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ESTIMATION OF SOME GENETIC PARAMETERS AND HETEROSIS IN MAIZE BY USING HALF DIALLEL CROSS

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ABSTRACT

A half diallel cross compression six purelines of maize (DKEC6022, ZP-197, Sargrin, IK58, Vegasfrun, ZP-595) was carried out, the purelines and their hybrids planted in 5 July 2018 at the field of college of agricultural engineering sciences, university of Duhok. Using randomize complete block design with three replicates to studies heterosis and genetic parameters. The result showed significant difference among parent and their crosses for all characters. The combining ability analysis of variance results indicated that mean square of genotypes, general and specific combining ability was significant for all traits indicated that the presence of additive and non-additive gene effects controls all traits.

The parents Sargrin had the highest value for the yield components and the hybrid (IK58 x Vegasfrun) exhibit significant average performance and give the highest heterosis for grain yield 89.5% and yield 230.379 g). the heritability broad sense was high for days to 75% tasseling and silking, plant and height, leaf area, No. of rows/ear, No. of grain/ row, kernels weight/ear, weight of ear and shelling percent.

KEY WORDS: Heterosis, genetic parameters, general and specific combing ability, genetic advance, half diallel cross.

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INTRODUCTION

Many procedures have been established by plant breeders to improve grain yield of maize crop and hybrids. In order to choose the best hybrid combination a large numbers of subjective chosen inbred line are crossed. Before crosses, it would be a consider advantage to be able determine the combining ability of parents, gene effects and heterotic effect of crosses among inbred lines. Half diallel crossing program have been applied to get this goal by providing a systematic approach for the detection of suitable parents and crosses for the investigated traits. (Ramalho, Abreu and Stantons, 2001) indicated that the half diallel crosses is one of methods available in plant breeding that allows the selection of parents to improve the performance of the F_1 hybrid. Moreover half diallel cross help to analyze the genetic design, providing estimates useful genetic parameters that allow for the selection of the best genitors to get hybrid and to understand the genetic effect on traits. (Craz *et al.*, 2004; Melani and Carena, 2005 and Goncalves *et al.* 2014. Also the half diallel method has been used to estimate several agronomies traits, in hybrid obtained from inbred line maize. (Dona-paterniani and Datta.J. 2011, Bernini and Paterniani, 2012 and Tonette and Carena, 2014) and in specially corn such as popcorn (Solalinde *et al.*, 2014 and Cabral *et al.*, 2015). Abde-mouean *et al.*, 2014 reported that the effect of General combining ability (GCA) and specific combining ability (SCA) are important indicators of potential value for assessing inbred lines in hybrid combination as a step to improve hybrid varieties in genotype maize. Heterosis is the superiority in performance of hybrid individuals compared with parents. Concerning to previous studies on heterosis in maize crop, the researcher (Ogo *et al.*, 2007 and Dawod *et al.*, 2009) found significant desirable heterosis for grain yield and yield components measured as departure of F_1 from mid parents. The aim present study to investigate combining ability, heterosis and some genetic parameter in single cross hybrids of maize and their parents using

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half diallel cross according Grifting (1956) method 2.

MATERIALS AND METHODS

The study consisted of six inbred lines which were selected based on different agronomic traits. Was carried out at the field of College of Agriculture, University of Duhok. In spring season, 1 March, 2019, six inbred lines were sown to perform half diallel crosses between them. Each inbred line was sown in a row 3 m long, 0.75 m between rows and 0.25 m between plants, then getting 15 hybrids, in autumn season the F_1 and their parents lines were sown in (1/7/2019) using Randomized Complete Block Design (RCBD) with three replications, one row for each genotype with 3 m long, 0.75 m between rows and 0.25 m between plants. Field was fertilized with (N. P. K; 27, 27.0) at rate 400 kg/ ha, as the first doses at planting date and 200 kg/ha of urea (46% N) were added. All the agronomy practices were taken for establishment of proper stand in field. Data were recorded for.

Date of tasseling and silking, Plant height and ear height, Leaf area, No, of row ear^{-1}, No. of kernel row $^{-1}$, 300- kernel weight, Weight of kernel ear^{-1}, Weight of ear, and Shelling percent (Bectash. 1979), Shelling percent = grain weight (g) / total weight of ear.

Data obtained from this F_1 progeny and six parents were analyzed by Griffing,1956 method 2. The heterosis for all traits estimated according to Fehr (1991).

$H= F_1- \overline{MP}/\overline{MP}$

Where:

F1: hybrid mean

$\overline{MP}$: mid parents

$\overline{MP}$: $\overline{P1} + \overline{P2}$ / 2

P1: parent 1

P2: parent 2

HP: best parent

and better parents

$H=F_1$- HP/ HP

The heterosis test by Ahmed (1982):

$$t(H) = \frac{H-0}{\sqrt{v\,H}}$$

$$V(H) = \frac{3}{2}\,\sigma^2 e$$

$$\sigma^2 e = \frac{mse}{r}$$

other genetic parameters calculated by these equations:

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

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

Genetic advance.

Genetic advance was calculated according to the following formula:

GA= h^2.n.s. ×i × $\sigma^2 P$

Where:

h^2: heritabilty in narrow sense

i: selection intensty 10% =1.76

$\sigma^2 P$: standared variance phenotype

After teh expected genetic advance as present was calulated according the following equation

% $\wedge G = \wedge G / \bar{y}_{..}$ *100

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

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

Using Duncan Multiple Range Test (DMRT) to compression mean of hybrids and parents.

Table (1): Genetic material used in the experiment.

	Inbred line	Source
1	Dkcc 6022	central of Scientific Agriculture Research Erbil
2	ZP- 197	Collage of Agricultural – Duhok University
3	Sargrin	Collage of Agricultural – Duhok University
4	Ik 58	Collage of Agricultural – Duhok University
5	Vegasfrun	Central of Scientific Agriculture Research Erbil
6	ZP-595	Collage of Agricultural – Duhok University

RESULTS AND DISCUSSION

Preliminary analysis of variance and combing ability of variance indicated that genotypes were significant different for all examined characters (Table 2), the result in the table showed significant difference between parents and their hybrids for the same characters.

The general combining ability (GCA) and specific combining ability (SCA) effect of genotypes were also significantly varied for studied characters except the shelling percent GCA/SCA ratio was greater than unity one for all maize studied characters with exception weight of ear and shelling percent

Table (2): Analysis of variance for maize characters using Grifting method.

SOV	Df	days to 75% tasseling	days to 75% silking	plant height (cm)	Ear height (cm)	leaf area (cm^2)	No. of rows ear^{-1}	No. of kernels row^{-1}	kernel weight ear^{-1}	300-kernels weight (g)	weight of ear (g)	shelling percent %
Rep,	2	12.0	14.1	11.921	7.47	7284.5	0.3	1.73	131.25	275.9	0.0002	3.34
Genotypes	20	58.44**	36.9**	1368.9**	341.4**	23356.3**	4.7**	75.88**	3923.3**	299.7**	43896.7**	901.66*
Parents	5	104.1**	67.7**	2227.9**	330.1**	39537.9**	3.6**	79.8**	8517.7**	263.3**	11867.4**	138.38**
Hybrid	14	46.269**	27.46**	1027.7**	231.8**	18969.2*	3.8**	61.7**	2158.9**	329.0	56293.1**	1237.1**
Parent vs hybrid	1	0.63**	15.87**	1851.43**	670.6**	3868.3**	23.6**	255.2**	5651.4**	72.2**	30493.2**	22.456
GCA	5	172.7**	95.58**	3794.3**	472.7**	24867.2**	7.58**	95.76**	5264.86**	565.1**	12869.7**	712.9**
SCA	15	20.346	17.41	560.495	297.61	22852.74	3.781	69.256	3476.09	211.29	54239.06	964.591
Error of genotypes	40	0.350	0.328	67.754	12.159	1033.716	0.121	7.412	92.679	69.649	146.515	27.524
Error of parents	10	0.256	0.200	135.389	8.789	1463.281	0.000	8.200	107.464	23.454	271.773	34.668
Error of hybrids	28	0.356	0.94	39.089	13.608	740.411	0.165	7.003	91.259	90.006	108.335	26.914
gca/sca		8.48	5.49	6.76	1.58	1.08	2.00	1.38	1.51	2.67	0.23	0.73

***** and ****** significant at .05 and 0.01 probability level.

The effect of General combining ability for parent's characters was presented in Table (3). The parent (2) and (4) were found as good combiner for eight traits (days to 75% tasseling and silking, plant and ear height, No. of kernels /row, leaf area, weight of ear for parent (2) and kernel weight/ear, 300 kernel weight and shelling percent for parent (4) accession (3) had higher GCA values for leaf area, No. of row/ear kernels weight, 300 kernels weight and shelling. Also from table (3) noted that the parents 2,4,3 were the best lines for displaying high value in most characters. This results agreed with the results of the researchers (Amirzzan *et al.*, 2010; Pablo *etal.*,2011 and Hella *et al.*, 2017.

Table (3): Effect of General combining ability for parent's characters.

Parent	Characters										
	days to 75% tasseling	days to 75% silking	plant height cm	Ear height cm	leaf area cm^2	No. of rows ear^{-1}	No. of kernels row^{-1}	kernels weight ear^{-1}	300-kernel weight (g)	weight of ear (g)	shelling percent %
1	2.542-	2.764-	1.361-	1.750-	28.689*	0.722-	1.236*	9.632*	1.408	15.372-	4.305
2	2.958*	1.944*	17.847*	4.958*	23.310*	0.611*	1.028*	14.693-	8.821-	29.631*	6.239-
3	1.458-	0.139-	0.864	1.833-	14.876*	0.694*	0.278	19.153*	2.675*	1.322-	4.016*
4	1.500*	1.486*	6.764*	2.583*	58.645-	0.222-	1.861*	10.690*	4.804*	17.268-	6.291*
5	3.083-	2.014-	20.236-	7.125-	3.628	0.027	3.639-	12.426-	1.929*	22.909-	4.564-
6	2.625*	1.486*	3.778-	3.167*	11.858-	0.389-	0.764-	12.356-	1.996-	27.240*	3.809-
SE	0.110	0.107	1.534	0.649	5.991	0.065	0.507	1.794	1.555	2.256	0.978

The results of SCA effects of diallel cross and their performance mean for the different traits are presented in table (4) and seem that the number of cross showed a desirable significant SCA effect for traits , the cross (3x5) gave four desirable SCA effect for days to 75% tasseling and Silking, leaf area, No. of rows/ ear, while the cross (1x4) exhibited three desirable SCA effect for plant height ear height and leaf area.

For some yield components, the specific combining ability effect due to the diallel Crosses showed that the maximum positive value was exhibited by cross (4x5) with 8.429, 8.452, 57.711 and 67.981 for number of kernels row^{-1},300 kernels weight, weight of kernels ear^{-1} and kernels weight ear-1respectively. parent 4 and 5 had the large contribution in the inheritance of these characters to the hybrid.

Concerning the shelling percent, the cross 2x3 had the maximum values of SCA followed by cross 5x6 with values 14.122 and 7.939 respectively. Final from the results in the Table(3), the cross 3x5 appeared a short day to tasseling and silking, while the cross 4x5 exhibited highly significant SCA for number of kernel row^{-1}, 300 kernel weight, kernels weight ear-1and weight of ear. These results were in agreement with Sali *et al.*, 2008; Muna *etal.*,2011 and Mohamed *etal.*,2014.

Table (4): Effect of specific combining ability for hybrid characters.

Hybrid	Characters										
	days to 75% tasseling	days to 75% silking	plant height cm	Ear height cm	leaf area cm^2	No. of rows ear^{-1}	No. of kernels row^{-1}	kernels weight ear^{-1}	300-kernels weight g	weight of ear	shelling percent
1x2	1.464-	1.387-	3.946-	8.077*	3.803	0.143	4.720*	39.369*	2.865	3.110	3.098*
1x3	4.256*	2.363*	1.529-	5.202*	38.386*	0.059	5.137*	17.977-	10.931-	5.298	6.363-
1x4	1.661*	3.405*	28.137*	13.785*	111.261*	1.024-	5.113-	16.814-	1.107	15.623-	5.223*
1x5	0.911*	0.095-	7.137	2.506-	14.769	0.726*	4.387*	23.769*	0.448	49.518*	2.048-
1x6	2.095-	2.607-	5.726-	18.012-	172.935-	0.619*	3.976-	7.358-	3.842	42.881-	5.171*
2x3	0.881-	3.012-	10.262*	17.949*	119.901-	1.393*	3.988-	53.185-	8.968-	123.807-	14.122*
2x4	1.827*	2.363*	4.929*	4.923-	25.487-	0.357-	5.095*	7.956-	1.364-	60.961-	6.958*
2x5	2.411*	2.863*	6.595*	5.119*	5.324	1.393*	0.929	14.527*	8.289-	29.452-	5.781*
2x6	1.262-	1.065-	14.018-	6.804-	95.714*	1.381-	3.685-	8.351*	8.429*	324.270*	41.489-
3x4	0.577*	1.220-	6.988-	1.131-	21.736*	0.441-	1.488-	0.198	4.639*	29.873-	20.384*
3x5	6.173-	3.387-	7.345*	0.423-	122.714*	1.309*	2.655-	19.018-	5.582*	29.768*	14.122-
3x6	1.321*	2.518*	1.656	13.762-	53.085-	0.964-	4.565*	59.546*	6.776*	54.499*	6.028-
4x5	0.536	1.012-	1.679	0.827	9.735	0.226*	8.429*	57.711*	8.952*	67.981*	4.466*
4x6	3.887-	2.357-	20.768-	7.012-	6.095-	1.119*	5.185-	23.599-	10.212-	6.463-	19.008-
5x6	0.863*	0.190-	15.768-	1.220-	100.838-	1.631-	5.351-	22.949-	5.179*	63.005-	7.939
SE	0.303	0.293	4.212	1.785	16.454	0.178	1.393	4.927	4.271	6.195	2.685

The data in Table (5). represent the mean of parents, for the number of days to 75 tasseling, parent 6 took the maximum number of days to tasseling of 72.66 days, while parent 1 with 57.66 days found to be earliest. The difference among parental values affected significantly in their diallel crosses value. Regarding the hybrids values, the cross 2x4 was found to be the latest, in which spent maximum days to 75% tasseling 72.33. The hybrid 5x3 required the short days to 75% tasseling of 55.33 days, this hybrid had the negative minimum value for SCA (table,2). So that it produced minimum days to 75% days to tasseling. For days to 75% silking, parent I1 was the earliest with 62.00 days, while parent 6 was the latest with 75.00 days, the difference between parent reflected significantly on their crosses, the cross 5x3 was the earliest for days to 75% silking with 63.67 days, where're, the cross 2x4 took the longest period for days to 75% silking, this cross deviated from their diallel cross value, minimum negative effect value was -3.387 for SCA Table 2. The results in the same revealed that the tallest plant among six parent was exhibited in parents 2 with 220.00cm, while the shortest plant by parent 5 with 140.66cm. so results reflected on plant height for crosses, the cross 1x4 exhibited the highest crosses with 221.67 cm, while the shortest cross was 5x6 155.33cm,The parent 4 was superior in this trait and the cross 1x4 had the positive value for SCA and the value was 28.137 there for this cross superior in this trait, also in the same table , for ear height the maximum value recorded by parent 6 with 98.00cm and minimum value exhibited by parent 5 with value 70.66cm. The cross 1x5 obtained the minimum value (75.33cm) and the maximum was observed by cross 2x3 with value 107.33cm, the parent 2 which was consist of one of parent the cross 2x3 had the high GCA and the cross 2x3 gave the maximum value for SCA so that this cross superior in this trait. The largest leaf area was obtained by parent 2 with 589.77cm^2 and parent 4 had the smallest value with 274.76cm^2.Regarding to crosses , the cross 5x3 gave the largest leaf area with value 644.42cm^2 whereas the smallest value 242.38cm^2 was obtained by cross 1x6, the increase the total leaf area is due to the cross 3x5 had the largest positive for SCA Table 3 .For yield components the result in Table 4 indicated that the parent 2 was recorded the highest value for number of rows ear^2 and the number of kernels row^{-1} with values 16 and 34.66 respectively ,meanwhile the lowest values was recorded by parent 5.The highest values for this traits, The cross 3x5 and 1x2 which obtained 18 and 42.67 respectively, For 300-kernal weight the parent 3 had the maximum value with 99.86 g while the lowest value produced by parent 6 with value 79.56g.

For weight kernels ear^{-1} the cross 4X5 had maximum value (230.37), one of the reasons which caused the increasing in kernels weight because this cross had the maximum value of SCA (revision Table 3). For the shelling percent was the highest for cross 3X4 and 1X4 with 115.57 and 100.69 in sequence, while the cross 2X6 gave the lowest percent with 21.81. Same results were recorded by Noor *et al*, 2010; Zare *et al*., 2011; Ahmed, 2013; Aminu *et al*., 2014 and Shapal *et al*., 2014.

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Table (5): Mean of parents and hybrid maize characters.

	days to 75% tasseling	days to 75% silking	plant hieght cm	Ear height cm	leaf area cm^2	No. of rows ear^{-1}	No. of kernels row^{-1}	kernels weight ear^{-1}	300-kernels weight g	weight of ear	shelling percent
Parents											
1	57.67f	62.00e	161.33cd	76.67c	565.29a	14.00b	33.00a	172.67 b	97.10 a	195.20 c	88.40 ab
2	71.33b	73.33b	220.00a	77.67c	589.77a	16.00a	34.67a	143.90c	81.30b	171.47c	83.93abc
3	64.00d	71.67c	179.00bc	75.67cd	522.50ab	16.00a	34.67a	243.33a	99.87a	286.83a	84.92abc
4	68.33c	71.00c	194.67b	90.33b	274.76c	16.00a	37.67a	186.23b	98.10a	235.77b	79.43bc
5	61.33e	67.00d	140.67e	70.67d	458.75b	14.00b	22.67b	95.50e-	83.60b	130.73d	73.73c
6	72.67a	75.00a	181.67bc	98.33a	533.78a	14.00b	32.33a	115.067d	79.57b	123.47d	93.17a
Crosses											
1x2	**65.00f**	**67.00gh**	**200.67b**	**98.00 b**	**559.00b**	**16.00b**	**42.67 a**	**208.70b**	**87.07b-e**	**242.73bc**	**86.04def**
1x3	66.33e	68.67ef	186.00cd	88.33cd	585.15b	16.00b	42.33ab	185.20c	84.77abc-	213.97de	86.83def
1x4	66.67de	71.33bc	221.67 a	101.33ab	584.50b	14.00c	33.67def	177.90cd	98.96a-d	177.10g	100.69b
1x5	61.33g	64.33i	173.67e	75.33f	550.28b	16.00b	37.67bcd	195.37bc	95.40a-d	236.60bc	82.57ef
1x6	67.3cde	67.00gh	201.33b	76.67ef	342.38e	16.00b	37.33cd	185.30c	92.20a-e	193.77fg	95.62bcd
2x3	66.67de	68.00fg	217.00 a	107.33a	422.08 d	18.67a	33.00def	125.67f	76.50e	129.87h	96.77bc
2x4	72.33 a	75.00a	217.67 a	89.33c	442.38cd	16.00b	43.67 a	162.43de	86.23b-e	176.77g	91.88b-e
2x5	68.33c	72.00b	192.33bc	89.67c	535.46b	18.00a	34.00def	161.80de	76.43e	202.63ef	79.85f
2x6	71.00b	71.33bc	192.00bc	107.00 a	570.42b	16.00b	35.33 de	156.80e	81.90de	719.67 a	21.81h
3x4	66.67de	69.33de	188.67c	ج86.33d	481.17c	16.00b	36.33de	204.43b	103.73ab	176.90g	115.57a
3x5	55.33h	63.67i	176.00de	77.33ef	644.42 c	18.00 a	29.67f	162.10de	101.8abc	230.90cd	70.21 g
3x6	67.67cd	70.33cd	197.33bc	81.67def	463.58cd	16.67b	41.33abc	210.30b	96.17a-d	241.67bc	87.05def
4x5	65.00f	67.67fgh	176.33de	83.00cde	457.92cd	16.00b	42.33ab	230.37 a	107.30a	253.17b	91.07cde
4x6	67.00de	71.00bc	177.33de	87.00cd	537.75b	16.00b	33.33def	158.67e	87.33b-e	183.93g	86.37def
5x6	65.00f	66.67h	155.33f	83.33cde	445.83gd	16.00b	31.67ef	180.70c	108.60a	209.50ef	86.46def
mean parents	65.889	70.000	179.556	81.556	490.809	15.000	32.500	159.417	89.922	190.578	83.931
mean hybrids	66.111	68.889	191.556	88.778	508.154	16.356	36.956	180.382	92.291	239.278	85.253
General mean.	66.048	69.206	188.127	86.714	503.199	15.968	35.683	174.392	91.614	225.264	84.875

Mean with each column followed by the same letter are not significantly different from each other According DMRT at 0.05 and 0.01 probability level respectively.

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Data presented in Table (6) illustrated some genetic parameters for eleven VSCA characters. The variance component relating to GCA (vg) was less than variance components VSCA (VS) causing the ratio VGCA /VSCA value less than one for all examined characters except, days to 75% tasseling, this indicating that the non-additive gene action was more in the inheritance of all studied characters, the average degree of dominance (a) for diallel cross was more than one, and also the data in same table exhibited the variance of dominance was more than the variance of additive for all characters this mean the great role of non-additive gene effect inheritance of these characters and this reflected on the heritability in broad sense that's why its value become higher than the heritability in narrow sense.

According to the results values in the Table 6, the results perceived the heritability narrow sense in general was low to moderate with exception of days to 75% tasseling (67%), moderate for days to 75% silking, plant height, ear height, No. of rows ear^{-1}, No. of kernels ear^{-1}, kernels weight ear^{-1}, 300 kernel weight and for kernel weight of ear and shelling percent, the value range 5% to 40%, whilst the heritability broad sense were obtained to be high in quantity for ten characters under realization with exception of 300-kernel weight which was moderate. High heritability in broad sense range from 51% for 300 kernel weight to 98% for days to 75% tasseling. The difference between heritability broad sense and heritability narrow sense estimate which was obtained for the most characters studied was expected due to more effective role of non-additives genes in the inheritance of these traits. These results wherein according with Bernini *et al.*, 2012; Also the results in Table (6) shows the genetic advance as mean, it was low for all studied characters with exception plant height and kernels weight ear^{-1} was medium with value 12.40 and low for all other traits and value range 5.37 for days to 75% silking and 8.23 for days to 75 silking. Regarding to genetic advance it was low for the most studied characters, so that the selection was not effective to improve these characters. Similar results were proved by Qurban *et al.*, 2013; Mohammed and Ismail, 2014 and Parriy *et al.*, 2014.

Table (6): Estimates of genetic parameters for studied characters using Griffing method 2.

parameters	days to 75% tasseling	days to 75% silking	plant height cm	Ear height cm	leaf area cm^2	No. of rows ear^{-1}	No. of kernels row^{-1}	kernels weight ear^{-1}	300-kernel weight g	weight of ear g	shelling percent
Vg	7.18	3.96	155.27	19.18	993.06	O.310	3.68	215.50	20.64	530.13	28.55
Vs	6.66	5.69	164.24	95.14	7273.00	1.22	20.61	1127.80	47.21	18030.85	312.35
Ve	0.35	0.32	67.75	12.15	1033.71	0.121	7.412	92.679	69.64	146.15	27.52
Vg/Vs	1.07	0.69	0.94	0.20	0.13	0.25	0.17	0.19	0.43	0.02	0.09
G	0.96	1.19	1.02	2.22	2.70	1.98	2.36	2.28	1.51	5.83	3.30
VD	14.36	5.69	164.24	38.37	1986.12	0.62	7.36	431.01	41.28	1060.26	57.11
VA	6.66	7.93	310.54	95.14	7273.00	1.22	20.61	1127.80	47.21	18030.85	312.35
VG	21.02	13.62	474.78	133.51	9259.12	1.84	27.97	1558.81	88.49	19091.11	369.46
Ve	0.35	0.32	67.75	12.15	1033.71	0.12	7.41	92.67	69.64	146.15	27.52
VP	21.37	13.94	242.53	145.66	10292.83	1.96	35.78	1651.48	158.13	19237.28	396.98
SEA	7.69	4.25	169.01	21.05	1107.83	0.33	4.26	234.52	25.20	573.26	31.75
SED	2.32	1.99	64.27	34.03	2613.83	0.43	7.94	397.48	24.68	6201.29	110.30
SEC	0.07	0.07	14.78	2.65	225.57	0.02	1.61	20.22	15.19	31.97	6.00
h².n.s	0.67	0.40	0.30	0.26	0.19	0.31	O.20	0.26	0.26	0.05	0.14-
h².b.s	0.98	0.97	0.87	0.91	0.89	0.93	0.79	0.94	0.55	0.99	0.93
GA	5.43	3.71	23.33	5.56	34.25	0.77	2.16	18.56	5.74	13.37	5.01
GAY	8.23	5.37	12.40	6.41	6.80	0.86	6.06	10.64	6.27	5.98	5.90

Vg: Variance effect of GCA, Vs: Variance effect of SCA, Ve: Variance effect of environment Vg/Vs: Ratio of GCA to SCA, VA: Additive variance, VD: Dominance variance, VG: Total genetic variance, VP: Phenotypic variance. SE(A) stander error to test significant additive variance. SED, Standard error to test dominance. SEC, Standard error to test crosses, HNS Heritability narrow sense. HBS, Heritability broad sense, GAK, Genetic advance as mean.

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The results in the table (7) showed positive and negative heterosis for days to 75% tasseling and silking, the cross 1 x 4 gave significant positive heterosis with values 3.66% and 4.83 for days to 75% tasseling and silking, whilst the cross 3x5 gave the maximum significant negative heterosis with values -7.33% and-5.66%, this indicates this crosses were the earliest to these characters, also for plant height, only three crosses had significant negative heterosis and the reminder had significant positive heterosis, the cross 1x4 identified as significant positive heterosis with maximum heterosis 43.66, so that, the cross 1x4 was superior in days to 75% tasseling, silking and plant height. For plant height, heterosis over mid parents was found in the range of 10.83% to 43.66 %. The crosses 4x6 and 5x6 exhibited negative heterosis over mid parents. Whilst, the crosses, 1x4 and 1x6 gave high positive heterosis with values 43.66 and 29.83 respectively. The crosses had significant negative heterosis for ear height and twelve crosses showed significant positive heterosis. The crosses 2x3 and 1x2 remarked high values heterosis with value 30.66% and 20.83% consequently. Comparable results by Shalim *et al*., 2006; Amanullah *et al*., 2011 and Mohammed, 2015. Regarding to leaf area, the estimation of heterosis for this traits, five cross showed negative heterosis and ten cross were obtained significant positive heterosis, the maximum heterosis perceived by cross 3x5with value 153.79%, followed by cross 4x5 was produced heterosis value (133.47%). For number of row ear^{-1} fifteen cross showed positive heterosis with range of 0 to 2.66%. The number of kernels row^{-1} and 300 kernel weight are important role in kernels yield, most of the crosses exhibited low heterosis for this trait, the maximum value recorded by cross 4x5 with value 12.16%, followed by cross 1x5 with value 9.83% for 300 kernel weight, the percent heterosis ranged from 14.08% in cross 2x3 to 27.01% in cross 5x6, followed by cross 3x5 (10.06%), five crosses expressed their positive heterosis for yield components (number of row ear^{-1}, number of kernels row^{-1} and 300-kernel weight). In case of kernels yield plant^{-1} six cross gave negative heterosis, while nine crosses exhibited positive heterosis and the percent heterosis varied from 8.01% to 89.5%. The highest heterosis 85.5% remarked by cross 4x5 followed by cross 5x6 with value 75.41%. For shelling percent, the cross 3x4 gave the highest positive heterosis (33.39%), the cross 2x6 recorded the maximum value 66.74. These results in agreement with the results proved by Solalinde *et al*., 2014 and Cabral *et al*., 2015.

From the results in the same table, the hybrid 4x5 was characterized by the significant describe heterosis for the most traits including weight of ear, 300 kernels weight, and No. of kernels/rows flowed by hybrids 1x5 for weight for weight of ear, kernels weight and No. of kernels/rows. These results indicated the performance of depending behavior hybrid in development of high. Productivity hybrid variates, as well as exploit the phenomena of heterosis.

Table (7): Estimation of heterosis for studied characters according to mid-parents.

	days to 75% tasseling	days to 75% silking	plant height cm	Ear height cm	leaf area cm^2	No. of rows ear^{-1}	No. of kernels row^{-1}	kernels weight ear^{-1}	300-kernels weight g	weight of ear	shelling percent
1x2	0.5	-0.67	10	20.83**	-18.53	1**	8.83**	50.42**	-2.13	59.40**	-0.13
1x3	5.5**	1.83	15.83**	12.17*	41.25	1**	8.5**	-22.70	-13.72	-27.05	0.17
1x4	3.667**	4.83**	43.67**	17.83**	164.48**	-1	-1.67	-1.55	1.33	-38.38	16.77*
1x5	1.83*	-0.17	22.67**	1.67	38.26	2**	9.83**	61.28**	5.05	73.63**	1.50
1x6	2.17**	-1.5	29.83**	-10.83*	-207.16**	2**	4.67	41.43**	3.87	34.43**	4.83
2x3	-1	-4.5	17.5**	30.67**	-134.05**	2.67**	-1.67	-67.85	-14.08	-99.28	12.35
2x4	2.5**	2.83*	10.33	5.33	10.11	0	7.50**	-2.63	-3.47	-26.85	10.20
2x5	2*	1.83	12*	15.50**	11.20	3**	5.33	42.10**	-6.52	51.53**	1.02
2x6	-1	-2.83*	-8.83	19.00**	8.64	1*	1.83	27.32	1.47	57.20**	-66.75**
3x4	0.5	-2	1.83	3.33	82.54	0	0.17	-10.25	4.75	-84.4	33.39**

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3x5	-7.334**	-5.67**	16.17**	4.17	153.79**	3**	1	-7.22	10.07	22.12	-9.12
3x6	-0.667	-3	17**	-5.33	-64.56	1.67*	7.83**	31.2	6.45	36.52**	-2.00
4x5	0.167	-1.33	8.67	2.5	91.16	1*	12.17**	89.5**	16.45	69.92**	14.49
4x6	-3.5**	-2*	-10.83	-1.33	133.48**	1*	-1.67	8.02	-1.5	4.32	0.07
5x6	-2*	-4.33**	-5.83	-1.17	-50.43	2**	4.17	75.42**	27.02	82.4**	3.00

* and ** significant at level 0.05 and 0.01

Heterosis F_1's over better parent for different characters in maize are presented in Table (8). For days to 75% tasseling, the crosses 3x5, 4x6 and 2x6 showed negative heterosis over mid parents, the same table revealed twelve crosses gave positive heterosis and the maximum value 9.66% was perceived in cross 1x6, while the maximum value 2.66% was obtained by cross 3x4. For days to 75 silking, four crosses showed negative heterosis and the value range -3.33% for cross 3x6 and -1.6% recorded by cross 4x5, the others crosses exhibited positive heterosis with maximum value obtained by cross 1*4 with value 9.33 %, so we can say that the cross 3x5 was earliest for days to 75% tasseling and silking. From the results in table 6, for plant height the all crosses had negative heterosis except three cross gave positive heterosis and the maximum value was demonstrated by cross 1x6, followed by cross 3x6 with values 19.66% and 15.66% respectively. Regarding for ear height six crosses exhibited negative heterosis and highest value was noticed by cross 2x3 with value 29.66 %. The negative heterosis for plant height and ear height indicated dwarfness for cross.

Concerning heterosis for leaf area varied from 87.95% to 121.91% for cross 5x6 and 3x5 respectively. Mohammed and Ismail, 2014 and Mohammed, 2015 reported negative and positive heterosis for different of maize traits. The number of rows ear^{-1} and number of kernels row^{-1} both are important yield component. Therefore, positive heterosis is desirable for them.

Most of crosses exhibited low heterosis for number of row ear^{-1}, the percent of heterosis ranged from (0-) in seven crosses and seven cross showed positive heterosis with maximum value (2.66%) recorded by cross 2x3., whilst six cross were noticed negative heterosis for number kernels row^{-1} and nine crosses expressed their positive heterosis, the maximum positive value was viewed by cross 1x3 with value 7.66% and following by cross 3x6 with value 2.67 %. Heterosis for 300 kernel weight, nine crosses showed negative heterosis for this traits, never the less the cross 5x6 exhibited the highest value (25%) and the other crosses gave low values. In case of kernels yield plant^{-1}, the percent heterosis varied from- 117.46% to 65.63%. Among the fifteen crosses, seven crosses exhibited positive heterosis and the highest heterosis 65.63% for kernels yield plant^{-1} was shown by cross 5x6, on other hand, two crosses 4x5 and 1x2 those showed positive heterosis. For shelling percent, nine crosses were noticed negative over better parent. Six crosses gave positive heterosis, the maximum value was recorded by cross 3x4 with value 30.65%, followed by cross 1x4 with 12.29. This was confirmed by Melkamu *etal*., 2013; Shapal., 2014 and Mohammed, 2017.

Table (8): Estimation of heterosis for studied characters according to better parent.

Hybrids	days to 75% tasseling	days to 75% silking	plant height cm	Ear height cm	leaf area cm^2	No. of rows ear^{-1}	No. of kernels row^{-1}	kernels weight ear^{-1}	300-kernels weight g	weight of ear	shelling percent
1*2	7.33**	5**	-19.33**	20.33**	-30.77	0	8**	36.03**	-10.03	47.53**	-2.37
1*3	8.67**	6.67**	7	11.67*	19.86	0	7.66**	-57.93**	-15.1	-72.87**	-1.57
1*4	9**	9.33**	27**	11*	-5.26	-2**	-4	-8.33	0.83	-58.67**	12.29
1*5	3.67**	2.33*	12.33*	-1.33	-15.01	2**	4.67	22.7	-1.7	41.4**	-5.84
1*6	9.67**	5**	19.67**	-21.67**	-222.92**	2**	4.33	12.63	-4.9	-1.43	2.45
2*3	2.67*	-3.67**	-3	29.67**	-167.68**	2.67**	-1.67	-117.47**	-23.37*	-156.97**	11.86
2*4	4**	4**	-2.33	-1	-147.39**	0	6	-23.8	-11.87	-59**	7.96
2*5	7**	5**	-27.67**	12*	-54.31	2**	-0.67	17.9	-7.17	31.17**	-4.08
2*6	-0.33	-2*	-28**	8.67	5.12	0	0.67	12.9	0.6	548.2**	-71.37**
3*4	2.67*	-1.67*	-6	-4	-41.33	0	-1.133	-38.7	3.87	-109.93**	30.65**
3*5	-6**	-3.33**	-3	1.67	121.92**	2**	-5	-81.03	1.93	-55.93**	-14.71
3*6	3.67**	-1.33	15.67*	-16.67**	-70.2	0.66	6.67*	-32.83*	-3.7	-45.17**	-6.13
4*5	3.67**	0.66	-18.33*	-7.33	-0.83	0	4.67	44.13**	9.2	17.4	11.63
4*6	-1.33	4**	-17.33*	-11.33*	3.97	0	-4.33	-27.57	-10.77	-51.83**	-6.80
5*6	3.67**	-0.33	-26.33**	-15**	-87.95	2**	0.67	65.63**	25	78.77**	-6.72

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