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NATURE OF GENE ACTION AND HETEROTIC PERFORMANCE FOR YIELD AND YIELD COMPONENTS IN SUMMER SQUASH (*Cucurbita pepo* l.)

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ABSTRACT

Six inbred lines of summer squash representing wide range of variability in most of the studied traits were utilized in a half diallel cross. The studied traits were Plant height, days to female flowers, number of fruits/plant, average fruit length, average fruit diameter, average fruit weight, early yield/plant and total yield/plant. Heterotic performance, graphically variance/covariance analysis and genetic components were used to analyze the obtained data. Results showed that the maximum significant true heterosis (BP) in desirable direction (179.9%) was recorded for early yield/plant followed by total yield (106.9%), fruits number/plant(57.0%), plant height (40.9%), average fruit weight (32.5%) and days to female flowering date (-17.2%). Data of diallel table for each trait were subjected to graphical analysis to obtain information on the adequacy of the additive-dominance model of gene action. The relative position of array points on Vr/Wr graph indicated that parental genotype P_1 (line-280) contained high frequency of dominant alleles for earliness, fruit length, fruit diameter, fruits number and both early and total yield. Results of diallel analysis indicated that the value $(H/D)^{1/2}$ was more than unity for all studied traits indicating the presence of over-dominance and supporting the graphical conclusions. However, the predominance of non-additive gene effects and values of $h_{n.s}$ for most important traits suggesting the possibility exploiting dominance gene effects for improving such traits through heterosis breeding.

Keywords: Summer squash, Heterosis, Genetic Components, Heritability, Variance, Covariance

INTRODUCTION

Summer squash (*Cucurbita pepo* L.) is an important vegetable crop grown in Egypt. The cultivated area reached 84571feddan with average of 7.491 tons total yield / feddan (Department of Agricultural Economics and Statistics, Ministry of Agriculture and Land Reclamation A. R. Egypt, 2012). All the mentioned area is cultivated with imported seeds and this cost a lot of money. Introducing of local squash hybrids with good fruit qualit. As hybrids have the capacity for higher yield and earliness over open-pollinated squash cultivars, there is need to develop new hybrid squash cultivars. This breeding method based on the principle of crossing two inbred lines. The first step is to obtain the homozygous lines by using inbreeding. Lopez-Anido *et al* (1998) and Ahmed *et al* (2003) reported the importance of non-additive gene actions for plant height. In addition, they reported the importance of additive and non-additive gene actions for total fruit number. In summer squash, Metwallally (1985) reported that the broad sense heritability was high value for number of days to anthesis of first female flower. In some summer squash genotypes, Abd El-Maksud *et al* (2003) and Hussein *et al* (2013) reported that total yield was controlled mainly by over dominance and narrow sense heritability of all characters was between moderate to low. Marie *et al* (2012) found that the heterosis for fruit number per plant was (57.57%) in (IL3 × XIL6) hybrid while, heterosis for total yield/plant, the hybrid (IL6 × IL7) and (IL3 × XIL6) had maximum value (32.38, 28.68%) respectively. In some summer squash genotypes, El-Mighawry *el al* (2008) reported that the dominant components (H_1, H_2) were highly significant for all studied traits. In addition, the dominance components (H_1 and H_2) were large than additive effects of the gene (D) indicating the importance of non-additive and additive gene action in inheritance of days to anthesis female flower, fruits weight and number of fruits per plant.

The objectives of the present investigation were to estimate the magnitude of heterosis as well as genetic components, variance and covariance for traits under study in a half diallel set to recognize desirable parents and their cross combinations as genetic resources for improving these important traits and to identify suitable material to be used in summer quash breeding programs. It is hoped that the present study may help summer squash breeder to produce new hybrid varieties of summer squash of higher yielding potentiality

MATERIALS AND METHODS

Six inbred lines of squash (*Cucurbita pepo* L.) were selfed for four successive generations during summer and fall seasons of 2010 to 2012 to obtain uniform inbred lines before using it as parental lines in a half diallel cross mating design during summer season of 2013.These inbred lines were developed by the author of this present study. These lines named; Line-280 (P_1), Line-281(P_2), Line-283 (P_3), Line-284 (P_4) Line -285, (P_5) and Line-286 (P_6), were crossed to obtain 15 F_1 hybrids. On march15 th 2014 the seeds of F_1 hybrids and parents were evaluated in a field experiment at Kaha Vegetable Research Farm, Kaliobia Governorate. Randomized complete block design with three replicates were used in this study. The seeds of F_1 hybrids and parents were directly seeded; plants were spaced 50 cm apart in rows 4 m long and 1 m width with 3 rows for each plot. All the agricultural practices were applied according to the recommendation of Ministry of Agriculture, Egypt.

Data were recorded on individual plants from 10 plants of each parents and F_1 hybrids for some important traits as Plant height, days to anthesis of female flowers, number of fruits/plant, average fruit length, fruit diameter and fruit weight, early yield/plant and total yield/plant.

Statistical analysis:

Genetic components were estimated according to Hayman (1954). The covariance matrix of Hayman (1954) was used to provide estimates of the standard error for the genetic parameters of the expected environmental component of variation (E), the component of variation due to the additive effects of the genes (D), the mean of Fr over the arrays (F), the component of

variation due to the dominance effect of the genes (H_1) and the dominance which indicate the symmetry of positive and negative effects of genes (H_2). These parameters provided the estimation of the following ratios:
$(H_1/D)^{1/2}$ = measure the average degree of dominance over all loci .
$(H_2/4H_1)$ = measure the mean value of the product U and V which are the frequencies of positive (u) and negative (v) alleles in the parents .It has a maximum value of 0.25 when p = q = 1/2 .
Variance/covariance (Vr/Wr) graphs of each character were prepared (according to Jinks 1954).
Heritability: broad and narrow sense heritability were estimated according to the diallel analysis system.
Relative heterosis and heterobeltiosis were estimated as the deviation of F_1 mean over the mid-parent (MP) and better parent (BP) in each cross, respectively (according to Mather and Jinks 1971).

RESULTS AND DISCUSSION

Mean performance of the parental lines and their F_1 hybrids

The mean performance of the evaluated parents and their F_1 hybrids for some vegetative and fruit characteristics are presented in Table 1. The mean six parent's value for plant height is 66.30 cm with a range from 44.6 cm (P_5) to 87.0 cm (P_6). Their 15 F_1 hybrids ranged from 50.23 cm ($P_4 \times P_5$) to 92.17. cm ($P_2 \times P_3$), with a mean of 72.56 cm. Plant heights were not shorter in any of the crosses than the shortest-parent (over all parents).

Ten out of 15 crosses had plants significantly taller than mid-parent value corresponding to each of them. Values for number of days to anthesis first female flower (Table 1) showed that the parental values ranged from 38.33 to 54.67 days with the mean of 45.41 days. Their 15 F_1 hybrids ranged from 36.33 days ($P_2 \times P_4$), to 54.0 ($P_3 \times P_5$), with a mean of 41.38 days. Regarding number of fruits/plant, the parental values ranged from 5.87 to 11.05 fruits/plant with the mean of 8.45 fruits/plant. Their 15 F_1 hybrids ranged from 7.84 to 12.91fruits/plant. The parental value for fruit length, (P_1) had the highest value 13.4 cm followed by (P_2), 13.1cm. On the other hand, lowest parent in this trait was (P_4) had 11.4 cm. With respect to the parental performance for fruit diameter (Table 1), the (P_5) gave the highest mean value of (3.03cm) and the parental genotype (P_1) had the lowest mean value (2.41cm) with significant differences between them. Their 15 F_1 hybrids ($P_2 \times P_3$) had the highest mean value (2.94 cm), while the hybrids ($P_2 \times P_4$) had the lowest one (2.03 cm). The average fruit weight of parental genotypes ranged from 75.76 g (P_6) to 86.12 g (P_4) with a mean of 78.9 g. Their 15 F_1 ranged from 73.64 g ($P_3 \times P_5$) to 114.13 g ($P_3 \times P_4$) with mean average of 91.2 g. Data of early yield /plant for six parental genotypes ranged from 0.13 kg (P_5) to 0.28 kg (P_4) and their hybrids ranged from 0.14 kg ($P_1 \times P_5$) to 0.5 kg ($P_4 \times P_5$) with a mean of 0.2 kg and 0.3 kg for parents and their hybrids, respectively. Regarding total yield/plant, the parental values ranged from 0.44 kg (P_6) to 0.91Kg (P_1) with a mean of 0.3 Kg and their hybrids ranged from 0.58 Kg ($P_3 \times P_5$) to 1.33 Kg ($P_1 \times P_2$) with a mean of 0.96 Kg.

Table 1. Mean performance of the studied squash inbred lines and their F_1 for studied traits in summer season of 2014.

Genotypes	Plant height (cm)	Days to anthesis female flowers	No of fruits /plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Early yield/plant (Kg)	Total yield/plant (kg)
Line 280(P_1)	57.23	39.33	11.05	13.40	2.41	82.52	0.26	0.91
Line 281(P_2)	62.77	44.67	7.50	13.10	2.83	84.00	0.15	0.63
Line 283(P_3)	82.00	52.33	7.33	12.83	2.79	66.67	0.26	0.49
Line284(P4)	44.60	38.33	9.09	11.40	2.61	86.12	0.28	0.78
Line 285(P_5)	64.33	44.33	9.88	12.42	3.03	78.40	0.13	0.77
Line 286(P_6)	87.00	54.67	5.87	12.82	2.62	75.67	0.15	0.44
Mean	66.32	45.41	8.45	12.66	2.71	78.90	0.20	0.67
P_1×P_2	83.57	49.00	12.00	12.83	2.50	111.07	0.27	1.33
P_1× P_3	85.90	40.67	10.35	13.80	2.72	83.17	0.35	0.86
P_1× P_4	59.50	41.00	10.50	12.87	2.51	78.82	0.25	0.83
P_1× P_5	73.93	42.00	9.75	13.43	2.52	79.67	0.14	0.78
P_1× P_6	76.90	38.00	10.91	13.39	2.79	77.37	0.36	0.84
P_2× P_3	92.17	44.67	9.24	12.65	2.94	74.96	0.16	0.69
P_2× P_4	60.00	36.33	12.91	13.39	2.03	97.32	0.32	1.26
P_2× P_5	90.57	45.67	9.12	12.33	2.72	97.82	0.18	0.89
P_2× P_6	63.33	37.00	11.78	11.69	2.69	105.43	0.42	1.24
P_3× P_4	64.17	39.33	11.33	12.20	2.51	114.13	0.37	1.29
P_3× P_5	90.17	54.00	7.84	13.60	2.53	73.64	0.27	0.58
P_3× P_6	82.90	47.33	10.55	14.07	2.24	80.43	0.25	0.85
P_4× P_5	50.23	37.33	10.33	12.88	2.48	112.28	0.42	1.16
P_4× P_6	51.33	36.67	10.90	13.36	2.25	104.26	0.50	1.14
P_5× P_6	63.73	40.67	8.90	13.72	2.54	80.65	0.26	0.72
Mean	72.56	41.38	10.43	13.08	2.53	91.20	0.30	0.96
LSD at 0.05	3.861	3.294	0.811	0.391	0.334	7.545	0.045	0.127

Heterosis types

Mid-parent and better parent heterosis of all studied traits are presented in Table (2). Heterosis for plant height ranged from -41.0% to 42.5%. Nine out 15 hybrids were significant and positive over mid-parent (MP) and six over better parent (BP), days to anthesis first of female flower varied from -25.5% to 21.8% when the two types of heterosis are considered. Desirable negative MP heterosis for the earliness was observed in ten F_1 crosses, of which four F_1 crosses exhibited desirable BP. These results are in agreement with those of Obiadalla-Ali (2006), Tamil *et al* (2012) and El- Adl *et al* (2014).

Hetrosis for number of fruits /plant, (Table 2), the most important yield component was significant positive up to 76.2 % over mid-parent and 57.0% over better parent. Desirable positive MP heterosis was observed in eleven F_1 crosses while seven showed desirable BP ones. The heterotic expression for fruit length varied with extreme values ranging from -14.4% to 10.3% for both types of heterosis (Table 2). Desirable positive MP heterosis was observed in ten F_1 crosses and two showed desirable BP heterosis. These findings agreed with those obtained by Abd El-Hadi *et al* (2014). The heterotic expression for fruit diameter varied with extreme values ranging from -28.0% to 10.9% for both types of heterosis (Table2). Only one cross showed MP heterosis and none of crosses showed BP heterosis. Average fruit weight, the most important yield component, had significant positive heterosis was up to 49.5 % over mid-parent and 32.5% over better parent. Nine crosses showed mid-parent heterosis and seven crosses exhibited BP one. Heterosis for early yield/plant ranged from -46.10% to 182.1%. Twelve out 15 hybrids were significant and positive over mid-parent (MP) and eleven over better parent (BP) for this trait. These results are in agreement with those of El- Adl *et al* (2014). The heterotic expression for total yield/plant varied with extreme values ranging from -27.9% to 131.5 % for both types of heterosis (Table 2). Desirable positive MP heterosis was observed in tweleve F_1 crosses and nine showed desirable BP one. These results confirm those of Hussein *et al* (2013).

Graphical analysis

Data of diallel Table for each trait were subjected to graphical analysis to obtain information on the adequacy of the additive-dominance model of gene action. It is clear that the slope of the Vr/Wr regression line was significantly different from zero and not from unity in days to flowering indicating the expression of additive inheritance pattern. On the other hand, the value (b) dos not depart significantly from unity in all studied traits. Thus, so far as this analysis goes there is good evidence of dominance, but no evidence that dominance is not wholly able to account for the relation observed between Wr and Vr. In the other words, dominance is present but there is no indication of non-allelic interaction: the additive-dominance model is sufficient to account for the data of all studies traits. Absence of significant differences from zero for the regression value (all studied traits except flowering) can be due to non-allelic interaction, when the points are more widely scattered around the theoretical regression line. The scattering pattern of the different points of the parents for all studied traits (except flowering) confirmed the presence of non-allelic gene interactions in all traits except flowering date (Fig. 1- 8).

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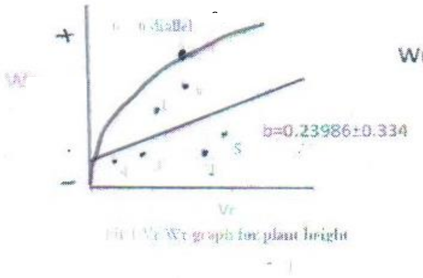

Fig. 1: Vr/Wr graph for plant

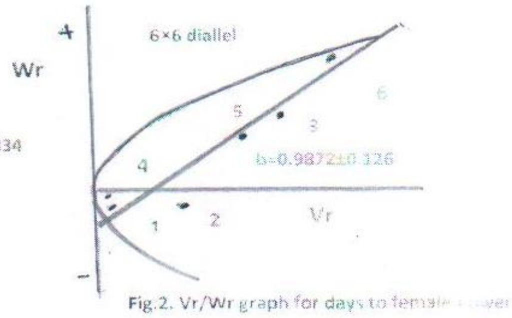

Fig. 2: Vr/Wr graph for days to female

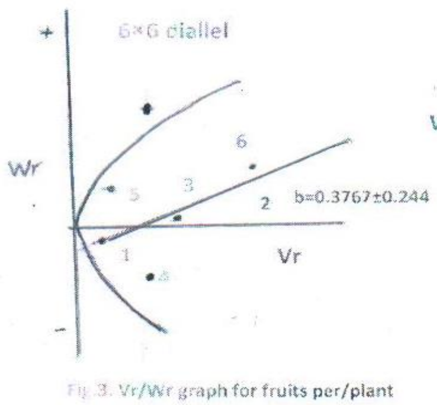

Fig. 3: Vr/Wr graph for fruits /plant.

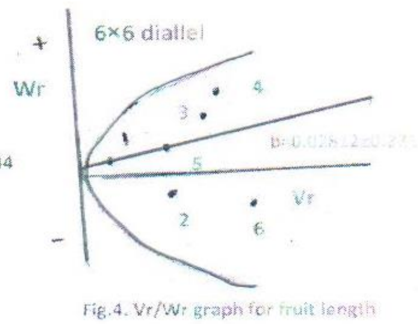

Fig. 4: Vr/Wr graph for fruit length.

The regression line intercepted the Wr axis above the origin in plant height (Fig.1) shows a clear cut case of partial dominance. However, the regression line cut the Wr axis below the point of origin in all other traits except fruit length, (Fig3). indicating over-dominance in flowering date, average fruit weight, fruit diameter, fruits number/plant, early yield/plant and total yield/plant . On the other hand, complete dominance played a mjor role in controlling fruit length trait(Fig.4). The relative position of array points on Vr/Wr graph indicated that parental genotypes P_1 (line-280) contained high frequency of dominant alleles for earliness, fruit length, fruit diameter , fruits number/pant and both early and total yield/plant, P_4 (line-285) for earliness, shortest plant and number of fruits/plant. However, both dominant and recessive alleles were approximately of equal proportion in the genetic makeup of the parental squash genotype P_3 (line-283) for flowering date, fruit length, fruit diameter and fruits number/plant. Whereas, the genotype P_6 (line-286) array lies close to the upper most part of the regression line and therefore is carrying recessive factors for lateness, few early yield/plant, few fruits number/plant and few total yield/plant as well as P_2 (line-281) for few fruit number/plant, few fruit diameter and few total yield/plant.

Accordingly, it could be observed high level of genetic diversity among the parental genotypes, therefore breeders could be use these materials for producing squash cultivar with high yield potentiality through the studied physiological characters.

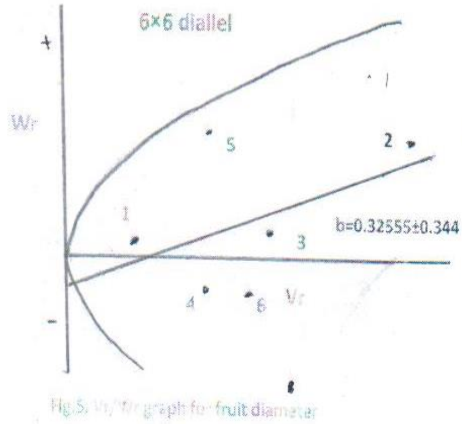

Fig. 5: Vr/Wr graph for fruit diameter.

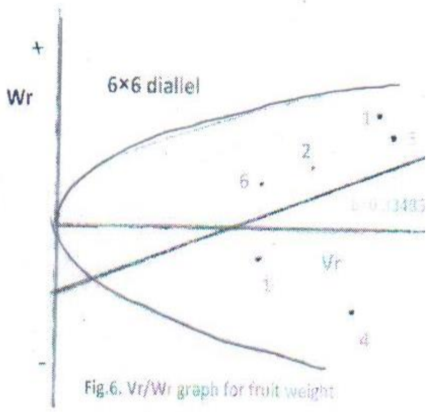

Fig. 6: Vr/Wr graph for fruit weight.

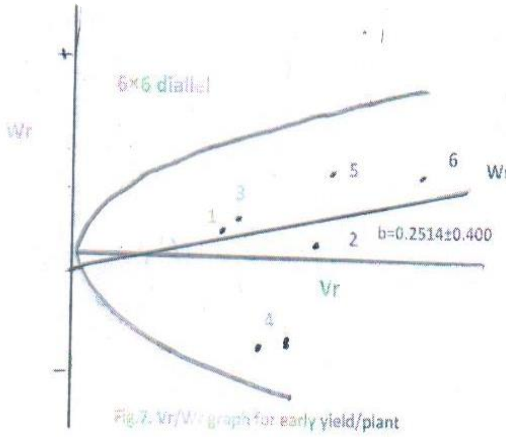

Fig. 7: Vr/Wr graph for early yield/plant.

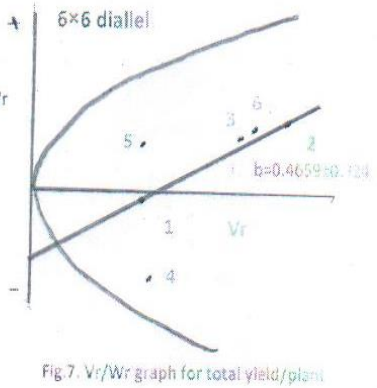

Fig. 8: Vr/Wr graph for total yield/plant.

Genetic components

The data were further subjected to the diallel analysis proposed by Hayman (1954) to separate out the components of genetic variance and their ratios for all studied traits. Additive genetic component (D) was significant in flowering date, fruits number per plant, plant height and fruit length. Non-additive (H_1 and H_2) components were found to be significant in all studied traits. The results are in contrast with those obtained by El- Mighawry *el al* (2008). However, the values of dominant effect (H_1) were smaller than D components for only early yield/plant. Moreover, estimates of (H_2) which represent the mean dominant effect of the parents, were smaller than (H_1) for all studied traits except early yield/plant.

This indicates that the frequencies of positive and negative alleles at the loci governing these traits were not equally distributed among parental genotypes. This result confirm with those of $H_2/4H_1$ which deviated from its theoretical value of (0.25) in all studied traits. The value $(H_1/D)^{1/2}$ was more than unity for all studied traits indicating the presence of over-dominance and supporting the graphical conclusions. The relative frequencies of dominant and recessive alleles in the parental population as indicating by "F" value was positive and significant for flowering date and number of fruits/plant, indicating that dominant alleles were more frequent than the recessive ones. However, negative "F" value for average fruit weight, suggested that recessive alleles responsible of few average fruit weight were more frequent than dominant ones. It is interesting to mentions that the environmental variance was significant for average fruit weight and fruit diameter, revealing that these characters were much affected by the environmental changes. However, all other traits found to be less influenced by the environmental fluctuation. These results are in agreement with those of El- Mighawry *el al* (2008).

The proportion of dominant to recessive alleles in the genetic makeup of parents (KD/KR) was more than unity, revealing the preponderance of dominant alleles in the parental genotypes for all studied traits except average fruit weight.

Broad and narrow sense heritability values were estimated (Table 3). Broad sense heritability was found to be high for all studied traits. However, heritability in narrow sense (h^2n) was high (68%) for plant height. These results are in agreement with those of Dahiya *et al* (1990) and El-Gendy (1999).

Whereas, h^2n values were moderate (30- 43%) for number of fruits/plant, total yield/plant, early yield/plant and flowering date. The results are in contrast with those obtained by Kash and El-Diasty (1989) who reported that the narrow sense heritability were low. However, the estimates of narrow sense heritability were low and valued 13% (fruit length), 21% (fruit diameter), and 27% (average fruit weight), hereby selection was difficult and should be delayed to later segregating generations in respect to the latest these traits. These results confirm those of El-Lithy (2002), Abd El-Hadi *et al* (2004) and Hussein *et al* (2013). However, for the other abovementioned traits, selection in the early segregating generations could be effective.

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طبيعة فعل الجين وسلوك قوة الهجين للمحصول ومكوناته فى الكوسة

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أجريت هذه الدراسة بمزرعة بحوث البساتين بقها محافظة القليوبية خلال الفترة من ٢٠١٠ إلى ٢٠١٤م بهدف دراسة قوة الهجين وطبيعة فعل الجين وكذلك مكونات التباين لبعض الصفات الإقتصادية الهامة وبيان إمكانية تحسين هذه الصفات عن طريق التهجين.

وقد استخدم لهذا الغرض ستة آباء مختلفة وراثياً من الكوسة وهى سلالة ٢٨٠ (الأب الأول) ، السلالة ٢٨١ (الأب الثانى) ، السلالة ٢٨٣ (الأب الثالث) ، السلالة ٢٨٤ (الأب الرابع) ، السلالة ٢٨٥ (الأب الخامس) ، السلالة ٢٨٦ (الأب السادس) وقد أجريت جميع التهجينات الممكنة دون العكسية بطريق التهجين الدائرى.

تم تقييم الهجن وآباؤها (٢١ تركيب وراثى) فى تجربة بنظام القطاعات كاملة العشوائية فى ثلاث مكررات وقدرت قوة الهجين بطريقتين وكذلك تم حساب التباين والتغاير الوراثى وتحليله بيانياً لمعرفة درجة السيادة ودورها فى توريث الصفات وكذلك توزيع الجينات السائدة والمتنحية بين الآباء. كما تم دراسة طبيعة فعل الجين بالاضافة لتقدير بعض المعالم الوراثية للصفات تحت الدراسة.

وقد أوضحت النتائج أن أعلى قوة هجين حقيقية معنوية موجبة (١٧٩.٩%) كانت لصفة المحصول المبكر/نبات يتبعها المحصول الكلى للنبات (١٠٦.٩%) ثم عدد الثمار/نبات (٥٧%) ثم إرتفاع النبات (٤٠.٩%) ثم متوسط وزن الثمرة (٣٢.٥%) ثم التبكير فى خروج أول زهرة مؤنثة (-١٧.٢%).

أظهرت النتائج أن السلالة ٢٨٠ (الاب الاول) يحتوى على تكرار عالى للجينات السائدة للتبكير ، طول الثمرة ، قطر الثمرة ، عدد الثمار/نبات ، المحصول المبكر والكلى/نبات.

دلت مؤشرات التباين أهمية الدور الذى يلعبه الفعل الجينى السيادى لمعظم الصفات تحت الدراسة مما يدل عل إمكانية استغلال قوة الهجين فى تحسين هذه الصفات.

Table 2. Relative heterosis (over mid-parent, MP) and (over better parent heteobeltiosis, BP) in summer squash for studied traits in summer season of 2014.

Genotypes	Plant height		Days to anthesis female flowers		No. of fruits /plant		Fruit length		Fruit diameter		Average of fruit weight		Early yield/plant		Total yield/plant	
	MP	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**	**MP**	**BP**
$P_1 \times P_2$	39.3**	33.1**	3.2	10.2*	29.4**	8.6*	-3.1*	-7.0**	-4.3	-11.2*	33.4**	32.2**	30.6**	2.7*	73.1**	48.1**
$P_1 \times P_3$	23.4**	4.8*	-11.3**	3.4	12.6**	-6.4*	5.2**	0.0	4.7	-3.5	11.5*	0.8	32.5**	32.4**	22.9**	-4.4
$P_1 \times P_4$	16.9**	4.0	5.6	7.0	4.3	-4.9	3.8**	-6.8**	0.1	-3.7	-6.5	-8.5*	-7.8*	-10.7*	-2.2	-7.9*
$P_1 \times P_5$	21.6**	15.0**	0.4	6.8	-6.8*	-11.7**	4.1**	-2.7*	-7.4	-16.7**	-1.0	-3.5	-26.9**	-46.1**	-7.8*	-13.6*
$P_1 \times P_6$	6.6*	-11.6**	-19.1**	-3.4	29.0**	-1.3	2.2*	-2.9*	10.9*	-7.7	-2.2	-6.2	76.6**	38.3**	24.6**	-6.2*
$P_2 \times P_3$	27.3**	12.4**	-14.8**	-7.4*	24.6**	23.2**	-2.5*	-7.4**	4.8	4.3	-0.5	-10.8*	-21.5*	-38.3**	23.9**	15.5*
$P_2 \times P_4$	11.8**	-4.5	-12.4**	-5.2	55.7**	42.0**	9.3**	-2.0*	-25.4**	-28.0**	14.4**	13.0**	48.4**	22.6**	78.0**	57.1**
$P_2 \times P_5$	42.5**	40.9**	2.6	3.0	5.0	-7.7*	-3.3*	-9.7**	-6.9	-9.8*	16.8**	12.9**	30.5*	19.5*	23.5**	8.3*
$P_2 \times P_6$	-15.4**	-27.2**	-25.5**	-17.2**	76.2**	57.0**	-9.8**	-14.4**	-1.1	-4.5	32.1**	25.5**	182.1**	179.9**	131.5**	106.9**
$P_3 \times P_4$	1.4	-21.7**	-13.2**	2.6	38.1**	24.7**	0.7	-9.6**	-7.2	-9.8*	49.4**	32.5**	37.5**	33.5**	103.2**	61.7**
$P_3 \times P_5$	23.2**	10.0**	11.7**	21.8**	-8.9*	-20.6**	7.7**	0.7	-13.1**	-16.3**	1.5	-6.1	38.1**	2.0*	-8.8*	-27.9**
$P_3 \times P_6$	-1.9	-4.7*	-11.5**	-9.5**	59.8**	43.9**	9.7**	4.2**	-17.1**	-19.4**	13.0*	6.3	22.6*	-4.1*	81.9**	69.8**
$P_4 \times P_5$	-7.8**	-21.9**	-9.7*	-2.6	9.0*	4.6	8.1**	2.1*	-12.2*	-18.0**	36.5**	30.4**	107.9**	50.4**	49.0**	45.1**
$P_4 \times P_6$	-22.0**	-41.0**	-21.1**	-4.3	45.8**	19.9**	10.3**	-1.1	-14.1**	-14.2**	28.9**	21.1**	132.2**	77.5**	85.0**	41.9**
$P_5 \times P_6$	-15.8**	-26.7**	-17.8**	-8.3*	13.0*	-9.9*	8.7**	1.6	-10.0*	-15.9**	4.7	2.9	87.0**	72.6**	17.8*	-10.3*

***and ** indicate significance at 0.05 and 0.01 probability levels, respectively.**

Table 3. Estimates of genetic variance components and their derived from a half diallel cross for studied traits in summer season of 2014.

Item	Genetic components					Derived parameters				
	D	H_1	H_2	F	E	$(H_1D)^{1/2}$	$H_2/4H_1$	h^2n	h^2b	KD/KR
Plant height	247.278**± 58.699	490.70**± 149.05	304.048*± 133.15	97.997± 143.440	1.605± 22.188	1.4086	0.1549	0.6839	0.9934	1.3273
Days to anthesis of female flower	42.947**± 3.888	87.710**± 9.874	66.443**± 8.821	36.307**± 9.503	1.481± 1.47	1.4290	0.1894	0.4354	0.9537	1.8400
Number of fruits/plant	3.528**± 1.071	11.338**± 2.718	7.757**± 2.4288	5.343*± 2.616	0.077± 0.4047	1.7925	0.1710	0.3045	0.9732	2.4625
Average fruit weight	36.331± 46.091	757.299**± 117.04	690.88**± 104.55	-28.032± 112.630	6.910**± 17.422	4.5655	0.2281	0.2668	0.9717	0.8441
Fruit length	0.406*± 0.1887	1.692**± 0.479	1.488**± 0.428	0.480± 0.461	0.074± 0.0713	2.0411	0.2199	0.1265	0.8539	1.8158
Fruit diameter	0.033± 0.0203	0.192**± 0.0516	0.162**± 0.0461	0.0342± 0.050	0.013**± 0.0077	2.4188	0.2113	0.2088	0.8080	1.5505
Early yield/plant	0.005± 0.0033	0.037**± 0.0085	0.031**± 0.0076	0.003± 0.008	0.0002± 0.0013	2.8222	0.2047	0.3500	0.9814	1.2535
Total yield/plant	0.031± 0.0162	0.256**± 0.041	0.206**± 0.0367	0.033± 0.039	0.0019± 0.0061	2.8538	0.2008	0.3102	0.9747	1.4630

***and ** indicate significance at 0.05 and 0.01 probability levels, respectively.**