Heterosis in Relation to Combining Ability Variances in Eggplant (*Solanum melongena* L.)

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Abstract: This study was carried out at the Experimental Farm, Fac. of Environ. Agric. Sci., El Arish, Suez Canal Univ., Egypt, during three successive summer seasons (2009 to 2011). Seven elongated eggplant fruit lines were used in 7x7 half- diallel cross mating design to produce 21F_1 hybrids. In the two successive summer seasons of 2010 and 2011, all 28 genotypes were evaluated in a field experiment with check hybrid "Snow F_1". A randomized complete block design with three replicates was used in the two seasons of 2010 and 2011 to estimate heterosis relative to mid parents, better parent and check hybrid, also dominance type and its relation to combining ability variances were determine for some plant and fruit characters. The obtained results showed high significant differences among the parental lines and their 21F_1hybrids for all studied traits. Heterosis over mid-parents, better parent and check hybrid were recorded in 14, 8 and 4 ones for total fruit yield/plant, respectively. However, heterosis over mid-parents and check hybrid were reflected by 5 and 4 crosses for number of branches, 5 and 12 ones for number of fruits/cluster, 10 and 15 ones for percent of fruit clusters/plant and 8 and 11 ones for total fruit number /plant, respectively. However, no heterosis was detected for average fruit weight, fruit length and diameter. Determination of dominance type and GCA and SCA variances showed that additive gene action play the main role in the inheritance of all studied traits, except total yield/plant trait. The non-additive gene action was predominance and more important in the inheritance of total yield/plant.

***Keywords*:** Heterosis, Combining Ability Variances, Eggplant.

INTRODUCTION

Eggplant (*Solanum melongena* L.) is one from the important solanaceous vegetable crops cultivated in tropical and subtropical regions of the world and grown all around the year in Egypt. It is cultivated for its unripe fruits which are used in various ways as fresh, pickled, fried and cooked food. In Egypt, some consumers prefer long fruit type, with white or purplish white color, so it is necessary to develop varieties and hybrids with high yield, quality and having desirable color.

Exploitation of heterosis in eggplant has been recognized as a practical tool in providing the breeders with means of increasing yield and other economic traits. Heterosis studies give idea about different types of gene effects which can be utilized further for improvement (Jain and Sastry, 2012). The success of breeding procedure is determined by the useful gene combinations organized in the form of good combining lines and isolation of valuable germplasm.

Heterosis in eggplant over mid-parents, better parent and commercial hybrid were studied and observed by many researchers among them, Mandal and Dana (1993) for total yield, Mankar *et al.* (1995) for number of branches, fruit length, diameter, number of fruits and total yield/plant, Ingale and Patil (1996) for fruit length, diameter, average fruit weight and total yield and Prasath *et al.* (1998) for total yield, number of branches, fruit length, average fruit weight and number of fruits/plant. Shafeeq *et al.* (2007) found heterosis over mid-parents, better parent and check hybrid for number of fruits/cluster and total yield/plant. Sao and Mehta (2010) showed significant heterosis over better parent for number of fruits/cluster (98.73%), average fruit weight (83.27%) and number of branches (41.69%). Heterosis over mid-parents, better parent and commercial hybrid were detected in 7, 4 and 1 cross from 12 ones for total yield (Ramireddy *et al.*, 2011) they also showed heterosis for number of fruits/cluster and average fruit weight. Singh *et al.* (2012) found significant heterosis over better parent for fruit length, diameter, number of fruits and total yield/plant. In other studies, significant positive heterosis was observed for number of branches, number of clusters/plant, number of fruits/clusters, while negative heterosis was observed for fruit diameter (Saraswathi, 2003).

Additive and non- additive gene action involved in the inheritance of important traits is required in order to frame an efficient breeding plan leading to rapid improvement. In the inheritance of eggplant traits many studies revealed that, additive gene action played the important role, among them Ingale and Patil (1997) for fruit length and diameter, Ahmed *et al.* (2006) for fruit diameter and average fruit weight, Rai *et al.* (1998) for average fruit weight, total yield, fruit length and number of fruits, Chezhian *et al.* (2000) for fruit number, average fruit weight and total yield, Das and Barua (2001) for fruit length, diameter, average fruit weight and number of branches, Singh *et al.* (2002) for number of branches, fruit diameter, average fruit weight and number of fruits/plant and Patil *et al.* (2006) for number of branches/plant, total yield and total fruit number. On the other hand, the preponderances of non-additive gene actions were observed by other researchers; viz., Ingale and Patil (1997) for average fruit weight and total yield/plant; Aswani and Khandelwal (2005) for number of clusters/plant, fruit length, diameter, number of fruits, average fruit weight and total yield, and Bendale *et al.* (2005) and Suneetha and Kathiria (2006) for number of branches and total yield/plant. On the other hand, some investigators found that both additive and non- additive gene effects were approximately similar in the inheritance of these traits, among them, Kavita *et al.* (2005) for total fruit weight and number of fruit/plant and Ahmed *et al.* (2006) for fruit length, number of fruits and total fruit yield/plant. The objectives of the present study were to determine average degree of heterosis, dominance type and general and specific combining ability variances to gain information about mode of gene actions in order to identify superior hybrids of excellent qualities coupled with high yields.

MATERIALS AND METHODS

The present study was carried out at the Experimental Farm, Faculty of Environmental Agricultural Sciences, El Arish, Suez Canal University, Egypt, during three successive summer seasons from 2009 to 2011. The genetic materials used in this study were seven elongated eggplant fruit lines; viz., LW 6-1, LW 14-1, CLW 1-1, CLW 4-2, LPW 2-1-6, LPW 12-3 and LB 78-4-1. Seeds of these materials were obtained from Veg. Res. Dep., Hort. Res. Inst., Agric. Res. Center, Giza, Egypt (Kansouh and Hussien, 2009). In the summer season of 2009, the parental lines were used in 7x7 half- diallel cross mating design, to produce 21F_1 hybrids. In the two successive summer seasons of 2010 and 2011, all genotypes (seven parents and their 21F_1 hybrids) were evaluated in a field experiment with the commercial F_1 hybrid "Snow" as a check hybrid. In the three seasons, the seedlings were transplanted in the field in the first week of March. A randomized complete block design with three replicates was used in the two seasons of 2010 and 2011, each replicate contained 29 plots, the plot area was 24m^2 (24m long and 1.0m width). Drip irrigation system was used, dripper lines were spaced 1m between each other, plants spaced 50 cm in the same row. Other normal agricultural practices for eggplant production were done as recommended in the open field in North Sinai region.

The studied characters:

After four months from transplanting, 10 plants were randomly chosen from each plot to calculate number of primary branches/plant. Number of fruits /cluster and percent of fruit clusters/plant were determined during one month at the middle of growth season. Total fruit weight (kg) and number /plant were calculated from all harvested fruits. Average fruit weight (g) was calculated by dividing total weight of all harvested fruits over total number of fruits. Fifteen fruits from each plot were taken randomly from the fourth harvest to determine fruit length (cm) and diameter (cm), while fruit color was determined visually at marketable and ripening stages.

Data were recorded during the two seasons of 2010 and 2011, then the combined data over the two seasons were calculated and statistically analyzed as outlined by Cochran and Cox (1957), in order to test the significance of the differences among the various means according to the least significant differences (L.S.D.) (Snedecor and Cochran, 1990). Average degree of heterosis (ADH%) was estimated as a percent increase or decrease of F_1 performance from the mid parents (MPH%), better parent (PBH%) and check hybrid (CH%). Dominance types (no, partial, complete and over dominance) were obtained according to the dominance line which depended on the results of MPH% and BPH% values (Kansouh, 2014). Heterosis over the better parent (BPH%) was only calculated for the crosses that showed significant positive MPH% values (the genotypes which showed zero percentage of fruit clusters/plant were considered equal one to calculate average degree of heterosis). General and specific combining ability analysis of variances (σ^2GCA and σ^2SCA), were done as reported by Griffing (1956), method II – model I.

RESULTS AND DISCUSSION

Mean performance of parents and their F_1hybrids:

Data presented in Table 1 show high significant differences among the parental lines and 21F_1hybridsfor all studied traits. For number of primary branches/plant, the two lines CLW 4-2 and LPW 2-1-6 had the highest number (9.0 and 8.03, respectively), while the lowest parents were LW 6-1 and LB 78-4-1 (5.97 and 6.03, respectively). With regard to crosses, four crosses (LW 6-1xCLW 4-2, LW 14-1xCLW 4-2, CLW 1-1xCLW 4-2 and CLW 4-2xLPW 2-1-6) had the highest number of primary branches/plant (10.23, 10.03, 9.43 and 9.43, respectively) and significantly exceeded that of the check hybrid (Snow). In general, the overall mean of F_1 hybrids exceeded that of parental lines by heterosis value of 10.47%.

For number of fruits/cluster and percent of fruit clusters/plant (Table 1), only the three lines CLW1-1, CLW4-2 and LB78-4-1 produced fruit number/cluster (4.67, 3.33 and 1.67, respectively) and percent of fruit clusters/plant (75.67, 60.82 and 22.75%, respectively). For crosses, 15 ones showed percent of fruit clusters/plant, values ranged from 12.53 in the cross LPW12-3xLB78-4-1 to 71.38 in the crossCLW1-1xCLW4-2 and significantly exceeded that of the check hybrid. The same trend was observed also for number of fruits/cluster. In both traits, the cross CLW1-1xCLW4-2 showed the highest values for the two traits. However, this cross involved the high two parents for these two traits. The overall mean of the crosses significantly exceeded that of their parents by heterosis valuesof 12.82% and 45.03% for number of fruits/cluster and percent of fruit cluster/plant, respectively (Table 1).

Concerning total yield/plant, data in Table 1 show high differences among parents, where the values ranged from 2.785 to 3.872 kg/plant, the highest yield was produced by the line CLW4-2 (3.872kg/plant) followed by LPW2-1-6 (3.665kg/plant), while the lowest one was LW6-1(2.785kg/plant). The overall mean of F_1 crosses (3.612kg/plant) exceeded that of their parental line (3.291) by 9.69%. The hybrids showed values ranged from 2.816 to 4.279 kg/plant. The two crosses LW6-1xCLW4-2 and LW14-1xCLW4-2 produced the highest total yield (4.279 and 4.234 kg/plant, respectively)and significantly exceeded the check hybrid "Snow F_1" (3.887 kg/plant) by 10.08% and 8.93%, respectively, indicating that these promise crosses could be introduced or replaced "Snow F_1" in the commercial cultivation.

For total fruit number/plant, data presented in Table1 show that parental lines CLW1-1 and CLW4-2 recorded the highest number (128.36 and 124.86 fruits/plant, respectively), while the lowest number of fruits (49.93) was obtained by the line LW6-1. Among the studied crosses, CLW1-1xCLW4-2 and CLW1-1xLB78-4-1 produced the highest number of fruits (127.67 and 115.17, respectively), while the lowest number (53.72) was observed in the cross LW6-1xLPW12-3, also eleven crosses significantly exceeded that of the check hybrid "Snow F_1". Generally, the overall mean value of the F_1 crosses (85.26) exceeded that of parental lines (79.84) by 6.78% and check hybrid (64.16) by 32.89%.

Table (1): Mean performances of the evaluated eggplant F1 hybrids and their parents for some plant characteristics

Characters / Intries	No. of primary branches/plant	No .of fruits /cluster	Percent of fruit clusters/plant	Total yield /plant (kg)	total fruit number /plant
LW.6-1	5.97	1.000	0.00	2.785	49.93
LW.14-1	6.50	1.000	0.00	2.941	57.02
CLW.1-1	7.03	4.667	75.67	3.21	128.36
CLW.4-2	9.00	3.333	60.82	3.872	124.86
LPW.2-1-6	8.03	1.000	0.00	3.665	61.98
LPW.12-3	6.96	1.000	0.00	3.028	59.97
LB.78-4-1	6.03	1.667	22.75	3.541	76.78
Mean	7.08	1.950	22.75	3.291	79.84
Crosses					
LW.6-1 x LW14-1	6.60	1.000	0.00	2.816	57.24
LW.6-1 x CLW1-1	7.83	4.000	66.08	3.876	100.78
LW6-1 x CLW4-2	10.23	3.667	57.1	4.279	95.21
LW.6-1 x LPW2-1-6	7.50	1.000	0.00	3.538	86.52
LW.6-1 x LPW12-3	6.83	1.000	0.00	2.94	53.72
LW.6-1 x LB.78-4-1	6.23	1.333	15.55	3.308	64.66
LW.14-1 x CLW.1-1	7.00	3.333	62.67	3.938	105.88
LW.14-1 x CLW.4-2	10.03	3.333	58.43	4.234	98.13
LW.14-1 x LPW.2-1-6	7.40	1.000	0.00	3.428	62.84
LW.14-1 x LPW.12-3	6.90	1.000	0.00	2.925	59.06
LW.14-1 x LB.78-4-1	6.57	1.667	14.78	3.273	67.23
CLW.1-1 x CLW.4-2	9.43	4.333	71.38	4.012	127.67
CLW.1-1 x LPW.2-1-6	8.83	3.000	65.33	3.861	110.31
CLW.1-1 x LPW.12-3	7.50	2.667	55.17	3.705	93.89
CLW.1-1 x LB.78-4-1	6.50	3.333	62.38	3.561	115.17
CLW.4-2 x LPW.2-1-6	9.43	2.667	47.45	4.059	105.83
CLW.4-2 x LPW.12-3	8.33	2.333	38.62	3.77	103.58
CLW.4-2 x LB.78-4-1	8.30	2.333	51.80	3.939	102.50
LPW.2-1-6 x LPW.12-3	8.43	1.000	0.00	3.406	62.66
LPW.2-1-6 x LP.78-4-1	7.30	1.333	13.43	3.596	68.87
LPW.12-3 x LB.78-4-1	6.83	1.333	12.53	3.366	66.65
Mean	7.82	2.210	32.98	3.612	85.26
Average of heterosis	10.47	12.820	45.03	9.69	6.78
Snow F1	8.10	1.000	0.00	3.887	64.16
L.S.D.5%	1.25	0.57	5.60	0.332	8.43
L.S.D.1%	1.79	0.82	8.01	0.475	12.07

Regarding average fruit weight, data presented in Table 2 show that the parental lines showed values ranged from 25.06 to 59.61g with a mean value of 45.80g. The line LPW 2-1-6 recorded the heaviest fruits (59.61g) followed by the line LW6-1 with a value of 55.94g. On the other hand, the lightest average fruit weight (25.06 and 31.07g) were recorded by the two lines CLW1-1and CLW4-2, respectively. The resulted hybrids produced fruits with average weight ranged from 30.97g (in the cross CLW1-1xLB78-4-1) to 55.34g (in the cross LW6-1xLPW12-3) with a mean value of 44.47g. Concerning fruit length and diameter (Table 2), the line LW14-1produced the longest fruits (25.47cm), while the line LW6-1 showed the highest fruit diameter value (6.63 cm). On the contrary, the two lines CLW1-1 and CLW4-2 produced the shortest and thinnest fruits. They showed fruits with length of 14.13 and 16.47 cm, respectively, with diameter of 3.03 and 3.69 cm, respectively. The resulted hybrids produced fruits ranged from 15.13 to 25.03 cm in length, and from 3.50 to 6.20cm in diameter. The cross LW14-1xLB78-4-1 produced the longest fruits (25.03cm), while the cross LW6-1xLPW2-1-6 showed the highest fruit diameter value (6.20cm). On the other hand, the cross CLW1-1xCLW4-2 produced the shortest and thinnest fruits (15.13 and 3.5 cm, respectively). Generally, the cross CLW1-1xCLW4-2 and their parents recorded the lowest values for average fruit weight, fruit length and diameter. These low values may be attributed to fruit bearing habit, since they produced cluster fruit type involved 4-5 fruits per cluster, as mentioned before.

Data obtained (Table 2) showed great variations in fruit color among the studied lines and their hybrids, at both marketable and ripening stages.

Table (2): Mean performances of the evaluated eggplant F1 hybrids and their parents for some fruit characteristics

Characters / Intries	Average fruit weight (g.)	Fruit length (cm)	Fruit diameter(cm)	Fruit color at marketable stage	Fruit color at ripening stage
LW.6-1	55.94	22.07	6.63	White	Yellow
LW.14-1	51.82	25.47	4.63	White	Yellow
CLW.1-1	25.06	14.13	3.03	White	Yellow
CLW.4-2	31.07	16.47	3.69	White	Yellow
LPW.2-1-6	59.61	23.43	5.56	Purplish-white	Dark-yellow
LPW.12-3	50.83	19.50	4.53	Light purple	Dark-yellow
LB.78-4-1	46.26	24.97	5.03	Black	Brown
Mean	45.8	20.86	4.73		
Crosses					
LW.6-1 x LW14-1	49.40	24.03	6.03	White	Yellow
LW.6-1 x CLW1-1	38.53	20.07	5.67	White	Yellow
LW6-1 x CLW4-2	45.08	20.53	6.03	White	Yellow
LW.6-1 x LPW2-1-6	51.65	23.03	6.20	Purplish-white	Dark-yellow
LW.6-1 x LPW12-3	55.34	21.10	5.77	Purplish-white	Dark-yellow
LW.6-1 x LB.78-4-1	51.62	24.07	6.13	Brown	Light-brown
LW.14-1 x CLW.1-1	37.24	22.50	4.07	White	Yellow
LW.14-1 x CLW.4-2	43.18	23.10	5.53	White	Yellow
LW.14-1 x LPW.2-1-6	54.65	24.03	5.33	Purplish-white	Dark-yellow
LW.14-1 x LPW.12-3	49.72	23.53	4.63	Purplish-white	Dark-yellow
LW.14-1 x LB.78-4-1	49.38	25.03	5.03	Brown	Light-brown
CLW.1-1 x CLW.4-2	31.43	15.13	3.50	White	Yellow
CLW.1-1 x LPW.2-1-6	35.07	21.03	4.90	Purplish-white	Dark-yellow
CLW.1-1 x LPW.12-3	39.50	17.53	4.10	Purplish-white	Dark-yellow
CLW.1-1 x LB.78-4-1	30.97	22.53	4.50	Brown	Light-brown
CLW.4-2 x LPW.2-1-6	38.47	21.53	5.07	Purplish-white	Dark-yellow
CLW.4-2 x LPW.12-3	36.43	18.60	4.33	Purplish-white	Dark-yellow
CLW.4-2 x LB.78-4-1	38.57	23.03	4.73	Brown	Light-brown
LPW.2-1-6 x LPW.12-3	54.50	22.07	5.20	Purple	Light-brown
LPW.2-1-6 x LP.78-4-1	52.38	24.07	5.53	Brown	Light-brown
LPW.12-3 x LB.78-4-1	50.67	23.53	5.03	Brown	Light-brown
Mean	44.47	21.91	5.07		
Average of heterosis	-2.90	5.03	6.97		
Snow F1	60.93	21.03	7.03	White	Yellow
L.S.D.5%	4.73	3.91	1.44		
L.S.D.1%	6.76	5.59	2.06		

The lines and their hybrids produced fruits with color degreed from white to dark. However, the fruit color at marketable stage vs. ripening stage as follow: white vs. yellow, purplish white and light purple vs. dark yellow, purple and brown vs. light brown and black vs. brown. These results are in agreement with those of Rai *et al*. (1998), Das and Barua (2001), Kaur *et al.* (2001), Kumar *et al.* (2012) and Praneetha *et al.* (2013) who found significant differences among evaluated lines and hybrids for most studied traits. Also, the results confirmed those of Valavigna (2007), Rotino *et al.* (2007) and Kansouh and Hussein (2009) regarding cluster fruit type.

Average degree of heterosis, dominance type and combining ability variances:

Data presented in Table 3 show that 16 crosses from 21 ones exhibited insignificant values relative to mid parent values, indicating no dominance for number of primary branches/plant in these crosses. However, 5 crosses showed dominance toward the high parent, since they showed significant positive mid parents heterosis (MPH%) values ranging from 17.26% (in the cross CLW1-1xLPW2-1-6) to 36.67% (in the cross LW6-1xCLW4-2). Heterosis over the better parent (BPH%) for these 5 crosses showed complete dominance to the high parent, since they exhibited insignificant values.

Compared with the check hybrid, four crosses showed significant or highly significant positive heterosis values. The cross LW6-1xLPW2-1-6 reflected the highest value (26.3%). It is clear from the previous data (Table 3), the distribution of the crosses were: 16 ones showed no dominance, suggesting additive variance effects, and 5 ones showed complete dominance, suggesting non additive effects. Therefore, the inheritance of primary branches is mainly controlled by additive gene effects. This suggestion was confirmed by calculating the mean square values due to general and specific combining ability variance (Table 3), which were highly significant and insignificant, respectively, indicating the importance of additive gene action in the inheritance of this trait. In addition, the estimated σ^2GCA/σ^2SCA ratio was 2.5, indicating that additive gene action plays the main role in the inheritance of primary branches/plant. Similar results were obtained byMankar *et al.* (1995), Prasath *et al.* (1998) and Saraswathi (2003) who showed heterosis for this trait. Also, Das and Barua (2001), Singh *et al.* (2002) and Patil *et al.* (2006) found that additive gene action played the main role in the inheritance of this trait.

Table (3): Average degree of heterosis (ADH%) based on mid-parents (MP), better parent (BP), commercial hybrid (CH), dominance type and combining ability variances for number of primary branches/plant in eggplant.

Crosses	ADH%			Dominance type
	MP	BP	CH	
LW.6-1 x LW14-1	5.85		-18.52*	No-dominance
LW.6-1 x CLW1-1	20.46*	11.38	-3.33	Complete dominance
LW6-1 x CLW4-2	36.67**	13.67	26.3**	Complete dominance
LW.6-1 x LPW2-1-6	7.14		-7.41	No-dominance
LW.6-1 x LPW12-3	5.64		-15.68*	No-dominance
LW.6-1 x LB.78-4-1	3.83		-23.08**	No-dominance
LW.14-1 x CLW.1-1	3.47		-13.58	No-dominance
LW.14-1 x CLW.4-2	29.42**	11.44	23.83**	Complete dominance
LW.14-1 x LPW.2-1-6	1.86		-8.64	No-dominance
LW.14-1 x LPW.12-3	2.53		-14.81	No-dominance
LW.14-1 x LB.78-4-1	4.87		-18.89*	No-dominance
CLW.1-1 x CLW.4-2	17.65*	4.78	16.42*	Complete dominance
CLW.1-1 x LPW.2-1-6	17.26*	9.96	9.01	Complete dominance
CLW.1-1 x LPW.12-3	7.22		-7.41	No-dominance
CLW.1-1 x LB.78-4-1	-0.46		-19.75*	No-dominance
CLW.4-2 x LPW.2-1-6	10.75		16.42*	No-dominance
CLW.4-2 x LPW.12-3	4.38		2.84	No-dominance
CLW.4-2 x LB.78-4-1	10.45		2.47	No-dominance
LPW.2-1-6 x LPW.12-3	12.47		4.07	No-dominance
LPW.2-1-6 x LB.78-4-1	3.84		-9.88	No-dominance
LPW.12-3 x LB.78-4-1	5.16		-15.68*	No-dominance
Mean sum of square and variance (MS &σ^2)				
		GCA	**SCA**	
	Ms	4.88**	0.481	
	σ^2	0.511	0.201	
	σ^2 GCA /σ^2 SCA	2.5		

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

Concerning number of fruits/cluster, data in Table 4 show that, out of 21 crosses, only 5 ones exhibited significant positive values of heterosis over mid parents, suggesting dominance towards the high parent. The remaining 16 ones showed insignificant values, indicating no dominance for this trait. Heterosis over the better parent for these 5 crosses showed different degrees of dominance, since 3 crosses showed significant negative BPH% values suggesting partial dominance and two ones showed complete dominance, since they reflected insignificant BPH% values. Relative to the check hybrid, heterosis was detected in 12 crosses, where they showed significant positive values ranging from 67% (LW14-1xLB78-4-1) to 333% (CLW1-1xCLW4-2). From the previous data for number of fruits/cluster, the additive variance was predominance and play the main role in the inheritance of this trait, since no dominance was found in most crosses (16 ones), while 2 ones showed complete dominance suggesting non additive effects, as well as 3 ones reflected both additive and non-additive, since they showed partial dominance. Analysis of variance for combining ability revealed highly significant mean square values due to GCA and SCA, indicating that both additive and non- additive genetic variance were important in the inheritance of this trait. However, the σ^2GCA/σ^2SCA ratio was more than unity (7.5), indicating that additive gene effects played a greater role in the inheritance of this trait. Heterosis were observed for number of fruits/cluster by Saraswathi (2003), Shafeeq *et al.* (2007) and Ramiereddy *et al.* (2011). For percent of fruit clusters/plant, data in Table

5 illustrate that, 11 crosses showed no dominance, since they recorded insignificant mid parent's heterosis values. Partial dominance for high percent of clusters was found in 8 crosses, since they had significant positive heterosis values over mid parents and significant negative values of heterosis over the better parent. However, two crosses showed complete dominance to the high percent, since they reflected insignificant heterosis values over the better parent. Out of 21 crosses, 15 ones revealed highly significant positive values of heterosis over the check hybrid.

The highest value (7038%) was reflected by the cross CLW1-1xCLW4-2, followed by value of 6508% in the cross LW6-1xCLW1-1. According to the previous result, the additive variance was predominance and played the main role in the inheritance of this trait, since most crosses (11 F_1's) showed no dominance, and eight crosses reflected additive and non-additive (partial dominance) effects, while only two crosses exhibited complete dominance that expressed non additive variance. The results are confirmed by analysis of variance for combining ability which revealed highly significant mean square values due to GCA and SCA, indicating that both additive and non-additive gene actions played a significant role for the expression of this trait. Meanwhile, σ^2GCA/σ^2SCA ratio was 3.6, indicating that additive gene action was prevalence and played the main role in the inheritance of percent of fruit clusters/plant. Significant positive heterosis for percent of fruit cluster/plant was observed by Saraswathi (2003).

As for total yield /plant, data in Table 6 show that from 21 crosses, 14 ones exhibited significant positive heterosis values over mid-parents, indicating dominance toward the high total yield, while the remaining seven ones showed insignificant MPH% values, indicating no-dominance for this trait in these crosses. Estimate of heterosis over the better parent for the 14 crosses, eight ones exhibited over dominance, three ones showed partial dominance and other three ones exhibited complete dominance, since they showed significant positive, significant negative and insignificant values of heterosis over the better parent, respectively. Only four crosses (LW6-1xCLW4-2, LW14-1xCLW4-2, CLW4-2xLPW2-1-6 and LW1-1xCLW4-2) from 21 ones showed significant and highly significant positive values of heterosis over the check hybrid (10.08, 8.93, 4.43 and 3.24%, respectively). It is obvious from Table 6, that the studied crosses are distributed as follow, seven ones showed no-dominance, suggesting additive variance effects, 11 ones showed complete and over dominance, suggesting non-additive effects, while the remaining three ones showed partial dominance, indicating both of additive and non-additive effects. Therefore, the inheritance of total yield/plant under this study was controlled by non-additive gene effects. This suggestion was confirmed by the analysis of variance for combining ability, where both GCA and SCA mean squares were highly significant, indicating that both additive and non- additive genetic variances were involved in the inheritance of total yield/plant. The estimated ratio of σ^2GCA/σ^2SCAwas 0.6, which confirms the above results that non-additive was more important in the inheritance of this trait. Similar results were obtained by many investigators regarding average degree of heterosis for total yield, among them, Das and Barua (2001), Kaur*et al.* (2001), Shafeeq *et al.* (2007) and Ramireddy *et al.* (2011). Also, Ingale and Patil (1997), Aswani and Khandelwal (2005), Bendale *et al.* (2005) and Suneetha and Kathiria (2006) reported that preponderance of non-additive gene actions in the inheritance of total yield.

Regarding total fruit number/plant, the obtained data (Table 7) showed that,13 crosses had insignificant heterosis values relative to mid- parents, indicating no-dominance for the trait. The remaining 8 crosses reflected heterosis over mid-parents, since they recorded highly significant positive values ranging from 8.82 % (in the cross LW6-1xCLW4-2) to 22.46% (LW6-1xLPW2-1-6), suggesting dominance toward the high number of fruits/plant. The estimated values of heterosis over the better parent in these 8 crosses showed partial dominance for the large number of fruits in seven crosses, since they gave significant negative heterosis values. A complete dominance for the large number of fruits was detected in the remaining cross (LW6-1xLPW2-1-6) which showed insignificant positive value. Compared with the check hybrid, eleven crosses showed highly significant positive values of heterosis over the check hybrid ranging from 46.34% (CLW1-1xLPW12-3) to 98.99% (CLW1-1xCLW4-2). It is suggested from the previous result that additive gene action was more important in the inheritance of this trait, since 13 crosses from 21 ones showed no-dominance and seven crosses showed partial dominance (additive and non-additive).This suggestion was confirmed by analysis of variance due to GCA and SCA, which were highly significant, indicating the importance of both additive and non-additive gene actions, while the estimated ratio of σ^2GCA/σ^2SCA which was 16.6, suggested that additive was more important in the inheritance of this trait. These results were agreed with those of Mankar *et al.* (1995), Prasath *et al.* (1998) and Singh *et al.* (2012) who showed heterosis in this trait. Also, similar results for the mode of gene actionwere obtained by Rai *et al.* (1998), Chezhian *et al.* (2000), Das and Barua (2001), Singh *et al.* (2002) and Patil *et al.* (2006).

As regard to average fruit weight, data in Table 8show that, the studied crosses exhibited no-dominance in 15ones,and dominance toward the small fruits was observed in sex ones, since they showed insignificant and significant negative values relative to mid-parents. Therefore, no heterosis over the better parent and check hybrid were detected, where all hybrids produced fruits significantly decreased in average fruit weight relative to better parent and check hybrid Snow F1. In this respect, absence of heterosis over better parent and check hybrid, did not imply the absence of superior F1 hybrids for total yield.

So, it could suggested that weight of eggplant fruits was mainly controlled by additive gene action. This suggestion was confirmed by the analysis of variance forcombining ability, since GCA and SCA mean squares were significant, indicating both additive and non-additive gene action were found in this trait, while the high ratio of σ^2GCA/σ^2SCA (8.9), indicated that additive gene action play the main role in the inheritance of average fruit weight. These results are in agreement with those of Saraswathi (2003) and Ram and Singh (2012) who reported that all crosses exhibited significant negative heterosis for average fruit weight. Also, many researchers reported that additive gene action was more important than non-additive ones in the inheritance of this trait (Rai *et al.*, 1998; Chezhian *et al.*, 2001; Das and Barua, 2001; Ahmed *et al.*, 2006; Suneetha and Kathiria, 2006; Ram and Singh, 2012).

Regarding fruit length and fruit diameter, data in Tables 9&10 presented that, all studied crosses reflected no dominance for both traits, since they gave insignificant heterosis values over mid parent values. Therefore, no better parent heterosis or heterosis over the check hybrid were obtained. In this respect, we can suggest that fruit length and diameter were mainly governed by additive genetic variance. This suggestion was confirmed by estimated analysis of variance for combining ability, which revealed high significant and insignificant mean square values due to general and specific combining ability variances, respectively for both traits. Moreover, the estimated σ^2GCA/σ^2SCA showed positive and negative values, respectively, indicated that only additive gene action play the significant role in the inheritance of fruit length and fruit diameter in eggplant crop. Similar results were obtained by Ram and Singh (2012) who reported that, none of the crosses (60 ones) exhibited heterosis for fruit diameter, also Saraswathi (2003) found the same trend for fruit diameter. Additive gene action was more important in the inheritance of both traits as reported by Ingal and Patil(1997); Das and Barua(2001); Suneetha and Kathiria (2006) and Ram and Singh (2012).

Generally, it is obvious from the determination of heterosis, dominance type and combining ability variances that, additive genetic variance played the main role in the inheritance of all studied characters, except total yield/plant.So, these characters could be improved by selection methods. While non-additive gene action was predominance and more important in the inheritance of total yield /plant, therefore hybrid breeding method is effective to improve total yield/plant.

Over two years of 2010 and 2012, there were four superior F_1 hybrids (LW6-1 x CLW4-2, LW14-1 x CLW4-2, CLW1-1 x CLW4-2 and CLW4-2 x LPW2-1-6) over the check hybrid "Snow" $F_1$for total yield/plant. So, these crosses could be recommended to be used in commercial production of long eggplant.

Table (4): Average degree of heterosis (ADH%) based on mid-parents (MP), better parent (BP), commercial hybrid (CH), dominance type and combining ability variancesfor number of fruits / cluster in eggplant.

Crosses	ADH%			Dominance type
	MP	BP	CH	
LW.6-1 x LW14-1	0		0	No-dominance
LW.6-1 x CLW1-1	41.09**	-14.34*	300**	Partial dominance
LW6-1 x CLW4-2	69.51**	10.21	267**	Complete dominance
LW.6-1 x LPW2-1-6	0		0	No-dominance
LW.6-1 x LPW12-3	0		0	No-dominance
LW.6-1 x LB.78-4-1	-0.37		33	No-dominance
LW.14-1 x CLW.1-1	17.46*	-28.69**	233**	Partial dominance
LW.14-1 x CLW.4-2	53.81**	0	233**	Complete dominance
LW.14-1 x LPW.2-1-6	0		0	No-dominance
LW.14-1 x LPW.12-3	0		0	No-dominance
LW.14-1 x LB.78-4-1	25.09		67*	No-dominance
CLW.1-1 x CLW.4-2	8.25		333**	No-dominance
CLW.1-1 x LPW.2-1-6	5.82		200**	No-dominance
CLW.1-1 x LPW.12-3	-5.82		167**	No-dominance
CLW.1-1 x LB.78-4-1	5.05		233**	No-dominance
CLW.4-2 x LPW.2-1-6	23.33*	-19.82**	167**	Partial dominance
CLW.4-2 x LPW.12-3	7.62		133**	No-dominance
CLW.4-2 x LB.78-4-1	-6.8		133**	No-dominance
LPW.2-1-6 x LPW.12-3	0		0	No-dominance
LPW.2-1-6 x LB.78-4-1	-0.37		33	No-dominance
LPW.12-3 x LB.78-4-1	-0.37		33	No-dominance
Mean sum of square and variance (MS &σ^2)				
		GCA	**SCA**	
	Ms	6.08**	0.17**	
	σ^2	0.82	0.11	
σ^2 GCA /σ^2 SCA		7.5		

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

Table (5): Average degree of heterosis (ADH%) based on mid-parents (MP), better parent (BP), commercial hybrid (CH), dominance type and combining ability variances for percent of fruit clusters/plant in eggplant.

Crosses	ADH%			Dominance type
	MP	BP	CH	
LW.6-1 x LW14-1	0		0	No-dominance
LW.6-1 x CLW1-1	72.38**	-12.67**	6508**	Partial dominance
LW6-1 x CLW4-2	84.73**	-6.11	5610**	Complete dominance
LW.6-1 x LPW2-1-6	0		0	No-dominance
LW.6-1 x LPW12-3	0		0	No-dominance
LW.6-1 x LB.78-4-1	30.95		1455**	No-dominance
LW.14-1 x CLW.1-1	63.48**	-17.18**	6167**	Partial dominance
LW.14-1 x CLW.4-2	89.03**	-3.93	5743**	Complete dominance
LW.14-1 x LPW.2-1-6	0		0	No-dominance
LW.14-1 x LPW.12-3	0		0	No-dominance
LW.14-1 x LB.78-4-1	24.46		1378**	No-dominance
CLW.1-1 x CLW.4-2	4.59		7038**	No-dominance
CLW.1-1 x LPW.2-1-6	70.42**	-13.66**	6433**	Partial dominance
CLW.1-1 x LPW.12-3	43.92**	-27.09**	5417**	Partial dominance
CLW.1-1 x LB.78-4-1	26.76**	-17.56**	6138**	Partial dominance
CLW.4-2 x LPW.2-1-6	53.51**	-21.98**	4645**	Partial dominance
CLW.4-2 x LPW.12-3	24.94**	-36.50**	3762**	Partial dominance
CLW.4-2 x LB.78-4-1	23.97**	-14.83**	5080**	Partial dominance
LPW.2-1-6 x LPW.12-3	0		0	No-dominance
LPW.2-1-6 x LB.78-4-1	13.09		1243**	No-dominance
LPW.12-3 x LB.78-4-1	5.52		1153**	No-dominance
Mean sum of square and variance (MS &σ^2)				
		GCA	**SCA**	
	Ms	3278.28**	106.60**	
	σ^2	363.63	100.99	
	σ^2 GCA /σ^2 SCA	3.6		

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

Table (6): Average degree of heterosis (ADH%) based on mid-parents (MP), better parent (BP), commercial hybrid (CH), dominance type and combining ability variances for total yield/plant in eggplant.

Crosses	ADH%			Dominance type
	MP	BP	CH	
LW.6-1 x LW14-1	-1.64		-27.55**	No-dominance
LW.6-1 x CLW1-1	29.29**	20.71**	-0.28	Over dominance
LW6-1 x CLW4-2	28.56**	10.51**	10.08**	Over dominance
LW.6-1 x LPW2-1-6	9.71*	-3.47*	-8.98**	Partial dominance
LW.6-1 x LPW12-3	1.15		-24.36**	No-dominance
LW.6-1 x LB.78-4-1	4.58**	-6.58**	-14.90**	Partial dominance
LW.14-1 x CLW.1-1	28.02**	22.64**	1.31	Over dominance
LW.14-1 x CLW.4-2	24.29**	9.35**	8.93**	Over dominance
LW.14-1 x LPW.2-1-6	3.78*	-6.47**	-11.81**	Partial dominance
LW.14-1 x LPW.12-3	-1.99		-24.75**	No-dominance
LW.14-1 x LB.78-4-1	0.99		-15.80**	No-dominance
CLW.1-1 x CLW.4-2	13.31**	3.64*	3.24*	0ver dominance
CLW.1-1 x LPW.2-1-6	12.30**	5.35**	-0.67	Over dominance
CLW.1-1 x LPW.12-3	18.80**	15.42**	-4.66**	Over dominance
CLW.1-1 x LB.78-4-1	5.51**	0.59	-8.36**	Complete dominance
CLW.4-2 x LPW.2-1-6	7.71**	4.83**	4.43**	Over dominance
CLW.4-2 x LPW.12-3	9.28*	-2.63	-3.01*	Complete dominance
CLW.4-2 x LB.78-4-1	6.3**	1.76	1.36	Complete dominance
LPW.2-1-6 x LPW.12-3	1.78		-12.37**	No-dominance
LPW.2-1-6 x LB.78-4-1	-0.19		-7.48**	No-dominance
LPW.12-3 x LB.78-4-1	2.48		-13.40**	No-dominance
Mean sum of square and variance (MS &σ^2)				
		GCA	**SCA**	
	Ms	0.512**	0.092**	
	σ^2	0.057**	0.089**	
	σ^2 GCA /σ^2 SCA	0.6		

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

Table (7): Average degree of heterosis (ADH%) based on mid-parents (MP), better parent (BP), commercial hybrid (CH), dominance type and combining ability variances for total fruit number/plant in eggplant.

Crosses	ADH%			Dominance type
	MP	BP	CH	
LW.6-1 x LW14-1	6.98		-10.83	No-dominance
LW.6-1 x CLW1-1	13.06**	-21.48**	57.08**	Partial dominance
LW6-1 x CLW4-2	8.82**	-23.83**	48.24**	Partial dominance
LW.6-1 x LPW2-1-6	22.46**	10.55	6.80	Complete dominance
LW.6-1 x LPW12-3	-2.24		-16.27*	No-dominance
LW.6-1 x LB.78-4-1	2.06		0.78	No-dominance
LW.14-1 x CLW.1-1	14.24**	-17.51**	65.02**	Partial dominance
LW.14-1 x CLW.4-2	7.90		52.95**	No-dominance
LW.14-1 x LPW.2-1-6	5.63		-2.04	No-dominance
LW.14-1 x LPW.12-3	0.94		-7.96	No-dominance
LW.14-1 x LB.78-4-1	0.49		4.78	No-dominance
CLW.1-1 x CLW.4-2	0.84		98.99**	No-dominance
CLW.1-1 x LPW.2-1-6	15.92**	-14.05**	71.95**	Partial dominance
CLW.1-1 x LPW.12-3	-0.29		46.34**	No-dominance
CLW.1-1 x LB.78-4-1	12.29**	-10.27*	79.50**	Partial dominance
CLW.4-2 x LPW.2-1-6	13.28**	-15.25**	64.94**	Partial dominance
CLW.4-2 x LPW.12-3	12.08**	-17.05**	61.44**	Partial dominance
CLW.4-2 x LB.78-4-1	1.66		59.76**	No-dominance
LPW.2-1-6 x LPW.12-3	2.77		-2.32	No-dominance
LPW.2-1-6 x LB.78-4-1	-0.74		7.34	No-dominance
LPW.12-3 x LB.78-4-1	-2.51		3.90	No-dominance
Mean sum of square and variance (MS &σ^2)				
		GCA	**SCA**	
	Ms	2754.40**	31.10**	
	σ^2	304.63**	18.36**	
σ^2 GCA /σ^2 SCA		16.6		

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

Table (8): Average degree of heterosis (ADH%) based on mid-parents (MP), better parent (BP), commercial hybrid (CH), dominance type and combining ability variances for average fruit weight in eggplant.

Crosses	ADH%			Dominance type
	MP	BP	CH	
LW.6-1 x LW14-1	-8.31*		-18.92**	Dominance to low P.
LW.6-1 x CLW1-1	-4.86		-36.76**	No-dominance
LW6-1 x CLW4-2	3.62		-26.01**	No-dominance
LW.6-1 x LPW2-1-6	-10.6*		-15.23**	Dominance to low P.
LW.6-1 x LPW12-3	3.66		-9.17*	No-dominance
LW.6-1 x LB.78-4-1	1.02		-15.28**	No-dominance
LW.14-1 x CLW.1-1	-3.12		-38.88**	No-dominance
LW.14-1 x CLW.4-2	4.19		-29.13**	No-dominance
LW.14-1 x LPW.2-1-6	-1.91		-10.31*	No-dominance
LW.14-1 x LPW.12-3	-3.13		-18.40**	No-dominance
LW.14-1 x LB.78-4-1	0.69		-18.96**	No-dominance
CLW.1-1 x CLW.4-2	11.99		-48.42**	No-dominance
CLW.1-1 x LPW.2-1-6	-17.16**		-42.44**	Dominance to low P.
CLW.1-1 x LPW.12-3	4.09		-35.17**	No-dominance
CLW.1-1 x LB.78-4-1	-13.15**		-49.17**	Dominance to low P.
CLW.4-2 x LPW.2-1-6	-15.15**		-36.86**	Dominance to low P.
CLW.4-2 x LPW.12-3	-11.04**		-40.21**	Dominance to low P.
CLW.4-2 x LB.78-4-1	-0.25		-36.70**	No-dominance
LPW.2-1-6 x LPW.12-3	-1.30		-10.55*	No-dominance
LPW.2-1-6 x LB.78-4-1	-1.05		-14.03**	No-dominance
LPW.12-3 x LB.78-4-1	4.38		-16.84**	No-dominance
Mean sum of square and variance (MS &σ^2)				
		GCA	**SCA**	
	Ms	354.82**	8.36*	
	σ^2	38.98	4.35	
σ^2 GCA /σ^2 SCA		8.9		

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

Table (9): Average degree of heterosis (ADH%) based on mid-parents (MP), better parent (BP),commercial hybrid (CH), dominance type and combining ability variances for fruit length in eggplant.

Crosses	ADH%			Dominance type
	MP	BP	CH	
LW.6-1 x LW14-1	1.09		14.27	No-dominance
LW.6-1 x CLW1-1	10.88		-4.56	No-dominance
LW6-1 x CLW4-2	6.54		-2.38	No-dominance
LW.6-1 x LPW2-1-6	1.23		9.51	No-dominance
LW.6-1 x LPW12-3	1.52		0.33	No-dominance
LW.6-1 x LB.78-4-1	2.34		14.46	No-dominance
LW.14-1 x CLW.1-1	13.64		6.99	No-dominance
LW.14-1 x CLW.4-2	10.16		9.84	No-dominance
LW.14-1 x LPW.2-1-6	-1.72		14.27	No-dominance
LW.14-1 x LPW.12-3	4.65		11.89	No-dominance
LW.14-1 x LB.78-4-1	-0.75		19.02	No-dominance
CLW.1-1 x CLW.4-2	-1.11		-28.06**	No-dominance
CLW.1-1 x LPW.2-1-6	11.98		0	No-dominance
CLW.1-1 x LPW.12-3	4.25		-16.64	No-dominance
CLW.1-1 x LB.78-4-1	15.24		7.13	No-dominance
CLW.4-2 x LPW.2-1-6	7.92		2.38	No-dominance
CLW.4-2 x LPW.12-3	3.41		-11.55	No-dominance
CLW.4-2 x LB.78-4-1	11.14		9.51	No-dominance
LPW.2-1-6 x LPW.12-3	2.82		4.95	No-dominance
LPW.2-1-6 x LB.78-4-1	-0.54		14.46	No-dominance
LPW.12-3 x LB.78-4-1	5.82		11.89	No-dominance
Mean sum of square and variance (MS &σ^2)				
		GCA	**SCA**	
	Ms	35.98**	1.11	
	σ^2	3.72	-1.38	
	σ^2 GCA /σ^2 SCA	-		

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

Table (10): Average degree of heterosis (ADH%) based on mid-parents (MP), better parent (BP),commercial hybrid (CH), dominance type and combining ability variances for fruit diameter in eggplant.

Crosses	ADH%			Dominance type
	MP	BP	CH	
LW.6-1 x LW14-1	7.1		-14.22	No-dominance
LW.6-1 x CLW1-1	17.39		-19.35	No-dominance
LW6-1 x CLW4-2	16.86		-14.22	No-dominance
LW.6-1 x LPW2-1-6	1.72		-11.8	No-dominance
LW.6-1 x LPW12-3	3.41		-17.92	No-dominance
LW.6-1 x LB.78-4-1	5.15		-12.8	No-dominance
LW.14-1 x CLW.1-1	6.27		-42.11**	No-dominance
LW.14-1 x CLW.4-2	8.89		-35.56**	No-dominance
LW.14-1 x LPW.2-1-6	4.61		-24.18*	No-dominance
LW.14-1 x LPW.12-3	1.09		-34.14**	No-dominance
LW.14-1 x LB.78-4-1	4.14		-28.45*	No-dominance
CLW.1-1 x CLW.4-2	4.17		-50.21**	No-dominance
CLW.1-1 x LPW.2-1-6	14.09		-30.30**	No-dominance
CLW.1-1 x LPW.12-3	8.47		-41.68**	No-dominance
CLW.1-1 x LB.78-4-1	11.66		-35.99**	No-dominance
CLW.4-2 x LPW.2-1-6	9.62		-27.88*	No-dominance
CLW.4-2 x LPW.12-3	5.35		-38.41**	No-dominance
CLW.4-2 x LB.78-4-1	8.48		-32.72**	No-dominance
LPW.2-1-6 x LPW.12-3	3.07		-26.03*	No-dominance
LPW.2-1-6 x LB.78-4-1	4.44		-21.34*	No-dominance
LPW.12-3 x LB.78-4-1	5.23		-28.45*	No-dominance
Mean sum of square and variance (MS &σ^2)				
		GCA	**SCA**	
	Ms	3.15**	0.062	
	σ^2	0.308	-0.308	
	σ^2 GCA /σ^2 SCA	-		

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

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قوة الهجين وعلاقتها بتباين القدرة على التآلف في الباذنجان

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أجريت هذه الدراسة بمزرعة كليه العلوم الزراعية البيئية بالعريش- جامعه قناة السويس- مصر، خلال الموسم الصيفي في الفترة من ٢٠٠٩ حتى ٢٠١١. استخدم في الدراسة سبعه سلالات من الباذنجان طويل الثمار وتم التهجين بينها بنظام دائرة نصف تلقيحية لإنتاج ٢١ هجينا، تم تقييم جميع التراكيب الوراثية (٢٨ تركيبا) بالإضافة إلى الهجين التجاري (سنو F1) خلال موسمي ٢٠١٠ و٢٠١١ في تجربه مصممه بطريق القطاعات الكاملةالعشوائية في ثلاث مكررات، بهدف حساب قوه الهجين بالنسبة لمتوسط الأبوين، الأب الأفضل, والهجين المقارن، وتقدير نوع السيادة، وعلاقتها بتباين القدرة على التآلف لبعض الصفات في الباذنجان. وكانت أهم النتائج المتحصل عليها ما يلي: وجدت اختلافات معنوية بين الآباء والـ٢١ هجينا الناتجة منها في جميع الصفات المدروسة. ظهرت قوه هجين بالنسبة لمتوسط الأبوين, الأب الأفضل, والهجين المقارن في ١٤ و ٨ و٤ هجنا على التوالي لصفة المحصول الكلى/نبات، بينما ظهرت قوه هجين بالنسبة لمتوسط الأبوين، والهجين المقارن على التوالي في ٥ و٤ هجنا لعدد الأفرع/نبات، ٥ و١٢ لعدد الثمار/للعنقود، ١٠و١٥ لنسبه العناقيد الثمرية/نبات، و٨ و١١ لعدد الثمار الكلي/نبات. لم تظهر قوه هجين في صفات متوسط وزن الثمرة, طول وقطر الثمرة. أظهرت تقديرات نوع السيادة وحسابات تباين القدرة العامة والخاصة على التالف أن الفعل الإضافي للجين كان أكثرأهميه في توريث كل الصفات المدروسة، ما عدا صفه المحصول، بينما لعبت العوامل الغير مضيفه الدور الرئيسي في توريث صفه المحصول الكلى/نبات.