GENE ACTION AND HETEROSIS FOR YIELD AND YIELD COMPONENTS IN SUMMER SQUASH (*cucurbita pepo* L.) USING HALF DIALLEL CROSSES.

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ABSTRACT

This study was aimed to determine some genetic parameters of summer squash (*cucurbita pepo* L.), half diallel cross among eight inbred lines carried out in summer season 2021 at field of College of Agricultural Engineering Sciences, University of Duhok. The experiment lay out using randomized complete block design with three replications. The results revealed that the mean square for all genotypes was highly significant effect in all studied traits. The inbred lines LBL2 and CNS2881 was superior in yield plant^{-1} obtained 9.67 kg and 10.94 kg, the crosses (CNS2881 x PEP1670) and (PEP1670 x N33133) recorded the highest value 13.83 and 13.53 respectively. The crosses (PEP512 x, CNS2881), (CNS2881 x PEP1670) and (PEP1670 x N33133) revealed significant heterosis for most traits. The heritability in broad sense was higher than narrow sense heritability in all traits ranged between 0.949 and 0.827 for fruit diameter and fruit weight. The average degree of dominance was higher than one in all traits except fruit length and fruit diameter.

Keywords: Summer squash, Diallel cross, Heterosis, Gene action.

***Part of Ph.D. dissertation for the 1st stauthor**

الفعل الجيني وقوة الهجين لصفة الحاصل ومكوناته في قرع الكوسا باستعمال التهجين التبادلي النصفي

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المستخلص

يهدف البحث الى تقدير بعض المعالم الوراثية لقرع الكوسا (*cucurbita pepo* L.) تحليل نصف التبادلي لثمانية سلالات من قرع الكوسا زرعت في الموسم 2021 في حقل كلية علم الهندسة الزراعية جامعة دهوك. نفذت تجربة المقارنة باستعمال تصميم العشوائي الكامل بثلاث مكررات. كان تأثير التراكيب الوراثية عالي المعنوية لكل الصفات. اظهرت السلالات LBL2 و CNS2881 تفوقا معنويا ملحوظا في صفة الحاصل بلغت 9.67 كغم و 10.94 كغم، بينما اظهر الهجن (6X7) و (7X8) قيم عالية لصفة الحاصل بلغت 13.83كغم و 13.53 كغم بالتناوب. بينما اظهرت الهجن ,(PEP512 x, CNS2881) (CNS2881 x PEP1670) (PEP1670 x N33133) قوة هجين معنوية لأغلب الصفات. وكان التوريث بالمعنى الواسع اكبر من قيمة التوريث بالمعنى الضيق لكل الصفات وتراوحت القيمة بين 0.95 و 0.82 لقطر الثمرة ووزن الثمرة. كان معدل درجة السيادة كان اكبر من الواحد لكل الصفات المدروسة باستثناء صفتي طول الثمرة وقطر الثمرة.

الكلمات المفتاحية: قرع الكوسا، التهجين التبادلي، قوة الهجين، الفعل الجيني.

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INTRODUCTION

Summer squash (*cucurbita pepo* L.) is one of species under genus Cucurbita in the gourd family Cucurbitaceae. The cucurbita genus native to and originally cultivated in the Mesoamerica and Andes (6). Summer squash (*cucurbita pepo L.*) is one of most important source of nutritional content and essential minerals which consumed by human for a healthy and active life. Fruits and fruit pulp have high content of crude fibers and moisture; also the fresh fruits had high content B- carotene, high content of potassium, magnesium, phosphorus, sodium, manganese and calcium. (20). Heterosis, gene action and heritability enable the plant breeder to selection any crop breeding program, therefore, over two past decades, several researches studied different diallel crosses design in many vegetable crops such as summer squash. Plant breeder can be obtained good information about genetic variation in a population from using diallel cross among selected parents. The half diallel crosses were the most commonly method for estimation the abilities and it has been often conduct in genetic research to estimate the inheritance of yield and yield components and more important characters with in asset of genotypes (5, 17), also the objective of the half diallel study the genetic in parameters like heterosis, heritability and gene action to recognize and choose the best parents and crosses in breeding programs. Curtis, (9) and Curtis, (8) study the early heterosis in summer squash for the number of fruit per plant and earliness of fruit harvest, the value of the heterosis range 114% over mid parentals mean and 87% over best parents mean. Hussien, (17) studied the heterosis and indicated that in summer squash maximum significant true heterosis with high parent (179.9 %) for early yield, total yield (106.9 %), fruits number /plant (57.0%), average fruit weight (32.5%) and plant height (40.9 %). Abd EL-Hadi *et al.* (1) estimated heterosis in summer squash and reported, that the maximum significant desirable heterosis values over mid-parent were (-17.19, 61.36, 44.14, -5.46, 17.26, 308.83, 296.41, -23.58, and -12.79%) for stem length, number of branches plant^{-1}, leaves plant^{-1}, days to opening the first female flower, average fruit weight, number of fruit plant^{-1}, yield plant^{-1}, fruit length and diameter, respectively, while the heterosis over best parent were reached (-18.18, 32.47, 37.66, -6.97, 14.77, 205.54, 204.98, -32.63, -14.48%) for the same traits respectively. The nature and magnitude of gene action is an important factor in developing an effective breeding program. The genetic improvement of various traits depends on the nature and magnitude of genetic variability, in addition to hybridization which offers new combination likewise variance of general and specific combining ability are included to the type of gene action involved. Variance for gca includes additive portion, while that of sca includes non additive portion of total variance arising largely from dominance and epistatic deviation. Hussein, (17) studied the nature of gene action in summer squash for some vegetative trait plant height, flowering, date to first female flower anthesis and number of fruits per plant, fruit quality(fruit length, fruit diameter and average fruit weight) and yield traits (early and total yield per plant). Degree dominance was more than one for all studied traits, indicating the presence of over-dominance. broad sense heritability was high 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, total yield per plant, early yield per plant and flowering date. Narrow sense heritability was low and valued 13% for fruit length, 21% for fruit diameter and 27% average for fruit weight. Hassan *et al*., (15) studied summer squash and found that the broad sense heritability were ranged from 80.47% to 90.36% for plant height, 66.84% for number of branches per plants. While, narrow sense heritability ranged from 39.77% to 77.39% for plant height. The objective of this study to determine the nature of the gene action, heritability and the heterosis (calculated as deviation of the hybrid from mid parents, best parents and check variety) for the yield and some important traits in summer squash, using half diallel cross.

MATERIALS AND METHODS

This study was consisted of eight inbred lines obtained from different sources Table 1, and carried out at the field of College of Agricultural Engineering Science, University of Duhok. The planting date was 18 /4 /2020 to cross between eight inbred line according to half diallel crosses second model proposed by Griffing (14) to produce 28 F1 hybrids. The eight inbred lines and their hybrids with local variety were compared using randomized complete block design with three replications. The genetic materials were planted in 12/ 4/ 2021 at the same field. The experimental unit were consisted of one row of (4m) length, the distance with the row (1m) and the distance between plant to plant (0.40m). The crop were fertilized with NPK (20-20-20) 280 kg ha^{-1} in two times, the first after three weeks from planting and the second at the beginning of fruit setting (21), all the recommended agronomic package of practices and protection of plant measure were followed to obtain good health crop. 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, fruit weight (g) and yield per plant (kg). The data were analyzed for each trait by analysis of variance according to the experimental design (4), and parameters were estimated as follows:

1- Heterosis:

Heterosis was determined for various characters for each hybrid from the replicates mean related to the differences of F1 hybrids generation from the mid parent value, better parent and local variety and the equation to estimate each heterosis as follows:

1- $(H) = \overline{F}1 - \frac{\overline{p}1 + \overline{p}2}{2}$

$2-(H) = \frac{F1 - BP}{BP}$

$3-(H) = \frac{F1 - CC}{CC}$

Where:
F’1: mean of hybrid,
P1: parent one,
P2: parent two,
BP: better parent, and
CC: local variety.

The significance of heterosis was tested from calculation of **t** value for each hybrid according to the following equation:

Where the heterosis variance V (H) will be

$$V(H) = V(\overline{F}1) + (1/4)(V(\overline{pi}) + V(\overline{pj}))$$
$$V(H) = \sigma^2 e + (1/4)(\sigma^2 e + \sigma^2 e)$$
$$V(H) = (3/2)(Mse/r)$$

2- **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 (19).

$\sigma^2 A = 2\sigma^2 g$
$\sigma^2 D = \sigma^2 s$
$\sigma^2 E = \sigma^2 e$
$\sigma^2 G = \sigma^2 A + \sigma^2 D$
$\sigma^2 P = \sigma^2 G + \sigma^2 E$
$\sigma^2 P = \sigma^2 A + \sigma^2 D + \sigma^2 E$

where:
$\sigma^2 A$: Additive genetic variance,
$\sigma^2 D$: Non-additive (dominance and epistasis) genetic variance,
$\sigma^2 g$: Variance of general combining ability,
$\sigma^2 s$: Variance of specific combining ability
$\sigma^2 E$: Variance of experimental error, i.e. environmental variance
$\sigma^2 G$: Total genetic variance,
and $\sigma^2 P$: Phenotypic variance (genetic and environmental variance).

3- Heritability:

Heritability was calculated in broad sense (H^2) and narrow sense (h^2) concept and average Degree of Dominance for each characteristic 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: $\bar{a}$ = zero denote no dominance,
$\bar{a} < 1$ denote partial dominance
$\bar{a} = 1$ denote complete dominance,
$\bar{a} > 1$ denote over dominance

4- **Expected genetic advanced**

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

Table 1. Genetic materials used in the experiment

Genotypes		Sources
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
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. show the analysis of variance for genotypes (parents and hybrids), GCA and SCA for six studied traits, it is noted that the genotypes were highly significant effected on studied traits. The highly significant differences of genotypes, indicating that there is a genetic divergence between parental lines used in this study, which caused a greater divergence between the resulting hybrids, therefore in all the traits had significant differences among the genotype. The highest significant of the mean square of both general and specific combining ability indicating that there was enough variation for successful in selection of the desirable cross combination, and the ratio of the GCA/SCA is less than one for all the traits except fruit length and diameter, indicating that the dominant gene action were more important than the additive in controlling the inheritance of the traits except fruit length and diameter. The current observations are in conformation with finding of (1, 11,12, 24) in summer squash.

Table 2. Analysis of variance of summer squash genotypes for yield and yield components

Source of variation	d.f.	Mean Square Traits: Day to 50% female flowering	Fruit length (cm)	Fruit diameter (cm)	No. of fruits/ plant	Fruit weight (g)	yield plant^{-1}(kg)
Rep.	2	3.58	2.78	0.17	1.18	522.06	0.59
Genotypes	35	63.79**	34.71**	8.46**	93.68**	4519.59**	9.37**
GCA	7	159.84**	157.12**	38.95**	281.85**	14975.67**	15.26**
SCA	28	39.77**	4.11**	0.84**	46.64**	1905.57**	7.89**
Error	70	2.35	0.71	0.14	3.34	313.61	0.31
$\frac{\phi^2 g.c.a}{\phi^2 s.c.a}$		0.420	4.603	5.594	0.643	0.921	0.197

(**) Significant at 1% probability level

The data regarding to the mean of parental lines for different traits were show in Table 3a. The results revealed the days to 50% female flowering, the parent 2 was early in days to 50% female flowering and maturity and the value was 38 days compare with other parents, following by parent 8 which gave late maturity and value was 49.66 days. For the fruit length the parental 1 recorded the highest values 17.82 cm followed by parent 7 which had the lowest value 5.73 cm. The highest value of fruit diameter had given by the parent 7 was 9.84 cm followed by parent 4 which had 8.38 cm. The parents 2 and 8 gives the highest values more than other parents for the number of fruits plant^{-1} and fruit weight 40.66 gm and 362.66gm respectively. Yield per plant the highest value obtained by the parent 6 (10.94kg) followed by parent 2 which gave 9.67kg. The differences between the means of the highest and lowest parents indicated that the presence of genetic differences between the parental lines. The results in the same Table indicated that the coefficient variability was highest for the length and diameter traits which gave the values 104.54 and 97.66 respectively, and also it is clear from the same table that the lines have differed in the components of the yield, so it is not possible to be relied up on to explain the increase in the yield of one components and leave other components. Table 3b. show the means performance of single crosses for the studied traits, it is noticed that the hybrids 2x4, 6x7 and local variety which showed the most early hybrids in flowering date 37.33 days followed by the hybrid 1x8 which gave late maturity value 52.66 days. In fruit length the highest mean produced by hybrid 1x3 (20.02 cm) followed by hybrid 1x2 which gave 17.57 cm. The hybrid 6x7 had the larger value for number of fruit per plant 43.33 followed by the hybrid 2x7 which recorded 40.77. For the fruit diameter, fruit weight and yield per plant traits the hybrid 7x8 recorded the highest values 9.14cm, 352.01gm and 13.53kg plant^{-1} respectively. It is clear through Duncan's multiple range test that the differences between the hybrids, these differences can be due to the genetic background of the parents used in this study. The present results were in congruence with the reports of (13, 2, 1, 22, 23).

Table 3a. Means of parents for studied traits in summer squash

Genotypes (parents)	Traits Day to 50% female flowering	Fruit length (cm)	Fruit diameter (cm)	No. of fruits/ plant	Fruit weight(g)	yield kg plant^{-1}
1	43.33 ijk	17.82 b	3.56 p	34.88 f-i	207.29 m	7.17 mn
2	38 op	16.72 b-e	4.40 l-o	40.66 ab	237.08 ml	9.67 f-i
3	42.66 i-l	16.32 b-f	3.85 op	34.22 hij	234.04 ml	8.01 klm
4	47 e-g	8.56 no	8.38 cd	25.44 l	353.19 a	8.97 h-k
5	52 ab	7.26 o	7.84 de	21.55 m	311.06 c-h	6.70 n
6	43.33 ijk	13.20 ij	5.90 ghi	37 c-h	288.07 g-j	10.94 de
7	43.33 ijk	5.73 p	9.84 a	28.33 kl	227.98 ml	6.74 n
8	49.66 bcd	10.36 lm	7.40 e	22.22 m	362.66 a	8.03 klm
X	44.91	11.99	6.39	30.53	277.67	8.27
C.V.%	28.15	104.54	97.66	54.99	44.07	47.24

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

Table 3b. Means hybrids for studied traits in summer squash

Genotypes (hybrids)	Traits Day to 50% female flowering	Fruit length (cm	Fruit diameter (cm)	No. of fruits/ plant	Fruit weight (g)	yield kg plant^{-1}
1x2	48 c-f	17.57 bc	3.77 op	32 ij	247.60 kl	7.89 lm
1x3	45 ghi	20.02 a	4 op	38.88 b-e	242.21 kl	9.42 g-j
1x4	45 ghi	14.07 ghi	6.02 f-i	32.22 ij	309.91 c-h	9.97 e-h
1x5	45.33 f-i	12.73 ijk	5.89 ghi	31.22 jk	313.97 c-h	9.80 fgh
1x6	44.33 g-j	15.04 fg	5.41ijk	32.44 ij	296.07 f-i	9.60 f-i
1x7	41.66 j-n	14.90 fgh	5.48 ij	34.44 g-j	307.56 c-h	10.88 de
1x8	52.66 a	14.93 fgh	4.10 nop	28.55 kl	271.19 ijk	7.97 klm
2x3	38.33 op	17.04 bcd	4.30 mno	38.88 b-e	259.64 jkl	10.08 efg
2x4	37.33 p	12.67 ijk	5.85 hi	32 ij	299.11 e-i	9.71 f-i
2x5	38.33 op	12.12 jk	6.63 f	37.77 b-g	297.57 e-i	11.22 cd
2x6	39.33 m-p	13.37 hij	4.75 k-n	38.22 b-f	273.16 ijk	10.44 d-g
2x7	40.66 k-o	15.30 efg	6.28 fgh	40.77 ab	295.38 i-f	12.04 bc
2x8	38 op	15.86 def	5 jkl	34.55 g-j	300.90 d-i	10.31 d-g
3x4	50 abc	12.40 jk	6.57 fgh	25.88 l	337.51 abc	8.71 i-l
3x5	40.33 l-o	13.38 ijk	6.71 f	31 jk	319.48 b-g	10.11 efg
3x6	42 j-m	16.13 c-f	4.93 j-m	37.44 b-h	280.74 hij	10.50 def
3x7	39 nop	11.46 kl	6.38 fgh	40.44 abc	309.11 c-h	12.49 b
3x8	49 cde	14.26 ghi	5.32 ijk	26.11 l	311.20 c-h	8.09 klm
4x5	50.33 abc	9.24 mn	7.84 de	27 l	314.63 c-h	8.49 jkl
4x6	44 hij	10.03 lmn	7.54 e	34 hij	308.75 c-h	10.50 def
4x7	41.66 j-n	9.06 mn	8.96 bc	40 bcd	309.86 c-h	12.39 b
4x8	46.66 e-h	10.28 lm	7.34 e	27.22 l	351.48 ab	9.57 f-i
5x6	43.33 ijk	9.82 mn	7.82 de	32.11 ij	348.87 ab	11.21 cd
5x7	40.66 k-o	7.30 o	8.96 bc	36.66 d-h	331.25 a-e	12.15 bc
5x8	50.66 abc	9.80 mn	7.70 de	27.44 l	335 a-d	9.39 g-j
6x7	37.33p	11.96 jk	6.59 fg	43.33 a	319.51 b-g	13.83 a
6x8	38 op	12.13 jk	6.53 fgh	32.33 ij	329.60 a-f	10.65 def
7x8	38 op	8.63 no	9.14 b	38.44 b-e	352.01 ab	13.53 a
check	37.33 p	17.28bcd	4.12 nop	36.44 e-h	238.63 lm	8.71 i-l
X	42.83	13.06	6.20	34.06	303.85	10.33
C.V.%	14.72	15.52	14.80	20.05	14.36	27.20

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

The heterosis values estimated for yield and yield components in a 8x8 half diallel of summer squash crosses are shows in Table 4. Among the crosses, the estimated value for mid parents, best parents and check variety. For days to 50% female flowering significant negative heterosis over mid parent was observed from ten crosses ranged between -8.5 for 6x8 and 7x8 and -4 for 3x7 cross, significant negative heterosis over best parent was showed from three crosses 6x7, 6x8 and 7x8 given -6.333, -5.333 and -5.333 respectively, while over check there is no cross gave negative significant heterosis, and fifteen crosses exhibited positive significant heterosis over local variety. For fruit length five crosses had significant positive heterosis out of 28 crosses which were ranged between 2x7 and 2x8 over mid parent. Over better parent 13 crosses showed significant negative heterosis, while most crosses appeared significant negative heterosis over local variety, and only one cross recorded significant positive heterosis (2.74) by hybrid 1x3. Regarding fruit diameter one cross recorded significant positive heterosis over mid parent (0.957) by cross 5x6. For over best parent there is no significant positive showed by crosses, while 14 crosses showed negative significant heterosis. Concerning heterosis over local variety most of crosses exhibited significant positive heterosis ranged 1.2 and 5.027 for cross 3x8 and 7x8 respectively. (13,16) in pumpkin were obtained similar results. Eight crosses had significant positive heterosis over mid parent the maximum value 13.7 recorded by the cross 7x8 and lower value 5.55by 5x8 while 1x2 cross gave significant negative heterosis was -5.777 for for no. of fruit per plant. Regarding to the heterosis over better parent, six crosses appeared significant positive heterosis with maximum value 11.667 for the cross 4x7 followed by the cross 7x8 and 5x7 with 10.111 and 8.334 respectively, while for heterosis over local variety eight crosses recorded significant negative heterosis only one cross gave positive significant value was 6.889 for 6x7cross. For fruit weight eleven crosses had significant positive heterosis over mid parent ranged between 89.926 and 43.894 for 1x7 and 3x4 crosses. Over best parent three crosses exhibited significant positive heterosis, the highest value 79.582 was obtained by cross 1x7 followed by 3x7 and 2x7 with receptive value 75.072 and 58.306 respectively, while for local variety out of 28 crosses 22 crosses produced significant positive heterosis, the maximum value 113.38 was noticed in cross 7x8 and minimum value 57.444 recorded by the cross 1x6. For the same trait the crosses 1x7, 2x7 and 3x7 showed significant positive heterosis for mid parent , best parent and local variety. concerning heterosis for yield per plant for mid parent, 15 crosses showed significant positive heterosis the largest value 6.142 produced by the cross 7x8. Nine cross recorded significant positive heterosis over best parent ranged between 5.496 and 2.363 obtained by the crosses 7x8 and 2x7. Over local variety significant positive heterosis obtained by 14 crosses the highest value 5.117 for cross 6x7 and the cross 2x6 gave the lowest value 1.724. For the same traits seven crosses exhibited significant positive heterosis over mid parent, best parent and local variety, the crosses were 1x7, 2x7, 3x7, 4x7, 5x7, 6x7 and 7x8. Present result are in agreement with the finding of (3; 13,7,17,18).

Table 4. Heterosis values for yield and yield components in summer squash estimated over mid parent, best parent and check variety.

hybrids	Traits: Day to 50% female flowering			Fruit length (cm)			Fruit diameter (cm)		
	mid par	B. P	Ch V	mid par	B. P	Ch V	mid par	B. P	Ch V
1x2	7.333**	10.00**	10.667**	0.3	-0.25	0.29	-0.21	-0.63	-0.35
1x3	2.00	2.333	7.667**	2.947**	2.2	2.74*	0.25	0.053	-0.113
1x4	-0.167	1.667	7.667**	0.88	-3.747**	-3.207*	0.053	-2.36**	1.907**
1x5	-2.333	2.00	8.00**	0.193	-5.087**	-4.547**	0.193	-1.947**	1.773**
1x6	1.00	1.00	7.00**	-0.467	-2.773*	-2.233	0.683	-0.487	1.293*
1x7	-1.667	-1.667	4.333*	3.13**	-2.913*	-2.373	-1.217*	-4.36**	1.367*
1x8	6.1667**	9.333**	15.333**	0.84	-2.887*	-2.347	-1.383**	-3.307**	-0.02
2x3	-2.00	0.333	1.00	0.523	0.327	-0.233	0.123	-0.1	0.18
2x4	-5.167**	-0.667	0.00	0.03	-4.047**	-4.607**	-0.54	-2.533**	1.733**
2x5	-6.667**	0.333	1.00	0.137	-4.593**	-5.153**	0.513	-1.207*	2.513**
2x6	-1.333	1.333	2.00	-1.59	-3.347**	-3.907**	-0.397	-1.147*	0.633
2x7	0.00	2.667	3.333	4.08**	-1.413	-1.973	-0.837	-3.56**	2.167**
2x8	-5.833**	0.00	0.667	2.317*	-0.86	-1.42	-0.903	-2.407**	0.88
3x4	5.1667**	7.333**	12.667**	-0.047	-3.927**	-4.88**	0.403	-1.813**	2.453**
3x5	-7.00**	-2.333	3.00	1.587	-2.947*	-3.9**	0.817	-1.127*	2.593**
3x6	-1.00	-0.667	4.667*	1.367	-0.193	-1.147	0.007	-0.967	0.813
3x7	-4.00*	-3.667	1.667	0.4367	-4.86**	-5.813**	-0.513	-3.46**	2.267**
3x8	2.833	6.333**	11.667**	0.917	-2.063	-3.017*	-0.36	-2.087**	1.2*
4x5	0.833	3.333	13	1.333	0.68	-8.033**	-0.267	-0.54	3.727**
4x6	-1.167	0.667	6.667**	-0.853	-3.173*	-7.247**	0.4	-0.843	3.423**
4x7	-3.5	-1.667	4.333*	1.91	0.493	-8.22**	-0.15	-0.88	4.847**
4x8	-1.667	-0.333	9.333**	0.82	-0.08	-6.993**	-0.557	-1.047	3.22**
5x6	-4.333*	0.00	6.00**	-0.407	-3.38**	-7.453**	0.957*	-0.013	3.707**
5x7	-7.00**	-2.667	3.333	0.81	0.047	-9.973**	0.123	-0.88	4.847**
5x8	-0.167	1.00	13.333**	0.987	-0.567	-7.48**	0.077	-0.14	3.58**
6x7	-6.333**	-6.333**	-0.333	2.497*	-1.24	-5.313**	-1.28**	-3.253**	2.473**
6x8	-8.5**	-5.333*	0.667	0.347	-1.073	-5.147**	-0.12	-0.873	2.413**
7x8	-8.5**	-5.333*	0.667	0.583	-1.733	-8.647**	0.52	-0.7	5.027**

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

Table 4. Continue

hybrids	Traits: No. of fruit/plant: mid par	B. P	Ch V	Fruit weight(g): mid par	B. P	Ch V	yield kg plant^{-1}: Mid p.	B.P	CH. V.
1x2	-5.777*	-8.666**	-4.444	25.413	10.520	8.966	-0.534	-1.786*	-0.825
1x3	4.333	4.00	2.444	21.543	8.167	3.578	1.83**	1.409	0.707
1x4	2.056	-2.666	-4.222	29.665	-43.287	71.276**	1.902**	0.999	1.260
1x5	3.0002	-3.666	-5.222*	54.796*	2.909	75.343**	2.868**	2.633**	1.089
1x6	-3.499	-4.555	-3.999	48.393*	8.001	57.444*	0.549	-1.34	0.893
1x7	2.834	-0.444	-2.00	89.926**	79.582**	68.929**	3.931 **	3.717**	2.172**
1x8	0.0002	-6.333*	-7.889**	-13.786	-91.47**	32.559	0.369	-0.062	-0.743
2x3	1.445	-1.778	2.445	24.076	22.559	21.005	1.237	0.405	1.367
2x4	-1.055	-8.666**	-4.444	3.973	-54.086*	60.477*	0.391	0.041	1.002
2x5	6.667**	-2.889	1.334	23.501	-13.493	58.941*	3.033 **	1.545	2.507**
2x6	-0.611	-2.444	1.778	10.587	-14.912	34.531	0.127	-0.509	1.724 *
2x7	6.278**	0.111	4.333	62.855**	58.306*	56.752*	3.831**	2.363**	3.325**
2x8	3.111	-6.111*	-1.889	1.028	-61.765*	62.267*	1.461*	0.639	1.601*
3x4	-3.944	-8.333**	-10.56**	43.894*	-15.681	98.881**	0.221	-0.261	0.00
3x5	3.111	-3.222	-5.444*	46.932*	8.421	80.854**	2.753**	2.097**	1.394
3x6	1.834	0.445	1.000	19.681	-7.335	42.108	1.027	-0.441	1.792*
3x7	9.167**	6.222*	4.00	78.104**	75.072**	70.484**	5.121**	4.485**	3.782 **
3x8	-2.111	-8.111**	-10.33**	12.846	-51.464*	72.568**	0.072	0.061	-0.62
4x5	3.5	1.556	-9.444**	-17.496	-38.56	76.003**	0.654	-0.483	-0.222
4x6	2.778	-3.00	-2.444	-11.888	-44.448	70.115**	0.545	-0.441	1.792*
4x7	13.11**	11.667**	3.556	19.271	-43.337	71.226**	4.532**	3.415**	3.676**
4x8	3.389	1.778	-9.22**	-6.448	-11.182	112.85 **	1.069	0.598	0.859
5x6	2.833	-4.889	-4.333	49.303*	37.807	110.24**	2.388**	0.264	2.497**
5x7	11.72**	8.334**	0.222	61.73**	20.187	92.621**	5.436 **	5.416**	3.442 **
5x8	5.556*	5.222*	-8.999**	-1.859	-27.658	96.374**	2.029**	1.363	0.681
6x7	10.67**	6.333*	6.889*	61.483**	31.436	80.878**	4.987**	2.883**	5.117**
6x8	2.722	-4.667	-4.111	4.236	-33.059	90.973**	1.163	-0.294	1.939*
7x8	13.17**	10.111**	2.00	56.687*	-10.655	113.38 **	6.142**	5.496**	4.814 **

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

Table 5. shows the estimation of genetic parameters for six studied traits, it is clear that additive, dominance and environmental variances were significant from zero for all traits, indicating their important in controlling the inheritance of these traits. The results indicated that the values of additive variance were greater than dominance variance in all traits except days 50% female flowering and yield per plant, indicating the additive genetic effect were more important in the inheritance for all traits except days 50% female flowering and yield per plant. And it is showed that phenotypic variance were greater than genotypic variance in all traits, this caused to increase the values of heritability in broad sense compared with heritability in narrow sense in all traits. The heritability in broad sense were highest for all the traits ranged between 0.949 for fruit diameter and 0.827 for fruit weight. Heritability in narrow sense showed highest values for fruit length and diameter 0.849 and 0.871respectively which reflecting the greatest role of additive gene effect of these traits. Traits that revealed high heritability in broad sense reflect the high dominance genetic variation method, signifying the important of hybridization method to improve these traits. The average degree of dominance is more than one for all trait except fruit length and diameter indicating the presence of over dominance gene action

for all traits and partial dominance for fruit length and diameter. Finally, it is appeared that the expected genetic improvement as a percent was highest for two traits fruit length was 41.211% and fruit diameter 41.880% and moderate for no. of fruits and fruit weight was 16.319% and 13.442% respectively. present results are corroboration with finding of (1, 2, 11, 18, 25).

Table 5. Variance components and genetic parameters for studied traits in summer squash

	Traits					
	Day to 50% female flowering	Fruit length (cm)	Fruit diameter (cm)	No. of fruits/ plant	Fruit weight(g)	yield kg plant^{-1}
σ^2A	10.499 ± 3.552	10.428 ± 3.491	2.587 ± 0.866	18.567 ± 6.264	977.471 ± 332.802	0.997 ± 0.339
σ^2D	12.474 ± 3.426	1.133 ± 0.356	0.231 ± 0.073	14.432 ± 4.019	530.655 ± 164.929	2.529 ± 0.680
σ^2E	2.355 ± 0.392	0.713 ± 0.119	0.149 ± 0.025	3.347 ± 0.558	313.613 ± 52.269	0.310 ± 0.051
σ^2G	22.973	11.560	2.818	32.999	1508.127	3.526
σ^2P	25.328	12.274	2.966	36.346	1821.739	3.837
h^2_{BS}	0.907	0.941	0.949	0.907	0.827	0.919
h^2_{NS}	0.414	0.849	0.871	0.510	0.536	0.259
$\bar{a}$	1.541	0.466	0.422	1.246	1.042	2.252
Mean	43.444	12.711	6.311	33.216	299.851	9.926
GA	3.672	5.238	2.643	5.420	40.306	0.896
GA%	8.452	41.211	41.880	16.319	13.442	9.026

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