COMBINING ABILITY AND GENETIC PARAMETERS FOR YIELD AND ITS COMPONENETS USING LINE X TESTER ANALYSIS IN SUMMER SQUASH

Zhiyan A. T **Mohammed A. Hussain**
Researcher **Prof.**
Dept. Horticulture **Dept. Field Crop**
Coll. of Agric. Engin. Sci., University Duhok
zhiyan.teli@uod.ac **dr.mohammedali1953@gmail.com**

ABSTRACT

This study was aimed to investigate combining ability and genetic parameters in summer squash (*cucurbita pepo* L.). Eight inbred lines of summer squash were crossed in line x tester method in summer season 2020. The parental lines (3 tester and 5 lines) and their off springs (15 hybrids) were planted out in the summer season 2021 at vegetable field, Horticulture Department, College of Agricultural Engineering Science, Duhok University. The experiment lay out using randomized complete block design with three replications. The results indicated that the mean square for genotypes were highly significant effect for tester , line and line x tester in all studied traits. The Tester LBL2 and line PEP1670 were the best combiner for days to 50% female flowering, number of fruit plant^{-1} and yield kg plant^{-1}. The crosses (LBL2 X N33133) and (LES3 X CNS2881) exhibited significant positive effect of specific combining ability for fruit length cm, number of fruit plant^{-1} and yield plant^{-1}. The heritability in broad sense were higher than narrow sense heritability for all studied traits ranged between 93% for days to 50% female flowering to 40% for fruit weight. The average degree of dominance less than one in all traits except days to 50% female flowering and fruit length.

Keywords: Summer squash, line x tester , Combining ability, Genetic parameters.
***Part of Ph.D. dissertation for the 1st author**

قابلية الائتلاف والمعالم الوراثية للحاصل ومكوناته باستخدام طريقة الفاحص X السلالة في قرع الكوسا

زيان عسكر تيلي **محمد علي حسين**
الباحث **استاذ**
قسم البستنة **قسم المحاصيل الحقلية**
كلية علوم الهندسة الزراعية ، جامعة دهوك

المستخلص

يهدف البحث الى تقدير قابلية الائتلاف وبعض المعالم الوراثية في قرع الكوسا تضمن البحث التضريب بين ثمان سلالات من قرع الكوسا باستعمال طريقة الفاحص X السلالة في موسم 2020 اجريت تجربة المقارنة (3 فواحص ، 5 سلالات و 15 هجينا) في الموسم الصيفي 2021 في حقل الخضراوات قسم البستنة، كلية علوم الهندسة الزراعية جامعة دهوك. باستعمال تصميم القطاعات العشوائية الكاملة بثلاث مكررات. اشارت النتائج الى وجود تأثير الفاحص، السلالة، والفاحص X السلالة لكل الصفات المدروسة. الفاحص LBL2 والسلالة PEP1670 اعطت افضل مساهمة لعدد الايام 50 % تزهير انثوي وعدد الثمار في النبات والحاصل لكل نبات. كما اظهرت الهجن (LBL2 X N33133) و (LES3 X CNS2881) تأثير معنوي لقابلية الائتلاف الخاصة لطول الثمرة، عدد الثمار في النبات وحاصل النبات. وكانت نسبة التوريث بالمعنى الواسع اكبر من نسبة التوريث بالمعنى الضيق لجميع الصفات المدروسة وتراوحت القيمة بين 0.93 لعدد الايام 50 % تزهير انثوي 0.40 لوزن الثمرة . كان معدل درجة السيادة اكبر من الواحد لجميع الصفات المدروسة باستثناء عدد الايام 50 % تزهير انثوي وطول الثمرة.

الكلمات المفتاحية : قرع الكوسا، السلالة X السلالة، قابلية الائتلاف، المعالم الوراثية
***جزء من اطروحة الدكتوراه للباحث الاول.**

Received:17/11/2021 Accepted:13/3/2022

INTRODUCTION

Summer squash (*Cucurbita pepo* L.) is one of common necessary from the Cucurbit plants. This importance comes from utilizing it as a food for human, in addition to many medicinal uses (22). It is a cross pollinated plant and its diploid chromosome number (2n=40). The importance of summer squash fruits are contain some nutritional elements (P, Ca & Fe), and some vitamins with medium percentages (Vitamin-A, Vitamin-C, Riboflavin &Niacin) (3, 25). Many breeding systems have been widely used in breeding programs, the most important of which are full diallel, partial diallel, Line x tester crossing, during which inbred lines and cultivars are evaluated (23, 24, 32). Line x tester crossing method is consider as an expansion for the top cross that suggested by Davis, (13), who used only one line as tester whereas (19) used many testers. Also line x tester is considered one of the effective procedure for estimation the general and specific combining ability, hybrid vigor and gene action to select the inbred lines for the late generation (11, 19). The concept of general and specific combining ability was founded by (11). Narasannavar (28) evaluated fifteen traits using line x tester approaching, the maximum GCA effect was noticed in cross KRG-9 X ASJ (0.24) followed by KRG-10 X PN (0.22), KRC-6 X ASM (0.16), KRG-5 X ASM(0.15), KRG-3 X ASJ (0.14) for fruit plant^{-1}. Cross KRG-9 X ASJ showed significant effect for days to open first female flower. While Kumara (21) studied combining ability using six lines and four testers in a line x tester mating design. Out of ten parents Panurthy, Coimbatore Long, Chidambaram Small and VRBT-100 were observed to be the best general combiners as they have made significant contribution in yield contributing characters. The crosses (Coimbatore Long x Panurthy) exhibited high SCA effect for fruit yield per plant. Elsharkawy (14) reported when studied seven lines and three tester and matting exhibited two lines and two testers gave significant values of GCA effects on number of fruits plant^{-1} trait. Also, three lines showed significant or highly significant positive values of GCA effects on yield plant^{-1} Therefore, these lines considered good combiners for yield traits. In concern of SCA effects, three crosses out of twenty ones gave significant or highly significant positive values for total yield plant^{-1}. Hussien, (17) studied the nature of gene action in summer squash for some vegetative trait, plant height, flowering, date to open the first female flower, number of fruits per plant, fruit quality (fruit length, fruit diameter and average fruit weight) and yield per plant and also noticed the degree dominance was more than one for all studied traits, indicating over-dominance effect. broad sense heritability was highest for all studied traits, while the narrow sense heritability was 68% for plant height and ranged from 30 % to 43% for number of fruits per plant, yield per plant, early yield per plant and flowering date. Hassan (16) reported that the broad sense heritability ranged from 80.47 % to 90.36 % for plant length, 66.84 % for number of branches/plants. While, narrow sense heritability ranged from 39.77 % to77.39 % for plant length. Ahmed, (4) recorded in their study, the tester whitaker is a good combiner for yield and exhibited significant positive GCA, while eskandarany showed a significant negative GCA. The contribution of lines to total variance is 20.3%, 40.4% for testers, and 39.3% for Lx T. Nevertheless, the contribution to the total variance of lines, testers, and Lx T is 63.2%, 4.7%, and 32.1%; respectively. The objective of the study is to estimate the effect of general and specific combining ability, genetic parameters, contribution of testers, lines and line x testers for yield and its components in summer squash using line x tester mating design.

MATERIALS AND METHODS

This experiment was consisted of eight inbred lines obtained from different sources (Table 1) the experiment was carried out at the field of College of Agricultural Engineering Science, University of Duhok. The planting date was 18 /4 /2020 to produce fifteen cross (3 testers and 5 lines) according to line × tester mating design (19). The three lines, five testers and 15 line x tester were planted in 12/ 4/ 2021 at the same field, the experimental units layout in randomized complete block design with three replications, the experimental unit contained of one row of (4m) length, the distance between them (1m) and the distance within the plant (0.40m). The crop were fertilized with NPK

(20-20-20) 280 kg ha^{-1} in tow periods, the first after three weeks from planting and the second at the beginning of fruit setting (25) all the recommended agronomic package of practices and protection of plant measure were followed to obtain healthy plant. The data on the individual plants (five plants randomly selected from each experiment unit) were collected for the following studied traits; days to female flowering 50% , fruit length (cm) ,fruit diameter cm, number of fruits $plant^{-1}$, average fruit weight (g) and yiaeld $plant^{-1}$ (kg). Data of genotypes (line, tester and line x tester) were analyzed for each trait according to the experimental design method used (10), and the sum squares of genotypes was divided into the components according to line x tester method, and the following parameters were estimated:

1- **Analysis of variance**

Line X tester analysis

a- S.S. due to lines

SS lines = (∑Yi.. 2 /tr)-(∑Yij.) 2 /ltr

b- S.S. due to tester

SS testers=(∑Y.j. 2 /lr)-(∑Yij.) 2 /ltr

c- S.S. due to line x tester

SS lines x testers = SScrosses - SSlines – Sstesters

no. of crosses = Lxt = 5x3 =15

no. of parents = L+t = 5+3 = 8

no. of genotypes = no. of crosses + no. of parents = 10 + 15= 25

2- **Estimation of general and specific combining ability effects**

a- GCA for testers

b- GCA for lines

c- SCA for interaction (line x tester)

3- Estimation of component of variance and genetic interpretation. The Additive, Dominance and Environmental variances were estimated by using EMS from Griffing analysis. and their significance from zero were tested in the manner explained by Kempthorne, (19).

$\sigma^2 A = 2\sigma^2 g$

$\sigma^2 D = \sigma^2 s$

$\sigma^2 E = \sigma^2 e$

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

$\sigma^2 P = \sigma^2 G + \sigma^2 E$

where:

$\sigma^2 A$: additive genetic variance,

$\sigma^2 D$: non-additive (dominance and epistasis) genetic variance,

$\sigma^2 g$: the variance of general combining ability

$\sigma^2 s$: the variance of specific combining ability

σ^2 E: the variance of experimental error, i.e. environmental variance

$\sigma^2 G$: total genetic variance,

and $\sigma^2 P$: phenotypic variance (genetic and environmental variance).

4- Heritability

Heritability was calculated in broad sense ($H_{b.s}$) and narrow sense ($H_{n.s}$) concept and average Degree of Dominance for each character were calculated as follows:

$$H.b.s = \frac{\sigma^2 G}{\sigma^2 p} \times 100$$

$$H.n.s = \frac{\sigma^2 A}{\sigma^2 p} \times 100$$

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

where:

H b.s: heritability in broad sense,

H n.s: heritability in narrow sense,

If: ā = zero denote no dominance,

ā < 1 denote partial dominance

ā = 1 denote complete dominance,

ā > 1 denote over dominance

5- Expected genetic advance

EGA = (i)(h_{ns})(σP)

EGA% = (EGA/ȳ) x 100

Where

EGA: Expected genetic advanced

i: intensity of selection (which equals 1.76 when 10% of plants are selected

$h_{n.s}$: narrow sense heritability

σP: phenotypic deviation

6- Estimation of contribution for testers, lines and line x tester

a- Tester contribution = (Ms tester / Ms hybrids) x 100

b- lines contribution = (Ms lines / Ms hybrids) x 100

c- Interaction contribution = (Ms line x tester / Ms hybrids) x 100

Table 1. Genetic materials used in the experiment

Genotypes			Sources
Testers	1	LB 3	Ministry of Agriculture / Iraq / Directorate of Horticulture
	2	LBL2	Ministry of Agriculture / Egypt / Agriculture research center, Giza / Egypt
	3	LES3	Ministry of Agriculture / Egypt / Agriculture research center, Giza / Egypt
Lines	4	PEP15	University of Cairo / college of Agriculture / vegetable Department.
	5	PEP512	University of Cairo / college of Agriculture / vegetable Department.
	6	CNS2881	University of Cairo / college of Agriculture / vegetable Department.
	7	PEP1670	University of Cairo / college of Agriculture / vegetable Department.
	8	N33133	University of Cairo / college of Agriculture / vegetable Department.

RESULTS AND DISCUSSION

Table 2. Shows the analysis of variance for the studied traits. It is noted that the mean square of the genotypes was highly significant for all traits, indicating the presence of genetic divergence between the parents used in this study. When analyzed in to its components (all parents, crosses and parents vs crosses), it is noted that the mean square of parents and crosses were highly significant in all traits and in case of parent vs crosses it is only significant in yield kg plant^{-1}. Also the same Table it is revealed that the mean square for testers and lines were highly significant in all traits except fruit length in case testers, indicating the additive gene effect controlling these traits, also the mean square of line x tester interaction was highly significant in all traits except fruit weight, indicating that there is a dominant gene effect controlling their inheritance. Ratio of general combining ability to specific combining ability was more than one in all traits except days to 50% female flowering and fruit length this indicates that the additive gene effect were more important than dominant in controlling the inheritance of these traits. The current observations are in conformation with finding in summer squash (1, 14, 18, 27)

Table 2. Analysis variance for genotypes and combining ability for studied traits in summer squash.

Source of variation	d.f.	MS. Traits					
		Day to 50% female flowering	Fruit length (cm)	Fruit diameter(cm)	No. of fruits plant^{-1}	Fruit weight(g)	Yield kg plant^{-1}
Reps.	2	1.79	2.04	0.13	3.04	791.44	1.55
Genotypes	22	64.43**	27.36**	6.59**	97.79**	4414.02**	7.66**
Parents	7	58.92**	65.36**	15.94**	153.20**	10767.71**	6.76**
P. vs C.	1	65.77	57.20	8.11	140.79	8905.06	53.24**
Crosses	14	67.08**	6.23**	1.81**	67.01**	916.40*	4.85**
Tester	2	203.46**	2.48	1.35**	110.53**	1303.40*	4.74**
Line	4	54.74**	9.47**	4.67**	130.80**	1487.55**	11.47**
T x L	8	39.16**	5.55**	0.48**	24.23**	534.07	1.57**
Error	44	2.17	0.86	0.13	3.66	361.30	0.22
σ^2gca/σ^2sca		0.781	0.340	2.510	1.549	1.632	1.721

(**) and (*) Significant at 1% and 5% probability level respectively

For regarding to the mean of the parents (testers and lines) for the different traits was represented in Table 3. The results revealed that the tester 2 and line 6 and 7 were earliest in days to 50% female flowering 38, 43.33 and 43.33 respectively. For the fruit length the tester 1 and the line 6 recorded the highest value (17.82 cm) and (13.20 cm) respectively. The tester 2 and line 7 recorded the highest values (4.40 cm) and (9.84 cm) for fruit diameter. The tester 2 and line 6 obtained the highest values (40.66) and (37) for number of fruits plant $^{-1}$. Concering the fruit weight the highest values obtained by the tester 2 (237.08 g) and line 8 (362.66 g). For yield plant $^{-1}$ the highest mean produced by tester 2 (9.67 kg) and (10.94 kg) by line 6. (6, 9, 31, 35) obtained similar results in cucumber.

Table 3. Means of parents (Testers and lines) for studied traits in summer squash

Parents	Traits					
	Days to 50% female flowering	Fruit length (cm)	Fruit diameter (cm)	No. of fruits plant^{-1}	Fruit weight(g)	Yield kg plant^{-1}
			Testers			
1	43.33 fgh	17.82 a	3.56 m	34.88 cde	207.29 g	7.17 h
2	38 lm	16.72 ab	4.40 kl	40.66 a	237.08 g	9.67 de
3	42.66 f-i	16.32 abc	3.85 lm	34.22 def	234.04 g	8.01 g
			Lines			
4	47 ed	8.56 m	8.38 b	25.44 h	353.19 a	8.97 ef
5	52 ab	7.26 m	7.84 bc	21.55 i	311.06 bcd	6.70 h
6	43.33 fgh	13.20 g-j	5.90 e-h	37 bcd	288.07 c-f	10.94 bc
7	43.33 fgh	5.73 n	9.84 a	28.33 gh	227.98 g	6.74 h
8	49.66 bc	10.36 l	7.40 c	22.22 i	362.66 a	8.03 g

Values followed by the same letter for each trait are not significantly different

Data in Table 4. shows the estimation of general combining ability for all studied traits. From this Table can be notice that the parental tester 2 and line 7 exhibited the highest value (-4.13) and (-2.42) for the days to 50% female flowering indicating that contribution of these parents in decreasing the number of days to 50% female flowering. For fruit length and diameter the tester 1 and 3 recorded the highest values (0.42) and (0.29) respectively, while the maximum positive values (1.10) and (0.72) for line 8 and 5 were obtained for fruit length and fruit diameter respectively. The positive general combining ability effect for number of fruit plant^{-1} was recorded by tester 2 with (3.12), while for line 7 recorded (5.01). Regarding the general combining ability effect for fruit weight the tester 3 had the highest positive effect value (10.08), while the line 4 obtained (13.98). concering the yield plant^{-1} the tester 2 and line 7 produced the highest positive effect of GCA with value 0.61 and 1.68 respectively. From the results of parents (tester and lines), tester 2 and 7 had superior desirable significant effect for days to 50% female flowering, number of fruit plant^{-1} and yield kg plant $^{-1}$. From the results above we can say that this parents significantly contribute in increasing the yield of its hybrids. The results in this study are in agreement with the finding of (7, 8, 15, 16, 34) in summer squash.

Table 4. General combining ability effects of parents (testers and lines) for studied traits in summer squash

Parents	Traits					
	Days to 50% female flowering	Fruit length (cm)	Fruit diameter (cm)	No. of fruits plant^{-1}	Fruit weight(g)	Yield kg plant^{-1}
			Testers			
1	2.93	0.42	-0.30	-1.76	-1.78	-0.47
2	-4.13	-0.04	0.01	3.12	-8.30	0.61
3	1.20	-0.38	0.29	-1.36	10.08	-0.14
SE	0.38	0.23	0.09	0.49	4.90	0.12
Lines						
4	1.24	-0.86	0.45	-3.50	13.98	-0.65
5	-1.53	-1.16	0.72	-0.20	8.81	0.25
6	-0.97	0.93	-0.68	2.49	-18.20	0.05
7	-2.42	-0.01	0.36	5.01	2.49	1.68
8	3.68	1.10	-0.88	-3.80	-7.09	-1.33
SE	0.49	0.30	0.12	0.63	6.33	0.15

The mean performance of the crosses for different traits were shows in Table 5. The differences between the parents reflected significantly on the crosses, the cross 2x4 was

the earliest for days to 50% female flowering with value with value 37.33 days. The cause of earliness or lateness is due to the parents which involved in the cross. For the fruit length and fruit diameter the crosses 3x6 and 3x5 the highest means values more than other crosses were 16.13 cm and 6.71 cm respectively. In the same Table the cross 2x7 produced the largest number 40.77 of fruits plant^{-1} followed by the cross 3x7 which had 40.44. The highest value (337.51) g of fruit weight produced by the cross 3x4. For the yield kg plant^{-1} the crosses 2x7 and 3x7 recorded the highest mean values 12.04 kg and 12.49 kg. It is clear through Duncan's multiple range test that the differences between the crosses, these differences may be due to the genetic background of the parents used in this study. It is noted that the most of the crosses with disred significant effect for a specific trait, was at least one of their patents gave a desirable significant GCA effect for that traits. Present results are corroboration with finding of (5, 20, 31) in cucumber.

Table 5. Means of crosses for studied traits in summer squash

Hybrids	Traits					
	Days to 50% flowering	Fruit length (cm)	Fruit diameter (cm)	No. of fruits plant^{-1}	Fruit weight(g)	Yield kg plant^{-1}
1x4	45 ef	14.07 e-I	6.02 d-g	32.22 ef	309.91 b-e	9.97 d
1x5	45.33 ef	12.73 h-k	5.89 e-h	31.22 fg	313.97 bcd	9.80 ed
1x6	44.33 fg	15.04 b-f	5.41 g-j	32.44 ef	296.07 c-f	9.60 ed
1x7	41.66 g-k	14.90 c-g	5.48 ghi	34.44 def	307.56 b-f	10.88 bc
1x8	52.66 a	14.93 c-g	4.10 lm	28.55 gh	271.19 f	7.97 g
2x4	37.33 m	12.67 h-k	5.85 fgh	32.00 ef	299.11 c-f	9.71 de
2x5	38.33 lm	12.12 jk	6.63 d	37.77 a-d	297.57 c-f	11.22 b
2x6	39.33 j-m	13.37 f-j	4.75 jk	38.22 abc	273.16 ef	10.44 bcd
2x7	40.66 h-l	15.30 b-e	6.28 def	40.77 a	295.38 c-f	12.04 a
2x8	38 lm	15.86 bcd	5.00 ijk	34.55 def	300.90 c-f	10.31 cd
3x4	50 bc	12.40 ijk	6.57 de	25.88 h	337.51 ab	8.71 fg
3x5	40.33 i-l	13.38 f-j	6.71 d	31.00 fg	319.48 bc	10.11 cd
3x6	42 g-j	16.13 bc	4.93 ijk	37.44 a-d	280.74 def	10.50 bcd
3x7	39 klm	11.46 kl	6.38 def	40.44 ab	309.11 b-e	12.49 a
3x8	49 cd	14.26 f-h	5.32 hij	26.11 h	311.20 bcd	8.09 g
X	42.86	13.91	5.69	33.54	301.52	9.48
C.V.%	3.10	7.37	6.58	6.29	6.24	4.95

Values followed by the same letter for each trait are not significantly different

The data in Table 6. revealed the estimation of SCA effect for studied traits in crosses. For the days to 50 % female flowering, the shortest period (-4.42) was noticed in the cross 2x8 followed by the crosses 2x4 and 3x7 with value (-2.64). Value of the estimated SCA effect of crosses for the fruit length indicated that the SCA effect for this trait (1.66) , while the maximum positive value (1.45) noticed by the cross 2x7 . The data in the same Table reveals that the highest SCA effect (0.88) for fruit diameter produced by the cross 3x8. For the number of fruit plant^{-1} 5 crosses out of 15 crosses obtained positive significant effect of SCA ranged between 3.94 and 1.31 for the cross 1x4 and 2x5 respectively. Regarding fruit weight of the crosses 2x8, 1x6 and 3x4 recorded significant positive effect for SCA and the value were 14.77, 14.52 and 11.91 respectively. Four crosses exhibited significant positive effect of SCA for yield kg plant^{-1} ranged between 0.98 and 0.46 for the crosses 1x4 and 3x4. From the results in Table 6 shows that the crosses 2X8 and 3x6 had significant desirable effect of SCA of all traits except fruit diameter in 2x8 and fruit weight in cross 3x6. The results are agreement with (1, 2, 12) in summer squash.

Table 6. Specific combining ability effects of crosses for studied traits in summer squash

Crosses	Traits					
	Days to 50% flowering	Fruit length (cm)	Fruit diameter (cm)	No. of fruits plant^{-1}	Fruit weight (g)	Yield kg plant^{-1}
1x4	-2.04	0.59	0.18	3.94	-3.81	0.98
1x5	1.06	-0.44	-0.21	-0.34	5.41	-0.09
1x6	-0.46	-0.23	0.68	-1.82	14.52	-0.09
1x7	-1.71	0.58	-0.25	-2.34	5.32	-0.44
1x8	3.17	-0.51	-0.39	0.57	-21.45	-0.34
2x4	-2.64	-0.33	-0.31	-1.16	-8.09	-0.37
2x5	1.13	-0.57	0.20	1.31	-4.47	0.22
2x6	1.57	-1.43	-0.29	-0.94	-1.86	-0.36
2x7	4.35	1.45	0.21	-0.90	-0.33	-0.38
2x8	-4.42	0.88	0.17	1.68	14.77	0.90
3x4	4.68	-0.26	0.79	-2.78	11.91	-0.61
3x5	-2.20	1.01	0.67	-0.97	-0.94	-0.12
3x6	-1.08	1.66	0.27	2.77	-12.66	0.46
3x7	-2.64	-2.04	0.70	3.25	-4.99	0.83
3x8	1.24	-0.37	0.88	-2.26	6.68	-0.55
SE	0.85	0.53	0.21	1.10	10.97	0.27

Table 7. Shows the estimation of genetic parameters for the different traits. and it is clear that the additive and non additive variances were significant from zero for all traits, indicating their importance in controlling the inheritance of the traits. It is noted that the values of additive variance greater than of dominant variance for all traits except fruit length, indicating that the additive genetic effects, and also the phenotypic variance were greater than the genotypic variance in all studied traits, this caused to increase the values of heritability in broad sense compared with the heritability in narrow sense in all traits .The heritability in broad sense was higher for all the traits except fruit weight ranged between 0.93 for days to 50% female flowering to 0.40 for fruit weight. Narrow sense heritability ranged between 0.60 for yield kg plant^{-1} to 0.30 for fruit length. Traits exhibited highest heritability in broad sense reflect the dominance genetic variance method , this means the hybridization method is important to improve these traits. The average degree of dominance is less than one for all traits except the days to 50% female flowering and fruit length, indicating the presence of partial dominance for all traits and over dominance for days to 50% female flowering and fruit length. Finally, it is noticed that the expected genetic improvement as a percent was moderate for all traits except fruit length and fruit weight ranged between 20.417% for number of fruit plant^{-1} and 13.386% for days to 50% female flowering and low for fruit length and fruit weight were 7.575% and 4.579% respectively. The results in this study agree with those of (2, 12, 15) in summer squash.

Table 7. Variance components and genetic parameters for studied traits in summer squash

Parameters	Traits					
	Days to 50% female flowering	Fruit length (cm)	Fruit diameter (cm)	No. of fruits plant^{-1}	Fruit weight(g)	Yield kg plant^{-1}
σ^2A	19.260 ± 14.445	1.065 ± 0.876	0.586 ± 0.434	21.251 ± 13.969	187.946 ± 161.101	1.552 ± 0.523
σ^2D	12.328 ± 5.839	1.564 ± 0.829	0.117 ± 0.074	6.856 ± 3.622	57.589 ± 83.481	0.450 ± 0.235
σ^2E	2.176 ± 0.454	0.861 ± 0.179	0.139 ± 0.029	3.669 ± 0.765	361.302 ± 75.337	0.220 ± 0.046
σ^2G	31.589	2.629	0.702	28.107	245.536	2.004
σ^2P	33.765	3.489	0.842	31.777	606.838	2.224
$H._{BS}$	0.935	0.753	0.834	0.884	0.404	0.900
$H._{NS}$	0.570	0.305	0.695	0.668	0.309	0.698
$\overline{a}$	1.131	1.713	0.631	0.803	0.782	0.761
Mean	43.579	13.247	5.942	32.497	293.228	9.486
GA	5.839	1.003	1.123	6.635	13.428	1.832
GA%	13.386	7.575	18.901	20.417	4.579	19.319

Proportional contribution of testers, lines and their interaction are shows in Table 8. The total variance for the six traits under study shows predominant role of lines in four traits, fruit diameter 73.83%, yield kg plant $^{-1}$ 67.52%, number of fruit plant^{-1} 55.76% and fruit weight 46.37% followed by tester for days to 50% female flowering 43.32% and line x tester interaction for fruit length 50.89%, the higher contribution of lines than the tester and line x tester interaction indicate its great role in variability for the crosses. The same results obtained by (9, 29, 30) in cucumber.

Table 8. Contribution as % of testers, lines and line x tester for studied traits in summer squash

No.	traits	Testers%	Lines%	Line x tester%
1	Days to 50% female flowering	43.32	23.31	33.35
2	Fruit length (cm)	5.68	43.41	50.89
3	Fruit diameter (cm)	10.69	73.83	15.43
4	No. of fruits plant^{-1}	23.56	55.76	20.66
5	Fruit weight(g)	20.31	46.37	33.30
6	Yield kg plant^{-1}	13.94	67.52	18.50

REFERENCES

1. Abd El-Hadi, A. H.; S. M Farid. and E. H. El-Khatib, 2013. Combining ability and genetic variance components of a diallel cross among some squash varieties. J.Agric.Chem. And Biotechn., Mansoura Univ. 4 (3): 119 – 131.
2. Abdein, M. Abd. El. ; H. M. F. Hassan and H. M Dalia., 2017. General performance, combining abilities and heritability of yield and yield component traits in pumpkin (*Cucurbita moschata* Poir.) at different conditions. KMITL Sci. Tech. J. ,17 (1): 121-129.
3. Abdil-All, Z.A.; A. Khalaf Allah and M.A. Abdulgadir. 1975. Vegetable first part production. Al-Jedeeda press. Alexandria, Egypt (In Arabic).
4. Ahmed, E. A. HS Ibn Oaf, and AE El Jack., 2003. Combining ability and heterosis in line x tester crosses of summer squash (*Cucurbita pepo* L.). Cucurbit Genetics Cooperative Report 26:54-56
5. Al-Araby, A.A. 2010. Estimation of Heterosis, Combining Ability and Heritability in Inter Varietals Crosses of Summer Squash (*Cucurbita pepo* L.) M. Sc. Thesis, Fac. Agric., Tanta Univ., Egypt. pp. 82
6. Al-asadi R. A. A. and K. D. Al-jebory. 2021. Development of single cross hybrid from (*Momordica charantia)* by full diallel crosses Iraqi Journal of Agricultural Sciences –2021:52(1):88-96. https://doi.org/10.36103/ijas.v52i1.1239
7. Al-Ballat, I. A., 2008. "Breeding Studies on Summer Squash Crop *(Cucurbita pepo, L.)"*. M.Sc. Thesis, Fac. of Agric., Tanta. Univ. pp. 87
8. AL-Jebory, K. D. H. 2006. Genetic analysis for several summer squash *(Cucurbita pepo* L.*)* characters by line x tester analysis. Iraqi Journal of Agricultural Sciences 37 (3):59 -66
9. AL-Jebory, K. D. H. and M. A. B. Almashhadani, 2018. Hybrid vigor of cucumber hybrids development locally which suitable for open field cultivation. Iraqi Journal of Agricultural Sciences, 49(3):777-787. https://doi.org/10.36103/ijas.v49i3.108
10. Al-Zubaidy, K. M. D. and M. A. H. Al-Falahy 2016. Principle and Procedures of Statistics and Experimental Design. Duhok University Press, Iraq. pp. 159
11. Ceranka, C. O. and R. F., Mumm, 1998. Heterosis among populations of maize *(Zea mays L.)* with differentlevels of exotic germplasm. Theor. Appl. Genet., 73 : 445-450
12. Chaudhari, D.J.; R.R Acharya; J.N. Patel; SB Gohil and K.C Bhalala, 2017. Variability, correlation, and path analysis in Pumpkin (*Cucurbita moschata* Duch. ex. Poir.). J. Pharmacognosy and Phytochemistry, 6(6): 142-145

13. Davis, R.L. 1927: Report of the plant breeder. Rep. Puerto Rico. Agric. Exp. Sta. P: 14-15
14. Elsharkawy, S.E.M.; L.A.A. Badr,; A.S. Shams and E.M. Khalil, 2018. Heterosis and Combining Ability Studies for Fruits Yield and Quality Characters in Squash (*Cucurbita pepo* L.). Annals of Agric. Sci., Moshtohor, 56(3): 731 – 740
15. El-Shoura, A.M., and M. Y. Abed, 2018. "Heterosis and combining ability for development of squash hybrids *(Cucurbita pepo L.)".* J. Plant Production, Mansoura Univ., 9 (12): 1181 – 1187
16. Hassan, A. A.; K. E. A. Abdel-Ati and M. I. A. Mohamed 2016. Inheritance of some important characters in summer squash *(Cucurbita pepo, L.).* Curr. Sci. Int., 5(2): 165-174
17. Hussien, A.H. and A. A. Hamed 2015. Diallel analysis for studying heterosis and combinig ability of some economical yield triats in pumpkin. J. Plant Production, Mansoura Univ, Egypt, 6 (3): 261 -270
18. Kamal B. E. and E. Al- H. Jasim, 2020. Study the line x tester hybridization, [I] flowering and yield in squash (*Cucurbita pepo* L.) International Journal of Agriculture and Environmental Science Volume 7 Issue 6, 18-25
19. Kempthorne, O. 1957. An Introduction to Genetic Statistics. John Wiley and Sons Inc., Landon, New York
20. Kumar, S., R. Kumar, D. Kumar, N. Gautam, N. Singh, C. Parkash, M. R. Dhiman and Y. R. Shukla 2017. Heterotic potential, potence ratio, combining ability and 1193 genetic control of yield and its contributing traits in cucumber (*Cucumis sativus* L.). New Zealand J. Crop and Horticultural Science. 45 (3):175–190
21. Kumara, B.S.; T.B Puttaraju,.; H. Shivan,; K. Prakash,; K. Jainag, and N.K. Sudheesh, 2011. Combining ability studies in bitter gourd (*Momordica charantia* L.) for quantitative characters.Asian J. Horti., 6(1): 135-140
22. Lama, D. I. and S. I. Neamah. 2023. Metabolic responses to *in vitro* in drought-tolerant in a *Cucurbita pepo* L. elicited by salicylic acid and zinc oxide nanoparticles. Iraqi Journal of Agricultural Sciences –2023:54(5):1223-1233. https://doi.org/10.36103/ijas.v54i5.1817
23. Lawand, F. M, S. I. Towfiq, and D. A. Abdulkhaleq. 2022. Gene action of some agronomic traits in maize by half diallel cross at two locations in sulaimani -Iraq Iraqi Journal of Agricultural Sciences, 53(2):329-340. https://doi.org/10.36103/ijas.v53i2.1540
24. Masood, S. M. and S. I. Towfiq. 2022. Combining ability and gene action for some maize inbred lines using half diallel crossing at two locations during two seasons. Iraqi Journal of Agricultural Sciences, 53(5):1223-1234. https://doi.org/10.36103/ijas.v53i5.1636
25. Matlob, A.N.; E. Sultan and K.S. Abdul. 1989. Vegetable Production.Part one and two. Dar Al-Kutub Publication, Mosul Univ., Iraq. (In Arabic).
26. Moradipour, F., J. A. Olfati, Y. Hamidoghli, A. Sabouri and B. Zahedi 2016. General and specific combining ability and heterosis for yield in cucumber fresh market lines. Int. J. of Veg. Sci. 23: 285–293
27. Moualla M. Y; M. G. Boras and A. K. Marie , 2011. "Studying the genetic behavior of squash yield and its components *Cucurbita pepo, L*". Tishreen University Journal for Research and Scientific Studies - Biological Sciences Series, 33 (1): 110-125.
28. Narasannavar, G., V.D, S.S Malghan, and B.R Kumara , 2014. .Gene action and Combining ablity analysis for yield and yield related traits in ridge gourd *(Luffa acutangula* (L.) Roxb.) Global Journal of Science Frontier Research:D Agriculture and Veterinary 14 :110 -112
29.Rajaguru K., T. Arumugam, D. Sassi kumar, S. Jeeva, R. Baskaran5 and A. Baskaran, 2019. Heterosis and gene action for yield and quality traits in cucumber *(Cucumis sativus L.)* International Journal of Current Microbiology and Applied Sciences. 8(10): 1618-1625
30. Sharma M. 2010. Gene Action and Heterosis Studies Involving Gynoecious lines in in Cucumber (*Cucumis sativus* L.). Ph.D. Dissertation, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur (HP).192p
31. Sharma, S., R. Kumar and H. R. Sharma 2017. Studies on variability, heritability and

genetic gain in cucumber (*Cucumis sativus* L.). Indian Journal of Ecology. 44(6):829-833

32. sheikh Abdulla, S. M., D. A. Abdulkhaliq, and Sh. I. Towfiq. 2022. Partial diallel analysis of maize inbrid lines for kernal yield and its components in Sulaimani- Iraq. Iraqi Journal of Agricultural Sciences, 53(5):1190-1202. https://doi.org/10.36103/ijas.v53i5.1633

33. Sprague, G. F.; Tatum, L. A. 1942: General Vs Specific Combining Ability in Single Crosses of Corn.]. Amer. Soc. Agron. 34: 923-32

34. Tak S.; R. A. Kaushik; K. D. Ameta; R. B. Dubey; RS Rathore and A. Nath, 2017. Combining ability studies on cucumber and snap melon hybrids. Int .J. Curr.Microbiol.App. Sci. , 6(6): 942-949.

35. Thakur, M., R. Kumar and S. Kumar. 2017. Estimation of heterosis for earliness and yield contributing traits in cucumber (*Cucumis sativus* L.). International Quarterly Journal of Life Sciences.12(2):1189-1194.