain was observed in line (10) and was (80.09), while the low weight of grain was recorded in line (4) (52.26). The tester (A) gave a highly grain weight and the value was (77.90). The low grain weight was found in tester (D) (63.44). The highly grain weight was observed in hybrid (Dx5) and reached (85.58), whereas the low value of this trait was observed in hybrid (Bx9), i.e., (61.79).**

Table (15): Means grain weight for parents and hybrids of maize.

| Lines | Testers A | B | C | D | Mean of Lines |
|---|---|---|---|---|---|
| 1 | 62.27 | 66.55 | 63.54 | 74.05 | 63.12d |
| 2 | 73.43 | 74.88 | 68.34 | 67.13 | 55.46f |
| 3 | 64.39 | 73.46 | 72.15 | 67.66 | 57.65e |
| 4 | 71.23 | 77.10 | 67.40 | 64.27 | 52.26f |
| 5 | 82.88 | 76.55 | 75.16 | 85.58 | 64.28d |
| 6 | 68.38 | 73.87 | 64.11 | 72.48 | 58.88e |
| 7 | 76.57 | 85.55 | 75.61 | 68.70 | 72.73b |
| 8 | 78.63 | 82.79 | 76.25 | 82.10 | 62.94d |
| 9 | 74.14 | 61.79 | 74.79 | 68.28 | 58.33e |
| 10 | 68.67 | 73.96 | 65.62 | 75.99 | 80.09a |
| Mean of Testers | 77.90a | 69.74b | 67.53c | 63.44d | |

Twenty eight (28) Hybrids obtained significant positive heterosis in favorable direction at level 1% for grain weight over mid parent (table 16). Among them the hybrids (Bx8) and (Ax5) were superior in positive desirable direction heterosis for grain weight scoring (20.18) and (19.84) respectively. Significant and not significant negative values heterosis of this trait was. Similar results in maize were reported by Ali (1999); Al-Mamori (2002) and Al-Falahi (2003).

Table (16): Heterosis of hybrids for grain weight of maize.

| Testers / Lines | Heterosis A | B | C | D |
|---|---|---|---|---|
| 1 | 4.58* | 12.69** | 8.58** | 8.97** |
| 2 | 9.72** | 15.007** | 7.37** | - 3.96 |
| 3 | 3.38 | 16.28** | 13.87** | - 0.72 |
| 4 | 3.29 | 13.005** | 2.20 | - 11.04** |
| 5 | 19.84** | 17.34** | 14.85** | 15.16** |
| 6 | 7.65** | 16.97** | 6.11* | 4.36* |
| 7 | 4.96* | 17.77** | 6.74* | - 10.29** |
| 8 | 12.19** | 20.18** | 12.55** | 8.27** |
| 9 | 8.81** | 0.29 | 12.19** | - 4.43* |
| 10 | 5.38* | 14.50** | 5.07* | 5.31* |

*Significant at level 5%

**** Significant at level 1 %**

**The data in table (17) shows that there were positive and negative values of G.C.A for lines and testers. the S.C.A also appeared in positive and negative values of hybrids for grain weight, the inbred line (5) gave a highly positive general combining ability (7.63) for grain weight, on the other hand, the inbred line (1) obtained a highly negative value general combining ability and the value was (-5.80). For testers the highly positive G.C.A was (B) tester which reached (2.24) while the tester (C) gave a highly negative G.C.A which reached (- 2.11). (Dx1) hybrid gave high S.C.A in positive direction (7.22), but highly negative S.C.A was observed in hybrid (Bx9), i.e., (- 10.20). The results are in agreement with studies of Dawood and Mohammed (2000); Dawood and Ali (2006); Ahmed *et al.* (2003), and Gautam (2003).**

**Table (١٧): Estimation of the general combining ability G.C.A effect for lines and testers, specific combining ability effect for hybrids and genotypic parameters for grain weight.**

| Testers / Lines | S.C.A A | B | C | D | G.C.A for Lines |
|---|---|---|---|---|---|
| 1 | - 3.98 | - 2.29 | - 0.95 | 7.22 | - 5.80 |
| 2 | 2.83 | 1.69 | - 0.49 | - 4.03 | - 1.46 |
| 3 | - 4.67 | 1.80 | 4.84 | - 1.96 | - 2.99 |
| 4 | 1.57 | 4.86 | - 0.48 | - 5.94 | - 2.40 |
| 5 | 3.18 | - 5.73 | - 2.77 | 5.32 | 7.63 |
| 6 | - 0.98 | 1.91 | - 3.49 | 2.55 | - 2.69 |
| 7 | 0.30 | 6.70 | 1.11 | - 8.12 | 4.20 |
| 8 | - 0.96 | 0.60 | - 1.58 | 1.93 | 7.53 |
| 9 | 4.73 | - 10.20 | 7.15 | - 1.68 | - 2.65 |
| 10 | - 2.03 | 0.65 | - 3.33 | 4.71 | - 1.34 |
| GCA for Testers | - 0.34 | 2.24 | - 2.11 | 0.21 | |

| | Lines | Testers | Hybrids |
|---|---|---|---|
| S.E | 0.83 | 0.53 | 1.67 |

| $\sigma^2$ gca/$\sigma^2$ sca | $\Sigma^2$ A | $\sigma^2$ D | ā | $H^2$ b.s. | $H^2$ n.s. |
|---|---|---|---|---|---|
| 0.56 | 24.39 ± 11.48 | 21.50 ± 6.39 | 1.32 | 84.47 | 44.89 |

**The $\sigma^2$ g.c.a/$\sigma^2$ s.c.a was less than one (0.56) indicating the responsibility of non-additive gene for grain weight. Similar results in maize were found by Todorovic (1996) and Ali *et al*. (2007). The additive gene effects were more dominant than the dominance gene effects for grain weight and reached (24.394). Similar results in maize were reported by Johnson (1973); Al-Zawbai (2001); Al-Falahi (2002) and Al-Dilemi (1986). The average degree of dominance was more than one (1.32) which conifirms grain weight was under control of the over dominance.**

**The heritability of broad sense was highe (84.47%), while heritability narrow sense was medium value (44.89%) for this trait. Similar results in maize were found by Dawood and Mohammed (1993), and Dawood and Ali (2006). Appendix (2) shows that the lines (٥١.435 %) contributed much more than line x tester interaction and testers for inheritance of grain weight trait, the interaction of line x tester contributed in ration (42.33%) whereas, the testers contributed (6.22%) for improvement of this trait, and the value of expected genetic improvement was low (6.81) for grain weight of maize.**

**5- Grain yield (ton/ ha)**

**The results in table (18) demonstrate that there were significant differences among genotyps for grain yield. High mean of grain yield was observed in inbred line (2) which reached (7.55) ton/ ha, whereas the lowest quantity of grain yield was obtained in inbred line (9) (4.50) ton/ ha. (B) Tester gave highly quantity of this trait (7.73) ton/ ha, but the lowest grain yield was recorded in tester (A) (4.48) ton/ ha. The hybrid (Cx6) gave a highly grain yield and the value was (11.35) ton/ ha, while the lowest grain yield was obtained in hybrid (Dx3) (6.67) ton/ ha.**

**Table (18): Means of grain yield for parents and hybrids of maize**

| | Testers | | | | Mean of Lines |
|---|---|---|---|---|---|
| Lines | A | B | C | D | |
| 1 | 10.05 | 9.13 | 10.38 | 7.33 | 4.57d |
| 2 | 8.57 | 8.32 | 9.78 | 7.22 | 7.55a |
| 3 | 7.43 | 7.43 | 8.58 | 6.67 | 6.42b |
| 4 | 9.19 | 9.48 | 10.59 | 8.65 | 5.28c |
| 5 | 9.43 | 9.94 | 9.30 | 8.41 | 4.59d |
| 6 | 7.73 | 9.62 | 11.35 | 7.72 | 4.51d |
| 7 | 9.20 | 9.82 | 10.68 | 7.43 | 5.69c |
| 8 | 8.30 | 9.66 | 9.50 | 7.43 | 4.68d |
| 9 | 9.32 | 9.55 | 7.59 | 6.75 | 4.50d |
| 10 | 8.86 | 9.24 | 9.16 | 8.41 | 6.66b |
| Mean of Testers | 4.48d | 7.73a | 7.50a | 5.58c | |

**Table (19) also clarifies that all hybrids obtained positively significant heterosis in desirable direction at level 1% for grain yield over mid parent except the hybrid (CX9) (0.63) which has significant positive heterosis in desirable direction at level 5%, (Cx6) the best hybrid in desirable direction at level 1% for grain yield was (5.89). Similar results in maize were reported by Ali (1999); Revilla *et al*. (2000); Al-Falahi (2003), and Rezaei *et al.* (2004).**

**Table (19): Heterosis of hybrids for grain yield of maize.**

| Testers / Lines | Heterosis | | | |
|---|---|---|---|---|
| | A | B | C | D |
| 1 | 5.12** | 2.71** | 4.53** | 2.45** |
| 2 | 3.98** | 2.24** | 4.27** | 2.68** |
| 3 | 2.88** | 1.40** | 3.11** | 2.17** |
| 4 | 4.06** | 2.86** | 4.53** | 3.56** |
| 5 | 4.80** | 3.82** | 3.75** | 3.82** |
| 6 | 3.19** | 3.59** | 5.89** | 3.22** |
| 7 | 3.58** | 2.71** | 4.14** | 1.86** |
| 8 | 2.14** | 2.01** | 2.42** | 1.32** |
| 9 | 3.28** | 2.02** | 0.63* | 0.75* |
| 10 | 3.78** | 2.67** | 3.16** | 3.37** |

***Significant at level 5%**
**** Significant at level 1 %**

**Table (20) states that the inbred line (4) proved a good combiner for positive direction general combining ability and the value was (0.64) for grain yield, on the other hand, the inbred line (3) obtained a highly negative value general combining ability scoring (-1.30) for this trait. Among the testers, only the testers(C) and (B) have positive general combining ability which were (0.86) and (0.38) respectively. (Cx6) hybrid gave a highly S.C.A effect in positive direction (1.38), but a highly negative S.C.A effect was observed in hybrid (CX9) which was (- 1.57). The results are in agreement with studies of Ahmed *et al*. (2003); Mohammadi1 *et al*. (2008), and Rezaei *et al*. (2004).**

**Table (20): Estimation of the general combining ability G.C.A for lines and testers, specific combining ability for hybrids and genotypic parameters for grain yield.**

| Testers / Lines | S.C.A A | S.C.A B | S.C.A C | S.C.A D | G.C.A for Lines |
|---|---|---|---|---|---|
| 1 | 0.84 | - 0.48 | 0.29 | - 0.66 | 0.39 |
| 2 | 0.11 | - 0.54 | 0.44 | - 0.02 | - 0.35 |
| 3 | - 0.07 | - 0.48 | 0.18 | 0.37 | - 1.30 |
| 4 | - 0.26 | - 0.38 | 0.25 | 0.39 | 0.64 |
| 5 | 0.18 | 0.27 | - 0.82 | 0.36 | 0.43 |
| 6 | - 1.35 | 0.12 | 1.38 | - 0.16 | 0.27 |
| 7 | - 0.06 | 0.14 | 0.53 | - 0.62 | 0.45 |
| 8 | - 0.40 | 0.54 | - 0.08 | - 0.06 | - 0.10 |
| 9 | 1.04 | 0.86 | - 1.57 | - 0.32 | - 0.52 |
| 10 | - 0.03 | - 0.06 | - 0.61 | 0.71 | 0.08 |
| GCA for Testers | - 0.02 | 0.38 | 0.86 | - 1.22 | |

| | Lines | | Testers | | Hybrids |
|---|---|---|---|---|---|
| S.E | 0.11 | | 0.07 | | 0.23 |
| $\sigma^2$ gca/$\sigma^2$ sca | $\Sigma^2$ A | $\sigma^2$ D | ā | $H^2$ b.s. | $H^2$ n.s. |
| 1.21 | 1.13 ± 0.65 | 0.46 ± 0.13 | 0.90 | 90.72 | 65.34 |

The ratio of σ2 g.c.a/σ2 s.c.a was more than one (1.21). This indicates that the additive genetic variance was more important for the inheritance of grain yield of maize. Similar results in maize were reported by Devi and Bectash (1979); Mustafa *et al.* (1996); Nawar *et al.* (1996); Meladenovic (1997); Mahajan and Singh (1997); Yousif (1997); Prodhan (2004), and Mustafa (2007). The additive gene effects were more dominant than the dominance gene effects for grain yield and reached (1.13). Similar results in maize wee reported by Devi and Bectash (1979); Mustafa *et al.* (1996); Nawar *et al*. (1996); Meladenovic (1997); Mahajan and Singh (1997); Yousif (1997); Prodhan (2004), and Mustafa (2007. The average degree of dominance was less than one (0.90) and this conifirms grain weight was under control of the partial dominance. The heritability of broad and narrow sense were high (90.72) and (65.34) respectively for this trait. The testers (47.41%) had the great contribution for grain yield, whereas the lines and lines x testers interaction contributed (٢٤.93%) and (27.65%) respectively for heredity of grain yield and the value of expected genetic improvement was low (1.76) for grain yield of maize as shown in appendix