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DETERMINATION OF HETEROSIS IN EGGPLANT (*Solanum melongena* L.) HYBRIDS

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ABSTRACT

Six parental genotypes i.e. Local cultivar white long (P_1), Local cultivar dark long (P_2) and Black beauty (P_3) (local cultivars of eggplant were obtained from Horticultural Research Institute, Agricultural Research center, Egypt, and three PIs viz., PI 408974 (P_4), PI 470273 (P_5) and PI 542612 (P_6) (USDA gene bank, USA) and their fifteen F_1 hybrids in a diallel cross system without reciprocals were used to estimate heterosis percentage relative to both mid ,better parents and two check hybrids for some characters in eggplant (*Solanum melongena* L.). The experiment was conducted at Kaha Research Farm, Kaliobia Governorate during three successive seasons of 2015 and 2018. The 23 genotypes (6 parents, 15 F_1 hybrids and 2 check hybrids) were evaluated for yield and yield components to determine the heterosis effects .Hybrid vigour was documented for total yield, as well as, most fruit characters. In some crosses, high rate of parent heterosis were attained for these traits supporting the over dominance hypothesis. The cross ($P_3 \times P_6$) had the highest mid- parent and better parent heterosis value with (230.02% and 218.85%, respectively) for the total yield.

INTRODUCTION

Eggplant (*Solanum melongena* L.) is the fourth most important crop of the Solanaceae, which is widespread due to its high nutrition value and the taste of the fruits. Eggplant widely cultivated as one of the most important vegetables in both subtropical and tropical areas through the worldwide, it can play a vital role in achieving the nutritional security **(Sarker et *al*., 2006)**. It is one of the most economic vegetable crops grown in Egypt. The total cultivated area in Egypt reached 106998 feddans in 2018/2019 producing 1346712 tons with an average of 12.586 tons/feddan[Z].

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[z]Department of Agricultural Statistics, Ministry of Agriculture and Land Reclamation, Egypt, 2017.

Eggplant is an inexpensive food, thus a major food component of human diet in most developing home in the world over. So, its fruits are rich source of minerals like calcium, magnesium, potassium, iron, zinc and copper. It is also a fair source of fatty acids and it is used for medicinal purposes incurring diabetes, asthma, cholera, bronchitis and diarrhea. It is reported to stimulate the metabolism reduction of blood cholesterol. Leaf and fruit, fresh or dry produce marked drop in blood cholesterol level **(Agoreyo et *al*., 2012; Nyadanu and Lowor, 2015).**

Exploitation of hybrid vigour has become a potential tool for improvement in eggplant. **Nagai and Kada (1926)** were the first to observe hybrid vigour in eggplant. The commercial exploitation of this phenomenon has been possible in the eggplant, especially with increasing popularity of F_1 hybrids in eggplant, it is imperative to obtain such hybrids, having excellent quality coupled with high yields. In crop manifestation of heterotic effect for different economically important characters have been reported by many scientists (**Joshi and Thakur, 2003; Thakur *et al* 2004; Ajjappalavar, 2006; Sao and Mehta 2010; Kumar *et al*., 2012 and Makani *et al*., 2013).**

The development of an effective heterosis breeding programme in eggplant needs to elucidate the genetic nature and magnitude of quantitatively inherited traits and judge the potentiality of parents in hybrid combinations. Selection of parents for hybridization has to be based on the complete genetic information and prepotency of the potential parents. Identification and selection of flexible parental lines are required to be used in any hybridization programme to produce genetically modified and potentially rewarding germplasm by assembling fixable gene effects more or less in a homozygous line (**Kumar *et al*., 2013, Pedapatiet *et al*., 2013, Potla *et al*., 2013, and Singh *et al*., 2013).** With these points in view, heterosis and combining ability studies are prerequisite in any plant breeding programme, which provides the desired information regarding the varietals improvement or exploiting heterosis for commercial purposes **(Singh *et al*., 2013).**

MATERIALS AND METHODS

This study was carried out in 2015 to 2018 at Kaha Research Farm, Kaliobia Governorate to improve some economic characteristics in eggplant. Six genotypes of eggplant viz., Local cultivar white long (P_1), Local cultivar dark long (P_2) and Black beauty (P_3) (local cultivars of eggplant were obtained from Horticultural Research Institute, Agricultural Research center, Egypt, which were Local cultivar white long) and three PIs viz., PI 408974 (P_4), PI 470273 (P_5) and PI 542612 (P_6) (USDA gene bank, USA.) were selfed for one generation to keep its homozygosity and homogeneity. Parents were crossed to produce the F_1 hybrid seed in Diallel cross design, without reciprocals during 2016 and 2017early summer seasons. Seeds of these genotypes were sown on 15 Jan. in both years in foam seedling trays under unheated greenhouse conditions. Seedlings were transplanted on 15 Mar. in both years under unheated greenhouse conditions. The seeds of twenty three genotypes (six parents, fifteen F_1 hybrids and two controls viz., La'ala (local hybrid, long white fruits) and Black King (imported commercial hybrid spreading in Egypt, round black fruits) were sown on 15 Feb. 2018 in foam seedling trays under unheated greenhouse conditions. Seedlings were transplanted on 15 Apr. 2018 summer season in the open field. A randomized complete block design (RCBD) with 3 replicates was used. Each replicate consisted of twenty-three experimental units (six parents, fifteen hybrids and two controls). Each experimental unit (EU) consisted of one row, 0.75 m-wide and 5 m-long for each row (EU area = 3.75 m^2). Plants were set 50 cm apart along the row and were given common agricultural practices. So, each EU consisted of ten plants. Five randomly selected plants were chosen in each EU to record the observations and the average from these five plants was worked out for statistical analysis. The studied characters were Plant height (cm), number of branches per plant, number of days from planting date to first flower anthesis, Fruit length (cm), Fruit diameter (cm), average fruit weight (g) and total furit per plant

.**Statistical analysis**

Data obtained on genetic stability and evaluation of the F_1 hybrids experiments were statistically analyzed according to **Gomez and Gomez (1984)** and mean comparisons were based on the LSD test **(Waller and Duncan, 1969).**

Average degree of heterosis (ADH%) was estimated as the increase or decrease percent of F_1 performance over the mid-parent (MP) and better parent (BP) (**Sinha and Khanna, 1975)** as follows:-

$$\textbf{Based on MP} = (\overline{F_1} - \overline{MP} / \overline{MP}) \times 100$$

$$\textbf{Based on BP} = (\overline{F_1} - \overline{BP} / \overline{BP}) \times 100$$

Based on standard heterosis = (F_1- standard heterosis / standard heterosis) x 100

Where F_1 was the mean performance of the F_1 hybrid, MP was the mean performance of P_1 and P_2 and BP was the mean performance of the better parent.

RESULTS AND DISCUSSION

Mean performance

Mean performance of the tested six eggplant parental genotypes, their 15 F_1 hybrids and two controls (Black King and La'ala hybrids) for plant height, number of branches , flowering date, Average fruit weight and Fruit length traits are presented in Table (1). Regarding plant height, the findings indicated that a significant differences among different parental genotypes and F_1 hybrids. Concerning plant height the data showed that the plant height of parental genotypes ranged from 42.66 (P_6) to 60.33 cm (P_5) with the mean of 50.49 cm, as compared to the hybrids F_1 which ranged from 48.00 ($P_2 \times P_4$) to 78.00 cm ($P_3 \times P_6$) with the mean of 58.28 cm. Regarding the parental genotypes, the Black beauty (P_3) and PI 470273 (P_5) had the highest plant height value and were significantly different from all other parental genotypes. Additionally, the genotypes Local cultivar white long (P_1) and Local cultivar dark long (P_2) ranked second in this trait. Meanwhile, the genotypes (P_4) and (P_6) showed the lowest significant value for this trait (42.00 cm). Similarly, in the case of hybrids, the hybrid ($P_3 \times P_6$) had the highest plant height and was significantly different from all other hybrids. Likewise, the hybrids ($P_2 \times P_3$), ($P_5 \times P_6$) and ($P_1 \times P_3$) ranked second in this trait. Meanwhile, the lowest plant height showed in the hybrid ($P_2 \times P_4$), but it wasn't significantly different from the most of hybrids and the two controls. These results coincided with those of **Roychowdhury *et al*., (2011)** who reported that the analysis of variance revealed highly significant differences among ten genotypes of eggplant for all the quantitative characters studied i.e., plant height and **Hamada *et al*., (2016)** who found that the parental genotype Balady dark long showed the highest means for plant height (61.63 cm) compared to the remaining genotypes. Also, they reported that the hybrid Balady dark long x Balady dark round obtained the highest means for plant height (60.73 cm) compared to the remaining genotypes.

As for the number of branches per plant, the recorded data indicated that a significant differences among different parental genotypes and F_1 hybrids. The number of branches per plant of parental genotypes ranged from 8.33 (P_1) to 14.33 (P_4) with the mean of 10.77, as compared to the F_1 hybrids which ranged from 11.33 ($P_1 \times P_2$) to 25.00 ($P_4 \times P_6$) with the mean of 17.77. Regarding the parental genotypes, the PI 408974 (P_4) had the highest value of number of branches per plant. The hybrid ($P_4 \times P_6$) had the highest number of branches per plant, but it wasn't significantly different from hybrids ($P_4 \times P_5$), ($P_2 \times P_6$) and ($P_2 \times P_4$). Likewise, the hybrids ($P_5 \times P_6$) ranked second in this trait, but it wasn't significantly different from hybrids ($P_2 \times P_6$) and ($P_2 \times P_4$). Whereas, the lowest number of branches per plant showed in the hybrid Black King (used as control), but it wasn't significantly different from the hybrids ($P_2 \times P_3$) and ($P_1 \times P_2$).

Table 1: Mean performance for some vegetative growth and flowering traits of different eggplant parental genotypes and their F_1 hybrids evaluated in the open field during the 2018 summer season.

Genotypes [z]	Plant height (cm)	No. of branches/plant	Flowering date (day)	Average fruit weight (g))	Fruit length (cm)
P_1	50.66 fghi	8.33 k	70.33 cde	54.00 jk	13.92 defg
$_2$P	49.00hij	11.00hijk	71.66 bcd	74.20 fghij	12.74 fghij
$_3$P	60.33cde	12.33ghijk	70.00cde	210.00 ab	11.267 k
$_4$P	42.66j	14.33efgh	60.33ij	34.41 k	13.59 efgh
$_5$P	60.33cde	9.33 jk	79.66a	80.40 fghi	12.66 ghijk
$_6$P	42.66j	9.33 jk	66.00efgh	95.97 defg	7.40
Mean	50.49	10.77	69.66	91.49	11.29
$_2$P $\times_1$P	57.00defg	11.33 hijk	72.00 bc	96.96 def	15.37 abcd
$P_1 \times P_3$	65.66 bc	18.66 cd	73.00 b	115.65 d	15.65 abc
$P_1 \times P_4$	56.00defgh	18.33 cde	67.00 def	62.90 ij	16.85 a
$P_1 \times P_5$	56.33defgh	13.66 fghi	75.66 ab	64.19 hij	14.17 cdef
$P_1 \times P_6$	52.00 fghi	13.33fghij	69.66 cde	62.84 ij	12.37 hijk
$P_2 \times P_3$	69.33 b	11.33 hijk	67.00 def	156.87 c	12.74 fghijk
$P_2 \times P_4$	48.00 ij	22.00 abc	59.33 j	73.33 fhhij	15.63 abc
$P_2 \times P_5$	53.33 efghi	16.00defg	66.66 efg	79.83fghi	12.71 fghijk
$P_2 \times P_6$	49.33 ghij	23.33 ab	59.33 j	157.66 c	14.20 cdef
$P_3 \times P_4$	54.66defghi	18.33 cde	62.00 ghij	105.53 de	12.85 fghi
$P_3 \times P_5$	51.00 fghi	14.00 fgh	58.33 j	80.71 fghi	13.98 defg
$P_3 \times P_6$	78.00 a	17.00 def	64.33fghi	189.25 b	11.28 jk
$P_4 \times P_5$	62.00 bcd	24.33 a	59.33 j	64.72 hij	15.32 bcd
$P_4 \times P_6$	52.33 fghi	25.00 a	61.66 hij	73.54 ghij	14.59 cde
$P_5 \times P_6$	69.33 b	20.00 bcd	72.00 bc	148.52 c	12.85 fghi
Mean	58.28	17.77	65.81	102.16	14.03
Black King	50.16 ghij	9.50 ijk	72.33 bc	217.68 a	11.69 ijk
Laala	54.66defghi	18.50 cde	66.00efgh	69.41 hij	13.60 efgh
Mean	52.41	14.00	69.17	124.46	13.83
LSD(0.05)	7.67	4.29	4.96	23.25	1.48

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These results matched with those of **Roychowdhury *et al.*, (2011)** who reported that the analysis of variance revealed highly significant differences among ten genotypes of eggplant for all the quantitative characters studied i.e., number of branches/plant and **Hamada *et al.*, (2016)** who found that the parental genotype Balady dark long showed the highest means for number of branches (8.27) compared to the remaining genotypes. While, they had contradiction when reported that the hybrid Balady dark round x Balady dark long showed the highest means for number of branches (8.93)compared to the remaining genotypes.

Referring flowering date (Table,1), the results indicated that a significant differences among different parental genotypes and F_1 hybrids in this trait (the number of days from planting date to first flower anthesis). The data showed that the number of days from planting date to first flower anthesis of parental genotypes ranged from 60.33 (P_4) to 79.66 days (P_5) with the mean of 69.66 days, as compared to the hybrids F_1 which ranged from 58.33 ($P_3 \times P_5$) to 75.66 days ($P_1 \times P_5$) with the mean of 65.81 days. With respect to parental genotypes, the genotype PI 408974 (P_4) was the earliest in the flowers anthesis and was significantly different from all other parental genotypes. Likewise, the PI 542612 (P_6) ranked second in this trait and significantly different from all other parental genotypes. Meanwhile, the genotype PI 470273 (P_5) was the tardiest in the flowers anthesis and significantly different from all other parental genotypes. Similarly, in the case of hybrids, the hybrid ($P_3 \times P_5$) was the earliest in the flowers anthesis), but it wasn't significantly different from hybrids ($P_2 \times P_4$), ($P_2 \times P_6$), ($P_3 \times P_4$), ($P_4 \times P_5$) and ($P_4 \times P_6$). On the contrary, the hybrid Local cultivar white long ($P_1 \times P_5$) was the tardiest in the flowers anthesis, but it wasn't significantly different from hybrids ($P_1\times P_2$), ($P_1 \times P_3$), ($P_5 \times P_6$) and Black King (used as control).

Regarding average fruit weight trait (Table1), the findings indicated that there were significant differences among different parental genotypes and F_1 hybrids. Concerning average Fruit weight trait the obtained data showed that the average fruit weight of parental genotypes ranged from 34.41 (P_4) to 210.00 g (P_3) with the mean of 91.49 g, as compared to the hybrids F_1 which ranged from 62.84 ($P_1 \times P_6$) to 189.25 g ($P_3\times P_6$) with the mean of 102.16 gm. Regarding the parental genotypes, the Black beauty (P_3) had the highest average fruit weight and was significantly different from all other parental genotypes. On the other hand, the genotype PI 408974 (P_4) showed the lowest average fruit weight, but it wasn't significantly different from the genotype Local cultivar white long (P_1). In the case of hybrids, the hybrid ($P_3\times P_6$) had the highest significant average fruit weight. Whereas, the lowest average fruit weight was measured in the hybrid ($P_1 \times P_6$), but it wasn't significantly different from the most of hybrids and La’ala hybrid (used as control).

Referring Fruit length, the results presented in Table 1 indicated that there were significant differences among different parental genotypes and F_1 hybrids. Concerning fruit length the data showed that the fruit length of parental genotypes ranged from 7.40 (P_6) to 13.92 cm (P_1) with the mean of 11.29 cm, as compared to the hybrids F_1 which ranged from 11.28 ($P_3 \times P_6$) to 16.85 cm ($P_1 \times P_4$) with the mean of 14.03 cm. The Local cultivar white long (P_1) give the longest fruits, but it wasn't significantly different from genotypes PI408974 (P_4) and Local cultivar dark long (P_2) and were significantly different from all other parental genotypes, In the case of hybrids, the hybrid ($P_1 \times P_4$) had the longest significant value for this trait, but it wasn't significantly different from hybrid ($P_2 \times P_4$). Whereas, the shortest fruit length showed in the hybrid ($P_3 \times P_6$) was value (11.28 cm) but it wasn't significantly different from hybrids ($P_1 \times P_6$), ($P_2 \times P_5$) and ($P_2 \times P_3$), were values (12.37, 12.71and 12.74cm, respectively).

Concerning fruit diameter (Table, 2) the data showed that fruit diameter of parental genotypes ranged from 1.79 (P_4) to 6.00 cm (P_6) with the mean of 3.46 cm, as compared to the hybrids F_1 which ranged from 2.23 to 7.24 cm with the mean of 3.73 cm. Mean of F_1 was larger little than mean of parents for fruit diameter. The PI 542612 (P_6) had the highest value for fruit diameter, and was significantly different from all other parental genotypes. Likewise, the Black beauty (P_3) ranked second in this trait and significantly different from all other parental genotypes. Whereas genotype (P_1) showed the lowest significant value for fruit diameter, but it wasn't significantly different from genotype (P_5). The cross ($P_3 \times P_6$) gave the largest value (7.24 cm) were significantly different from all other hybrids, but one hybrid from hybrids control (Black king) wasn’t significantly different for the same trait. On the contrary, the hybrid ($P_1 \times P_4$) recorded the lowest value (2.23 cm) it wasn’t significantly different for the hybrids ($P_1 \times P_5$), ($P_4 \times P_5$), ($P_2 \times P_4$), ($P_1 \times P_6$) and ($P_4 \times P_6$).

Regarding number of fruit /plant, the findings indicated that there were significant differences among different parental genotypes and F_1 hybrids. Concerning number of fruit /plant the data in Table 2 showed that the number of fruit /plant of parental genotypes ranged from 9.67 (P_3) to 54.00 (P_4) with the mean of 18.83, as compared to the hybrids F_1 which ranged from 8.67 ($P_1 \times P_3$), to 48.33 ($P_1 \times P_4$), with the mean of 22.199. The case of, hybrids, the hybrid (P1× (P_4) had the highest number of fruit /plant value and was significantly different from all other hybrids, except the hybrid ($P_4 \times P_5$) and one hybrid from control. In contrast the hybrid ($P_1 \times P_3$) had the lowest number of fruit /plant value and wasn’t significantly different from most other hybrids such as ($P_1 \times P_6$), ($P_5 \times P_6$), ($P_4 \times P_6$), ($P_2 \times P_3$) and ($P_2 \times P_5$).

The results presented in Table 2 indicated that a significant differences among different parental genotypes and F_1 hybrids. Concerning fruit yield per plant the data showed that the fruit yield per plant of parental genotypes ranged from 0.77 (P_2) to 2.36 kg (P_4) with the mean of 1.267kg, as compared to the hybrids F_1 which ranged from 1.28

($P_2 \times P_5$) to 4.02 kg ($P_3 \times P_4$) with the mean of 2.40. The PI 408974 (P_4) had the highest fruit yield per plant value and was significantly different from all other parental genotypes, whereas the genotype (P_2) was lowest value and wasn't significantly different for (P_1). Concerning crosses, ($P_3 \times P_4$) had highest value followed by ($P_3 \times P_6$), (P4 × P_5) and (P_2× P_4), respectively, however, the cross (P_2) × P_5) had the lowest for fruit yield per plant value and wasn't significantly different from crosses (P_1× P_2), ($P_1 \times P_3$), Local cultivar white long (P_1× P6).

Table 2: Mean performance for some fruit characters of different eggplant parental genotypes and their F_1 hybrids evaluated in the open field during the 2018 summer season

Genotypes	Fruit diameter (cm)	No. of fruit /plant	Total Fruit yield kg/ plant
P_1	2.25 k	11.67 hij	0.89 hi
P_2	2.91 hi	13.33 hij	0.77 i
P_3	5.16 c	9.67 ij	1.21 fghi
P_4	1.79 l	54.00 a	2.36 cdef
P_5	2.66 ijk	14.00 hij	1.06 ghi
P_6	6.00 b	10.33 ij	1.13 fghi
Mean	3.46	18.83	1.27
$P_1 \times P_2$	3.42 fg	26.33 efg	1.30 efghi
$P_1 \times P_3$	3.23 gh	8.67 j	1.38 efghi
$P_1 \times P_4$	2.23 kl	48.33 ab	2.57 bcde
$P_1 \times P_5$	2.33 jk	22.00 fgh	1.79 defghi
$P_1 \times P_6$	2.56 ijk	9.33 j	1.43 efghi
$P_2 \times P_3$	6.01 b	14.33 hij	1.98 defghi
$P_2 \times P_4$	2.53 ijk	35.33 cde	3.61 abc
$P_2 \times P_5$	3.56 efg	16.33 ghij	1.28 efghi
$P_2 \times P_6$	4.20 d	22.00 fgh	2.89 abcd
$P_3 \times P_4$	3.98 de	28.00 def	4.02 a
$P_3 \times P_5$	3.98 de	22.00 fgh	2.34 cdefg
$P_3 \times P_6$	7.24 a	20.33 fghi	3.89 ab
$P_4 \times P_5$	2.45 jk	41.00 bc	3.87 ab
$P_4 \times P_6$	2.66 ijk	10.00 ij	2.18 defgh
$P_5 \times P_6$	5.66 b	9.33 j	1.59 efghi
Mean	3.73	22.20	2.40
Black King	7.13 a	12.33 hij	2.43 cdef
La'ala	2.75 ij	38.00 bcd	2.91 abcd
Mean	4.53	25.17	2.67
LSD(0.05)	0.44	10.68	1.30

These results matched with those of **Hamada *et al*., (2016)** who found that the parental genotype Balady dark long (P_3) showed the highest means for total fruit yield (44.93 ton/feddan) compared to other genotypes. Also, they stated that the hybrid (Balady dark long x Balady dark round) obtained the highest means for total fruit yield (58.03ton/feddan) and showed that the hybrid (Balady white long x Balady dark round) exhibited positive and highly significant heterosis values relative to their mid-parents and better parent for total fruit yield.

Heterosis effects

Data in Table (3) show heterosis over mid and better-parent for 15 F_1 hybrids. All the crosses exhibited significant mid and better-parent heterosis for majority of the traits indicating predominance of non-additive gene action in genetic control of these traits.

Regarding plant height, estimates of mid parent (MP) and better parent (BP) heterosis of crosses are presented in Table 3: Showed that 9 crosses out of the 15 evaluated F_1 hybrids indicated highly significant positive mid-parent heterosis, and one hybrid recorded significant negative value was ($P_2 \times P_6$) with (-15.70%). Mid - parent heterosis ranged from -15.70 % for the ($P_3 \times P_5$) to 50.97% for the cross ($P_3 \times P_6$). Desirable positive BP heterosis for plant height was observed in six F_1crosses, One F_1 crosses exhibited desirable significant negative BP values, i.e. ($P_3 \times P_5$) with (-15.93 %), Concerning heterosis over standard check in Table (4), exhibited 4 crosses out of the 6 evaluated F_1 hybrids concerning standard check (a) indicated significant standard check heterosis, and ranged from -12.2 % for the cross ($P_2 \times P_4$) to 13.41% for the cross ($P_4 \times P_5$), while exhibited 8 crosses out of the 9 evaluated F_1 hybrids indicated significant standard check heterosis (b), and ranged from -1.66 % for the cross ($P_2 \times P_6$) to 55.48% for the cross ($P_3 \times P_6$) for standard check heterosis (b).

Table 3: Percentage of heterosis in the F_1 generations over both mid and better parents for some vegetative growth and flowering traits of 15 eggplant F_1 hybrids

Crosses	Plant height		Number of branches		Flowering date	
	M.P%	B.P(%)	M.P(%)	B.P(%)	M.P(%)	B.P(%)
$P_1 \times P_2$	14.38**	12.50**	17.24**	3.03	1.41	2.37
$P_1 \times P_3$	17.96**	8.24*	80.65**	51.35**	4.04	4.29
$P_1 \times P_4$	20.00**	10.53**	61.76**	27.91**	2.55	11.05**
$P_1 \times P_5$	1.50	-6.63	54.72**	46.43**	0.89	7.58**
$P_1 \times P_6$	11.43**	2.63	50.94**	42.86**	2.20	5.56*
P2×P3	26.44**	14.29**	-2.86	-8.11	-5.41*	-4.29
$P_2 \times P_4$	4.73	-2.04	73.68**	53.49**	-10.10**	-1.66
$P_2 \times P_5$	-2.44	-11.60	57.38**	45.45**	-11.89**	-6.98*
$P_2 \times P_6$	7.64*	0.68	129.51**	112.12**	-13.80**	-10.10**
$P_3 \times P_4$	5.81	-9.89	37.50**	27.91**	-4.86*	2.76
$P_3 \times P_5$	-15.70	-15.93	29.23**	13.51**	-22.05**	-16.67**
P3×P_6	50.97**	28.57**	56.92**	37.84**	-5.39*	-2.53
$P_4 \times P_5$	20.39**	2.76	105.63**	69.77**	-15.24**	-1.66
$P_4 \times P_6$	22.66**	22.66**	111.27**	74.42**	-2.37	2.21
$P_5 \times P_6$	34.63**	14.92**	114.29**	114.29**	-1.14	9.09**
LCD 5%	6.27	7.24	3.99	4.60	4.61	5.32
LCD 1%	8.40	9.69	5.33	6.16	6.17	7.12

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

Table 4: Percentage of heterosis values standard checks (La'ala$_a$)^z and (Black king$_b$)^z for some vegetative growth and flowering traits of 6 eggplant F_1 hybrids.

Crosses^Z	Plant height (cm)	Number of branches	Flowering date (day)
	Standard checks	Standard checks	Standard checks
P1×P2	4.27$_a$	-38.74$_a$	9.09$_a$
P1×P4	2.44$_a$	-0.9$_a$	1.52$_a$
P1×P5	3.05$_a$	-26.12$_a$	14.65$_a$
P2×P4	-12.2$_a$	18.92a	-10.1$_a$
P2×P5	-2.45$_a$	-13.51$_a$	1.01$_a$
P4×P5	13.41$_a$	31.53$_a$	-10.11$_a$
P1×P3	30.9$_b$	96.49$_b$	0.93$_b$
P1×P6	3.65$_b$	40.35$_b$	-3.68$_b$
P2×P3	38.2$_b$	19.29$_b$	-7.37$_b$
P2×P6	-1.66$_b$	145.61$_b$	-17.97$_b$
P3×P4	8.97$_b$	92.98$_b$	-14.28$_b$
P3×P5	1.66$_b$	47.37$_b$	-19.35$_b$
P3×P6	55.48$_b$	78.95$_b$	-11.06$_b$
P4×P6	4.31$_b$	163.16$_b$	-14.74$_b$
P5×P6	38.2$_b$	110.53$_b$	-0.46$_b$

Z a standard check Lal, la hybrid long fruit and b Black King hybrid round fruit

These results coincided with those of **Naresh *et al*., (2013)** estimated significant positive heterosis for plant height, based on mid-parent, ranged from 0.83 to 29.74 % in 36 crosses of eggplant and found that the maximum heterosis for this trait was exhibited by the crosses KS-6103 × KS-8822, KS-6103 × KS-8821and KS-8504 ×KS-8821, and **Hamada *et al*., (2016)** who reported that the hybrid (Balady white long x Balady dark round) exhibited positive and highly significant heterosis.

Referring the number of branches per plant, estimates of mid and better-parent heterosis of crosses are presented in Table 3. Results Showed that 14 crosses out of the 15 evaluated F1 hybrids indicated highly significant positive for mid-parent heterosis, and ranged from 17.24 % for the (P_1 × P_2) to 129.51% for the cross (P_2 × P_6). While, results showed that 13 crosses out of the 15 evaluated F_1 hybrids showed highly significant positive for better-parent heterosis, and ranged from 13.53% for the cross (P_3 × P_5) to 112.12% for the cross (P_2 × P_6).Concerning heterosis over standard check in Table 4 exhibited 2 crosses out of the 6 evaluated F1 hybrids for standard check (a) indicated standard check heterosis, and ranged from -38.74 % for the cross (P_1 × P_2) to 31.53% for the cross (P_4 × P_5). However, exhibited all F_1 hybrids indicated positive standard check (b) heterosis for the number of branches per plant. These results coincided with those of **Mahmoud (2014)** stated that mid and better parents heterosis values ranged from -0.46 to 36.67% and 4.78 to 13.67%, respectively, for number of branches per plant, and **Naresh *et al*., (2014)** who mentioned that positive heterosis over better parent ranged from 1.38 to 52.23% for number of branches per plant in eggplant hybrids.

Data obtained on the number of days from planting date to first flower anthesis of evaluated eggplant genotypes are presented in Table (3)In this regard, the number of days from planting date to first flower anthesis with negative values of heterosis or heterobeltiosis was considered to be better and desirable.

Results revealed that, 5 out of the 15 evaluated F_1 hybrids showed highly significant negative heterosis for over mid parent for number of days from planting date to first flower anthesis and three hybrids registered significant negative heterosis for over mid parent, and ranged from -22.05% for the hybrid ($P_3 \times P_5$) to -1.14% for the hybrid ($P_5 \times P_6$). Other wise, two hybrids i.e. ($P_3 \times P_5$) and ($P_2 \times P_6$) indicate highly significant negative values of heterosis over the better parent with (-16.7 and -10.10%, respectively).Heterosis over the better parent ranged from -16.67 for the hybrid ($P_3 \times P_5$) to 11.05% for the hybrid ($P_1 \times P_4$). In connection with, standard check heterosis indicates rustles in Table (4). Two out of the 6 hybrids evaluated F_1 hybrids for standard check (a) showed negative values for the number of days from planting date to first flower anthesis , and hybrid ($P_4 \times P_5$) had highly significant negative value. The date in table 3 showed that most hybrids significant negative values for the number of days from planting date to first flower anthesis to strand check (b). These results are in agreement with those of **Sao and Mehta (2010)** evaluated 48 hybrids along with their parents in line × tester design during rainy season 2004/2005. They reported that among the eleven attributes studied highly significant and negative heterosis for days to first flowering (-14.66 %), and **Al-Hubaity (2013)** reported that the heterosis values ranged from -4.33 to 7.33% for date of flowering.

Referring average of fruit weight, estimates of mid and better-parent heterosis of crosses are presented in Table (5). Results indicated that 6 crosses out of the 15 evaluated F_1 hybrids had highly significant positive for mid-parent heterosis, and ranged from 32.71 % for the cross ($P_3 \times P_6$) to 85.30 % for the cross ($P_2 \times P_6$). While 3 hybrids were ($P_2 \times$ (P_6), ($P_5 \times P_6$) and ($P_1 \times P_2$) showed highly significant positive better-parent heterosis.

Highly significant positive better-parent heterosis was observed only on three cross i.e., ($P_1 \times P_2$), ($P_5 \times P_6$) and ($P_2 \times P_6$) with (30.67, 54.76 and 64.28%).With reference to, standard check heterosis indicate rustles in Table 6 defined 3 crosses out of the 6 evaluated F_1 hybrids were positive value for standard check(a), and ranged from -9.12 % for the cross Local cultivar white long (P1)× PI 408974 (P4) to 40.10 % for the cross Local cultivar white long (P_1)× Local cultivar dark long (P_2) for the same standard check. Otherwise, data in Table 6 show standard heterosis (b) for 9 F_1 hybrids. All the crosses exhibited negative value, for average fruit weight. These results are in agreement with those reported by **Al-Hubaity (2013)** who observed the heterosis values ranged from -14.74 to 41.74% for average fruit weight, and **Mahmoud (2014)** stated that mid parents heterosis values ranged from -17.16 to 11.99% for average fruit weight, and its maximum heterosis was estimated in the cross CLW.1-1 × CLW.4-2. Check.

Table 5: Percentage of heterosis in the F_1 over both mid and better parents for some physical characters of 15 F_1 eggplant.

Genotype	Average fruit weight		Fruit length		Fruit diameter	
	M.P	B.P	M.P	B.P	M.P	M.P
P_1×P_2	51.26**	30.67**	15.25**	10.49**	32.39**	17.26**
P_1×P_3	-12.38	-44.93	24.29**	12.46**	-12.81	-37.42
P_1×P_4	42.29**	16.49	22.54**	21.10**	10.73**	-0.59
P_1×P_5	-4.47	-20.16	6.66**	1.87*	-5.22	-12.63
P_1×P_6	-16.19	-34.52	16.09**	-11.09	-37.86	-57.28
P_2×P_3	10.40	-25.30	6.02**	-0.21	48.78**	16.39**
P_2×P_4	36.88**	0.18	18.63**	15.04**	7.65**	-13.14
P_2×P_5	3.28	-0.70	0.00	-0.39	27.76**	22.29**
P_2×P_6	85.30**	64.28**	40.83**	11.23**	-5.79	-30.00
P_3×P_4	-13.64	-49.75	3.39**	-5.45	14.61**	-22.84
P_3×P_5	-44.41	-61.57	16.88**	10.42**	1.62**	-22.97
P_3×P_6	23.71**	-9.88	20.86**	0.12	29.73**	20.72**
P_4×P_5	12.74	-19.50	16.69**	12.73**	10.25**	-7.88
P_4×P_6	12.80	-23.37	39.05**	7.38**	-31.54	-55.56
P_5×P_6	68.42**	54.76**	28.07**	1.45	30.77**	-5.56
LCD 5%	17.32	20.00	1.26	1.46	0.40	0.46
LCD 1%	23.17	26.76	1.69	1.95	0.54	0.62

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

Data in Table 5 exhibited most hybrids highly significant positive values of heterosis over the mid-parent for fruit length. The hybrid ($P_2 \times P_6$) had the highest value (40.83%), while the hybrid ($P_3 \times P_4$) had the lowest one (3.39 %). Only one hybrid ($P_2 \times P_5$) did not have any heterosis for fruit length. Related the heterosis over the better parent, the hybrid ($P_1 \times P_4$) had the highly significant value (21.10%), while the hybrid ($P_1 \times P_6$) had the lowest one (-11.9 %). As for, check heterosis indicate rustles in Table (6). Results showed 5 crosses out of the 6 evaluated F1 hybrids for standard check (a) were positive value, and ranged from -6.49 % for the cross ($P_2 \times P_5$) to 23.92 % for the ($P_1 \times P_4$). However, standard check heterosis (b) for 9 F_1 hybrids. All the crosses exhibited positive value except the hybrid ($P_3 \times P_6$) was value -3.53%, whilst the hybrid ($P_1 \times P_3$) was highest value 33.84% for fruit length. This results is coincided with **Makani *et al*., (2013)** reported that significant positive heterosis, based on mid-parent and better parent in the cross GP-180 × KS-331 reaching to 21.11% and 12.11%, respectively, for average fruit length, and **Naresh *et al*., (2013)** found that average fruit length for eggplant of heterosis over mid- parent 6.04 to 72.73 %.

Table 6: Heterosis (%) values standard checks (La'ala$_a$)^z and (Black king$_b$)^z for some physical characters of 6 eggplant F_1 hybrids.

Genotypes ^{z}	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)
$P_1 \times P_2$	40.10_a	13.07_a	24.21_a
$P_1 \times P_4$	-9.12_a	23.92_a	-18.76_a
$P_1 \times P_5$	-7.25_a	4.24_a	-15.37_a
$P_2 \times P_4$	7.40_a	14.95_a	-7.99_a
$P_2 \times P_5$	15.34_a	-6.49_a	29.54_a
$P_4 \times P_5$	-6.49_a	12.65_a	-10.77_a
$P_1 \times P_3$	-46.87_b	$33.84A_b$	-54.67_b
$P_1 \times P_6$	-71.13_b	5.82_b	-64.07_b
$P_2 \times P_3$	-27.94_b	8.95_b	-15.70_b
$P_2 \times P_6$	-27.57_b	21.44_b	-41.12_b
$P_3 \times P_4$	-51.52_b	9.89_b	-44.11_b
$P_3 \times P_5$	-62.92_b	19.62_b	-44.21_b
$P_3 \times P_6$	-13.06_b	-3.53_b	1.54_b
$P_4 \times P_6$	-66.22_b	24.80_b	-62.62_b
$P_5 \times P_6$	-31.77_b	9.89_b	-20.56_b

Z a standard check Lal,la hybrid long fruit and b Black King hybrid round fruit

Concerning, fruit diameter; estimates of mid and better-parent heterosis of crosses are presented in Table 5. Results exhibited that 10 crosses out of the 15 evaluated F_1 hybrids defined highly significant positive mid-parent heterosis, and ranged from 1.62 % for the cross ($P_2 \times P_5$) to 48.78 % for the ($P_2 \times P_3$). However, results Showed that 4 hybrids out of the 15 evaluated F1 hybrids showed highly significant positive better-parent heterosis, and ranged from 16.39 % for the cross Local cultivar white long (P_2) × P_3) to 22.29 % for the cross ($P_2 \times P_5$). In connection with, standard check heterosis indicates rustles in Table (6). Two out of the 6 evaluated F_1 hybrids showed positive values over hybrids (La'ala) standard check(a) heterosis and ranged from -18.76 % for the cross ($P_1 \times P_4$) to 29.54% for the cross ($P_2 \times P_5$). On the other hand, the date in table 6 showed that most hybrids negative values for fruit diameter, except the hybrid Black beauty ($P_3 \times P_6$). These results are in agreement with those reported by **Patel *et al*,. (2013)** who estimated significant positive heterosis, based on mid-parent for average fruit diameter ranged from -11.10% to 65.20%, Seven crosses out of 21 crosses showed significantly positive heterosis for both traits.

Data presented in Table (7). indicated that, the magnitude of heterosis for no. of fruit per plant ranged from -68.91 for the hybrid ($P_4 \times P_6$) to 110.67 % for the hybrid ($P_1 \times P_2$) and from -81.48 for the hybrid ($P_4 \times P_6$) to 97.50 % for the hybrid ($P_1 \times P_2$) over mid- parent and better parent, respectively. Whereas, 9 out of the 15 hybrids and 5 out of the 15 hybrids exhibited significantly positive heterosis over mid- parent and better parent, respectively for no. of fruit per plant. The cross ($P_1 \times P_2$) followed by the cross ($P_3 \times P_6$), ($P_2 \times P_6$) and ($P_3 \times P_5$) had exhibited desirable significant positive heterosis over mid- parent and better parent. On the contrary, 4 out of the 15 hybrids and 8 out of the 15 hybrids exhibited highly significantly negative heterosis over mid- parent and better parent, respectively for no. of fruit per plant. The cross ($P_4 \times P_6$) had the lowest negative value over both types of heterosis. With regard to, standard check heterosis indicates rustles in Table 8. 2 out of the 6 evaluated F_1 hybrids increase positive over hybrids (La'ala) standard check (a) heterosis and ranged from -57.03 % for the cross ($P_2 \times P_5$) to 27.19% for the cross ($P_1 \times P_4$) no. of fruit per plant. On the other hand, The date in Table 8: showed that 5 out of the 9 evaluated F_1 hybrids increase positive over hybrids (Black king) standard check (b) heterosis and ranged from -29.71 for hybrid ($P_1 \times P_3$) to 127.09 for hybrid ($P_3 \times P_4$) for no. of fruit per plant.

Table 7: Percentage of heterosis in the F_1 generations over both mid and better parents for number of fruits and yield per plant characters of 15 eggplant F_1 hybrids.

genotypes	no. of fruit /plant		Yield/plant	
	M.p	B.p	M.p	B.p
$P_1 \times P_2$	110.67**	97.50**	56.36**	45.08**
$P_1 \times P_3$	-18.75**	-25.71**	61.08**	39.94**
$P_1 \times P_4$	47.21**	-10.49	57.57**	8.62**
$P_1 \times P_5$	71.43**	57.14**	83.24**	99.77**
$P_1 \times P_6$	-15.15**	-20.00**	41.29**	26.52**
$P_2 \times P_3$	24.64**	7.50	99.60**	62.77**
$P_2 \times P_4$	4.95	-34.57**	130.57**	52.65**
$P_2 \times P_5$	19.51**	-69.75**	39.97**	-46.03
$P_2 \times P_6$	85.92**	65.00**	205.11**	155.80**
$P_3 \times P_4$	-12.04	-48.15**	124.77**	70.11**
$P_3 \times P_5$	85.92**	57.14**	106.81**	93.42**
$P_3 \times P_6$	103.33**	96.77**	230.02**	218.85**
$P_4 \times P_5$	20.59**	-24.07**	126.20**	63.67**
$P_4 \times P_6$	-68.91**	-81.48**	24.51*	-7.94
$P_5 \times P_6$	-23.29**	-33.33**	45.33**	40.52**
LCD 5%	9.71	11.22	1.14	1.32
LCD 1%	13.00	15.01	1.53	1.77

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

Table 8: Heterosis (%) values standard checks (La'ala $_a$)^z and (Black king$_b$)^z for for number of fruits and yield per plant characters of 6 eggplant F_1 hybrids.

Genotypes	No. of fruit /plant	Yield/plant
$P_1 \times P_2$	-30.70_a	-55.43_a
$P_1 \times P_4$	27.19_a	-11.89_a
$P_1 \times P_5$	-42.11_a	-38.63_a
$P_2 \times P_4$	-7.02_a	23.82_a
$P_2 \times P_5$	-57.03_a	-56.22_a
$P_4 \times P_5$	7.89_a	32.76_a
$P_1 \times P_3$	-29.71_b	-43.04_b
$P_1 \times P_6$	-24.31_b	-40.98_b
$P_2 \times P_3$	16.24_b	-18.56_b
$P_2 \times P_6$	78.43_b	19.33_b
$P_3 \times P_4$	127.09_b	65.72_b
$P_3 \times P_5$	78.43_b	-3.22_b
$P_3 \times P_6$	64.91_b	59.53_b
$P_4 \times P_6$	-18.90_b	-10.31_b
$P_5 \times P_6$	-24.31_b	-34.45_b

Z a standard check Lal,la hybrid long fruit and b Black King hybrid round fruit

Data in Table (7) exhibited all hybrids highly significant positive values of heterosis over the mid-parent for total fruit per plant. The hybrid ($P_3 \times P_6$) had the highest value (230.02%), while the hybrid ($P_4 \times P_6$) had the lowest one (24.51 %). In the case of, heterosis over the better-parent, showed that most hybrids had highly significant positive values of heterosis over the better-parent, except two hybrids had highly significant negative values were cross ($P_2 \times P_5$) and ($P_4 \times P_6$) with (-46.03 and -7.94, respectively), and the hybrid ($P_3 \times P_6$) had the highest value (218.85%) for yield per plant. About standard check heterosis presented rustles in Table 8 Two out of the 6 evaluated F_1 hybrids increase positive over hybrids (La'ala) standard check (a) heterosis and ranged from -56.22 % for the cross ($P_2 \times P_5$) to 32.76% for the cross ($P_4 \times P_5$) for yield per plant. However, standard check (b) heterosis showed rustles 3 out of 9 evaluated F_1 hybrids highest positive over hybrids (Black king) standard check (b) heterosis and ranged from -43.04 for hybrid ($P_1 \times P_3$) to 65.72 for hybrid ($P_3 \times P_4$) for yield per plant. These results are in agreement with those reported by **Naresh *et al*., (2013)** who estimated significant positive heterosis, based on mid-parent, ranged from 21.04 to112.64% in 36 crosses of eggplant and found that the maximum heterosis for fruit yield per plant was exhibited by the cross KS-8507 x KS-7512 (112.64%) followed by KS-5623 x KS-7512 (110.39%) and KS-8204-2 x KS-8822(92.47%).

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تقدير قوة الهجين لبعض هجن الباذنجان

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(1) قسم البساتين – كلية الزراعة – جامعة بنها– (2) قسم وقاية النبات كلية الزراعة – جامعة بنها و(3) قسم بحوث تربية الخضر والنباتات الطبية والعطرية – معهد بحوث البساتين – مركز البحوث الزراعية.

أجريت هذة الدراسة في محطة بحوث الخضر بقها محافظة القليوبية وذلك باستخدام ستة أباء ثلاثة اباء منهم من الاصناف المحلية مثل الصنف المحلي الابيض الطويل الاب الاول – الصنف المحلي الاسود الطويل الاب الثاني والصنف البلاك بيوتي الاب الثالث وثلاثة اصناف مستورة من مركز الاصول الوراثية بالولايات المتحدة وهما PI 4089741 الاب الرابع PI 470273 الاب الخامس و PI 542612 الاب السادس . وتم أجراء التهجينات بطريقة الهجن الدا في اتجاه واحد بدون استخدام الخجن العكسية. وتم تقدير قوة الهجين بالنسبة لمتوسط الابوين وبالنسبة لاب الافضل وبالنسبة للهجين القياسي وتم الزراعة في الفترة من 2015 الي 2018 في ثلاث مواسم . وتم تقييم 23 التركيب الوراثي (ستة أباء و 15 الهجين الخاصة بها و 2 هجين كنترول) وتم تقيميها لتقدير قوة الهجين لمكونات المحصول وبعض الصفات الثمرية والصفات الاخري. في بعض الهجن ، تم تحقيق معدل مرتفع من قوة الهجين التي أثبت سيادة تامة لمعظم الصفات وكان الهجين (P3*P6) اعطي اعلي قوة هجين بالنسبة لمتوسط الابوين والاب الافضل بقيم (230.02 % و218.85 بالترتيب) لمحصول الكلي.