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COMBINING ABILITY AND CORRELATION BETWEEN YIELD AND DIFFERENT CHARACTERS IN EGGPLANT FOR PRODUCING HIGH QUALITY OF LOCAL HYBRIDS.

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ABSTRACT

A half diallel set crosses among six eggplant cultivars (*Solanum melongena* L.) viz., Brinjal Pusa Purple Cluster (P_1), Egyptian White (P_2), Long Purple (P_3), Round Dark Purple (P_4), Black Beauty (P_5) and Brinjal Pusa Bharav (P_6) was done. All the hybrids and parents were evaluated under greenhouse and open field during winter and summer months respectively from 2002 to 2004 at Kaha Vegetable Research Station, Kalubia, Egypt.

Both general combining ability and specific combining ability (GCA and SCA) were significant for plant height, number of primary branches per plant, number of flowers per cluster, early yield, total yield, number of fruits per plant, fruit length, fruit diameter, average fruit weight and total soluble solids, indicating the importance of both additive and non-additive gene actions for inheritance of these traits. The GCA: SCA ratio suggested that additive gene action played a greater role in the inheritance of all studied characters.

Among the cultivars, ($P_{1,}$ P_2), (P_3), ($P_{5,}$ P_6) and ($P_{1,}$ P_2) proved to be the best combiners for number of flowers per cluster, early yield, total yield and number of fruits per plant respectively and recommended for use in breeding programs.

The crosses (P_3 x P_5), (P_4 x P_5) and (P_5 x P_6) were a good specific combination for total yield per plant and fruit characters and considered as the promising hybrids for growing under greenhouses and open field.

Positive correlation was found between total yield (Kg/plant) and both of plant height, number of primary branches per plant, number of flowers per cluster, number of fruits per plant, fruit length, fruit diameter and fruit weight under the two growing systems. These results are indicating that the increase in total yield of eggplant fruits would be associated with an increasing in these characters.

INTRODUCTION

Eggplant (*Solanum melongena* L.) is an important vegetable crop grown in Egypt under protected cultivation and open field. Eggplant genotypes differed significantly for plant height, primary branches per plant, fruit length, fruit diameter, number of fruits per plant, fruit weight and yield as reported by Das and Barua (2001). Eggplant is a cold-sensitive vegetable crop that requires a long warm season for best yields. Esmat (1972) found that plant height was reduced by low night temperature (14-15.9^{o}C) and increased by high night temperature (17.8-18.9^{o}C). Also, Lee *et al* (2003) found that plant height, total number of fruits and marketable fruits were higher when the night temperature was 16°C comparatively to 12°C.

Numerous investigators suggested that both additive and non-additive components were important for fruit diameter (Chaudhary and Pathania, 2000), plant height, number of fruits per plant, fruit yield per plant (Chezhian *et al* 2000; Das and Barua, 2001), fruit weight (Chezhian *et al* 2000; Vaghasiya *et al* 2000 ; Das and Barua, 2001) and fruit length (Das and Barua, 2001).

Additive genetic variance played an important role in the inheritance of fruit weight (Salehuzzaman and Alam, 1983; Chaudhary and Pathania, 2000), early yield (Sanguineti *et al* 1985), fruit diameter (Ingale and Patil, 1997; Das and Barua, 2001; Major *et al* 2002; Singh *et al* 2002), fruit length (Ingale and Patil, 1997; Major *et al* 2002; Singh *et al* 2002), number of branches per plant (Das and Barua, 2001; Major *et al* 2002; Singh *et al* 2002) and number of fruits per plant (Major *et al* 2002; Singh *et al* 2002). On the other hand, non-additive gene action was important for inheritance of total soluble solids (Chaudhary *et al* 1998), fruit yield per plant (Chaudhary *et al* 1998; Vaghasiya *et al* 2000) and plant height, fruit diameter and number of fruits per plant (Vaghasiya *et al* 2000).

The magnitude of heterosis were observed in different eggplant crosses for fruit diameter (Prasath *et al* 1998), fruit yield, number of fruits per plant, fruit weight (Prasath *et al* 1998 ; Babu and Thirumurugan, 2001; Das and Barua 2001), plant height, number of branches per plant (Prasath *et al* 1998; Babu and Thirumurugan, 2001) and fruit length (Babu and Thirumurugan, 2001). On the other hand, negative heterosis was found for plant height, number of branches per plant, fruit length, number of fruits, fruit weight and fruit yield (Babu and Thirumurugan, 2000).

Positive correlation was found between total yield and both of plant height (Mishra and Mishra, 1990; Prasath *et al* 2001), number of flowers per cluster (Kumar *et al* 1990; Narendra and Kumar, 1995), number of primary branches per plant (Kumar *et al* 1990; Mishra and Mishra, 1990; Narendra and Kumar, 1995; Prasath *et al* 2001), number of fruits per plant (Kumar *et al* 1990; Mishra and Mishra, 1990; Narendra and Kumar, 1995; Mohanty and Prusti, 2000; Prasath *et al* 2001), fruit length (Kumar *et al* 1990; Narendra and Kumar, 1995); fruit diameter (Prasath *et al* 2001) and fruit weight (Mishra and Mishra, 1990; Mohanty and Prusti, 2000; Prasath *et al* 2001).

Since yield is known to be a complex trait highly affected by environmental conditions thus, the preset investigation was carried out to 1) evaluating different local F_1 eggplant hybrids 2) study the combining ability and heterosis for different qualitative and quantitative characters to select the best hybrids; 3) investigate the correlation between total yield and different characters.

MATERIAL AND METHODS

Six eggplant cultivars (*Solanum melongena* L) viz., Brinjal Pusa Purple Cluster (Bangladesh), Egyptian White (Egypt), Long Purple (Egypt), Round Dark Purple (China), Black Beauty (Egypt) and Brinjal Pusa Bharav (Bangladesh) were used in this study. Selfing for the parents was done for two generations to insure the purity of each parent before crossing. On 14 March 2002 half diallel set of crosses was made between the six parents giving a total of 15 F1 crosses. Hybrids and varieties were planted on 15 October 2002 and 2003 (winter season) under unheated greenhouse (experiment 1) and on 16 March 2003 and 2004 (summer season) under open field conditions (experiment 2). All the previous genotypes were planted in randomized complete block design with four replicates at Kaha Vegetable

Research Station, Kalubia, Egypt. Each genotype consisted of 15 plants. A spacing of 50 cm between rows and 50cm between plants within each row was maintained. All cultural operations were similar to those practiced in commercial field production. Data were recorded for the different characters as following:

1- Growth characters: plant height (cm), number of flower per cluster and number of primary branches per plant.
2- Yield: early yield (Kg/plant) measured as the weight of fruits harvested during the first 3 weeks of harvesting period. Total yield (Kg/plant) were measured as the weight of all fruits harvested. Number of fruits per plant was recorded from all harvesting fruits.
3- Fruit quality: average fruit weight (gm) was determined as the mean weight of six fruits randomly chosen from each replicate. Fruit length and fruit diameter were measured by using a caliper. Total soluble solids (TSS) were determined in four fruits per replicate using a hand refractometer.

The statistical analysis for combining ability based on mean values was done as method II Model 1 of Griffing (1956).

The degree of heterosis based on the mid parent was estimated according to the formula given by Mather and Jinks (1982) as follow: Heterosis = $\{(F_1 – MP) / MP\} \times 100$

Where: F_1 = the first hybrid generation, MP = mid parent.

Simple correlation was performed according to Singh and Chaudhary (1979).

Temperature distribution in winter and summer seasons under greenhouse and open field respectively during, 2002 to 2004 were recorded according to Central Laboratory of Climate, Ministry of Agriculture, Dokki, Giza, Egypt (Table 1).

Table 1: Average minimum and maximum temperatures (ºC) in Kalubia under greenhouse and open field during winter and summer seasons respectively in the two seasons.

Greenhouse							Open field				
Month	2002		2003		2004		Month	2003		2004	
	Min	Max	Min	Max	Min	Max		Min	Max	Min	Max
October	15.97	34	18.35	36.03	----	----	March	10.2	22.2	11.6	24.8
November	14.07	34.28	14.26	32.53	----	----	April	14.2	27.3	14.5	28.3
December	12.27	31.06	9.99	29.03	----	----	May	17.3	23.9	18.6	32.2
January	----	----	11.03	30.92	8.85	27.63	June	20.2	33.7	20.8	34.6
February	----	----	9.61	29.45	9.42	28.96	July	21.8	33.6	23.1	35.2
March	----	----	9.32	29.66	10.65	31.48	August	22.4	34.5	22.5	34.9
April	----	----	13.12	33.23	13.41	33.93					

RESULTS AND DISCUSSION

The general characteristics of six varieties and fifteen hybrids grown under the two growing systems are presented in Table (2) and Fig (1). It is clear that fruit shape and fruit color differed between different genotypes. Moreover, the fruit color of the parents was stable for the environments, while some crosses were depended on the light conditions through out different seasons for producing the good fruit color.

Table 2. General characteristics of six varieties and fifteen hybrids of eggplant.

Genotypes	Fruit shape	Fruit color	Seasonal effect on fruit color
(P_1): Brinjal pusa purple cluster	Short-slender	Purple	No effect
(P_2): Egyptian White	Long-slender	White (non-purple)	No effect
(P_3): Long Purple	Long-slender	Dark purple	No effect
(P_4): Round Dark Purple	Round	Purple	No effect
(P_5): Black Beauty	Oval to deep globe	Dark glossy maroon	No effect
(P_6): Brinjal pusa Bharav	Oval or egg	Dark purple	No effect
P_1 x P_2	Medium-slender	Light violet	Affected in winter
P_1 x P_3	Medium-slender	Dark purple	No effect
P_1 x P_4	Egg shaped	Violet	Affected in winter
P_1 x P_5	Elongated oval	Dark glossy maroon	Affected in winter
P_1 x P_6	Elongated oval	Glossy maroon	Affected in winter
P_2 x P_3	Long slender	Reddish purple	Affected in winter
P_2 x P_4	Egg shaped	White	Affected in winter
P_2 x P_5	Elongated oval	Glossy maroon	Affected in winter
P_2 x P_6	Egg shaped	Dark purple	Affected in winter
P_3 x P_4	Egg shaped	Dark purple	No effect
P_3 x P_5	Elongated oval	Dark purple	No effect
P_3 x P_6	Egg shaped	Violet black	No effect
P_4 x P_5	Round	Violet black	No effect
P_4 x P_6	Round	Purple	No effect
P_5 x P_6	Oval	Violet black	No effect

Fig1

1-Growth characters

There were highly significant differences among parents and crosses either grown in greenhouse or open field conditions for growth character, i.e. plant height, number of branches per plant and number of flowers per cluster as shown in Table (3). Similar results were reported by Das and Barua (2001). Moreover it is clear that the cultivars (P_3), (P_5), (P_6) and cross (P_3 x P_5) had the highest significant values regarding plant height in two previous growing systems (Table 4). Cultivar's (P_2), (P_3) and cross (P_3 x P_5) had the highest significant values regarding number of branches per plant while, (P_1) and crosses (P_1 x P_2) and (P_1 x P_3) had the highest significant values for number of flowers per cluster in two previous growing systems during the two seasons (Table 4). Generally, the growth characters had the highest values under open field than greenhouse. This could be attributed to the increase of the minimum temperatures under open field (summer season) than greenhouse (winter season) as shown in table (1), which affected on these traits as recorded by Esmat (1972), and Lee *et al* (2003).

Results in Table (3) showed that the mean squares due to general and specific combining ability (GCA and SCA) for plant height, number of branches per plant and number of flowers per cluster were highly significant at two environmental conditions and growing systems. This would indicate that either additive or non-additive effects are important for inheritance of these traits under such conditions. Therefore, it is suggested that both simple recurrent selection (additive) and heterosis breeding (non-additive) may be used to exploit genetic components of variations in eggplant. Similar results were reported by Chezhian *et al* (2000) and Das and Barua (2001) on plant height.

It is apparent from Table (3) that the ratio of GCA/SCA are higher than unity, for the previous traits, indicating that the additive gene action is more important than the non-additive gene action in inheritance of these traits under the two previous conditions. These results coincided with that of Das and Barua (2001), Major *et al* (2002), Singh *et al* (2002) on number of branches per plant. In contrast to our results, Vaghasiya *et al* (2000) recorded that the non-additive gene action played an important role in the inheritance of plant height.

The GCA ranged from -11.13 (P_1) to 8.69 (P_5) and -9.38 (P_1) to 7.67 (P_5) for plant height; -0.67 (P_4) to 0.69 (P_3) and –0.61 (P_1) to 0.54 (P_3) for number of branches per plant and -0.61 (P_5) to 1.17 (P_1) and –0.57 (P_5) to 1.04 (P_1) for number of flowers per cluster with significant positive (useful) estimates under greenhouse in the two-winter seasons respectively (Table 5). Moreover, the GCA ranged from -11.62 (P_1) to 11.10 (P_5) and -8.43 (P_4) to 9.53 (P_5) for plant height; -0.59 (P_1) to 0.53 (P_3) and –0.61 (P_1) to 0.59 (P_3) for number of branches per plant and -0.58 (P_5 and P_6) to 1.07 (P_1) and –0.59 (P_5) to 1.01(P_1) for number of flowers per cluster with significant positive (useful) estimates under open field in the two summer seasons respectively (Table, 5). This would indicate that the cultivars (P_5, P_3), (P_2, P_3) and (P_1, P_2) showed significant positive estimates for plant height, number of branches per plant and number of flowers per cluster respectively and considered to be the best combiners to improve this traits under both growing systems.

Table 3. Mean squares for genotypes, general and specific combining ability (GCA and SCA) difference of eggplant under greenhouse and open field.

Characters	Genotype		GCA		SCA		GCA \ SCA	
Greenhouse								
	2002	2003	2002	2003	2002	2003	2002	2003
Plant height (cm)	888.330**	647.706**	515.952**	401.093**	222.829**	154.171**	2.315	2.602
Number of branches /plant	2.717**	1.854**	2.742**	1.815**	0.293**	0.219**	9.349	8.286
Number of flowers/ cluster	2.785**	2.486**	3.404**	2.804**	0.103**	0.170**	33.133	16.450
Early yield (Kg\ plant)	0.011**	0.011**	0.010**	0.007**	0.002	0.002	6.673	3.224
Total yield (Kg\ plant)	0.580**	0.580**	0.369**	0.337**	0.135**	0.146**	2.745	2.310
Number of fruits / plant	16.105**	16.166**	15.398**	16.587**	2.025**	1.656**	7.603	10.018
Fruit length	11.398**	7.507**	10.856**	7.322**	1.447**	0.896**	7.501	8.173
Fruit diameter	13.691**	13.788**	15.445**	15.786**	0.936**	0.866**	16.493	18.223
Average fruit weight	5635.877**	5686.666**	6285.784**	6416.989**	409.573**	388.411**	15.347	16.521
TSS (%)	0.287*	0.268*	0.366**	0.338**	0.005	0.007	66.975	50.834
Open field								
Characters	2003	2004	2003	2004	2003	2004	2003	2004
Plant height (cm)	886.709**	934.960**	605.694**	447.899**	192.195**	266.238**	3.151	1.682
Number of branches /plant	1.727**	1.879**	1.769**	2.065**	0.178**	0.147**	9.946	14.061
Number of flowers/ cluster	2.557**	2.393**	2.979**	2.735**	0.143**	0.152**	20.774	18.003
Early yield (Kg\ plant)	0.022**	0.017**	0.014**	0.010**	0.005**	0.004**	2.813	2.455
Total yield (Kg\ plant)	0.824**	0.609**	0.522**	0.357**	0.192**	0.152**	2.717	2.354
Number of fruits / plant	15.052**	12.970**	15.233**	12.885**	1.612**	1.470**	9.450	8.767
Fruit length	11.878**	10.767**	11.265**	7.778**	1.524**	2.193**	7.392	3.547
Fruit diameter	15.248**	14.881**	17.745**	16.533**	0.862**	1.103**	20.582	14.993
Average fruit weight	6436.708**	6318.207**	7147.807**	7323.039**	478.157**	367.079**	14.949	19.949
TSS (%)	0.251**	0.256**	0.296**	0.330**	0.013	0.004	23.050	81.133

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

Table 4. Mean performance of six parental cultivars and F_1 crosses for growth characters of eggplant under greenhouse and open field.

Genotypes	Plant height (cm)				Number of branches per plant				Number of flowers per cluster			
	Greenhouse		Open field		Greenhouse		Open field		Greenhouse		Open field	
	2002	2003	2003	2004	2002	2003	2003	2004	2002	2003	2003	2004
P_1	97.87	101.67	105.33	115.07	4.00	4.27	4.43	4.50	5.03	4.94	5.21	5.14
P_2	133.67	134.00	138.20	136.73	6.93	6.07	6.47	6.83	2.70	2.72	2.90	2.72
P_3	136.33	137.40	139.36	143.27	6.50	6.37	6.57	6.80	2.00	1.99	2.10	2.17
P_4	130.87	128.87	133.37	136.95	3.67	4.00	4.23	4.33	1.97	2.00	2.08	2.10
P_5	147.33	148.87	161.20	155.20	5.77	5.33	5.87	5.80	1.03	1.07	1.40	1.33
P_6	143.80	143.87	148.47	149.54	5.57	5.83	5.73	5.67	1.07	1.13	1.17	1.27
P_1 x P_2	132.00	133.67	137.07	138.45	6.13	6.10	6.30	6.20	3.67	3.73	3.70	3.85
P_1 x P_3	156.67	155.33	160.00	161.73	5.67	5.27	5.53	5.67	3.30	3.33	3.41	3.31
P_1 x P_4	132.00	132.33	134.30	134.17	4.31	4.75	4.97	5.00	3.00	2.85	3.22	3.14
P_1 x P_5	152.67	155.23	160.67	185.00	5.33	5.50	5.67	5.83	1.85	1.77	1.92	1.92
P_1 x P_6	126.67	132.00	138.77	146.69	5.53	5.49	5.49	5.40	2.33	2.21	2.63	2.58
P_2 x P_3	153.33	155.33	160.00	170.00	6.75	6.77	7.00	7.13	2.10	2.21	2.51	2.70
P_2 x P_4	149.67	148.33	153.33	161.14	6.60	6.10	6.27	6.37	1.97	2.07	2.57	2.69
P_2 x P_5	148.33	150.33	158.33	161.67	5.34	6.50	6.43	6.57	1.67	1.78	1.90	1.81
P_2 x P_6	128.33	133.33	138.37	144.97	6.25	6.33	6.53	6.63	1.67	1.70	1.89	1.87
P_3 x P_4	126.67	132.67	139.00	138.73	6.40	6.43	6.50	6.60	1.87	1.90	2.08	2.30
P_3 x P_5	180.00	166.33	188.67	185.33	6.80	6.93	7.03	6.97	1.67	2.09	2.22	2.36
P_3 x P_6	168.33	164.33	173.33	175.00	6.57	6.73	6.60	6.70	1.63	1.78	1.97	2.13
P_4 x P_5	133.33	134.67	141.50	137.87	4.67	5.43	5.83	5.93	1.67	2.05	2.04	2.05
P_4 x P_6	131.20	128.20	142.40	146.99	5.00	5.70	5.69	5.57	1.43	2.01	2.13	2.06
P_5 x P_6	145.33	144.00	151.67	156.23	5.17	5.77	5.43	5.40	1.07	1.07	1.19	1.43
L.S.D (5%)	21.67	18.07	21.10	18.76	0.92	0.82	0.54	0.46	0.63	0.55	0.53	0.47
L.S.D (1%)	29.01	24.18	28.25	25.11	1.23	1.09	0.72	0.62	0.84	0.74	0.72	0.62

Estimates of SCA effects for growth characters of the single crosses (Table 5) revealed significant positive values in some crosses. The best crosses for plant height under both growing systems were (P_1 x P_3), (P_2 x P_6), (P_3 x P_5) and (P_3 x P_6). Moreover, the best crosses for number of branches per plant were (P_1 x P_2), (P_2 x P_4), (P_3 x P_4) and (P_3 x P_5) for both growing systems. Also, the best crosses for number of flowers per cluster was (P_1 x P_2), (P_4 x P_5) and (P_4 x P_6) for both growing systems. Therefore, it could be concluded that these hybrids seemed to be good F_1 cross combinations in this respect.

Table 5. General and specific combining ability effects on growth characters of eggplant under Greenhouse and open field.

Characters	Plant height (cm)				Number of branches per plant				Number of flowers per cluster			
	Greenhouse		Open field		Greenhouse		Open field		Greenhouse		Open field	
	2002	2003	2003	2004	2002	2003	2003	2004	2002	2003	2003	2004
Parents	**General combining ability**											
P_1	-11.13*	-9.38*	-11.62**	-8.01*	-0.58**	-0.61**	-0.59**	-0.61**	1.17**	1.04**	1.07**	1.01**
P_2	-0.73	0.26	-1.37	-1.32	0.66**	0.42**	0.49**	0.57**	0.20*	0.18*	0.20*	0.17*
P_3	9.11*	7.73*	8.16*	7.14*	0.69**	0.54**	0.53**	0.59**	-0.04	-0.02	-0.04	0.02
P_4	-6.28	-6.62*	-7.15*	-8.43*	-0.67**	-0.52**	-0.48**	-0.48**	-0.13	-0.07	-0.07	-0.07
P_5	8.69*	7.67*	11.10**	9.53*	-0.10	0.03	0.08	0.04	-0.61**	-0.57**	-0.58**	-0.59**
P_6	0.33	0.33	0.88	1.09	0.00	0.14	-0.04	-0.12	-0.58**	-0.55**	-0.58**	-0.55**
L.S.D (gi) 5%	6.80	5.67	6.62	5.88	0.29	0.26	0.17	0.15	0.20	0.17	0.17	0.15
L.S.D (gi) 1%	11.27	9.40	10.98	9.76	0.48	0.42	0.28	0.24	0.33	0.29	0.28	0.24
L.S.D (gi-gj) 5%	10.53	8.78	10.25	9.12	0.45	0.40	0.26	0.23	0.31	0.27	0.26	0.23
L.S.D (gi-gj)%	17.46	14.56	17.01	15.12	0.74	0.66	0.43	0.37	0.51	0.45	0.43	0.38
Crosses	**Specific combining ability**											
P_1 x P_2	3.17	1.80	2.28	-3.68	0.39*	0.50**	0.46**	0.24**	0.18	0.30**	0.34**	0.24**
P_1 x P_3	18.01**	15.99**	15.69**	11.14**	-0.10	-0.45**	-0.35**	-0.31**	0.05	0.11	0.00	-0.15*
P_1 x P_4	8.72*	7.35*	5.29	-0.86	-0.11	0.09	0.10	0.09	-0.16	-0.33**	-0.18*	-0.23**
P_1 x P_5	14.42**	15.95**	13.41**	32.01**	0.35*	0.29*	0.25**	0.40**	-0.83**	-0.90**	-0.95**	-0.92**
P_1 x P_6	-3.22	0.05	1.73	2.15	0.45**	0.17	0.19*	0.13	-0.38**	-0.48**	-0.26**	-0.31**
P_2 x P_3	4.26	6.35*	5.43	12.72**	-0.27	0.01	0.04	-0.02	-0.18	-0.16	-0.04	0.08
P_2 x P_4	15.98**	13.71**	14.07**	19.43**	0.94**	0.40**	0.32**	0.28**	-0.23*	-0.25**	0.04	-0.16*
P_2 x P_5	-0.32	1.41	0.82	1.99	-0.88**	0.25	-0.07	-0.05	-0.04	-0.04	-0.12	-0.19*
P_2 x P_6	18.21**	15.28**	16.52**	15.31**	0.21	0.26*	0.17*	0.23**	0.13	0.15	0.20*	0.23**
P_3 x P_4	-16.85**	-9.43**	-9.79**	-11.43**	0.71**	0.62**	0.51**	0.50**	-0.09	-0.21*	-0.20*	-0.08
P_3 x P_5	21.51**	9.94**	21.63**	17.20**	0.54**	0.57**	0.49**	0.34**	0.19	0.17	0.46**	0.51**
P_3 x P_6	18.21**	15.28**	16.52**	15.31**	0.21	0.26*	0.17*	0.23**	0.13	0.15	0.20*	0.23**
P_4 x P_5	-9.77**	-7.37*	-10.23**	-14.70**	-0.23	0.13	0.30**	0.38**	0.28**	0.48**	0.30**	0.28**
P_4 x P_6	-3.54	-6.50*	0.89	2.87	0.00	0.28*	0.27**	0.17**	0.01	0.43**	0.38**	0.25**
P_5 x P_6	-4.38	-5.00	-8.09*	-5.85	-0.40*	-0.20	-0.54**	-0.52**	0.13	-0.02	-0.05	0.14
L.S.D. (sij) 5%	6.92	5.77	6.74	5.99	0.29	0.26	0.17	0.15	0.20	0.18	0.17	0.15
L.S.D. (sij) 1%	9.65	8.05	9.40	8.36	0.41	0.36	0.24	0.21	0.28	0.25	0.24	0.21
L.S.D. (sij-sik) 5%	21.68	18.07	21.11	18.77	0.92	0.82	0.54	0.46	0.63	0.55	0.53	0.47
L.S.D. (sij-sik) 1%	30.22	25.20	29.43	26.17	1.28	1.14	0.75	0.65	0.88	0.77	0.75	0.65

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

High positive heterosis for plant height was observed on the crosses (P_1 x P_3), (P_1 x P_5) and (P_3 x P_5) under two growing systems which estimated as (33.79 and 29.95%); (24.52 and 23.92%) and (26.91and 16.21%) on greenhouse during the two-winter seasons respectively and as (30.78 and 25.21%); (20.56 and 36.90%) and (25.54 and 24.19%) on open field during the two-summer seasons respectively (Table 6). In general, high heterosis was noticed by the crossing with parents having high GCA status. Moreover, high positive heterosis for number of branches per plant was observed on the cross (P_3 x P_4) under two growing systems, which estimated as (25.90and 24.12%) and (20.37and 18.56%) on greenhouse and open field during the two seasons respectively. Also, high positive heterosis for number of flowers per cluster was observed on the cross (P_3 x P_5) under two growing systems, which estimated as (11.11and 36.53%) and (31.28 and 34.86%) on greenhouse and open field during the two seasons respectively. These results coincided with that of Prasath *et al* (1998) and Babu and Thirumurugan (2001) on plant height and number of branches per plant. In contrast to our results, Babu and Thirumurugan (2000) found negative heterosis for plant height and number of branches per plant.

Table 6. Heterosis (%) in fifteen crosses of eggplant for growth characters under greenhouse and open field.

Crosses	Plant height (cm)				Number of branches per plant				Number of flowers per cluster			
	Greenhouse		Open field		Greenhouse		Open field		Greenhouse		Open field	
	2002	2003	2003	2004	2002	2003	2003	2004	2002	2003	2003	2004
P_1 x P_2	14.02	13.44	12.57	9.97	12.20	18.06	15.60	9.41	-5.17	-2.52	-8.75	-1.91
P_1 x P_3	33.79	29.95	30.78	25.21	8.06	-0.94	0.61	0.29	-6.16	-3.80	-6.57	-9.36
P_1 x P_4	15.42	14.81	12.52	6.48	12.35	15.00	14.62	13.21	-14.29	-17.96	-11.75	-13.22
P_1 x P_5	24.52	23.92	20.56	36.90	9.22	14.58	10.03	13.27	-38.90	-40.95	-41.78	-40.55
P_1 x P_6	4.83	7.52	9.35	10.87	15.68	8.65	8.07	6.23	-23.50	-27.22	-17.57	-19.52
P_2 x P_3	13.58	14.47	15.29	21.43	0.50	8.85	7.42	4.65	-10.64	-6.02	0.47	10.50
P_2 x P_4	13.16	12.86	12.93	17.76	24.53	21.19	17.13	14.03	-15.71	-12.29	3.21	11.62
P_2 x P_5	5.58	6.29	5.77	10.76	-15.91	14.04	4.32	3.96	-10.71	-5.81	-11.85	-10.53
P_2 x P_6	-7.50	-4.03	-3.47	1.28	0.00	6.44	7.10	6.13	-11.50	-11.59	-7.13	-6.19
P_3 x P_4	-5.19	-0.35	1.93	-0.98	25.90	24.12	20.37	18.56	-5.88	-4.59	-0.56	7.81
P_3 x P_5	26.91	16.21	25.54	24.19	10.87	18.52	13.14	10.58	11.11	36.53	31.28	34.86
P_3 x P_6	20.18	16.85	20.44	19.53	8.84	10.38	7.32	7.49	6.52	13.98	20.61	24.27
P_4 x P_5	-4.15	-3.02	-3.93	-5.62	-1.06	16.43	15.51	17.11	9.89	33.48	17.32	19.22
P_4 x P_6	-4.47	-5.99	1.05	2.61	8.30	15.93	14.25	11.33	-5.93	28.51	27.05	22.57
P_5 x P_6	-0.16	-1.62	-2.05	2.53	-8.82	3.28	-6.32	-5.81	1.59	-3.03	-7.53	10.00

2- Yield

The results indicated that the genotypes were different significantly for early yield, total yield (Kg/plant) and number of fruits per plant under greenhouse and open field conditions (Table 3). Similar results were reported by Das and Barua (2001). Moreover, it is clear that cultivar (P_3) had the highest significant values for early yield on two previous growing systems during the two seasons (Table 7). Cultivar (P_5) gave the highest total yield (Kg/plant) followed by cultivar (P_6), while cultivar (P_1) gave the lowest yield and the largest number of fruits per plant (Table 7). Among crosses, the highest early yield was produced by hybrids (P_4 x P_5) and (P_4 x P_6) in greenhouse during the two growing seasons and by hybrids (P_2 x P_5) and (P_1 x P_5) in open field during the two summer seasons respectively. The highly significant total yield in greenhouse was produced by hybrids (P_4 x P_5) and (P_5 x P_6) in the first season and by hybrids (P_3 x P_4) and (P_4 x P_6) in the second season. While, the highest significant yield in open field was produced by hybrids (P_4 x P_6) and (P_5 x P_6) in the first season and (P_4 x P_5) and

(P_4 x P_6) in the second season (Table 7). Moreover, the highest significant number of fruits per plant was produced by hybrid (P_1 x P_2) in the two growing systems during the two seasons (Table 7). Generally, the early yield, total yield (Kg/plant) and number of fruits per plant were relatively higher under open field than greenhouse during summer and winter seasons respectively. This could be attributed to the increase of the minimum temperatures during summer than winter season as shown in Table (1), which affected these traits as recorded by Lee *et al.* (2003).

Table 7. Mean performance of six parental cultivars and F_1 crosses for early and total yields and number of fruits per plant of eggplant under greenhouse and open field.

Genotypes	Early yield (Kg \ plant)				Total yield (Kg \ plant)				Number of fruits per plant			
	Greenhouse		Open field		Greenhouse		Open field		Greenhouse		Open field	
	2002	2003	2003	2004	2002	2003	2003	2004	2002	2003	2003	2004
P_1	0.24	0.26	0.25	0.27	0.81	0.97	1.07	1.19	16.83	17.49	17.83	17.71
P_2	0.19	0.19	0.20	0.21	1.03	1.22	1.14	1.32	13.36	13.70	14.20	14.67
P_3	0.42	0.39	0.48	0.46	1.13	1.08	1.25	1.52	11.54	12.18	12.82	13.14
P_4	0.23	0.22	0.25	0.25	1.19	1.44	1.20	1.45	9.64	10.16	10.53	10.88
P_5	0.31	0.24	0.34	0.33	1.84	2.03	2.06	2.20	10.33	11.47	11.85	12.14
P_6	0.38	0.33	0.36	0.40	1.73	2.13	2.14	2.16	10.17	10.84	11.17	11.45
P_1 x P_2	0.25	0.28	0.29	0.31	1.41	1.60	1.35	1.74	17.80	18.14	18.40	18.07
P_1 x P_3	0.31	0.26	0.38	0.36	1.78	2.01	1.90	2.07	16.17	16.48	16.58	16.47
P_1 x P_4	0.28	0.30	0.31	0.35	1.46	1.78	1.98	2.22	16.48	16.88	17.17	17.43
P_1 x P_5	0.33	0.36	0.46	0.49	2.06	2.22	2.47	2.43	13.65	14.02	14.15	14.04
P_1 x P_6	0.35	0.35	0.45	0.41	1.53	1.85	1.89	2.23	13.34	12.92	13.14	13.51
P_2 x P_3	0.33	0.32	0.39	0.39	1.13	1.60	1.53	1.94	14.91	14.56	14.74	15.21
P_2 x P_4	0.29	0.27	0.28	0.35	1.86	1.93	2.25	2.14	14.93	14.59	14.92	15.08
P_2 x P_5	0.38	0.35	0.50	0.46	1.83	2.09	2.17	2.25	12.88	12.55	12.71	13.43
P_2 x P_6	0.31	0.34	0.45	0.43	1.78	2.16	2.28	2.22	10.38	10.48	10.89	11.33
P_3 x P_4	0.34	0.36	0.43	0.45	1.98	2.53	2.31	2.55	13.80	14.18	14.48	14.79
P_3 x P_5	0.38	0.33	0.37	0.42	1.72	1.96	2.44	2.48	12.98	12.64	12.98	13.45
P_3 x P_6	0.29	0.28	0.38	0.36	2.15	2.24	2.39	2.62	12.53	12.96	13.22	13.54
P_4 x P_5	0.39	0.38	0.44	0.46	2.38	2.23	2.45	2.65	12.08	12.42	13.09	12.95
P_4 x P_6	0.39	0.37	0.44	0.45	2.22	2.49	2.71	2.69	12.33	11.44	12.11	13.05
P_5 x P_6	0.35	0.36	0.43	0.41	2.28	2.34	2.68	2.63	11.32	10.99	11.75	12.02
L.S.D (5%)	0.11	0.10	0.10	0.09	0.66	0.56	0.34	0.32	1.54	1.48	1.06	0.85
L.S.D (1%)	0.14	0.14	0.13	0.12	0.88	0.75	0.45	0.44	2.06	1.98	1.42	1.14

Combing ability analysis (Table 3) revealed that GCA and SCA variances were highly significant for early, total yields (Kg/plant) and number of fruits per plant at two growing systems. This would indicate to the importance of both additive and non-additive gene actions for inheritance of these characters. Similar results were reported by Chezhian *et al* (2000) and Das and Barua (2001) on total yield and number of fruits per plant.

Higher GCA: SCA ratio (Table 3) exhibited additive gene effects for inheritance of all these studied characters suggesting their exploitation through simple breeding methods under the two previous conditions. These results coincided with that of Sanguineti *et al* (1985) on early yield, Major *et al* (2002) and Singh *et al* (2002) on number of fruits per plant. Although, these results disagree with those of Chaudhary *et al* (1998) and Vaghasiya *et al* (2000) on total yield per plant and Vaghasiya *et al* (2000) on number of fruits per plant who found that non-additive gene actions were important for inheritance of these characters.

The GCA ranged from –0.04 (P_2) to 0.06 (P_5) and –0.03 (P_2) to 0.05 (P_5) for early yield; -0.24 (P_1) to 0.27 (P_5) and –0.24 (P_1) to 0.26 (P_6) for total yield per plant and –1.53 (P_6) to 2.33 (P_1) and –1.65 (P_6) to 2.47 (P_1) for number of fruits per plant with significant positive (useful) estimates under greenhouse in the two-winter seasons respectively (Table 8). Moreover, the GCA ranged from –0.03 (P_1) to 0.07 (P_5) and –0.04 (P_2) to 0.06 (P_5) for early yield; -0.24 (P_1) to 0.31 (P_5) and –0.25 (P_2) to 0.24 (P_5) for total yield per plant and –1.60 (P_6) to 2.36 (P_1) and –1.47 (P_6) to 2.10 (P_1) for number of fruits per plant with significant positive (useful) estimates under open field in the two-summer seasons respectively (Table 8). This would indicate that the cultivars (P_3), (P_5, P_6) and (P_1, P_2) showed significant positive estimates for early yield and total yield (Kg/plant) and number of fruits per plant respectively and considered to be the best combiners to improve these traits under two growing systems.

Table 8. General and specific combining ability effects on early yield, total yield and number of fruits per plant of eggplant under greenhouse and open field.

Characters	Early yield (Kg \ plant)				Total yield (Kg \ plant)				Number of fruits per plant			
	Greenhouse		Open field		Greenhouse		Open field		Greenhouse		Open field	
	2002	2003	2003	2004	2002	2003	2003	2004	2002	2003	2003	2004
Parents	General combining ability											
P_1	-0.03*	-0.01	-0.03*	-0.03*	-0.24*	-0.24*	-0.27**	-0.23**	2.33**	2.47**	2.36**	2.10**
P_2	-0.04*	-0.03*	-0.04*	-0.04*	-0.21*	-0.19*	-0.25**	-0.25**	0.64*	0.50*	0.48**	0.54**
P_3	0.06**	0.05**	0.07**	0.06**	-0.09	-0.10	-0.10	-0.03	0.12	0.19	0.17	0.20
P_4	-0.01	-0.01	-0.03*	-0.01	0.06	0.07	0.03	0.03	-0.45	-0.48*	-0.43*	-0.38*
P_5	0.00	-0.02	0.00	0.00	0.27*	0.20*	0.31**	0.24**	-1.11**	-1.02**	-0.98**	-0.99**
P_6	0.03*	0.03	0.03	0.02	0.21*	0.26*	0.29**	0.23**	-1.53**	-1.65**	-1.60**	-1.47**
L.S.D (gi) 5%	0.03	0.03	0.03	0.03	0.21	0.18	0.11	0.10	0.48	0.46	0.33	0.27
L.S.D (gi) 1%	0.06	0.05	0.05	0.05	0.34	0.29	0.18	0.17	0.80	0.77	0.55	0.44
L.S.D (gi-gj) 5%	0.05	0.05	0.05	0.04	0.32	0.27	0.16	0.16	0.75	0.72	0.52	0.41
L.S.D(gi-gj) %	0.09	0.08	0.08	0.07	0.53	0.45	0.27	0.26	1.24	1.19	0.86	0.69
Crosses	Specific combining ability											
P_1 x P_2	0.00	0.01	-0.02	-0.01	0.18	0.13	-0.11*	0.09	1.62**	1.79**	1.82**	1.41**
P_1 x P_3	0.02	-0.02	0.03*	0.01	0.43**	0.45**	0.29**	0.20**	0.51*	0.44	0.30	0.15
P_1 x P_4	0.00	0.00	0.00	0.01	-0.04	0.05	0.24**	0.29**	1.39**	1.51**	1.49**	1.70**
P_1 x P_5	-0.01	-0.03*	0.05**	0.07**	0.35**	0.36**	0.45**	0.29**	-0.77**	-0.82**	-0.97**	-1.08**
P_1 x P_6	0.04*	0.05**	0.07**	0.03*	-0.12	-0.06	-0.12*	0.10*	-0.67*	-1.27**	-1.37**	-1.14**
P_2 x P_3	0.04*	0.06**	0.05**	0.05**	-0.25*	-0.01	-0.10	0.08	0.93**	0.48*	0.34*	0.45**
P_2 x P_4	0.02	0.00	-0.02	0.02	0.32**	0.18*	0.49**	0.22**	1.52**	1.19**	1.12**	0.90**
P_2 x P_5	0.04*	0.02	0.10	0.03*	0.09	0.18*	0.14*	0.12*	0.14	-0.32	-0.53**	-0.13
P_2 x P_6	-0.06**	-0.04**	-0.03*	-0.04*	0.36**	0.18*	0.21**	0.29**	0.72**	1.04**	0.90**	0.79**
P_3 x P_4	0.03*	0.07**	0.08**	0.08**	0.33**	0.66**	0.40**	0.42**	0.91**	1.09**	0.98**	0.95**
P_3 x P_5	0.01	-0.01	-0.07**	-0.02	0.22*	0.25**	0.25**	0.13*	0.76**	0.09	0.04	0.23
P_3 x P_6	-0.06**	-0.04**	-0.03*	-0.04**	0.36**	0.18*	0.21**	0.29**	0.72**	1.04**	0.90**	0.79**
P_4 x P_5	0.03*	0.02	0.03*	0.03*	0.36**	0.26**	0.14*	0.25**	0.45*	0.54*	0.75**	0.31*
P_4 x P_6	0.05**	0.06**	0.06**	0.06**	0.27*	0.27**	0.41**	0.31**	1.10**	0.29*	0.39*	0.89**
P_5 x P_6	-0.05**	-0.03*	-0.04**	-0.06**	0.29**	0.26**	0.17**	0.15**	0.45	0.27	0.58**	0.47**
L.S.D. (sij) 5%	0.03	0.03	0.03	0.03	0.21	0.18	0.11	0.10	0.49	0.47	0.34	0.27
L.S.D. (sij) 1%	0.05	0.04	0.04	0.04	0.29	0.25	0.15	0.14	0.69	0.66	0.47	0.38
L.S.D. (sij-sik) 5%	0.11	0.10	0.10	0.09	0.66	0.56	0.34	0.33	1.54	1.48	1.06	0.85
L.S.D. (sij-sik) 1%	0.15	0.14	0.13	0.12	0.92	0.78	0.47	0.45	2.15	2.06	1.48	1.19

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

Estimates of SCA effects (Table 8) for early yield, total yield (Kg / plant) and number of fruits per plant of the single crosses revealed significant positive values in some crosses. The best crosses for early yield under both growing systems were (P_2 x P_3), (P_3 x P_4) and (P_4 x P_6). Moreover, the best crosses for total yield per plant were (P_3 x P_5), (P_3 x P_6), (P_4 x P_5), (P_4 x P_6) and (P_5 x P_6) for both growing systems. Also, The best crosses for number of fruits per plant were (P_1 x P_2), (P_1 x P_4) and (P_4 x P_6) for both growing systems. Therefore, it could be concluded that these hybrids seemed to be good F_1 cross combinations in this respect.

High positive heterosis for early yield was observed on the crosses (P_2 x P_4) at the first season and (P_3 x P_4) at the second season under greenhouse, which estimated as (39.20 and 56.52%) respectively. While, high positive heterosis for early yield was observed on the crosses (P_2 x P_6) at the first season and (P_3 x P_4) at the second season under open field, which estimated as (60.71 and 53.41%) respectively (Table 9). Moreover, high positive heterosis for total yield was observed on the cross (P_1 x P_3) at the first season and (P_3 x P_4) at the second season under greenhouse, which estimated as (83.16 and 100.53 %) respectively. While, high positive heterosis for total yield was observed on the crosses (P_2 x P_4) at the first season and (P_3 x P_4) at the second season under open field, which estimated as (92.58 and 71.72%) respectively (Table 9). In addition, high positive heterosis for number of fruits per plant was observed on the cross (P_3 x P_4) under greenhouse and open field in the two seasons, which estimated as (30.29, 26.97, 24.01 and 23.16%) respectively (Table 9). These results coincided with that of Prasath *et al* (1998), Babu and Thirumurugan (2001) and Das and Barua (2001) on total yield and number of fruits per plant.

Table 9. Heterosis (%) in fifteen crosses of eggplant for early yield, total yield and number of fruits per plant under greenhouse and open field.

Crosses	Early yield (Kg \ plant)				Total yield (Kg \ plant)				Number of fruits per plant			
	Greenhouse		Open field		Greenhouse		Open field		Greenhouse		Open field	
	2002	2003	2003	2004	2002	2003	2003	2004	2002	2003	2003	2004
P_1 x P_2	16.54	23.88	30.83	28.28	52.74	46.87	22.41	38.54	17.94	16.32	14.91	11.61
P_1 x P_3	14.11	5.33	29.55	20.44	83.16	97.06	63.86	52.83	13.99	11.05	8.17	6.79
P_1 x P_4	18.57	23.61	27.03	33.76	46.33	47.44	75.04	68.22	24.56	22.07	21.05	21.98
P_1 x P_5	1.01	15.90	27.52	34.86	55.72	48.33	58.22	43.22	0.56	-3.22	-4.64	-5.91
P_1 x P_6	13.51	27.68	46.45	23.00	19.90	19.70	18.04	32.80	-1.21	-8.78	-9.38	-7.32
P_2 x P_3	32.43	51.56	45.34	42.68	4.34	39.53	27.86	36.46	19.73	12.51	9.16	9.42
P_2 x P_4	39.20	32.79	27.82	51.43	67.29	45.36	92.58	54.09	29.78	22.36	20.71	18.07
P_2 x P_5	23.50	20.23	48.77	38.31	27.77	28.88	35.97	27.53	8.77	-0.30	-2.38	0.24
P_2 x P_6	9.41	30.32	60.71	39.89	28.45	28.88	39.17	27.46	-11.80	-14.60	-14.12	-13.20
P_3 x P_4	26.71	56.52	47.73	53.41	71.47	100.53	88.57	71.72	30.29	26.97	24.01	23.16
P_3 x P_5	5.94	3.70	-8.94	5.49	15.86	26.10	47.23	33.15	18.70	6.91	5.22	6.45
P_3 x P_6	-14.56	-0.58	8.06	-2.28	50.35	39.50	40.81	42.39	15.36	12.60	10.24	10.14
P_4 x P_5	20.41	23.50	22.02	30.52	57.44	28.53	50.61	45.02	21.04	14.84	16.95	12.54
P_4 x P_6	25.68	41.82	44.26	39.49	51.83	39.37	62.40	49.22	24.50	8.94	11.63	16.95
P_5 x P_6	-12.03	0.00	2.77	-4.69	27.54	12.75	27.98	20.64	10.47	-1.49	2.04	1.91

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These results disagree with those of Babu and Thirumurugan (2000) who found negative heterosis for total yield and number of fruits per plants.

3- Fruit quality

Significant differences among genotypes were observed for fruit quality (fruit length, fruit diameter, average fruit weight and T.S.S.) under greenhouse and open field conditions as presented in Table (3). Similar results were reported by Das and Barua (2001). Moreover it is clear that's cultivars (P_5) and (P_6) had the highest significant values regarding the all previous fruit quality under both greenhouse and open field (Table 10). The hybrids (P_5 x P_6) and (P_3 x P_6) had the highest significant values regarding fruit length in greenhouse during the two seasons respectively. Moreover, the hybrids (P_3 x P_5) and (P_3 x P_6) had the highest significant values regarding fruit length in open field during the two seasons respectively (Table 10). The hybrids (P_4 x P_5) and (P_4 x P_6) had the highest significant values regarding fruit diameter in both greenhouse and open field during the two seasons. While, the hybrids (P_5 x P_6) had the highest significant values regarding average fruit weight and T.S.S. in both greenhouse and open field during the two seasons. Generally, the fruit length, fruit diameter and average fruit weight had the highest values under open field than greenhouse. This could be attributed to the increase of minimum temperatures during summer than winter season as shown in Table (1).

Both GCA and SCA mean squares were significant for the fruit length, fruit diameter and average fruit weight, indicating the importance of both additive and non-additive gene actions for inheritance of these traits. While, GCA mean square was significant for T.S.S. content, indicating the importance of additive gene action for inheritance of this trait (Table 3). Similar results were reported by Das and Barua (2001) on fruit length, Chaudhary and Pathania (2000) on fruit diameter and Chezhian *et al* (2000); Vaghasiya *et al* (2000) and Das and Barua (2001) on fruit weight.

It is apparent from Table (3) that the ratio of GCA/SCA are higher than unity, for the fruit quality, indicating that the additive gene action is more important than that non-additive gene action in inheritance of these traits under the two previous conditions. These results coincided with that of Ingale and Patil (1997); Major *et al* (2002) and Singh *et al* (2002) on fruit length, Ingale and Patil (1997); Das and Barua (2001); Major *et al* (2002) and Singh *et al* (2002) on fruit diameter and Salehuzzaman and Alam (1983) and Chaudhary and Pathania (2000) on fruit weight. In contrast to our results, Vaghasiya *et al* (2000) on fruit diameter and Chaudhary *et al* (1998) on total soluble solids recorded that the non-additive gene action played an important role in the inheritance of these traits.

The GCA ranged from –1.74 (P_4) to 1.09 (P_6) and –1.45 (P_4) to 0.94 (P_6) for fruit length; -1.50 (P_1) to 1.74 (P_5) and –1.50 (P_1) to 1.78 (P_5) for fruit diameter; -27.04 (P_1) to 38.89 (P_5) and –26.09 (P_1) to 37.50 (P_5) for fruit weight and –0.24 (P_1) to 0.27 (P_5) and –0.28 (P_1) to 0.24 (P_5) for T.S.S. with significant useful estimates under greenhouse in the two-winter seasons respectively (Tables 11 and 12). Moreover, The GCA ranged from –1.90 (P_4) to 1.04 (P_6) and –1.46 (P_4) to 0.89 (P_6) for fruit length; -1.64 (P_1) to 1.84 (P_5)

and –1.67 (P_1) to 1.50 (P_5) for fruit diameter, -30.72 (P_1) to 40.92 (P_5) and –28.64 (P_1) to 42.21 (P_5) for average fruit weight and –0.30 (P_1) to 0.21 (P_5) and –0.32 (P_1) to 0.22 (P_5) for T.S.S. with significant useful estimates under open field in the two-summer seasons respectively (Tables 11 and 12). This would indicate that the cultivars (P_6, P_5, P_3), (P_5, P_6, P_4), (P_5, P_6) and (P_5, P_6) showed significant positive estimates for fruit length, fruit diameter, average fruit weight and T.S.S. and considered to be the best combiners to improve these traits under two growing systems.

Estimates of SCA effects (Tables 11 and 12) for fruit length, fruit diameter and average fruit weight of the single crosses revealed significant values in some crosses. The best crosses for fruit length were (P_4 x P_6), (P_4 x P_5) under greenhouse and (P_2 x P_3) and (P_4 x P_6) under open field during the two seasons respectively. Moreover, The best crosses for fruit diameter were (P_4 x P_6) under greenhouse and (P_5 x P_6) under open field during the two seasons respectively.

Table 11. General and specific combining ability effects on fruit length (cm) and fruit diameter (cm) of eggplant under greenhouse and open field.

Characters	Fruit length (cm)				Fruit diameter (cm)			
	Greenhouse		Open field		Greenhouse		Open field	
	2002	2003	2003	2004	2002	2003	2003	2004
Parents	**General combining ability**							
P_1	-1.07**	-0.81**	-0.94**	-0.93**	-1.50**	-1.50**	-1.64**	-1.67**
P_2	0.06	-0.03	0.11	0.03	-1.30**	-1.24**	-1.37**	-1.30**
P_3	0.70**	0.59*	0.86*	0.71*	-0.88**	-0.96**	-0.92**	-0.85**
P_4	-1.74**	-1.45**	-1.90**	-1.46**	0.80**	0.69**	0.82**	0.82**
P_5	0.96**	0.75**	0.84*	0.76**	1.74**	1.78**	1.84**	1.49**
P_6	1.09**	0.94**	1.04**	0.89**	1.13**	1.23**	1.28**	1.50**
L.S.D (gi) 5%	0.26	0.42	0.55	0.45	0.22	0.18	0.31	0.21
L.S.D (gi) 1%	0.43	0.69	0.91	0.74	0.37	0.29	0.52	0.35
L.S.D (gi-gj) 5%	0.41	0.65	0.85	0.69	0.34	0.27	0.49	0.33
L.S.D (gi-gj) 1%	0.67	1.08	1.42	1.14	0.57	0.45	0.81	0.55
Cross	**Specific combining ability**							
P_1 x P_2	0.25	1.10**	0.51	1.26**	-1.37**	-1.29**	-0.99**	-0.90**
P_1 x P_3	1.12**	0.20	0.90**	1.15**	0.45**	0.54**	0.51**	0.55**
P_1 x P_4	-0.55**	-0.49*	-0.80**	-1.05**	-0.40**	-0.54**	-0.46**	-0.35**
P_1 x P_5	-0.39**	-0.80**	-0.48	-0.83**	-0.63**	-0.76**	-0.35*	-0.45**
P_1 x P_6	-1.61**	-1.32**	-0.81**	-1.30**	-0.93**	-0.98**	-0.82**	-1.02**
P_2 x P_3	0.61**	0.28	1.58**	1.66**	-0.04	-0.06	-0.43**	-0.49**
P_2 x P_4	1.08**	0.03	0.80**	0.23	0.45**	0.53**	0.80**	0.81**
P_2 x P_5	-1.77**	-1.21**	-1.74**	-1.09**	-0.99**	-0.96**	-0.82**	-0.73**
P_2 x P_6	-0.62**	0.55*	-0.38	0.46*	0.85**	0.78**	1.12**	1.85**
P_3 x P_4	0.17	0.93**	1.19**	1.21**	0.74**	0.91**	0.89**	0.90**
P_3 x P_5	-1.20**	-0.16	0.38	-0.77**	-0.38**	-0.57**	-0.14	-0.01
P_3 x P_6	-0.62**	0.55*	-0.38	0.46*	0.85**	0.78**	1.12**	1.85**
P_4 x P_5	0.58**	1.15**	0.88**	1.07*	0.70**	0.88**	1.09**	0.96**
P_4 x P_6	1.15**	1.06**	1.52**	1.97**	0.37**	0.63**	0.25	0.22*
P_5 x P_6	0.28*	-0.34	-0.16	0.88**	1.56**	1.03**	1.47**	-1.55**
L.S.D. (sij) 5%	0.27	0.43	0.56	0.45	0.23	0.18	0.32	0.22
L.S.D. (sij) 1%	0.37	0.59	0.78	0.63	0.32	0.25	0.45	0.30
L.S.D. (sij-sik) 5%	0.84	1.34	1.76	1.42	0.71	0.56	1.00	0.68
L.S.D. (sij-sik) 1%	1.16	1.86	2.45	1.98	0.99	0.78	1.40	0.94

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

Table 12. General and specific combining ability effects on average fruit weight (gm) and T.S.S. content of eggplant under greenhouse and open field.

Characters	Average fruit weight (gm)				T.S.S.			
	Greenhouse		Open field		Greenhouse		Open field	
	2002	2003	2003	2004	2002	2003	2003	2004
Parents	**General combining ability**							
P_1	-27.04**	-26.09**	-30.72**	-28.64**	-0.24*	-0.28*	-0.30**	-0.32**
P_2	-22.06**	-24.81**	-24.36**	-25.52**	-0.20*	-0.18*	-0.09	-0.04
P_3	-17.43**	-16.34**	-16.98**	-17.25**	0.00	0.08	0.07	0.10
P_4	-2.20	-2.44	0.03	-2.70	-0.07	-0.05	-0.07	-0.13
P_5	38.89**	37.50**	40.92**	42.21**	0.27*	0.24*	0.21*	0.22*
P_6	29.83**	32.17**	31.10**	31.91**	0.24*	0.19*	0.18*	0.17*
L.S.D (gi) 5%	4.67	5.62	4.41	6.95	0.17	0.18	0.16	0.16
L.S.D (gi) 1%	7.74	9.31	7.32	11.53	0.29	0.29	0.27	0.27
L.S.D (gi-gj) 5%	7.23	8.70	6.84	10.77	0.27	0.27	0.25	0.26
L.S.D (gi-gj) 1%	12.00	14.43	11.34	17.87	0.45	0.45	0.42	0.42
Cross	**Specific combining ability**							
P_1 x P_2	-2.36	1.96	-5.41*	4.26	0.07	0.04	-0.05	-0.01
P_1 x P_3	30.48**	33.23**	32.07**	35.42**	-0.02	-0.04	-0.13	-0.06
P_1 x P_4	9.88**	5.36	13.43**	15.11**	0.00	0.07	0.01	0.02
P_1 x P_5	14.79**	16.89**	20.47**	16.09**	-0.09	-0.11	-0.05	-0.09
P_1 x P_6	-5.58*	-0.18	-2.41	-9.17	-0.08	-0.07	-0.04	-0.08
P_2 x P_3	-14.64**	-16.51**	-16.08**	-18.67**	-0.02	-0.04	0.04	-0.02
P_2 x P_4	38.23**	38.32**	46.40**	38.95**	0.00	-0.03	0.02	0.06
P_2 x P_5	-1.53**	-14.79**	-11.22**	-10.03**	-0.09	-0.10	-0.04	-0.05
P_2 x P_6	-5.13*	-1.16	-0.61	4.01	-0.03	-0.04	-0.18	0.02
P_3 x P_4	14.50**	15.94**	15.96**	9.68	0.05	0.00	0.07	-0.03
P_3 x P_5	-19.19**	-17.71**	-11.27**	-11.30**	-0.04	-0.07	-0.19	0.01
P_3 x P_6	-5.13*	-1.16	-0.61	4.01	-0.03	-0.04	-0.18	0.02
P_4 x P_5	-20.12**	-18.96**	2.86	-13.09**	-0.06	0.09	-0.05	-0.07
P_4 x P_6	-6.09*	-13.29**	-22.69**	-11.31**	-0.06	-0.08	-0.05	-0.06
P_5 x P_6	12.92**	6.43*	5.32*	1.51	0.10	0.07	0.11	0.07
L.S.D. (sij) 5%	4.76	5.72	4.49	7.09	0.18	0.18	0.16	0.17
L.S.D. (sij) 1%	6.63	7.98	6.27	9.88	0.25	0.25	0.23	0.23
L.S.D. (sij-sik) 5%	14.89	17.91	14.07	22.18	0.55	0.56	0.52	0.53
L.S.D. (sij-sik) 1%	20.76	24.98	19.62	30.93	0.77	0.79	0.72	0.73

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

Also, The best crosses for average fruit weight were (P_2 x P_4) under greenhouse and open field during the two seasons. On the other hand, the estimates of SCA effects for T.S.S. (Table 12) of the single crosses revealed un-significant values for this trait.

High positive heterosis for fruit length was observed on the crosses (P_2 x P_4) at the first season and (P_3 x P_4) at the second season under greenhouse, which estimated as 14.56 and 23.46% respectively. While, high positive heterosis for fruit length was observed on the crosses (P_3 x P_4) at the first and second seasons under open field, which estimated as 32.70 and 33.36% respectively (Table 13). Moreover, high positive heterosis for fruit diameter was observed on the cross (P_1 x P_2) under greenhouse during two seasons, which estimated as 58.75 and 51.50% respectively. While, high positive heterosis for fruit diameter was observed on the crosses (P_1 x P_2) at the first season and (P_3 x P_4) at the second season under open field, which estimated as (47.80 and 51.15%) respectively (Table 13). Also, high positive heterosis for average fruit weight was observed on the cross (P_1 x P_3) under greenhouse and open field in the two seasons, which estimated as (114.38, 98.24, 90.48 and 100.12%) respectively (Table 13). One the other hand, no heterosis for T.S.S. was observed under greenhouse and open field in the two seasons. These results coincided with that of Babu and Thirumurugan (2001) on fruit length, Prasath *et al* (1998) on fruit diameter and Prasath *et al* (1998); Babu and Thirumurugan (2001) and Das and Barua (2001) on fruit weight.

Table 13. Heterosis (%) in fifteen crosses of eggplant for fruit characters under greenhouse and open field.

Crosses	Fruit length (cm)				Fruit diameter (cm)			
	Greenhouse		Open field		Greenhouse		Open field	
	2002	2003	2003	2004	2002	2003	2003	2004
P_1 x P_2	-4.33	6.17	1.97	9.34	58.75	51.50	47.80	41.84
P_1 x P_3	8.02	3.07	15.40	17.80	33.79	33.33	36.71	44.87
P_1 x P_4	-3.08	-1.80	-2.47	-4.50	0.83	-1.27	3.56	4.62
P_1 x P_5	-11.30	-12.88	-8.74	-13.54	-22.49	-23.71	-12.70	-16.16
P_1 x P_6	-21.93	-16.18	-11.09	-16.39	-27.07	-24.91	-18.29	-19.53
P_2 x P_3	1.89	5.49	20.17	22.22	15.71	18.03	10.34	18.40
P_2 x P_4	14.56	6.53	15.90	11.13	23.00	31.11	39.10	39.41
P_2 x P_5	-21.93	-14.06	-17.39	-13.59	-26.62	-23.16	-16.21	-14.78
P_2 x P_6	-22.39	-8.86	-16.42	-21.97	-19.43	-8.72	7.44	15.01
P_3 x P_4	8.94	23.46	32.70	33.36	38.02	48.12	45.66	51.15
P_3 x P_5	-13.84	-0.39	7.07	-3.67	-11.05	-12.44	-1.03	4.09
P_3 x P_6	-9.53	6.65	1.28	6.95	14.25	17.54	25.88	45.29
P_4 x P_5	5.70	15.27	7.41	12.28	5.66	11.23	16.29	14.65
P_4 x P_6	11.00	15.70	18.62	21.84	5.14	14.54	10.34	11.71
P_5 x P_6	-7.06	-6.70	-6.58	-14.09	-29.85	-20.59	-21.79	-21.68
Crosses	**Average fruit weight (gm)**				**T.S.S.**			
	Greenhouse		**Open field**		**Greenhouse**		**Open field**	
	2002	**2003**	**2003**	**2004**	**2002**	**2003**	**2003**	**2004**
P_1 x P_2	32.25	39.55	19.31	41.60	0.32	-0.85	-4.17	-2.30
P_1 x P_3	114.38	98.24	90.48	100.12	-2.13	-3.41	-8.45	-3.64
P_1 x P_4	55.09	42.47	64.46	58.98	-1.45	1.97	-1.77	-1.54
P_1 x P_5	22.54	20.79	30.87	22.02	-4.74	-4.51	-4.81	-4.79
P_1 x P_6	5.52	10.76	4.10	1.34	-4.41	-3.79	-4.48	-4.23
P_2 x P_3	-11.72	-17.36	-12.85	-17.17	-1.91	-3.77	-2.13	-1.26
P_2 x P_4	66.56	61.26	72.63	52.64	-1.23	-2.00	0.10	0.86
P_2 x P_5	-1.27	-15.52	-6.14	-9.10	-4.52	-4.82	-2.97	-2.42
P_2 x P_6	-5.55	-2.91	-10.95	-5.52	-4.28	-3.94	-2.64	-1.85
P_3 x P_4	34.24	31.59	39.57	26.09	0.68	-0.93	-0.93	-1.83
P_3 x P_5	-14.03	-15.57	-3.32	-7.34	-2.63	-3.64	-8.56	-1.08
P_3 x P_6	-3.33	-0.30	-2.07	2.98	-2.39	-3.42	-8.29	-0.51
P_4 x P_5	-9.98	-13.00	12.28	-5.55	-3.21	2.14	-2.97	-3.27
P_4 x P_6	0.20	-6.63	-10.77	-5.07	-2.97	-2.97	-2.64	-2.70
P_5 x P_6	3.69	-1.71	-0.23	-3.63	0.25	0.00	0.25	0.49

Correlation

The correlation coefficients (r) between total yield (Kg/plant) and different characters under greenhouse and open field are presented in Table (14). Significant positive correlation was found between total yield (Kg/plant) and both of plant height, number of primary branches per plant, number of flowers per cluster, number of fruits per plant, fruit length, fruit diameter and fruit weight under the two growing systems. These results be indicating that the increase in total yield of eggplant would be associated with increasing of these characters. The coefficient of determination (r^2) indicating that 10 to 11 % for plant height, 15 to 17% for number of primary branches per plant, 10 to 11 % for number of flowers per cluster, 12 to 14 % for number of fruits per plant, 10 to 11 % for fruit length, 16 to 18 % for fruit diameter and 20 to 23 % for fruit weight of the variation on total yield (Kg/plant) in greenhouse can be due to the effect of different previous characters. Moreover, the coefficient of determination (r^2) is indicating that 14 to 15 % for plant height, 16 to 18% for number of primary branches per plant, 10 to 12 % for number of flowers per cluster, 17 to 19 % for number of fruits per plant, 14 to 16 % for fruit length, 18 to 19 % for fruit diameter and 20 to 26 % for fruit weight of the variation on total yield (Kg/plant) in open field can be due to the effect of previous characters. It can be concluded that average fruit weight had the highest positive direct effect in total yield (Kg/plant) followed by the fruit diameter, number of primary branches per plant and number of fruits per plant. Similar results were found by (Mishra and Mishra, 1990; Prasath *et al* 2001) of plant height, (Kumar *et al* 1990; Narendra and Kumar, 1995) on number of flowers per cluster, (Kumar *et al* 1990; Mishra and Mishra, 1990; Narendra and Kumar, 1995; Prasath *et al* 2001) on number of primary branches per plant, (Kumar *et al* 1990; Mishra and Mishra, 1990; Narendra and Kumar, 1995; Mohanty and Prusti, 2000; Prasath *et al* 2001) on number of fruits per plant, (Kumar *et al* 1990; Narendra and Kumar, 1995) on fruit length, (Prasath *et al* 2001) on fruit diameter and (Mishra and Mishra, 1990; Mohanty and Prusti, 2000; Prasath *et al* 2001) on fruit weight.

Table 14. Correlation (r) and Coefficient of determination (r^2) between total yield (Kg/plant) and different characters of eggplant under greenhouse and open field.

Character correlated	Greenhouse				Open field			
	r		R^2		r		r^2	
Total yield and:	**2002**	**2003**	**2002**	**2003**	**2003**	**2004**	**2003**	**2004**
Plant height	0.34*	0.33*	0.11	0.10	0.39**	0.38**	0.15	0.14
Number of primary branches per plant	0.41**	0.39**	0.17	0.15	0.43**	0.40**	0.18	0.16
Number of flowers per cluster	0.28*	0.32*	0.10	0.11	0.31*	0.35*	0.10	0.12
Number of fruits per plant	0.39**	0.35*	0.14	0.12	0.41**	0.44**	0.17	0.19
Fruit length	0.34*	0.30*	0.11	0.10	0.38**	0.40**	0.14	0.16
Fruit diameter	0.43**	0.40**	0.18	0.16	0.44**	0.43**	0.19	0.18
Fruit weight	0.48**	0.45**	0.23	0.20	0.51**	0.48**	0.26	0.20

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

CONCLUSION

In general, it can be concluded that the hybrids (P_3 x P_5), (P_4 x P_5) and (P_5 x P_6) were a good specific combination for total yield per plant and good fruit characters and considered as promising hybrids for growing under greenhouse and open field.

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القدرة على الائتلاف والارتباط بين المحصول والعديد من الخواص في الباذنجان لإنتاج أعلى جودة من الهجن المحلية

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استخدمت طريقة التهجين الممكنة (بدون استخدام الهجن العكسية) للتهجين بين ستة أصناف من الباذنجان هي برنجال بيسا بيربيل كلاستر (P_1) ، ايجيبشين هوايت (P_2) ، لونج بيربيل (P_3) ، روند دارك بيربيل (P_4) ، بلاك بيوتى (P_5) ، برنجال بيسا بهراف (P_6). وقد تم تقييم جميع الهجن والأباء في الصوبة والأرض المكشوفة خلال أشهر الشتاء والصيف بالتتابع من سنة ٢٠٠٢ حتى ٢٠٠٤ بمحطة أبحاث الخضر بقها – قليوبية- مصر.

وقد وجد أن هناك فروق معنوية لكل من القدرة العامة والخاصة على الائتلاف لكل من طول النبات، عدد الفروع الأولية للنبات، عدد الأزهار في العنقود، المحصول المبكر، المحصول الكلى، عدد الثمار للنبات، طول الثمرة، قطر الثمرة، متوسط وزن الثمرة ومحتوى المواد الصلبة، وقد دلت النتائج على أهمية كل من تأثيرات الجينات المضيفة والغير مضيفة فى توريث هذه الصفات. وقد كانت النسبة بين القدرة العامة إلى القدرة الخاصة على الائتلاف عالية مما يدل على أن التأثيرات المضيفة تلعب دوراً هاماً في توريث هذه الصفات السابقة.

ومن بين الأصناف المستخدمة كان الصنف (P_1, P_2) و (P_3) و (P_5, P_6) و (P_1, P_2) من أفضل التوافيق لكل من عدد الأزهار في العنقود، المحصول المبكر، المحصول الكلى وعدد الثمار للنبات بالتتابع ويوصى بها باستخدامها في برامج التربية.

وقد كانت الهجن (P_3 x P_5) و(P_4 x P_5) و(P_5 x P_6) من أفضل التوافيق الخاصة للمحصول الكلى للنبات وصفات الثمار وتعتبر من الهجن التى يوصى بها للزراعة تحت الصوب والأرض المكشوفة.

وقد وجد ارتباط موجب بين المحصول الكلى (كجم/نبات) وبين كل من طول النبات، عدد الفروع الأولية للنبات، عدد الأزهار في العنقود، عدد الثمار للنبات، طول الثمرة، قطر الثمرة ومتوسط وزن الثمرة وذلك تحت نظم الزراعة المختلفة. وهذه النتيجة تدل على أن آي زيادة في المحصول الكلى لثمار الباذنجان ترتبط مباشرة بزيادة هذه الصفات.

Table 10. Mean performance of six parental cultivars and F_1 crosses for fruit characters of eggplant under greenhouse and open field.

Genotypes	Fruit length (cm)				Fruit diameter (cm)				Average fruit weight (gm)				T.S.S.			
	Greenhouse		Open field		Greenhouse				Greenhouse		Open field		Greenhouse		Open field	
	2002	2003	2003	2004	2002	2003	2003	2004	2002	2003	2003	2004	2002	2003	2003	2004
P_1	9.13	9.79	10.00	10.07	2.23	2.47	2.43	2.57	30.17	31.30	33.80	33.53	3.07	3.03	3.03	3.10
P_2	11.63	10.96	12.03	11.70	2.47	2.55	2.48	2.60	61.93	59.23	73.20	67.83	3.13	3.27	3.37	3.57
P_3	12.05	11.03	11.43	11.10	2.60	2.53	2.83	2.63	70.00	72.51	80.33	77.60	3.50	3.80	3.83	3.87
P_4	6.00	6.50	6.20	6.90	5.83	5.43	6.00	6.10	89.77	93.53	96.40	99.10	3.37	3.40	3.37	3.40
P_5	13.87	12.93	14.03	14.30	10.07	10.03	10.17	9.60	196.70	201.18	203.08	214.52	4.10	4.07	4.03	4.13
P_6	14.18	13.03	14.37	14.33	8.37	8.19	8.50	8.70	177.50	181.78	201.17	194.93	4.03	4.00	3.97	4.00
P_1 x P_2	9.93	11.02	11.23	11.90	3.73	3.80	3.63	3.67	60.90	63.17	63.83	71.77	3.11	3.12	3.07	3.26
P_1 x P_3	11.44	10.73	12.37	12.47	3.23	3.33	3.60	3.77	107.37	102.90	108.70	111.20	3.21	3.30	3.14	3.36
P_1 x P_4	7.33	8.00	7.90	8.10	4.07	3.90	4.37	4.53	93.00	88.93	107.07	105.43	3.17	3.28	3.14	3.20
P_1 x P_5	10.20	9.90	10.97	10.53	4.77	4.77	5.50	5.10	139.00	140.40	155.00	151.33	3.41	3.39	3.36	3.44
P_1 x P_6	9.10	9.57	10.83	10.20	3.87	4.00	4.47	4.53	109.57	118.00	122.30	115.77	3.39	3.38	3.34	3.40
P_2 x P_3	12.07	11.60	14.10	12.93	2.93	3.00	2.93	3.10	58.23	54.43	66.90	60.23	3.25	3.40	3.52	3.67
P_2 x P_4	10.10	9.30	10.57	10.33	5.11	5.23	5.90	6.07	126.33	123.17	146.39	127.40	3.21	3.27	3.37	3.51
P_2 x P_5	9.95	10.27	10.77	11.23	4.60	4.83	5.30	5.20	127.67	110.00	129.67	128.33	3.45	3.49	3.59	3.76
P_2 x P_6	10.02	10.93	11.03	10.16	4.37	4.90	5.90	6.50	113.07	117.00	122.17	124.13	3.43	3.49	3.57	3.71
P_3 x P_4	9.83	10.82	11.70	12.00	5.82	5.90	6.43	6.60	107.23	109.25	123.33	111.40	3.46	3.57	3.57	3.57
P_3 x P_5	11.17	11.94	13.63	12.23	5.63	5.50	6.43	6.37	114.63	115.55	137.00	135.33	3.70	3.79	3.60	3.96
P_3 x P_6	11.87	12.83	13.07	13.60	6.27	6.30	7.13	8.23	119.63	126.77	137.83	140.33	3.68	3.77	3.58	3.91
P_4 x P_5	10.50	11.20	10.87	11.90	8.40	8.60	9.40	9.00	128.93	128.20	168.13	148.10	3.61	3.81	3.59	3.64
P_4 x P_6	11.20	11.30	12.20	12.30	7.47	7.80	8.00	8.27	133.90	128.53	132.77	139.57	3.59	3.59	3.57	3.60
P_5 x P_6	13.03	12.11	13.27	13.93	6.47	7.23	7.30	7.17	194.00	188.20	201.67	197.30	4.08	4.03	4.01	4.09
L.S.D (5%)	0.84	1.34	1.76	1.42	0.71	2.47	1.00	0.68	14.89	17.91	14.07	22.17	0.55	0.56	0.52	0.53
L.S.D (1%)	1.12	1.79	2.35	1.90	0.95	2.55	1.34	0.91	19.93	23.97	18.83	29.68	0.74	0.75	0.69	0.70