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HERITABILITY AND EVALUATION FOR SOME GENETIC PARAMETERS IN SINGLE CROSS HYBRIDS OF MAIZE (*Zea Mays*) TRAITS

Dr. mohammed ali Hussain and Bafreen. A. Hussen
Dept. of Field Crops, College of Agriculture University of Duhok, Kurdistan Region - Iraq

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ABSTRACT

This experiment was conducted in spring 2013 by using full diallel cross among six maize inbred lines. The different traits for F_1s cross and parents with control were carried out during spring 2014 at the Coll. Agric. Univer. Duhok. Using Randomized Complete Block Design each treatment with three replications. The results showed that there was significant variance among them so the parent IK8 was more distinctive than other parents in the following traits; days to 75% tasseling, ear diameter, ear length, and yield plant^{-1} , the performance of the cross (IK8 x TH613) was good because it had high yield plant^{-1} followed by the crosses (IK58 x HS) and (HS x UN44052), and the cross (IK58 x TH613) was earlier than other crosses, some reciprocal crosses showed positive maternal effect for specific traits like cross (IK58 x OH40) in ear diameter and number of kernels row^{-1}, cross (HS x IK8) in ear length and yield plant^{-1}, and cross (UN44052 x IK8) in 300 - kernel weight. The highest value of heritability in broad sense was for ear height and yield plant^{-1} with 0.94, whereas the genetic advance was medium for yield plant^{-1} and was low for other traits.

INTRODUCTION

Dudley and Moll (1969) defined heritability as the ratio for genetic variance to phenotypic variance. The later mean the total variance among phenotypes when grown over the range of environments of interest for the breeder. The total genetic variance is the part of the phenotypic variance that can be attributed to genotypic differences among the phenotypic variance attributable to the failure of difference between genotypes to be the same in different environments. The total genetic variance can be further subdivided into additive variance, dominance variance, and epistatic variance (Robert, 1976). Also heritability was defined by Lush as the proportion of phenotypic variance among individuals in a population that is due to heritable genetic effects, this definition is now termed as heritability in narrow sense and it is designated (H or h^2_n). There are different methods used to estimate the heritability and which are used by Obilana and Fakorede (1981) and these methods are regression of offspring on parents, variance component estimate, and recurrent selection experiment. Rajesh *et al.* (2013)studied the broad sense heritability in newly developed 65 maize genotypes and the results demonstrated that the heritability was high with moderate estimates for genetic advance for grain yield, number of kernels row^{-1}, 100-kernel weight, ear length, ear height, and plant height which further leads to improvement of traits under selection, Nataraj *et al.* (2014) examined the broad sense heritability in 39 inbred of maize for twelve quantitative traits, days to 50% tasseling and silking, plant height, ear height, ear length, ear diameter, ear weight without husk, ear weight with husk, number of rows ear^{-1}, number of kernels row^{-1}, 100-seed weight and grain yield, the results manifested that ear weight without husk had highest heritability (97.30%) and lowest (65.10%) for ear diameter. Genetic advance was also high for grain yield plant^{-1}, ear height, plant height, number of kernels row^{-1}, number of rows ear^{-1}, ear length, and 100-grain weight with husk and without husk indicating their effectiveness in selection. The objective of current study was the estimation of heritability and some genetic parameters such as mean performance of parents, hybrids and reciprocals, gene action, average degree of dominance and genetic advance in single cross hybrids of maize traits.

MATERIALS AND METHODS

Experimental Material

The material under study consisted from six inbred lines (OH40, IK8, IK58, TH613, HS,

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UN44052) which were selected based on different agronomic traits. This study was carried out at the field of College of Agriculture, Duhok University. In the spring season, 15^{th} of March, 2013, grains of six inbred lines were sown to perform full diallel crosses between them, using full diallel cross method. Number of seeds, 2-4 seeds hole^{-1} were sown in a row, 3 m long for each experimental unit, 0.80 m between rows and 0.25 m within the row using two different sowing dates to get flowering compatibility among inbred lines, because of the differences in the flowering dates among inbred lines, 2-3 ears were pollinated for each cross for more precise results, then getting 30 hybrids.

Different varietal trial were carried out in spring season, 19^{th} of March, 2014, using F_1 hybrids and reciprocals with their parental lines and the check variety (Sangria), were planted using Randomized Complete Block Design (RCBD) with three replications, each replication consisted of 37 genotypes (30 F_1s , 6 parental lines and check variety). One row for each genotype with 3m long 0.80 m between rows and 0.25 m within the row. Field was fertilized at planting time with (N. P. K.; 27: 27: 0) with rate 400 kg /ha. and 200 kg/ha of urea (46%N) were added. Weed control and other managements were performed according to plant requirements. Data were collected from five consecutive plants row^{-1} and studied traits were days to 75% tasseling, plant height (cm), ear height (cm), leaf area (cm^2), no. of rows ear^{-1}, no. of kernels row^{-1}, ear length (cm), ear diameter (cm), 300- kernel weight (g) and kernel yield plant^{-1}.

Statistical Analysis

Heritability

Heritability further divided into broad sense and narrow sense, broad sense heritability was estimated as the ratio of genotypic variance to the phenotypic variance and was expressed in percentage, and narrow sense heritability was calculated by dividing additive variance by total variance.

$$h^2_{b.s} = \frac{\sigma^2 G}{\sigma^2 P} = \frac{\sigma^2 A + \sigma^2 D}{\sigma^2 A + \sigma^2 D + \sigma^2 e} = \frac{2\,\sigma^2 gca + \sigma^2 sca}{2\,\sigma^2 gca + \sigma^2 sca + \sigma^2 e}$$

$$h^2_{n.s} = \frac{\sigma^2 A}{\sigma^2 A + \sigma^2 D + \sigma^2 e} = \frac{2\sigma^2 gca}{2\sigma^2 gca + \sigma^2 sca + \sigma^2 e}$$

Heritability values in broad sense less than 40% were considered low, 40 to 60%, medium and more than 60% were considered high (Ali, 1999). Al – Farari(1999) reported that, heritability in narrow sense is considered low if it was less than 20%, 20 to 50% as medium and high if it is more than 50%

- Estimation of average degree of dominance

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

If: $\bar{a}$ = zero denotes no dominance;

$\bar{a} < 1$ denotes partial dominance;

$\bar{a} = 1$ denotes complete dominance, and

$\bar{a} > 1$ denotes over dominance.

(Comstock and Robinson, 1952)

- Estimation of reciprocal effects

$$\text{Reciprocal effect (RE \%)} = \frac{\bar{F_1 r} - \bar{F_1}}{\bar{F_1}} * 100$$

Where F_1: the average value of diallel hybrids,

F_1r: the average value of reciprocal hybrids.

- Genetic advance

Genetic advance was calculated according to the following formula:

$\Delta G = h^2 n.s\ i.\ \sigma p$

H^2_n= heritability in narrow sense.

i: selection intensity 10% = 1.76

σp: standard variance phenotype.

After that, the excepted genetic advance as present was calculated according to the following equation:

$$\%\Delta G = \frac{\Delta G}{\bar{y}_{..}} * 100$$

ΔG = Genetic advance

$\bar{y}_{..}$= mean of population.

The value of genetic advance is considered high when it is more than 30%, medium when the result is between 10 to 30% and is considered low when it is less than 10%, (Ahmed and Agrawal, 1982).

RESULTS AND DISCUSSION

1- The mean of performance of parents:

Data presented in Table (1) revealed the mean performance of six parents for different traits among the parental forms; parent 2 and parent 6 were the earliest with 78 days to 75% tasseling, while the parents 1 and 4 were the latest with 81 and 81.66 days to 75% tasseling, respectively. The tallest plant among the six parents was noticed in parent 1 with 193.40 cm, while the shortest plant with 162.00 cm was recorded for parent 6. For ear height the maximum value exhibited by parent 3 with 96.00 cm and minimum value 71.93 cm was shown for parent 6, and also. In the same table, the largest leaf area was exhibited in parent 4 with 883.23 cm^2, while parent 3 had the smallest value with 752.77 cm^2. And the widest ear diameter was found in parent 2 with 3.08 cm, whereas, the parent 4 had the narrowest diameter with 2.60 cm. Same table showed that the parent 2 had the longest ear with 19 cm ear length, while the parent 6 had the shortest ear with 16 cm ear length. For number of rows ear^{-1} and number of kernels row^{-1} parent 1 gave the highest value with 18.40 and 39.66, respectively, and the parent 3 gave maximum value (79.20g) for 300-kernel weight, whereas the parent 5 gave the minimum value with 74.73g, concerning to yield $plant^{-1}$,
the parent 2 showed the highest value with (173.91g) and the parent 6 gave lowest value with 101.42g.

We conclude from table (1) that the parent 2 (IK8) was more distinctive than other parents in these traits; days to 75% tasseling, ear diameter, ear length, and yield $plant^{-1}$ .The results were consistent with other researchers' studies like Beck *et al*. (1990), Wattoo *et al*. (2009), Zare *et al*. (2011) and Ahmed (2013).

Table (1):- Mean of parents for morphological and yield components traits

Traits / Parents	Days to 75% tasseling	Plant height Cm	Ear height cm	Leaf area cm^2	Ear diameter Cm	Ear length cm	No. of rows ear^{-1}	No. of kernels row^{-1}	300 kernel weight g	Yield $plant^{-1}$ g
1-OH40	81.00 ab	193.40 d-h	94.00 h-m	798.60 d-h	2.88 b-g	18.40 c-k	18.40 ab	39.66 a-d	75.06 i-o	169.60 h-k
2-IK8	78.00 d-f	185.00 e-h	73.53 q	770 f-h	3.08 ab	19.00 b-h	15.86 i-n	38.40 b-e	75.81 i-o	173.91 f-j
3-IK58	79.33 a-e	180.40 f-i	96.00 g-l	752.77 h	2.88 b-g	16.75 i-l	18.00 a-d	36.80 de	79.20 e-m	153.37 j-m
4-TH613	81.66 a	177.53 g-i	83.06 op	883.23 a-e	2.60 j-m	16.66 i-l	14.40 o	33.73 e	76.93 g-n	103.22 n
5-HS	80.33 a-d	183.53 e-h	84.93 n-p	834.57 c-h	2.81 d-j	17.33 g-l	16.80 c-k	37.53 c-e	74.73 i-o	142.00 lm
6-UN44052	78.00 d-f	162.0 i	71.93 q	764.80 gh	2.93 b-f	16.00 l	16.26 f-m	28.20 f	76.39 h-o	101.42 n

Mean followed by same letters for each column has no significant difference according to Duncan's test.

2- The mean performance of F_1 crosses

The mean performance of F_1 crosses for different traits were presented in table (2). The differences between parents reflected significantly on their crosses, the cross 3x4 was the earliest for days to 75% tasseling with 76.00 days , while, the cross 1x4 took the longest period for days to 75% tasseling with 81.30 days, the cause of earliness and lateness is due to the parents which involved in the cross. Concerning the plant height, the highest cross was 3x6 with 222.73 cm, while the shortest cross was 1x5 with 177.73 cm and for ear height the minimum height of 79.13 cm was recorded by cross 4x6 and the maximum ear height was observed in the crosses 5x6 and 2x5 with 111.46 cm and 111.20 cm, respectively.

The table (2) showed that the largest leaf area was exhibited by the cross 4x5 with 969.50cm^2 and followed by the cross 1x4 with 928.37cm^2, whereas the smallest value 771.73 cm^2 was recorded for cross 2x6. The increase in leaf area may be due to the parent 4 which had the largest area. For ear diameter crosses 2x3 and 2x6 gave the widest ear diameter with 2.94 cm, and the crosses 1x4 and 3x4 exhibited narrowest diameter with 2.64 cm and 2.65 cm, respectively, the increasing belongs to parent 2 which had the widest ear diameter while the parent 4 was responsible for the decrease in ear diameter, and for ear length the cross 1x2 was longest with 20.5 cm, whereas the cross 3x4 was noticed as the plant with shortest ear length with 16.50cm.

The greatest number of rows ear^{-1} (18.53) was noticed for cross 2x3, while the cross 1x4 showed the lowest number with 14.46, concerning to the number of kernels row^{-1} the cross 1x6 showed the highest value 43.46 and cross 1x4 exhibited the lowest value with 38.36, the kernel weight is an important yield component which may significantly contribute to yield increase in cereal crops including maize. Diallel cross expressed the maximum value was the cross 3x5 with 89.12 g, while the minimum weight was found in the cross 2x4 with 72.26 g. One of the reasons which caused the increasing in kernel weight was the temperature which was optimum (18-24c°) and this helped in filling the kernel.

For practical exploitation of hybrid vigor, the grain yield plant^{-1} remains the most important quantitative trait in maize breeding, in our experiment the cross 2x4 exhibited the maximum yield with 196.16 g, while the minimum yield 148.41g was noticed for cross 1x4. Parent 2 played an important role in increasing the yield of their cross. We can conclude from table (2) that the cross 2x4 was good because it had high yield plant^{-1} followed by the crosses 3x5 and 5x6, and the cross 3x4 was earlier than other crosses . The researchers (Haruna A., 2008, Amanullah *et al*., 2011) obtained similar result.

Table (2):- Mean of hybrids for morphological and yield components traits

Traits / Hybrids	Days to 75% tasseling	Plant height (cm)	Ear height (cm)	Leaf area (cm^2)	Ear diameter (cm)	Ear length (cm)	No. of rows ear^{-1}	No. of kernels row^{-1}	300 kernel weight (g)	Yield $plant^{-1}$ (g)
1x2	79.33 a-e	208.66 a-d	99.93 e-i	881.77 a-f	2.89 b-g	20.50 ab	18.50 ab	40.00 a-d	67.72 no	162.39 i-l
1x3	80.00 a-d	200.02 b-f	110.00 a-d	832.80 c-h	2.80 d-j	17.33 g-l	16.80 c-k	39.20 a-d	73.92 k-o	161.96 i-l
1x4	81.30 a	200.40 b-f	96.66 f-k	928.37 a-c	2.64 i-m	17.66 g-l	14.46 no	38.36 b-e	80.68 d-l	148.41 lm
1x5	78.66 b-e	177.73 g-i	82.66 op	868.93 a-g	2.75 e-k	19.50 a-f	15.33 k-o	40.86 a-d	88.23 a-e	173.14 g-j
1x6	78.33 c-f	182.80 e-h	84.93 n-p	834.1 c-h	2.66 h-l	19.08 b-h	15.33 k-o	43.46 ab	87.87 a-e	184.94 e-h
2x3	80.00 a-d	211.40 a-d	108.40 a-d	850.60 b-h	2.94 b-e	18.00 d-l	18.53 a	40.86 a-d	78.87 e-m	180.10 e-i
2x4	78.00 d-f	196.93 b-h	87.46 m-o	902.30 a-d	2.85 c-i	17.06 h-l	17.60 a-g	39.66 a-d	72.26 l-o	196.16 c-e
2x5	80.66 a-c	213.06 a-d	111.20 a b	882.60 a-e	2.71 f-k	19.33 a-g	14.80 m-o	40.06 a-d	86.36 b-f	150.63 k-m
2x6	77.33 e-g	211.93 a-d	110.93 a-c	771.73 e-h	2.94 b-e	18.00 d-l	17.06 a-i	38.53 b-e	84.09 b-i	188.2 e-h
3x4	76.00 fg	197.86 b-g	102.00 d-h	897.70 a-d	2.65 i-l	16.50 j-l	16.66 d-k	40.53 a-d	72.33 l-o	161.53 i-l
3x5	78.00 d-f	202.46 a-e	92.73 j-n	902.64 a-d	2.76 e-k	18.73 b-i	17.06 a-i	40.00 a-d	89.12 a-d	194.22 c-f
3x6	80.66 a-c	222.73 a	109.80 a-d	863.43 a-h	2.74 e-k	19.16 a-g	15.86 i-n	42.13 a-c	76.32 h-o	160.51 i-l
4x5	79.33 a-e	191.73 d-h	87.80 l-o	969.50 a	2.84 c-i	18.16 d-k	16.00 h-m	41.26 a-d	80.25 d-m	181.01 e-i
4x6	78.66 b-e	186.33 e-h	79.13 p q	894.33 a-d	2.84 c-i	18.00 d-l	15.46 j-o	40.86 a-d	76.85 g-n	169.05 h-k
5x6	80.00 a-d	210.33 a-d	111.46 a b	843.73 b-h	2.93 b-f	19.66 a-f	18.53 a	41.00 a-d	85.53 b-h	192.43 d-g

Mean followed by same letters for each column has no significant difference according to Duncan's test.

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3- The mean performance of reciprocals and check variety:

Table (3) revealed the mean of reciprocals and check variety for all studied traits, the reciprocal cross 6x3 with 75.00 days had the shortest period to 75% tasseling, it means that the reciprocal effect is in positive direction because it was earlier than it's parents, while 6x5 with 81.00 had the longest period to 75% tasseling, For plant height and ear height reciprocal 3x2 exhibited maximum plant and ear height with 218.05 cm and 113.86 cm, in sequence it means that there is positive change in plant height, whereas, the 6x1 had the minimum height for plant height with 176.33 cm, and 6x3 was reported minimum value for ear height with 84.20 cm. Data in the same table displayed that the largest leaf area was recorded by reciprocal cross 6x5 with 951.87cm^2, and this is because of the positive reciprocal effect, whereas, the smallest value (754.33cm^2) was noticed for reciprocal cross 6x3. For ear diameter the widest ear diameter was noticed in reciprocal 3x1 with 3.19 cm, and the narrowest ear diameter was reported in reciprocal 4x1 with 2.44 cm. Considering the ear length, the longest ear was found in reciprocal cross 5x2 with 21.16 cm, whereas, the shortest ear was noticed in reciprocal cross 5x3 with 16.33 cm.

Concerning the number of rows ear^{-1}, the reciprocal cross 3x2 had the biggest number of rows with 18.53 rows ear^{-1}, and the smallest number was reported in the check variety with 14.93, while, for number of kernels row^{-1} the highest value was noticed in reciprocal cross 3x1 with 44.00 kernels row^{-1} and the lowest value was recorded for the reciprocal cross 6x2 with 37.46 kernels. Table (3) revealed that there were differences between genotypes for 300-kernels weight in which the highest value was (92.96 g) noticed for the reciprocal cross 2x1 and it was the lowest for the reciprocal cross 4x1 with (67.12 g), and the reciprocal cross 5x2 exhibited the maximum value of yield plant^{-1} with (232.46 g), whereas, the reciprocal 4x1 gave the lowest value with (137.63 g), the crosses 1x2, 1x3, 1x5, and 2x5 exhibited the clear maternal effect (table 3 and 4). At the end of this table we can notice that some crosses showed positive maternal effect for specific traits like cross 3x1 in ear diameter and number of kernels row^{-1}, cross 5x2 in ear length and yield plant^{-1}, and cross 6x2 in 300 - kernel weight. The researchers Saad *et al.* (2004), Haruna (2008), Wattoo *et al.* and Mostafavi *et al.* (2009), Noor *et al.* (2010), Bidhenidi *et al.*, and Zare *et al.* (2011) and Ahmed (2013) submitted similar results.

Traits / Reciprocals	Days to 75% tasseling	Plant height (cm)	Ear height (cm)	Leaf area (cm^2)	Ear diameter (cm)	Ear length (cm)	No. of rows ear^{-1}	No. of kernels row^{-1}	300-kernel weight (g)	Yield plant^{-1} (g)
2x1	79.33 a-e	208.80 a-d	102.73 c-g	888.90 a-d	2.83 d-i	18.50 b-j	17.20 a-i	38.93 a-d	92.96 a b	224.44 a b
3x1	80.66 a-c	203.40 a-e	104.80 b-f	916.47 a-c	3.19 a	20.00 a-d	17.20 a-i	44.00 a	90.26 a-c	212.81 b c
4x1	76 f g	194.46 c-h	89.80 j-o	826.30 c-h	2.44 m	18.06 d-k	15.46 j-o	42.33 a-c	67.12 o	137.63 m
5x1	78 d-f	202.93 a-e	106.20 a-e	920.20 a-c	2.93 b-f	19.56 a-f	18.26 a-c	43.33 a b	86.00 b-g	224.90 a b
6x1	78.33 d-f	176.33 hi	89.66 j-o	881.67 a-f	2.81 d-j	18.50 b-j	17.33 a-i	40.00 a-d	89.52 a-d	178.90 e-i
3x2	80.00 a-d	218.05 a b	113.86 a	894.03 a-d	2.78 d-j	19.93 a-e	18.53 a	43.06 a b	74.34 j-o	208.99 b-d
4x2	78.00 d-f	203.73 a-e	90.26 j-o	835.57 c-h	2.87 b-h	18.06 d-k	17.86 a-e	43.26 a b	78.23 f-m	188.30 e-h
5x2	78.33 c-f	199.46 b-f	86.20 m-p	890.77 a-d	2.92 b-f	21.16 a	16.13 g-m	38.73 a-d	88.11 a-e	232.46 a

Table (3):- Mean of reciprocals for morphological and yield components traits.

6x2	77.33 d-g	203.80 a-e	92.66 j-n	883.47 a-e	3.04 a-c	18.00 d-l	16.40 e-l	37.46 c-e	96.07 a	187.18 e-h
4x3	78.66 b-e	208.73 a-d	108.13 a-e	765.47 c-h	2.78 d-j	17.83 e-l	17.46 a-h	41.53 a-d	71.35 l-o	179.68 e-i
5x3	80.00 a-d	192.00 d-h	97.46 f-k	887.33 a-d	2.55 k-m	16.33 k l	15.33 k-o	41.13 a-d	83.78 b-j	160.56 i-l
6x3	75.00 g	186.33 e-h	84.20 n-p	754.33 h	2.73 e-k	17.33 g-l	17.73 a-f	42.60 a-c	76.15 h-o	161.12 i-l
5x4	78.00 d-f	187.46 e-h	89.06 k-o	838.60 b-h	2.6 j-m	18.00 d-l	17.06 a-i	40.20 a-d	71.01 m-o	157.94 j-l
6x4	80.00 a-d	184.20 e-h	97.60 f-j	827.67 c-h	2.98 b-d	20.33 a-c	16.93 b-j	41.66 a-d	80.76 d-l	195.08 c-e
6x5	81.00 a b	202.66 a-e	104.40 b-f	951.87 a b	2.68 g-l	20.00 a-d	15.86 i-n	43.46 a b	76.84 g-n	183.00 e-h
Check	79.33 a-e	215.00 a-c	99.86 e-i	897.90 a-f	2.48 lm	19.66 a-f	14.93 l-o	40.26 a-d	82.51 c-k	193.34 c-g

Mean followed by same letters for each column has no significant difference according to Duncan’s test.

4- Some genetic parameters for studied traits:

Table (5) illustrated some genetic parameters for studied traits, for the number of the days to 75% tasseling the variance component relating to GCA(Vg)(0.17) was less than the variance components due to SCA(Vs)(3.31) and reciprocal variance RCA(Vr) (3.10), making the ratio Vgca/Vsca value less than one with (0.05), implying the large contribution of non-additive gene action in the inheritance of this trait, this was reflected on the average degree of dominance ($\bar{\alpha}$)value for diallel cross by giving more than one (4.30). Also table (5) showed the estimated values of additive, dominance and environment variances, heritability in broad sense and narrow sense. The data presented in this table showed the value of dominance variance (VD)was highest (3.31) compared to that of additive (0.35) and environmental variation (1.68).

The variance of genotype (VG) 3.67 was more than the environmental variance (VE) 1.68, so that the heritability in broad sense ($H_{b.s}^2$) was high (0.68) compared with heritability in narrow sense ($H_{n.s}^2$) (0.06). The high heritability in broad sense reflects the high additive genetic variance signifying the importance of selection to improve this trait, and the genetic advance (GA %) was low (0.34) for days to 75% tasseling.

Table (5) described some genetic parameters, for plant height, the variance components due to SCA (352.59) was more than the variance components due to GCA (62.26) and reciprocal variance (78.10), causing the ratio Vgca/Vsca to be less than one (0.17), clarifying the great role of non-additive gene effects in the inheritance of this trait, and the average degree of dominance was (2.37) confirming the over dominance. Dominance variance was (352.59) which was more than the additive (124.52) and environmental variance (113.6) and this reflected on the heritability in broad sense that’s why its value become higher (0.80) than the heritability in narrow sense (0.21), concerning the genetic advance, it was low with 4.56 for this trait.

The variance components due to SCA (258.77) were greater than variance components due to GCA (41) and reciprocal variance (128.25) making the ratio ofVgca/Vsca less than one (0.15). The average degree of dominance for diallel cross was 2.51, implying the role of additive gene effect as controlled the inheritance of this trait, and also the table showed the dominance (VD) 258.77 was more than the additive variance (VA) 82.01, and environmental variance(VE) 19.75 this leads to make the value of heritability in broad sense (0.94) to be more than the heritability in narrow sense (0.22), signifying the importance of hybridization method to improve this trait and the genetic advance (GA%) was low with 7.92 for ear height.

Some genetic parameters were estimated and clarified in table (5) for leaf area the RCA variance components (3589.07) was greater than GCA and SCA variance components, causing the ratio Vgca/Vsca to be less than one (0.35), implying the great role of non-additive gene effect in the inheritance of this trait, the average degree of dominance was 1.67. It means that this trait is under the over dominance effect, and also the table showed that the environmental variance 3244.31 is more than the dominance and additive variance , which may indicate that genotype of this trait was more affected by the environment, the variance of genotype 3978.48 was high and this cause the heritability in broad sense (0.55) to be more than the heritability in narrow sense (0.22), the value of genetic advance was low with (3.96) and this value was affected by the heritability in broad sense.

According to the data in table (5) showed for ear diameter, the variance components for SCA(0.03) was larger than GCA and reciprocal variance components making the ratio of Vgca/Vsca to be less than one (0.37) indicating the importance of non-additive gene effect in controlling the inheritance of this trait, for degree of dominance the value was (1.62) indicating that this trait was under the over dominance control, the variance of dominance is more than the variance of additive and environment, regarding to variance of genotype was (0.05) making the heritability in broad sense (0.81) to be more than the heritability in narrow sense, and the genetic advance was low with (5.54).

The variance of general and specific combining ability effects for both daillel and reciprocal cross are also presented in table (5). For ear length, the variance components of SCA (2.12) was greater than the variance components of GCA (0.62) and reciprocal (1.24), causing the ratio of Vgca/Vsca to be less than one (0.29), but the value of average degree of dominance (ā) was more than one (1.83), the variance of dominance (2.12) was bigger than the variance of additive (1.25) and environment (1.09), the variance of genotype (3.37) for this trait was high compared with variance of environment and this affect on the heritability in broad sense (0.75) compared with heritability in narrow sense (0.28) and the genetic advance was low with 5.65.

Regarding the yield components, the variance components of SCA were more than the variance components of GCA and reciprocal for the number of rows ear^{-1}, number of kernels row^{-1} and 300-kernel weight with respective values 2.45, 23.42 and 67.62, making the ratio Vgca/Vsca to be less than one for the same traits with 0.18, 0.03 and 0.26 respectively. The average degree of dominance was more than one for number of rows ear^{-1} (2.35), number of kernels row^{-1} (5.06), and (1.94) for 300-kernel weight.

The variance of dominance was larger than the variance of additive and environment for traits, number of rows ear^{-1}, number of kernels row^{-1} and 300-kernel weight with values 2.45, 23.42 and 67.62 respectively, this leads to the variance of genotype to be high for the same traits with 3.33, 25.25, and 103.23 respectively, and this cause to increase the values of heritability in broad sense compared with the heritability in narrow sense and the values were 0.85, 0.78 and 0.81, whereas the values of heritability in narrow sense for same traits were with these values 0.22, 0.05 and 0.28, and the genetic advance was low for these traits with 4.70, 1.40 and 6.92 and these values affected by the low value of heritability in narrow sense and so that the selection was not effective to improve these traits.

Concerning the yield plant^{-1}, the variance components due to SCA (1499.22) was greater the variance components due to GCA and RCA, and this made the ratio of Vgca/Vsca to be less than one, emphasizing the large contribution of non-additive gene action in the inheritance of this trait, this effect appeared on the average degree of dominance making its value more than one (2.26) indicating the over dominance control for this trait, and the value of dominance variance was more than the additive variance so the heritability in broad sense was higher than the heritability in narrow sense ,whereas the genetic advance was medium (12.53) for yield plant^{-1}.The same parameters were evaluated by the researchers Khalid *et al.* (2012), Rajesh *et al.* (2013), and Haochuan *et al.* (2014), and their results agreed with our results

Table (5):- Estimation of general (Vg), specific(Vs), reciprocal (Vr), additive V(A), dominance V(D), environment VE, genotype (VG), phenotype (VP), heritability broad sense(H^2_b), heritability narrow sense (H^2_n), average degree of dominance (a), and genetic advance (GA).

Traits / Parameter	Days to 75% tasseling	Plant height (cm)	Ear height (cm)	leaf area (cm^2)	Ear diameter (cm)	Ear length (cm)	No. of rows ear^{-1}	No. of kernels row^{-1}	300 kernel weight (g)	Yield plant^{-1} (g)

V g	0.17	62.26	41.00	827.1	0.01	0.62	0.44	0.91	17.8	293.16
V s	3.31	352.59	258.77	2324.27	0.03	2.12	2.45	23.42	67.62	1499.22
V r	3.1	78.1	128.25	3589.07	0.02	1.24	1.46	1.00	63.58	923.25
V e	1.68	113.6	19.75	3244.31	0.01	1.09	0.55	6.98	23.25	115.72
v g / V s	0.05	0.17	0.15	0.35	0.37	0.29	0.18	0.03	0.26	0.19
ā	4.30	2.37	2.51	1.67	1.62	1.83	2.35	5.06	1.94	2.26
V (A)	0.35	124.52	82.01	1654.21	0.02	1.25	0.88	1.82	35.6	586.32
SE A	0.28	18.93	3.29	540.71	0.002	0.18	0.09	1.16	3.87	19.28
V (D)	3.31	352.59	258.77	2324.27	0.03	2.12	2.45	23.42	67.62	1499.22
SE D	0.34	76.74	45.6	1176.69	0.01	0.77	0.52	1.61	21.11	323.73
V E	1.68	113.6	19.75	3244.31	0.01	1.09	0.55	6.98	23.25	115.72
SE E	1.48	143.98	92.71	1477.1	0.01	0.95	0.95	9.45	27.91	537.39
V G	3.67	477.12	340.78	3978.48	0.05	3.37	3.33	25.25	103.23	2085.55
V P	5.35	590.73	360.54	7222.8	0.06	4.47	3.88	32.24	126.48	2201.28
H^2_b	0.68	0.8	0.94	0.55	0.81	0.75	0.85	0.78	0.81	0.94
H^2_n	0.06	0.21	0.22	0.22	0.35	0.28	0.22	0.05	0.28	0.26
GA	0.24	8.98	7.35	32.90	0.15	1.04	0.76	0.50	5.54	21.46
GA%	0.34	4.56	7.92	3.96	5.54	5.65	4.70	1.40	6.92	12.53

CONCLUSION

In this study most of traits showed non-additive gene effect, which played a great role in their inheritance with high value of heritability in broad sense and low values of heritability in narrow sense, which preferred the hybridization and selection methods for improving these traits

REFERENCES

– Ahmed M. F. 2013. Diallel analysis and biochemical makers for heterosis and combining ability under two sowing dates of maize inbred lines. Asian J. Crop Science. (1): 81-94.
– Ahmed, C., and V. Agrawal, (1982). Heritability and genetic advance in triticale. Indian J. Agri. Res. (16): 19-23.
– Ali, A. A. (1999). Heterosis and gene action of maize (*Zea mays* L.) ph. D. thesis, collage of agriculture and forestry. Mosul University. In Arabic.
– Amanullah, S. Jehan, M. Mansoor and M. A. Khan, (2011). Heterosis studies in diallel crosses of maize. Sarhad J. Agri. 27(2): 207-211
– Al-Farari, A. K. 1999. Principles of genetics 3rd edition, Dar alkutub publications.
– Beck D. L., S. K. Vasal, and J. Crossa. (1990). Heterosis and combining ability of CIMMYT'S Tropical early and intermediate maturity maize (*Zea mays* L.) gtermplasm. Maydica. (35): 279-285.
– Bidhendi, M.Z., R.Choukan, F. Darvish, K. Mostafavi and E. M. Harvan.2011. Determination of combining ability and heterotic patterns of fourteen medium to late maturing Iranian maize inbred lines using diallel mating design. African journal of biotechnology Vol. 10 (74):16854-16856.
– Comstock, R. E. and H.F. Robinson (1952). Estimation of average dominance of genes. Chapter 30 in Heterosis, Ed. J. W. GOWEN. Ames. Pp. 497.
– Dudly, J.W., and Moll, R.H.1969.interpretation and use of estimates of heritability and genetic variances in plant breeding. Crop sci. 9(3): 257-261.
– Haochuan L., J. Tang, Y. Hn, J. Yang and Z. Liu 2014. Analysis on combining ability and estimation of genetic parameters for chlorophyll content in maize. J. Plant Breeding and Crop Science 6(8): 97-104.
– Haruna A. (2008). Diallel analysis of maize inbred lines for resistance to striga. Ph.M. Thesis submitted to the department of crop science, school of agriculture, university of cape coast, in partial fulfillment of the requirements for the master of philosophy degree in crop science.

– Khalid, M. D., A. H. Al-Falahy and A. A. Mohammad (2012). Genetic variations and gene effect controlling grain yield and some of its components in maize. J. Agri. science and techn. B2: 814- 823.
– Mostafavi,Kh., R. Choukan, M. Taeb, M.R. Bihamta and E.M. Heravan. (2009). Study of the gene action in controlling agronomic traits in maize (*Zea mays* L.) using diallel crossing design. Iranian J. Crop sciences. 10 (4):331-348.
– Nataraj, V., J. P. Shahi and D. Vandana, (2014). Estimates of variability, heritability and genetic advance in certain inbreds of maize (*Zea mays* L.) Intr. J. App. Bio. Phar. Tech. 5(1): 205-208.
– Noor, M.,Hidayay ur Rahman, Durrishahwar, M. Iqbal, S.M. Ali shah and Ihteramullah. (2010). Evaluation of maize half sib families for maturity and grain yield attribute. Sarhad J. Agric. Vol. 26, No.4:546-549
– Obilana A. T., and Fakorede M. A. B., (1981). Heritability: A treaties. Samaru J. Agri. Res., 1: 72-82.
– Rajesh, V., S. S. Kumar, V. N. Reddy and A. S. Sankar, (2013). Studies on genetic variability, Heritability and genetic advance estimates in newly developed maize Senotypes (zea mays L.) Int. J. App. Bio. Phar. Tech. 4(4): 242-244.
– Robert W. Jugenheimer, (1976). Corn improvement, seed production and uses. A Wiley-inter science publication. New York. USA.
– Saad, I. M., H. N. Malik, N. M. Minhas and M. Munir. 2004. General and specific combining ability studies in maize diallel crosses. Int. J. Agric. Bio. (5): 856-859.
– Wattoo, F.M., M.Saleem, M.Ahsan, M. Sajjad, and W. Ali 2009. Genetic analysis for yield potential and quality traits in maize (*Zea mays* L.), American Eurasian J. Agri. Environ. Sci. (6):723-729.
– Zare, M., R choukan, M. R. Bihamta, E. M. Heravan, and M. M. Kamelmanesh 2011. Gene action for some agronomic traits in maize (*Zea mays* L.) Crop Breeding Journal 1(2): 133- 141.