

Heterosis, Heritability and Combining Abilities for some Earliness Traits in Squash (*Cucurbita pepo*, L.)

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ABSTRACT

This study was conducted at Kaha Research Farm of Vegetables Breeding Department, Horticultural Research Institute, (HRI), Agric. Res. Center (ARC), Giza, Egypt, during the period from 2008 to 2010. The study aimed to estimate heterosis versus the mid-parents and the better parent, general (GCA) and specific (SCA) combining ability variances, nature of gene action, heritability in both broad and narrow senses in some summer squash for economic earliness traits. These traits included number of first female flowering node (No.1stF.F.N); date of first male flower (D.1stM.F.); data of first female flower (D.1stF.F.); first picking date (1stP.D.) and early yield per plant (E.Y./P.kg.). Seven imported squash varieties, namely Eskandarani (P₁); Zucca Patisson custard white (P₂); All Green Bush (P₃); Courgette Orelia (P₄); Sakiz (P₅); Copi (P₆) and Gapla (P₇) were used as parental varieties in the present investigation. Diallel crosses (with reciprocals) were made between these parents to obtain 42 F_{1,1r} hybrids according to the complete diallel crosses mating design. All genotypes were evaluated in randomized complete-blocks designs with three replications. The results indicated that the parental varieties Courgette Orelia (P₄) and Gapla (P₇) seemed to be the best combiners for earliness traits such as number of first female flowering node (No.1stF.F.N); date of first male flower (D.1stM.F.); data of first female flower (D.1stF.F.) and first picking date (1stP.D.). The parents Zucca Patisson custard white (P₂) and Copi (P₆) were the best combiners for early yield per plant (E.Y./P.kg.). In general, the performances of most F_{1,1r} hybrids were variable and the results cleared that no hybrid was the best all for earliness traits. The results showed the importance of general (GCA) and specific (SCA) combining abilities. GCA was larger than their corresponding estimates of SCA for most earliness traits. Reciprocal effects (r) were significant for most earliness traits. In the same time, the estimates of heritability in broad sense were larger in magnitudes than their corresponding estimates of narrow sense.

Keywords: squash, earliness, heterosis, combining abilities and heritability.

INTRODUCTION

Cucurbitaceae is one of the most important botanical families for human use as favorable vegetable crop. Thus, summer squash (*Cucurbita pepo*, L.) is considered to be one of the most popular vegetable crops grown in

Egypt. It is known as a vegetable marrow and is also called Kosa by the Egyptian. In Egypt, there are only two local cultivars of squash i.e. Balady, which is lately discarded for its prostrate growth habit and low yield and Eskandarani, which is high yielding and satisfies both the producer and consumer.

In squash and other cucurbits, F₁ hybrids were utilized aiming to increase both the productivity and earliness of traits. Many investigators studied heterosis among them; El-Adl *et al.*, (1988) who evaluated F₁ hybrids and their parents. They found that number of node to the first female flower expressed heterosis values of -1.66 and 12.48% versus the mid-parents and the better parent, respectively.

Similarly, Abd El-Maksoud *et al.*, (2003) showed that the average means of the F₁ hybrids, F_{1r} (reciprocal) hybrids and the average over all hybrids (F_{1,1r}) exceeded their mid-parents (H_{M.P.}%) for all studied traits except for sex ratio and days to first female flower. In another study by Abd El-Hadi *et al.*, (2005) they evaluated 12 F₁ hybrids obtained from four varieties of summer squash. They reported that the estimated amounts of heterosis showed highly significant values for flowering traits. Al-Ballat (2008) found that heterosis over the mid-parents was highly significant with negative values for number of days to first female flower and number of nodes to first female flower. Jahan *et al.*, (2012) found, in sweet gourd that node number of first female flower in the two hybrids, OP 10×OP 24 and OP 10×OP 20 recorded the highest significant positive heterosis from the mid and better parent. Tamil *et al.*, (2012) evaluated 15 pumpkin genotypes collected from various sources. Important heterosis values were recorded for days to first female flower appearance, node number for first female flower appearance, sex ratio, days to first harvest.

Concerning, GCA and SCA variances in cucumber, Abd El-Hafez *et al.*, (1997) evaluated a 5 × 5 diallel analysis to determine combining ability for some earliness traits. They reported significant positive values of SCA effects in some crosses which produced earlier flowers. El-Gendy (1999) reported that general combining ability and specific combining ability as well as reciprocal effects were significant for days to first

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female flower; numbers of fruits in the first seven pickings. In summer squash, El-Sharkawy (2000) regarded that a parental inbred line L_2 could be considered as a good general combiner for harvesting early yield. The results also indicated that the two crosses ($L_2 \times L_6$) and ($L_2 \times L_5$) gave the earlier F_1 hybrids and these crosses possessed the highest estimates of SCA effects. In squash, Sadek (2003) illustrated that the non-additive genetic variances including dominance were the most important source of genetic variance. The results showed that both additive and non-additive genetic variances contributed in the inheritance of position of the first female flower; days to the first female flower and early yield as number and weight of fruits. Obiadalla-Ali (2006), who worked in squash and recorded data for days to first female flower and sex ratio estimated as number of female flowers/number of total flowers. The magnitude of additive genetic variance ($\sigma^2 A$) were positive and lower than those of non additive ($\sigma^2 D$) one for both traits, indicating that non additive gene action played a major role in the inheritance of both traits. Al-Araby, (2010) estimated GCA effects and indicated that the parent E-4 was the best combiner for number of days to first female flower opening; number of days to female flowering; number of nodes to first female flower and number of female flowers/plant. It also was good combiner for early number and weight of fruits/plot. Recently, Sanin *et al.*, (2014) studied the predominance of additive gene action over the dominance type for the traits under study suggests that a recurrent selection program could serve as a strategy to increase the frequencies of genes that promote the expression of traits associated with seed production and starch content in butternut squash.

Zuradzka (1988) estimated heritability for number of female flowers in cucumber, using parental varieties, F_1 hybrids, F_2 generations and their two backcrosses for various unspecified crosses. The obtained results which showed that heritability estimates ranged from 0.38 to 0.77 in broad sense for this trait. Abd El-Hadi and El-Gendy (2004) studied four squash varieties and their 12 $F_{1,1r}$ hybrids. The results indicated that the magnitudes of heritability in broad sense (h^2_b %) were always larger than their corresponding estimates in narrow sense (h^2_n %) for all studied traits. Mishra *et al.*, (2007) who worked on cucumber, stated that minimum value of heritability was observed for number of days to first female flowering.

MATERIALS AND METHODS

The genetic materials used in the present investigation included seven squash varieties belong to the species (*Cucurbita pepo*, L.). These parental varieties were: Eskandarani (P_1); Zucca Patisson custard

white (P_2); All Green Bush (P_3); Courgette Orelia (P_4); Sakiz (P_5); Copi (P_6) and Gapla (P_7). The seeds of these parental varieties were obtained from different countries: (P_1) and (P_6) from Egypt; (P_2) from France; (P_3) from United Kingdom (U.K.); (P_4) from Germany; (P_5) from Turkey and (P_7) from Syria. The seven varieties were chosen to represent a wide range of variation in most characters.

Plants from each parental variety were self-pollinated for three successive generations to obtain inbreds from each variety. In the summer season of 2009, all single crosses including reciprocals were made among these seven varieties according to a complete diallel crosses mating design to produce 21 F_1 hybrids and their 21 F_{1r} (reciprocal) hybrids. In addition, the seven parental varieties were also self-pollinated to obtain enough seeds from each variety. All 49 genotypes (seven parents, 21 F_1 's and 21 F_{1r} reciprocals) were evaluated in a field trial in the growing summer season of 2010 at Kaha Vegetables Research Station, Kaha, Kalubia, Egypt.

The experimental design was a Randomized Complete Blocks Design (RCBD) with three replications. Data were recorded for five earliness traits. These traits were: number of first female flowering node (No.1stF.F.N.); date of first male flower (D.1stM.F.); date of first female flower (D.1stF.F.); first picking date (1stP.D.) and early yield per plant (E.Y./P.kg.).

Differences among genotypic means for all earliness traits were tested for significance according to the F-test. The form of analysis of variance and the expectations of mean squares were as outlined by Steel and Torrie (1960).

The amounts of heterosis were determined as the percentage deviation from the means of the F_1 hybrids (F_1), F_{1r} reciprocal hybrids (F_{1r}) and over all $F_{1,1r}$ hybrids from the average of all parents (mid-parents) or the better parent.

In this investigation, seven parental varieties were utilized in a complete diallel crosses mating design to estimate general combining ability (GCA) and specific combining ability (SCA). In addition, the variances of reciprocal effect (r) could be also obtained. The procedures of this analysis were described by Griffing (1956) method I. The estimates of GCA variance (δ^2_g) and SCA variance (δ^2_s) could be expressed in terms of genetic variances according to Matzingar & Kempthorne (1956) and Cockerham (1963).

RESULTS AND DISCUSSIONS

Squash varieties possess a wide range of variation for earliness traits. Vegetable breeders usually use this

variability as a tool to improve squash varieties through selection programs or to produce F_1 hybrids to make use of hybrid vigor phenomena and to obtain early yielding hybrids.

1. Analysis of variance:-

The analysis of variance and the mean squares for earliness traits for all genotypes were made and the results are presented in Table 1.

The mean squares of genotypes for the five earliness traits; number of first female flowering node (No.1stF.F.N.); date of first male flower (D.1stM.F.); date of first female flower (D.1stF.F.); first picking date (1stP.D.) and early yield per plant (E.Y./P.kg.) were highly significant. Therefore, this result reflected the presence of real difference among them. This finding was true for all other studies. The significance of mean squares of genotypes suggested that the planned comparisons to understanding the nature of variation and the determination of the amount of heterosis for these traits were valid and therefore, could be made. Similar results were obtained by El-Sharkawy (2000); Al-Ballat (2008); Al-Araby, (2010); Jahan *et al.*, (2012); Tamil *et al.*, (2012) and Sanin *et al.*, (2014).

2. The mean performance of all genotypes:

The mean performances of parental varieties and their F_1 hybrids including reciprocals for earliness traits are presented in Tables 2, 3 and 4.

The means of the seven parental varieties showed that the lowest parent is P_4 for earliness trait No.1stF.F.N. (desirable). While, the highest parent for all studied earliness traits was P_6 (undesirable) except E.Y./P.kg. (desirable). On the other hand, the parental variety P_7 was the lowest parent for D.1stM.F.; D.1stF.F. and 1stP.D., respectively (desirable). The results

revealed that the E.Y./P.kg. ranged from 0.841 to 1.175 kg/Plant for P_3 and P_6 parental varieties, respectively.

The results indicated that parental variety P_7 started to flower earlier than the other studied varieties. This finding would be confirmed by the means of days to first male flower (D.1stM.F.) 35.13 days; the days of first female flower (D.1stF.F.), 32.83 days and first picking date (1stP.D.) 34.93 days. Furthermore, the results indicated that P_6 was a very late variety. It is also regarded from the results that the parental variety P_7 was the earlier parent (desirable) and has the lowest parent for 1stP.D.

In addition, the earlier F_1 hybrids and F_{1r} (reciprocal) hybrids were obtained when the hybridization included any one of the earlier parental variety or both the two varieties P_7 and P_4 with respect to all the studied earliness traits. For instance, the hybrid $P_3 \times P_4$ exhibited the lowest mean value (desirable) for nodes to the first female flower (No.1stF.F.N.), but the hybrid $P_1 \times P_6$ exhibited the highest mean value (undesirable) for nodes to the first female flower (No.1stF.F.N.). On the other hand, the F_{1r} (reciprocal) hybrid $P_7 \times P_4$ was the lowest (desirable) and the hybrid $P_6 \times P_1$ was the highest (undesirable) for the same trait.

The results indicated that the highest (undesirable) F_1 hybrid for D.1stF.F. was $P_1 \times P_6$ with the mean value of 34.07 days. Whereas, the highest F_{1r} (reciprocal) hybrid for D.1stF.F. was $P_6 \times P_2$ with the mean value of 34.93 days. On the other hand, the F_1 hybrid $P_2 \times P_4$ was the lowest (desirable) with the mean value of 26.87 days. While, F_{1r} (reciprocal) hybrid $P_7 \times P_4$ was the lowest (desirable) with the mean value 26.37 of days for the same trait.

Table 1. Analysis of variance and expectation of mean squares for earliness traits

S.O.V.	d.f	Earliness traits				
		No.1 st F.F.N.	D.1 st M.F.	D.1 st F.F.	1 st P.D.	E.Y./P.kg.
Reps	2	0.012	6.740**	0.005	0.149	0.002
Genotypes	48	1.278 **	14.486**	40.086**	39.048**	0.387**
Error	96	0.245	0.800	0.626	0.631	0.003

*, ** Significant at 0.05 and 0.01 levels of probability, respectively.

Table 2. The mean performances of the seven parental varieties for earliness traits

No.	Parental varieties	Earliness traits				
		No.1 st F.F.N.	D.1 st M.F.	D.1 st F.F.	1 st P.D.	E.Y./P.kg.
1	P_1	5.37	39.93	41.23	43.37	1.056
2	P_2	5.43	39.63	38.07	40.87	1.139
3	P_3	4.91	38.07	36.17	38.27	0.841 ^L
4	P_4	4.11 ^L	36.17	34.87	36.87	0.885
5	P_5	4.93	37.13	35.23	37.33	1.031
6	P_6	6.09 ^H	43.33 ^H	44.17 ^H	46.07 ^H	1.175 ^H
7	P_7	4.41	35.13 ^L	32.83 ^L	34.93 ^L	1.044
L.S.D. _{0.05}		0.80	1.44	1.27	1.28	0.08
L.S.D. _{0.01}		1.05	1.91	1.69	1.69	0.11

H= The highest value

L= The lowest value

Table 3. The mean performances of the 21 F₁ hybrids for earliness traits

No	F ₁ hybrids	Earliness traits				
		No.1 st F.F.N.	D.1 st M.F.	D.1 st F.F.	1 st P.D.	E.Y./P.kg.
1	P ₁ × P ₂	4.02	32.27	28.07	31.17	1.797
2	P ₁ × P ₃	3.94	32.63	30.23	32.27	1.086
3	P ₁ × P ₄	3.18	30.67 ^L	27.67	29.83	1.104
4	P ₁ × P ₅	3.72	33.17	29.23	31.27	1.089
5	P ₁ × P ₆	4.81 ^H	35.77	34.07 ^H	36.23 ^H	1.904
6	P ₁ × P ₇	3.84	33.13	28.73	30.73	1.091
7	P ₂ × P ₃	4.24	34.67	29.03	31.67	1.919
8	P ₂ × P ₄	3.51	32.23	26.87 ^L	29.77	1.587
9	P ₂ × P ₅	3.93	33.93	27.73	30.77	1.689
10	P ₂ × P ₆	4.18	34.97	32.77	35.67	2.053 ^H
11	P ₂ × P ₇	3.39	33.67	28.87	31.77	1.542
12	P ₃ × P ₄	3.12 ^L	32.87	28.97	30.87	1.051 ^L
13	P ₃ × P ₅	3.77	34.23	29.57	31.83	1.113
14	P ₃ × P ₆	4.09	35.93	31.93	34.13	1.776
15	P ₃ × P ₇	3.34	34.73	29.13	30.83	1.126
16	P ₄ × P ₅	3.28	33.63	30.83	32.93	1.131
17	P ₄ × P ₆	3.59	35.73	31.73	34.07	1.218
18	P ₄ × P ₇	3.49	34.93	26.93	28.73 ^L	1.074
19	P ₅ × P ₆	4.58	36.23 ^H	33.93	36.17	1.389
20	P ₅ × P ₇	3.99	34.47	31.67	33.77	1.068
21	P ₆ × P ₇	4.39	32.83	31.27	33.37	1.338
L.S.D. _{0.05}		0.80	1.44	1.27	1.28	0.08
L.S.D. _{0.01}		1.05	1.91	1.69	1.69	0.11

H= The highest value

L= The lowest value

Table 4. The mean performances of the F_{1r} hybrids for earliness traits

No	F _{1r} hybrids	Earliness traits				
		No.1 st F.F.N.	D.1 st M.F.	D.1 st F.F.	1 st P.D.	E.Y./P.kg.
22	P ₂ × P ₁	3.78	34.57	29.83	32.83	1.734
23	P ₃ × P ₁	3.32	34.87	31.77	33.87	1.142
24	P ₃ × P ₂	4.23	33.57	28.77	31.93	1.875
25	P ₄ × P ₁	3.69	33.23	27.77	29.97	1.122
26	P ₄ × P ₂	3.43	34.13	28.17	31.37	1.644
27	P ₄ × P ₃	3.27	34.83	27.37	29.33	1.047 ^L
28	P ₅ × P ₁	3.97	33.87	28.83	31.13	1.119
29	P ₅ × P ₂	4.19	35.07	30.77	33.97	1.932
30	P ₅ × P ₃	3.16	34.77	28.67	31.07	1.161
31	P ₅ × P ₄	3.79	34.33	29.07	31.23	1.136
32	P ₆ × P ₁	4.89 ^H	36.13	34.67	36.93	1.731
33	P ₆ × P ₂	4.82	36.73 ^H	34.93 ^H	37.83 ^H	1.896
34	P ₆ × P ₃	4.31	36.27	33.17	35.27	1.356
35	P ₆ × P ₄	3.66	35.23	31.87	33.83	1.947
36	P ₆ × P ₅	4.71	35.63	34.33	36.27	1.228
37	P ₇ × P ₁	3.68	32.77	29.37	31.47	1.083
38	P ₇ × P ₂	4.04	34.17	27.87	30.67	2.031 ^H
39	P ₇ × P ₃	3.91	33.07	29.17	31.33	1.071
40	P ₇ × P ₄	3.06 ^L	31.97 ^L	26.37 ^L	28.17 ^L	1.059
41	P ₇ × P ₅	3.88	32.93	29.67	31.87	1.149
42	P ₇ × P ₆	4.12	33.77	31.43	33.33	1.839
L.S.D. _{0.05}		0.80	1.44	1.27	1.28	0.08
L.S.D. _{0.01}		1.05	1.91	1.69	1.69	0.11

H= The highest value

L= The lowest value

3. Heterosis:-

3.1. Heterosis versus the mid-parents ($H_{M.P.}$):-

Heterosis versus the mid-parents ($H_{M.P.}$) was estimated for earliness traits and the results are presented in Tables 5 and 6.

The heterosis percentage of the 42 $F_{1, 1r}$ hybrids relative to mid-parents for earliness traits. All $F_{1, 1r}$ hybrids showed highly significant and (desirable) negative heterotic values for No.1stF.F.N; D.1stM.F; D.1stF.F. and 1stP.D. toward earliness.

The results showed that heterosis percentages relative to mid-parents were found to range from -50.21 to -14.49% for No.1stF.F.N.; -19.28 to -2.11% for D.1stM.F; -29.10 to -6.67% for D.1stF.F; -26.00 to -6.55% for 1stP.D. and 2.99 to 79.9% for E.Y./P.kg. for F_1 hybrids. While, the values ranged for from -36.60 to -14.83%; -13.04 to -5.97%; -26.99 to -12.83%; -25.44 to -11.81% and 3.13 to 93.3% for No.1stF.F.N.; D.1stM.F.;

D.1stF.F.; 1stP.D and E.Y./P.kg., respectively F_{1r} (reciprocal) hybrids.

On the other hand, 18 F_1 and 19 F_{1r} hybrids out of 21 F_1 and 21 F_{1r} hybrids showed highly significant and positive (desirable) values for mid-parents heterosis estimates for E.Y./P.kg., respectively.

Concerning earliness traits for heterosis versus the mid-parents all the 21 F_1 hybrids had negative and highly significant (desirable) values for most studied earliness traits except the F_1 hybrid $P_5 \times P_7$ which showed insignificant values for E.Y./P.kg. In the same time all the 21 F_{1r} hybrids showed highly significant and negative (desirable) estimates for most studied earliness traits.

These results were in agreement with the results obtained by El-Adl *et al.*, (1988); Abd El-Maksoud *et al.*, (2003); Abd El-Hadi *et al.*, (2005); Obiadalla-Ali (2006); Al-Ballat (2008); Al-Araby (2010); Jahan *et al.*, (2012) and Tamil, *et al.*, (2012).

Table 5. Heterosis versus the mid-parents of the F_1 hybrids for earliness traits

No.	F_1 hybrids	Earliness traits				
		No.1 st F.F.N.	D.1 st M.F.	D.1 st F.F.	1 st P.D.	E.Y./P.kg.
1	$P_1 \times P_2$	-28.61**	-18.83**	-29.10** ^L	-26.00** ^L	66.7**
2	$P_1 \times P_3$	-50.21** ^L	-16.29**	-21.84**	-20.87**	14.5**
3	$P_1 \times P_4$	-32.37**	-19.28** ^L	-27.08**	-25.44**	13.8**
4	$P_1 \times P_5$	-27.87**	-13.77**	-23.51**	-22.48**	4.43
5	$P_1 \times P_6$	-14.96**	-13.94**	-20.19**	-18.94**	70.7**
6	$P_1 \times P_7$	-22.34**	-11.61**	-22.38**	-21.29**	3.79
7	$P_2 \times P_3$	-23.08**	-10.39**	-21.69**	-20.03**	97.9** ^H
8	$P_2 \times P_4$	-30.64**	-14.91**	-26.23**	-23.45**	59.9**
9	$P_2 \times P_5$	-28.40**	-11.60**	-24.33**	-21.26**	58.6**
10	$P_2 \times P_6$	-31.11**	-15.96**	-20.23**	-17.90**	80.5**
11	$P_2 \times P_7$	-34.84**	-11.25**	-18.48**	-16.22**	43.8**
12	$P_3 \times P_4$	-31.06**	-11.45**	-18.16**	-17.78**	21.7**
13	$P_3 \times P_5$	-23.02**	-9.27**	-16.90**	-15.82**	19.1**
14	$P_3 \times P_6$	-25.99**	-11.76**	-20.50**	-19.08**	76.3**
15	$P_3 \times P_7$	-29.24**	-5.01**	-15.65**	-15.79**	19.5**
16	$P_4 \times P_5$	-27.76**	-7.55**	-12.03**	-11.32**	18.1**
17	$P_4 \times P_6$	-29.10**	-10.07**	-19.70**	-17.85**	18.3**
18	$P_4 \times P_7$	-16.47*	-2.11 ^H	-20.43**	-19.96**	11.3**
19	$P_5 \times P_6$	-16.56**	-10.12**	-14.53**	-13.27**	25.5**
20	$P_5 \times P_7$	-14.49** ^H	-4.48**	-6.76** ^H	-6.55** ^H	2.99 ^L
21	$P_6 \times P_7$	-16.67**	-16.21**	-18.79**	-17.53**	20.6**
L.S.D. _{0.05}		0.60	1.09	0.96	0.97	0.06
L.S.D. _{0.01}		0.79	1.44	1.27	1.27	0.08

* ** Significant and highly significant at 0.05 and 0.01 probability levels, respectively.

H= The highest value

L= The lowest value

Table 6. Heterosis versus the mid-parents of the F_{1r} hybrids for earliness traits

No.	F_{1r} hybrids	Earliness traits				
		No.1 st F.F.N.	D.1 st M.F.	D.1 st F.F.	1 st P.D.	E.Y./P.kg.
22	$P_2 \times P_1$	-33.92**	-13.04** ^L	-24.73**	-22.04**	60.8**
23	$P_3 \times P_1$	-36.60** ^L	-10.56**	-17.97**	-16.95**	16.5**
24	$P_3 \times P_2$	-23.08**	-12.27**	-22.50**	-19.36**	93.3** ^H
25	$P_4 \times P_1$	-21.58**	-12.71**	-26.99** ^L	-25.44** ^L	15.6**
26	$P_4 \times P_2$	-31.99**	-9.99**	-22.76**	-19.33**	65.6**
27	$P_4 \times P_3$	-26.52**	-5.97** ^H	-22.95**	-21.95**	21.4**
28	$P_5 \times P_1$	-21.97**	-12.03**	-24.47**	-22.81**	7.30**
29	$P_5 \times P_2$	-23.46**	-8.56**	-15.87**	-13.34**	81.4**
30	$P_5 \times P_3$	-35.40**	-7.49**	-19.51**	-17.85**	24.2**
31	$P_5 \times P_4$	-14.83** ^H	-6.82**	-16.79**	-15.72**	18.1**
32	$P_6 \times P_1$	-14.96**	-13.14**	-18.70**	-17.45**	55.2**
33	$P_6 \times P_2$	-20.56**	-11.46**	-15.04**	-13.07**	66.7**
34	$P_6 \times P_3$	-21.71**	-10.77**	-17.43**	-16.40**	34.6**
35	$P_6 \times P_4$	-27.76**	-11.41**	-19.27**	-18.41**	89.1**
36	$P_6 \times P_5$	-14.11*	-11.36**	-13.60**	-13.19**	10.5**
37	$P_7 \times P_1$	-25.09**	-12.41**	-20.67**	-19.59**	3.13 ^L
38	$P_7 \times P_2$	-23.87**	-8.66**	-21.39**	-18.59**	89.4**
39	$P_7 \times P_3$	-16.25*	-9.30**	-15.46**	-14.52**	13.5**
40	$P_7 \times P_4$	-26.91**	-9.97**	-22.11**	-21.54**	9.78
41	$P_7 \times P_5$	-16.67*	-8.73**	-12.83** ^H	-11.81** ^H	10.8**
42	$P_7 \times P_6$	-21.79**	-13.82**	-18.35**	-17.70**	65.8**
L.S.D. _{0.05}		0.60	1.09	0.96	0.97	0.06
L.S.D. _{0.01}		0.79	1.44	1.27	1.27	0.08

** Significant and highly significant at 0.05 and 0.01 probability levels, respectively.

H= The highest value

L= The lowest value

3.2. Heterosis versus the better parent ($H_{B.P.}$):-

Data presented in Tables 7 and 8 gave the heterosis percentage of the 42 $F_{1,1r}$ hybrids relative to the better parent ($H_{B.P.}$ %) for earliness traits. Most hybrids showed highly significant and desirable negative heterotic values for D.1stF.F. and 1stP.D. At the same time, most hybrids showed not significant and desirable negative heterotic values for No.1stF.F.N.

The results showed that heterosis percentages relative to better parent ($H_{B.P.}$ %) were found to range from -30.73 to -0.76% for No.1stF.F.N.; -18.52 to -0.57% for D.1stM.F.; -26.18 to -3.35% for D.1stF.F.; -23.80 to -3.13% and 2.27 to 74.74% for E.Y./P.kg. for F_1 hybrids. While, the values ranged from -35.40 to -3.45%; -12.71 to -2.67%; -21.63 to -2.65%; -20.43 to -3.04% and 1.40 to 84.58% for No.1stF.F.N.; D.1stM.F.; D.1stF.F.; 1stP.D. and E.Y./P.kg., respectively for F_{1r} (reciprocal) hybrids.

In general, 4, 16, 18 and 18 F_1 hybrids out of the 21 F_1 hybrids showed highly significant negative ($H_{B.P.}$ %) (desirable) values for No.1stF.F.N.; D.1stM.F.; D.1stF.F.; 1stP.D., respectively. In the same time, 4, 14, 19 and 19 F_{1r} hybrids out of the 21 F_{1r} hybrids showed similar results for the same traits, respectively.

For E.Y./P.kg., 11 and 12 out of the 21 F_1 hybrids and 21 F_{1r} hybrids showed positive and highly significant ($H_{B.P.}$ %) (desirable) estimates, respectively.

Similar results were obtained by El-Adl *et al.*, (1988); Abd El-Hadi and El-Gendy (2004); Abd El-Hadi *et al.*, (2005); Obiadalla-Ali (2006); Al-Ballat (2008); Al-Araby (2010); Jahan *et al.*, (2012) and Tamil *et al.*, (2012).

4. Analysis of combining ability variances:

The variance for combining ability of seven varieties and their 42 $F_{1,1r}$ hybrids for earliness traits are shown in Table 9. The results revealed that the mean squares due to crosses were highly significant for all studied traits except for No.1stF.F.N.

The values of GCA mean squares were higher than those of SCA means for all studied traits. It means that additive genetic variance was more important in the inheritance of these earliness traits, while the reciprocal effect variance were highly significant for E.Y./P.kg. Similar results were obtained by Abd El-Hafez *et al.*, (1997); El-Sharkawy (2000); Obiadalla-Ali (2006); Al-Ballat (2008); Al-Araby, (2010) and Sanin *et al.*, (2014)

Table 7. Heterosis versus the better parent of F₁ the 21 hybrids for earliness traits

No.	F ₁ hybrids	Earliness traits				
		No.1 st F.F.N.	D.1 st M.F.	D.1 st F.F.	1 st P.D.	E.Y./P.kg.
1	P ₁ × P ₂	-24.38**	-18.52** ^L	-26.18** ^L	-23.80** ^L	63.31**
2	P ₁ × P ₃	-20.55*	-14.27**	-16.41**	-15.67**	2.81
3	P ₁ × P ₄	-20.34*	-15.12**	-20.46**	-18.90**	4.55
4	P ₁ × P ₅	-24.14**	-10.51**	-17.03**	-16.25**	3.13
5	P ₁ × P ₆	-9.38	-10.28**	-17.31**	-16.38**	62.06**
6	P ₁ × P ₇	-13.74	-5.51**	-12.49**	-11.83**	3.22
7	P ₂ × P ₃	-14.38	-8.58**	-19.63**	-17.32**	74.49**
8	P ₂ × P ₄	-12.71	-10.88**	-22.85**	-19.26**	44.23**
9	P ₂ × P ₅	-20.00*	-8.63**	-21.29**	-17.50**	53.50**
10	P ₂ × P ₆	-30.73** ^L	-12.04**	-13.84**	-12.71**	74.74** ^H
11	P ₂ × P ₇	-22.90*	-5.51**	-11.98**	-9.06**	40.14**
12	P ₃ × P ₄	-22.88*	-9.12**	-19.63**	-16.18**	18.64**
13	P ₃ × P ₅	-22.76*	-8.09**	-15.80**	-14.73**	8.09*
14	P ₃ × P ₆	-17.12*	-5.69**	-11.71**	-10.88**	51.19**
15	P ₃ × P ₇	-25.19**	-0.95	-11.37**	-19.50**	7.82*
16	P ₄ × P ₅	-19.49	-6.36**	-11.57**	-10.76**	9.84*
17	P ₄ × P ₆	-10.17	-1.20	-8.99**	-7.59**	3.69
18	P ₄ × P ₇	-11.86	-0.57 ^H	-17.97**	-17.75**	2.84
19	P ₅ × P ₆	-6.21	-2.61	-3.69*	-3.13 ^H	17.74**
20	P ₅ × P ₇	-18.62*	-1.71	-3.35 ^H	-3.34	2.27 ^L
21	P ₆ × P ₇	-0.76 ^H	-6.37**	-4.77*	-4.39*	13.90**
L.S.D. _{0.05}		0.80	1.44	1.27	1.28	0.08
L.S.D. _{0.01}		1.05	1.91	1.69	1.69	0.11

*,** Significant and highly significant at 0.05 and 0.01 probability levels, respectively.

H= The highest value

L= The lowest value

Table 8. Heterosis versus the better parent of F₁, the 21 hybrids for earliness traits

No.	F ₁ hybrids	Earliness traits				
		No.1 st F.F.N.	D.1 st M.F.	D.1 st F.F.	1 st P.D.	E.Y./P.Kg.
22	P ₂ × P ₁	-30.00**	-12.71** ^L	-21.63** ^L	-19.72**	57.59**
23	P ₃ × P ₁	-33.56**	-8.41**	-12.26**	-11.49**	4.55
24	P ₃ × P ₂	-14.38	-10.51**	-20.46**	-16.62**	70.40**
25	P ₄ × P ₁	-7.63	-8.20**	-20.36**	-18.90**	6.25
26	P ₄ × P ₂	-14.41	-5.71**	-19.22**	-14.92**	49.41**
27	P ₄ × P ₃	-17.80	-3.50	-21.51**	-20.43** ^L	18.31**
28	P ₅ × P ₁	-17.93	-8.72**	-18.07**	-16.61**	5.97
29	P ₅ × P ₂	-14.48	-5.48**	-12.49**	-9.20**	75.58**
30	P ₅ × P ₃	-35.40** ^L	-6.29**	-18.45**	-16.79**	12.72**
31	P ₅ × P ₄	-5.08	-5.62**	-16.35**	-15.19**	9.84*
32	P ₆ × P ₁	-9.38	-9.44**	-15.78**	-14.85**	47.36**
33	P ₆ × P ₂	-20.11**	-7.32**	-8.23**	-7.58**	61.41**
34	P ₆ × P ₃	-12.33	-4.64	-8.29**	-7.92**	15.44**
35	P ₆ × P ₄	-8.47	-2.67 ^H	-8.51**	-8.23**	65.75**
36	P ₆ × P ₅	-3.45 ^H	-3.95	-2.65 ^H	-3.04 ^H	3.69
37	P ₇ × P ₁	-16.79	-6.37**	-10.56**	-9.92**	2.56
38	P ₇ × P ₂	-9.92	-2.76	-15.13**	-11.64**	84.58** ^H
39	P ₇ × P ₃	-11.45	-5.42*	-11.17**	-10.40**	2.43
40	P ₇ × P ₄	-22.88*	-8.56**	-19.70**	-19.37**	1.40 ^L
41	P ₇ × P ₅	-12.21	-6.08**	-9.64**	-8.78**	10.02*
42	P ₇ × P ₆	-6.87	-3.71	-4.26*	-4.58*	56.56**
L.S.D. _{0.05}		0.80	1.44	1.27	1.28	0.08
L.S.D. _{0.01}		1.05	1.91	1.69	1.69	0.11

*,** Significant and highly significant at 0.05 and 0.01 probability levels, respectively.

H= The highest value

L= The lowest value

Table 9. Analysis of combining abilities and mean squares of all F₁ hybrids (F_{1,1r} hybrids) for earliness traits

S.V.	d.f.	Earliness traits				
		No.1 st F.F.N.	D.1 st M.F.	D.1 st F.F.	1 st P.D.	E.Y./P.kg.
Reps.	2	0.002	0.149	0.005	6.740**	0.012
Crosses	41	0.274	3.913**	9.870**	9.568**	0.140**
G.C.A.	6	1.536**	10.825**	39.307**	39.887**	0.891**
S.C.A.	14	0.463**	6.364**	18.282**	17.759**	0.203**
R.E.	21	0.072	1.278	0.989	0.923	0.071**
Error	82	0.245	0.8	0.626	0.631	0.003
G.C.A./S.C.A.	-	0.423	0.129	0.156	0.164	0.317

*,** Significant at 0.05 and 0.01 levels of probability, respectively

5. Genetic parameters and heritability:

The relative magnitudes of genetic parameters and heritability for earliness traits were estimated and the obtained results are shown in Table 10.

It appeared that, both additive (δ^2A), non-additive genetic variances including dominance (δ^2D) genetic variance were contributed in the inheritance of number of first female flowering node (No.1stF.F.N.); date of first male flower (D.1stM.F.); data of first female flower (D.1stF.F.); first picking date (1stP.D.) and early yield per plant (E.Y./P.kg.).

The dominance (δ^2D) genetic variance was larger than their corresponding values of additive genetic variance (δ^2A) for No.1stF.F.N trait. This suggests that dominance genetic variance played the major role in the genetic expression of this trait. Although, the magnitudes of δ^2A , were also smaller than δ^2D for D.1stM.F.; D.1stF.F.; 1stP.D. and E.Y./P.kg. This suggests that additive genetic variance played was presented role in the genetic expression of these traits. Furthermore, the reciprocal effect variances (δ^2r) were positive for all studied earliness traits except No.1stF.F.N trait, indicating that cytoplasmic factor played an important role in the expression of these traits in addition to nuclear genes.

Also, the estimates of heritability in broad sense (h^2_b %) were larger than their corresponding estimates in narrow sense (h^2_n %) for all studied earliness traits. These values were 57.242; 85.237; 95.975; 95.851 and 98.863% in broad sense and 34.554; 19.486; 26.988; 27.600 and 40.909% in narrow sense for No.1stF.F.N.; D.1stM.F.; D.1stF.F.; 1stP.D. and E.Y./P.kg., respectively.

In this respect, many authors, such as Abd El-Hadi and El-Gendy (2004); Mishra *et al.* (2007); Al-Ballat (2008); Al-Araby, (2010) and Sanin *et al.*, (2014) reported that both additive and non-additive genetic variances contributed in the inheritance of earliness traits.

6. General combining ability effects (g_i) for the parents:

The general combining ability effects (g_i) of the seven parental varieties for earliness traits are shown in Table 11.

The results revealed that the GCA effects (g_i) showed desirable negative and highly significant values to the parental variety P₄ for No.1stF.F.N.; D.1stM.F.; D.1stF.F. and 1stP.D. The results revealed that the GCA effects (g_i) showed desirable negative and highly significant values to the parent P₇ for D.1stM.F.; D.1stF.F. and 1stP.D. Meanwhile, the GCA effects were found to be highly significant and positive (undesirable) for the parent P₆ for all earliness traits except for E.Y./P.kg. which was desirable.

These results indicated that the parents P₄ and P₇ seemed to be the best combiners for earliness traits No.1stF.F.N.; D.1stM.F.; D.1stF.F. and 1stP.D. The two parents No.P₂ and P₆ were the best combiners for E.Y./P.kg. Similar results were obtained by El-Sharkawy (2000); Al-Ballat (2008); Al-Araby, (2010) and Sanin *et al.*, (2014).

7. Specific combining ability effects (s_{ij}):

Estimates of specific combining ability effects (s_{ij}) of the 42 F_{1,1r} hybrids for earliness traits are presented in Tables 12 and 13.

The F₁ hybrids P₃ × P₅ and P₄ × P₆ did not show significant negative (desirable) SCA effects for No.1stF.F.N. While, the F_{1r} (reciprocal) hybrids P₆ × P₂ and P₇ × P₂ show did not significant negative (desirable) SCA effects for the same trait. At the same time, the F_{1r} (reciprocal) hybrid P₇ × P₂ gave the highest negative value (-0.321) for the same trait.

For D.1stM.F. the F₁ hybrids P₁ × P₄ and P₆ × P₇ gave the highest desirable negative value (-0.321), while, the F_{1r} (reciprocal) hybrid P₄ × P₁ gave the highest negative value (-1.667) for the same trait.

Table 10. The relative magnitudes of different genetic parameters and heritability for earliness traits

Genetic parameters and heritability	Earliness traits				
	No.1 st F.F.N.	D.1 st M.F.	D.1 st F.F.	1 st P.D.	E.Y./P.kg.
$\delta^2 A$	0.198	1.056	4.068	4.198	0.108
$\delta^2 D$	0.130	3.324	10.550	10.235	0.119
$\delta^2 r$	-0.086	0.239	0.181	0.146	0.034
$\delta^2 E$	0.245	0.800	0.626	0.631	0.003
$h^2b\%$	57.242	85.237	95.975	95.851	98.863
$h^2n\%$	34.554	19.486	26.988	27.600	40.909

Note: Negative values were considered equal to zero during the calculation of heritability in broad and narrow senses

Table 11. General combining ability effects (gi) of the seven parents for earliness traits

Parents	Earliness traits				
	No.1 st F.F.N.	D.1 st M.F.	D.1 st F.F.	1 st P.D.	E.Y./P.kg.
P ₁	0.08	-0.299	0.418*	0.449*	-0.061**
P ₂	0.155	0.081	-0.415*	0.139	0.510**
P ₃	-0.136	0.153	-0.415*	-0.527**	-0.132**
P ₄	-0.509**	-0.727**	-1.556**	-1.693**	-0.132**
P ₅	0.026	0.010	-0.129	-0.074	-0.204**
P ₆	0.562**	1.748**	3.466**	3.329**	0.153**
P ₇	-0.179	-0.966**	-1.367**	-1.622**	-0.132**
L.S.D(gi) _{0.05}	0.242	0.438	0.387	0.389	0.026
L.S.D(gi) _{0.01}	0.319	0.577	0.510	0.513	0.035

*,**Significant and highly significant at 0.05 and 0.01 probability levels, respectively.

Table 12. Specific combining ability effects (s_{ij}) of the 21 F₁ hybrids for earliness traits

F ₁ hybrids	Earliness traits				
	No.1 st F.F.N.	D.1 st M.F.	D.1 st F.F.	1 st P.D.	E.Y./P.kg.
P ₁ × P ₂	-0.370	-1.224	-2.228**	-2.068**	0.204**
P ₁ × P ₃	-0.346	-0.796	-0.228	-0.235	-0.153**
P ₁ × P ₄	-0.164	-1.748*	-2.418**	-2.235**	-0.153**
P ₁ × P ₅	-0.294	-0.986	-2.347**	-2.687**	-0.081
P ₁ × P ₆	0.171	-0.224	-0.942	-0.759	0.561**
P ₁ × P ₇	-0.176	-0.510	-1.109	-1.139	-0.153**
P ₂ × P ₃	0.184	-1.010	-1.228	-1.425*	0.275**
P ₂ × P ₄	-0.206	-0.796	-1.585*	-1.425*	0.275**
P ₂ × P ₅	-0.156	-0.534	-1.347*	-1.044	0.346**
P ₂ × P ₆	-0.248	-0.772	-0.276	-0.449	-0.010
P ₂ × P ₇	-0.293	-0.058	-0.942	-0.997	0.275**
P ₃ × P ₄	-0.187	-0.367	-0.918	-1.092	-0.082
P ₃ × P ₅	-0.455	-0.272	-1.847**	-1.378*	-0.010
P ₃ × P ₆	-0.256	-0.510	-1.609*	-1.449*	0.132**
P ₃ × P ₇	-0.091	0.037	-0.109	-0.163	-0.081
P ₄ × P ₅	-0.017	-0.224	0.629	0.456	-0.010
P ₄ × P ₆	-0.459	-0.296	-1.299	-1.116	0.132**
P ₄ × P ₇	-0.066	0.418	-1.299	-1.663*	-0.081
P ₅ × P ₆	0.025	-0.534	-0.228	-0.568	-0.295**
P ₅ × P ₇	0.052	0.014	0.772	1.051	-0.010
P ₆ × P ₇	-0.163	-2.391**	-1.823**	-1.687*	0.132**
L.S.D.(s _{ij}) _{0.05}	0.840	1.517	1.342	1.348	0.092
L.S.D.(s _{ij}) _{0.01}	1.107	2.000	1.770	1.777	0.122

*,** Significant and highly significant at 0.05 and 0.01 probability levels, respectively.

Table 13. Specific combining ability effects (r_{ij}) of the 21 F_{1r} hybrids for earliness traits

F_{1r} hybrids	Earliness traits				
	No.1 st F.F.N.	D.1 st M.F.	D.1 st F.F.	1 st P.D.	E.Y./P.kg.
$P_2 \times P_1$	0.121	-1.00	-1.00	-0.833	0.001
$P_3 \times P_1$	0.306	-1.167	-0.667	-0.667	0.001
$P_3 \times P_2$	0.005	0.667	0.167	-0.167	0.001
$P_4 \times P_1$	-0.255	-1.667**	0.001	-0.167	0.001
$P_4 \times P_2$	0.041	-1.00	-0.667	-1.00	0.001
$P_4 \times P_3$	-0.075	-0.833	0.667	0.667	0.001
$P_5 \times P_1$	-0.121	-0.167	0.167	0.0001	0.001
$P_5 \times P_2$	-0.128	-0.667	-1.667**	-1.667**	0.001
$P_5 \times P_3$	0.303	-0.333	0.500	0.333	0.001
$P_5 \times P_4$	-0.255	-0.500	0.833	1.000	0.001
$P_6 \times P_1$	-0.040	-0.333	-0.167	-0.333	0.001
$P_6 \times P_2$	-0.318	-0.833	-1.333*	-1.00	0.001
$P_6 \times P_3$	-0.108	-0.167	-0.667	-0.667	0.500**
$P_6 \times P_4$	-0.031	0.167	-0.167	0.167	-0.500**
$P_6 \times P_5$	-0.066	0.333	0.001	0.001	0.001
$P_7 \times P_1$	0.080	0.001	-0.500	-0.333	0.001
$P_7 \times P_2$	-0.321	-0.167	0.500	0.500	0.001
$P_7 \times P_3$	-0.288	0.667	0.001	-0.333	0.001
$P_7 \times P_4$	0.216	1.833**	0.333	0.333	0.001
$P_7 \times P_5$	0.055	0.500	1.167*	1.000	0.001
$P_7 \times P_6$	0.135	-0.500	-0.167	0.001	-0.500**
L.S.D.(r_{ij}) _{0.05}	0.693	1.252	1.107	1.112	0.076
L.S.D.(r_{ij}) _{0.01}	0.913	1.650	1.460	1.466	0.101

*,** Significant and highly significant at 0.05 and 0.01 probability levels, respectively.

For D.1stF.F. the F_1 hybrids $P_1 \times P_4$ and $P_1 \times P_5$ gave the highest decimal negative (desirable) values -2.418 and -2.347, respectively. While, the F_{1r} (reciprocal) hybrid $P_5 \times P_2$ gave the highest negative value -1.667 for the same trait.

For 1stP.D. the F_1 hybrids $P_1 \times P_4$ and $P_1 \times P_5$ gave the highest negative (desirable) significant values -2.235 and -2.687, respectively. While, the F_{1r} (reciprocal) hybrid $P_5 \times P_2$ gave the highest negative significant value -1.667 for the same trait.

For E.Y./P.kg. the F_1 hybrids $P_1 \times P_6$ and $P_2 \times P_5$ gave the highest positive desirable significant values 0.561 and 0.346, respectively. While, the F_{1r} (reciprocal) hybrid $P_6 \times P_3$ gave the highest positive desirable highly significant value 0.500 for the same trait.

Similar results were obtained by Abd El-Hafez *et al.*, (1997); El-Sharkawy (2000); Abd El-Hadi *et al.*, (2005); Obiadalla-Ali (2006); Al-Ballat (2008); Al-Araby, (2010) and Sanin *et al.*, (2014).

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الملخص العربي

قوة الهجين ومعامل التوريث والقدرة على التآلف لبعض صفات التبكير في قرع الكوسة

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أظهرت النتائج أن Courgette Orelia (الأب الرابع) و Gapla (الأب السابع) يعتبران أفضل مصدر لصفات رقم أول عقدة تحمل زهرة مؤنثة، عدد الأيام حتى تفتح أول زهرة مذكرة، عدد الأيام حتى تفتح أول زهرة مؤنثة، عدد الأيام حتى أول جمعة، بينما كان Zucca Patisson custard white (الأب الثاني) و Copi (الأب السادس) أفضل مصدر لصفة المحصول المبكر (بالكيلوجرام) لكل نبات. أظهرت النتائج وجود اختلافات كبيرة بين هجن الجيل الأول والأول العكسي مع عدم تميز هجين معين بذاته لكل صفات التبكير المدروسة، ولكن معظم التراكيب الوراثية للجيل الأول الهجين تفوقت عن الآباء الداخلة في تكوينها، ولذا فإن كثير من الهجن قد فاقت الأب الأحسن في معظم الصفات محل الدراسة.

أظهرت النتائج تعاضم قيم كل من القدرة العامة على التآلف (GCA) والقدرة الخاصة على التآلف (SCA). وأوضحت النتائج أهمية القدرة العامة على التآلف لجميع صفات التبكير التي تمت دراستها للجيل الأول الهجين، بينما كانت قيمة تأثير التهجين العكسي معنوية لمعظم الصفات المدروسة. وكذلك تم تقدير معامل التوريث في مداه الواسع والضيق لجميع الصفات محل الدراسة وقيم معامل التوريث في مداه الواسع كانت أعلى منه في مداه الضيق لجميع الصفات محل الدراسة.

إجريت هذه الدراسة في مزرعة قها البحثية التابعة لقسم تربية الخضر بمعهد بحوث البساتين بمركز البحوث الزراعية بالجيزة بجمهورية مصر العربية في الفترة من ٢٠٠٨ إلى ٢٠١٠. تهدف الدراسة إلى تقدير قيم كل من قوة الهجين قياساً من متوسط الآباء وأفضل الآباء، والقدرة العامة والخاصة على التآلف وطبيعة فعل الجين، ومعامل التوريث في مداه الواسع والضيق لبعض صفات التبكير الهامة في قرع الكوسة مثل: رقم أول عقدة تحمل زهرة مؤنثة، عدد الأيام حتى تفتح أول زهرة مذكرة، عدد الأيام حتى تفتح أول زهرة مؤنثة، عدد الأيام حتى أول جمعة، المحصول المبكر (بالكيلوجرام) لكل نبات.

في هذه الدراسة تم استخدام سبعة أصناف من قرع الكوسة كآباء وهي: Eskandarani (الأب الأول)، Zucca Patisson custard white (الأب الثاني)، All Green (الأب الثالث)، Courgette Orelia (الأب الرابع)، Sakiz (الأب الخامس)، Copi (الأب السادس)، Gapla (الأب السابع).

تم التهجين الدوري الكامل في اتجاهين بين جميع الآباء المستخدمة في الدراسة ونتاج عنه ٤٢ هجيناً نصفها (٢١) هجن عكسية وتم تقييم جميع التراكيب الوراثية في تجربة ذات قطاعات كاملة العشوائية من ثلاث مكررات.