Proceeding Fifth Plant Breeding Conference May 27, 2007 (Giza)

Egypt. J. Plant Breed. 11(2): 969-985 (2007) Special Issue

GENETIC STUDIES ON EARLINESS OF FLOWERING AND EARLY AND TOTAL YIELD IN EGGPLANT (*Solanum melongena* L.)

A. R. Aggour, L. A. Badr, F. A. Abo Sedera and Mona A. Ayad

Dept. of Horticulture, Fac. of Agric., Benha Univ., Egypt

ABSTRACT

Six parental genotypes of eggplant, i.e., Balady Long Purple, Black Beauty, *Balady Long White, Belleza Nera, Violetta Lunga and Baker were used in making non-reciprocal diallel pattern of crosses. The results indicated the involvement of both additive and non-additive type of gene action in the inheritance of earliness of flowering and early and total yield per plant. However, the GCA/SCA ratio indicated that the non-additive type of gene action was more important in the inheritance of early yield/plant and total yield/plant, while the additive type was more important in the inheritance of earliness of flowering. Partial dominance was observed in the inheritance of number of days to first flower bud anthesis. The direction of dominance was toward the parents with higher expression of this character. The relative values of the Vr and Wr showed that the parental cultivars Belleza Nera, Violetta Lunga, Baker and Balady Long White had the highest values of Vr-Wr concerning number of days to first flower bud anthesis, which indicated that these parental cultivars had the most recessive genes, while cultivars Balady Long Purple and Black Beauty had the lowest values and, hence had the most dominant genes concerning this character. The results indicated the unequal distribution of alleles which decreased the expression of number of days to first flower bud anthesis character and that which increased it over the related loci in the six parents. The narrow sense heritability estimates for number of days to first flower bud anthesis, and early yield, were 68.13 and 57.99%, respectively. The narrow sense heritability estimate for total yield/plant was 12.96% and hence selection should be performed in replicated experiments.*

Key words: ***Solanum melongena* L., Breeding, Diallel analysis, Earliness, Yield.**

INTRODUCTION

Eggplant (*Solanum melongena* L.) is one of the popular vegetable crops in Egypt which is used diet of many people from different social classes.

Genotypic variations among different eggplant genotypes concerning earliness of flowering were reported by Gulam *et al* (1999), Prasad and Singh (2003), Illangakoon *et al* (2004) and Mahaveer *et al* (2004). Additive gene action was found to be predo,inant in the inheritance of earliness of flowering (Srivastava and Bajpai, 1977). Different natures of dominance were reported, i.e. partial (Biswajit *et al* 2005a), complete (Hani *et al* 1977) and over-dominance (Peter and Singh, 1973, Hani *et al* 1977). Heritability estimates for earliness of flowering ranged from low (Mahaveer *et al* 2004) to high (Biswajit *et al* 2005a, Omkar and Kumar, 2005). Genetic differences among eggplant genotypes were reported concerning early yield per plant (Aggour, 1981) and total yield (Aggour, 1981, Khurana *et al* 1987, Rashid *et al* 1988, Patil and Shinde, 1989, Vadivel and Bapu, 1990b, Chezhian *et al* 2000, Roman *et al* 2001, Antonini *et al* 2002, Prasad and Singh, 2003, Mahaveer *et al* 2004, Thangamani *et al* 2004). In addition the superiority of the F_1 hybrids over one or the two parental genotype has been reported for both early yield/plant (Aggour, 1981, Biswajit *et al* 2005b) and total yield per plant (Aggour, 1981, Warade, 1986, Prasath *et al* 1998, Kaur *et al* 2001, Aswani and Khandelwal, 2003, Kanthaswamy *et al* 2003, Biswajit *et al*, 2005b, Prabhu *et al* 2005, Suneetha and Kathiria, 2006). The predominance of non-additive gene action was reported for early yield (Hani *et al* 1977, Narendra and Ram, 1987, Biswajit *et al* 2005b) and for total yield (Hani *et al* 1977, Singh and Singh, 2004, Bendale *et al* 2005, Biradar *et al* 2005 and Suneetha *et al* 2005). It was reported by Peter and Singh (1973), Joarder *et al* (1981), Salehuzzaman and Alam (1983) and Nualsri *et al* (1986) that out of the non-additive effects, the dominance and/or duplicate epistasis effects were more important in the inheritance of yield/plant. On the other hand, the additive gene action was reported to be predominant in the inheritance of this character (Vadivel and Bapu, 1990a, Omkar and Kumar, 2005). It has been reported by Warade (1986) and Baig and Patil (2002) that the estimates of both additive and non-additive gene actions were prone to change with the different environments and/or different eggplant genotypes. The high yielding capacity of cultivar Black Beauty and its suitability as a good combiner in forming hybrids with high yield have been reported (Biradar *et al* 2005, Aswani and Khandelwal, 2005). Aswani and Khandelwal (2005) found that the eggplant crosses having high specific combining ability (SCA) effects and also involved at least one good general combiner parent may be considered useful because such crosses provide transgressive type of segregants in the advanced generation more frequently than crosses with the poor combiner parents. However, Thakur *et al* (1968) found that the eggplant cultivar with the highest yield was not the best combiner. In addition, Warade (1986) found that the eggplant crosses between parents with high general combining ability (GCA) effects but had low magnitude of non-additive of gene effect for certain characters, resulted in small degree of SCA effects and heterosis. Moderate to high heritability estimates were recorded for early yield/plant (Harbans and Nandpuri, 1974) and total yield per plant (Mahaveer *et al* 2004, Omkar and Kumar, 2005). On the other hand, low heritability estimates for total yield/plant were recorded by Sidhu *et al* (1980), Aggour (1981), Salehuzzaman and Alam (1983), Nualsri *et al* (1986) and Narendra and Ram (1989).

The objectives of this study were to evaluate some eggplant cultivars for some important economic characters and to obtain the genetic parameters required to design successful breeding programs for improving earliness and yield of eggplant through genetic analysis of non- reciprocal set of diallel crosses among certain eggplant cultivars.

MATERIALS AND METHODS

This study was conducted at the Experimental Farm and Germplasm Preservation Laboratory, Faculty of Agriculture- Moshtohor, Benha University, Moshtohor, Kalubia Governorate, Egypt, during the summer seasons of 2003 and 2004.

Parental Genotypes and Crosses

Six parental genotypes of eggplant (*Solanum melogena* L.), i.e., Balady Long Purple, Black Beauty, Balady Long White, Belleza Nera, Violetta Lunga and Baker were used in making non-reciprocal diallel pattern of crosses durng summer season of 2003. Seeds of the parental genotypes were obtained from the Germplasm Preservation Laboratory, Faculty of Agriculture- Moshtohor, Benha University. Selection and selfing were performed in the populations of the different parental cultivars for three generations before starting the present study.

The seeds of different parental genotypes and their F_1's were planted in 30cm-pots filled with sand and clay (1:1, v:v) on March 8th, 2004.The seedlings of the different genotypes, i.e. parents and related F_1 populations were transplanted in the field on May 15th, 2004. Each experimental plot consisted of 3-ridges. Each ridge was 3 m long and 80 cm wide. The space between individual plants within each ridge was 50 cm apart. A randomized complete block design with three replicates was utilized in conducting this experiment.

Measurements

The individual plants of the different parental genotypes and related F_1 hybrids were evaluated for the following characters:

- Flowering date

Number of days elapsed from transplanting to the first flower bud anthesis of the individual plants was recorded.

- Early yield/plant (g)

Fruit yield of the first three harvests were used as a measurement for early yield/plant.

- Total yield/plant (g)

Total yield/plant was recorded over the growing season.

Genetic statistical analysis

The data obtained for the different traits were analyzed on individual plant mean basis. The analysis of variance was performed for the parents and F_1 hybrids according to the method described by Gomez and Gomez (1984).

Griffing Diallel Analysis

General and specific combining abilities were investigated by performing the Griffing's diallel cross analysis (Method 2), according to the method described by Griffing (1956).

Jinks- Hayman Diallel Analysis

Data from parents and the related F_1 generations were analyzed using the diallel cross methods of Jinks (1954) and Hayman (1954).

Heritability

Narrow and broad-sense heritability estimates were calculated from the genetic components according to the formulas proposed by Mather and Jinks (1971). However, in cases where the assumptions required for Jinks-Hayman analysis were not valid, the broad and narrow sense heritability values were calculated according to the method described by Pandey and Gritton (1975) using the general and specific combining ability components.

RESULTS AND DISCUSSION

Number of days to first flower bud anthesis

The results presented in Tables 1 and 2 indicated significant differences among the different parental genotypes and hybrids concerning number of days from transplanting to first flower bud anthesis. Plants of cultivar Violetta Lunga had the lowest number of days from transplanting to first flower bud anthesis (43.6 days) followed by Baker (43.8 days), Balady Long White (51.4 days), Balady Long Purple (54.6 days), Black Beauty (56.2 days). On the other hand, the cultivar Belleza Nera had the highest number of days from transplanting to first flower bud anthesis (59.0 days). The importance of genotypic variations among eggplant germplasm in breeding programs to improve this character has been reported (Gulam *et al* 1999, Prasad and Singh, 2003, Illangakoon *et al* 2004, Mahaveer *et al* 2004).

The results presented in Table 2 showed significant general and specific combining ability effects which indicated the presence of both additive and non- additive type of gene actions. However, the calculated ratio of GCA/SCA was 7.85, which indicates that the additive type of gene action was more important in the inheritance of this character. The predominance of additive gene action in the inheritance of this character was reported by Srivastava and Bajpai (1977).

The lowest values of general combining ability effect were associated with the parental cultivars Baker (-3.17) and Violetta Lunga (-2.72). Based on these results, the parental cultivars Baker and Violetta

Table 1. Means of number of days from transplanting to first flower bud anthesis and early and total yield per plant of different parental genotypes and its F_1 hybrids evaluated in the field.

Genotypes	Measurements		
	No. of days to first flower bud anthesis	Early yield /plant (g)	Total yield/ plant (g)
Balady Long Purple	54.6	147.0	1070.0
Balady Long Purple × Black Beauty	55.0	297.0	4739.0
Balady Long Purple × Balady Long White	54.2	992.0	3226.0
Balady Long Purple × Belleza Nera	54.4	204.2	2552.0
Balady Long Purple × Violetta Lunga	53.2	140.6	2389.0
Balady Long Purple × Baker	52.0	512.0	3104.0
Black Beauty	56.2	438.0	3604.0
Black Beauty × Balady Long White	55.6	356.0	2818.0
Black Beauty × Belleza Nera	52.8	130.6	1964.6
Black Beauty × Violetta Lunga	53.8	374.0	2866.0
Black Beauty × Baker	54.2	399.0	2908.0
Balady Long White	51.4	94.0	1944.0
Balady Long White × Belleza Nera	51.6	478.0	3216.8
Balady Long White × Violetta Lunga	50.6	394.6	1923.0
Balady Long White × Baker	46.4	677.0	2571.0
Belleza Nera	59.0	512.2	2818.8
Belleza Nera × Violetta Lunga	47.2	528.0	3240.0
Belleza Nera × Baker	48.2	748.0	3436.0
Violetta Lunga	43.6	535.0	2229.0
Violetta Lunga × Baker	48.2	750.0	2362.0
Baker	43.8	90.2	1788.8
L.S.D 5%	2.15	122.63	246.90
L.S.D. 1%	2.85	162.64	327.46

Table 2. Mean square values of number of days from transplanting to first flower bud anthesis and early and total yield per plant for the different sources of variance

Sources of variance	d.f.	No. of days to first flower bud anthesis	Early Yield /plant	Total yield/ plant
Genotypes	20	84.49**	293905.19**	3072064.0**
Parents	5	209.63**	229114.09**	3855686.5**
Hybrids	14	45.60**	297537.34**	2374340.5**
Parents Vs Hybrids	1	3.34 $^{n.s}$	567010.50**	8922080.0**
Error	80	2.93	9502.57	38521.6
General combining ability (GCA)	5	48.91**	19141.40**	502240.0**
Specific combining ability (SCA)	15	6.23**	71994.25**	651803.7**
Error	80	0.58	1900.51	7704.3
GCA / SCA		7.85	0.27	0.77

Lunga will be relatively good combiners for forming hybrids with low number of days from transplanting to first flower bud anthesis (Table 3).

The lowest specific combining ability effects were associated with F_1 hybrids Belleza Nera X Violetta Lunga (-3.06), Black Beauty X Belleza Nera (-2.91) and Balady Long White X Baker (-2.04). Such F_1 hybrids will give plants with low number of days from transplanting to first flower bud anthesis (Table 4).

Table 3. General combining ability effects (g_i) for number of days from transplanting to first flower bud anthesis and early and total yield per plant for the different parental genotypes .

Genotypes	Measurements		
	No. of days to first flower bud anthesis	Early yield/ plant	Total yield/ plant
Balady Long Purple	2.00	-61.58	-96.67
Black Beauty	2.72	-62.48	447.53
Balady Long White	-0.10	19.14	-160.07
Belleze Nera	1.27	22.59	140.46
Violetta Lunga	-2.72	40.59	-210.67
Baker	-3.17	41.74	-120.59
L.S.D 5%	0.49	27.99	56.35
L.S.D 1%	0.65	37.12	74.73

Table 4. Specific combining ability effects (S_{ij}) of the different F_1 hybrids for number of days from transplanting to first flower bud anthesis and early and total yield per plant.

Genotypes	Measurements		
	No. of days to first flower bud anthesis	Early yield /plant	Total yield /plant
Balady Long Purple × Black Beauty	-1.44	2.14	1684.80
Balady Long Purple × Balady Long White	0.59	615.52	779.40
Balady Long Purple × Belleza Nera	-0.59	-175.73	-195.12
Balady Long Purple × Violetta Lunga	2.21	-257.33	-7.00
Balady Long Purple × Baker	1.46	112.92	617.92
Black Beauty × Balady Long White	1.26	-19.58	-172.80
Black Beauty × Belleza Nera	-2.91	-248.43	-1326.72
Black Beauty × Violetta Lunga	2.09	-23.03	-74.20
Black Beauty × Baker	2.94	0.82	-122.27
Balady Long White × Belleza Nera	-1.29	17.34	533.07
Balady Long White × Violetta Lunga	1.71	-84.06	-409.60
Balady Long White × Baker	-2.04	197.19	148.32
Belleza Nera × Violetta Lunga	-3.06	45.89	606.87
Belleza Nera × Baker	-1.61	264.74	712.80
Violetta Lunga × Baker	2.39	248.74	-10.07
L.S.D 5%	1.35	76.86	154.75
L.S.D 1%	1.79	101.94	205.25

The analysis of homogeneity of Wr-Vr over arrays indicated the validity of Jinks- Hayman's genetic assumptions (Table 5). A further prove for the validity of these assumptions was indicated by the regression coefficient (b) for the Wr-Vr which was significantly different from zero and, in the same case, it was not significantly different from unity (Table 5 and Figure 1). This indicated the absence of appreciable epistatic interaction.

Table 5. Manual plotting for parabola limits and regression line, calculated statistics and tested hypothesis in the diallel eggplant crosses for number of days from transplanting to first flower bud anthesis according to Jinks-Hayman analysis

Parents	Vr	Wr-Parabola	Wr-Regression
Balady Long Purple (P1)	1.22773	7.17460	3.18855
Black Beauty (P2)	1.55195	8.06650	3.54245
Balady Long White (P3)	10.16602	20.64529	12.94509
Belleza Nera (P4)	18.55957	27.89520	22.10703
Violetta Lunga (P5)	15.03047	25.10336	18.25486
Baker (P6)	14.17637	24.37969	17.32257

Calculated statistics	Value
Regression Coefficient (b)	1.091545
Intercept (a)	1.848421
Parental Mean	51.43333
Mean of N^2 progeny	51.76111
Mean of N^2 progeny – parental Mean	0.3277741
Variance of Parents (VoLo)	41.92676
Variance of the Mean of Arrays (VoL_1)	5.406641
Mean covariance of Arrays with Non-Recurring Parents ($WoLo_1$)	12.89343
Mean variance of Arrays (V_1L_1)	10.11869

Tested Hypothesis	Calc. $t_{0.05}$	Signif.[K]
Ho: Wr - Vr is homogenious	0.8781769	ns
Ho:b=o (not significantly different from zero)	4.590913	**
Ho:b=1(not significantly different from unity)	- 0.3850291	ns

k $_{ns}$ = Not significant
**= Significant at 1% level of significance

The intercept (a) of the regression line of Vr-Wr was 1.848421 which indicated that the regression line intersected the Wr axis above the origin (Table 5 and Figure 1). This indicated the presence of partial dominance. This result agreed with that of Biswajit *et al* (2005a), who reported partial dominance for number of days to first flowering in eggplant. However, different nature of dominance was recorded by Peter and Singh

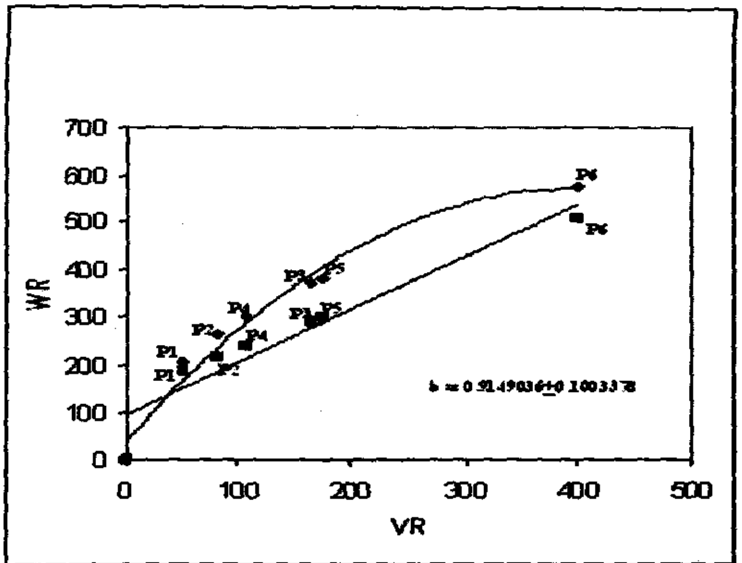

Fig. 1: Variance (VR) and covariance (WR) graph of number of days from transplanting to first flower bud anthesis in F_1 generation of egg plant germplasm (P_1 = Balady Long Purple, P_2 = Black Beauty, P_3 = Balady Long White, P_4 = Belleza Nera, P_5 = Violetta Lunga and P_6 = Baker).

(1973), who reported that number of days to first flowering was controlled by over-dominant genes. In addition, Hani *et al* (1977) reported complete dominance and over-dominance for this character. Such differences could be due to the involvement of different eggplant genotypes with different genes controlling this character. The mean of (N^2 progeny-parental mean) was + 0.3277741 (Table 5), which indicated that the partial dominance was toward the plants which had relatively higher number of days from transplanting to first flower bud anthesis. In addition, the sigh of h, which measures the direction of dominance, was positive (+ 0.0969473), (Table 6). This result indicated that the dominance acted in the direction of the parents with high number of days from transplanting to first flower bud anthesis. Moreover the degree of dominance, averaged over all loci, measured by $(H_1/D)^{1/2}$ was 0.8410009 (Table 6). This can be considered as a further prove that the partial dominance was toward the plants that had relatively high number of days from transplanting to first flower bud anthesis.

The relative values of the Vr and Wr (regression), (Table 5 and Figure 1) showed that the parental cultivars Belleza Nera, Violetta Lunga, Baker and Balady Long White had the highest values (i.e., 18.55957 and 22.10703, 15.03047 and 18.25486, 14.17637 and 17.32257, and 10.16602 and 12.94509, respectively). These results indicated that these parental

Table6. Estimates of genetic components of variation and heritability values for number of days from transplanting to first flower bud anthesis, according to Jinks-Hayman analysis

Component	No. of days to first flower bud anthesis
D	41.32772 **
H_1	29.23038 **
H_2	17.65012 **
F	31.48111 **
h	0.0969473 ns
$(H_1 / D)^{1/2}$	0.8410009
$H_2/4 H_1$	0.1509569
$((4DH_1)^{1/2}+F)/((4DH_1)^{1/2} - F)$	2.655497
h_{bs}	96.19%
h_{ns}	68.13%

ns = Not significant
* = Significant at 5% level of significance
** = Significant at 1% level of significance

cultivars contained the most recessive genes. On the other hand, the parental cultivars Balady Long Purple and Black Beauty had the lowest values of Vr and Wr (regression) (i.e., 1.22773 and 3.18855, and 1.55195 and 3.54245, respectively), (Table 5 and Figure 1) and, hence contained the most dominant genes. Since the values of Vr and Wr associated with the parental cultivars Balady Long White, Belleza Nera, Violetta Lunga and Baker were close to each other (Table 5 and Figure 1), it can be suggested that these parental cultivars have similar genotypes concerning number of days to first flower bud anthesis. On the other hand, the parental cultivars Balady Long Purple and Black Beauty have similar genotypes concerning the studied character.

The ratio, $H_2/4H_1$ which is used to estimate the average frequency of negative versus positive alleles in the parents was 0.1509569 (Table 6). Since this value was less than 0.250, it indicated the unequal distribution of alleles which decreased the expression of the studied character and that which increased it over the related loci. In addition, the ratio $((4DH_1)^{1/2} + F)/((4DH_1)^{1/2} - F)$ which measures the total numbers of dominant to recessive alleles in all parents was >1, i.e., 2.655497 (Table 6). This result indicated that the six parents used in this study carried more dominant than recessive alleles. This conclusion was supported also by the positive value of F, i.e., +31.48111 (Table 6), which indicated that there were more dominant than recessive alleles in the parents used in the present study.

The results presented in Table 6 showed high broad sense heritability (96.19%) and relatively high narrow sense heritability (68.13%) which indicated that the additive gene action had an important role in the inheritance of this character. High heritability estimates for the inheritance of early flowering have been reported (Biswajit *et al* 2005a, Omkar and Kumar, 2005). On the other hand, low values of heritability estimates were recorded by Mahaveer *et al* (2004). Such differences could be due to the fact that the additive and non-additive gene effects calculated by breeders under the environmental conditions of different locations are prone to change with the different environments (Warade, 1986, Baig and Patil, 2002). These results indicated that selection in segregating generations on individual plant basis will be effective in eggplant breeding programs to improve this character.

Early yield per plant

The results presented in Tables 1 and 2 indicated significant differences among different parental genotypes and hybrids concerning early yield per plant. Plants of cultivar Violetta Lunga had the highest early yield/plant (535.0 g) followed by Belleza Nera (512.2 g), Black Beauty (438.0 g), Balady Long Purple (147.0 g), Balady Long White (94.0 g) and Baker (90.2 g). Genetic differences among eggplant genotypes concerning early yield per plant was reported by Aggour (1981). In addition, the F_1 hybrids Balady Long Purple X Balady Long White (992.0 g), Violetta Lunga X Baker (750.0 g), Belleza Nera X Baker (748.0 g) and Balady Long White X Baker (677.0 g) exceeded the cultivar with the highest early yield/plant (Violetta Lunga). The superiority of the F_1 hybrids over the better parent concerning early yield per plant has been reported (Aggour, 1981, Biswajit *et al* 2005b).

The results presented in Table 2 showed significant general and specific combining ability effects which indicate the presence of both additive and non- additive type of gene actions. The calculated GCA/SCA ratio was 0.27 (less than unity), which indicates that the non-additive type of gene action was more important in the inheritance of this character. Same conclusion was reached by Hani *et al* (1977), Narendra and Ram (1987) and Bendale *et al* (2005).

The highest values of desirable general combining ability effect were associated with the parental cultivars Baker (41.74) and Violetta Lunga (40.59), (Table 3). These parental genotypes will be good combiners for forming hybrids with high early yield.

The highest desirable specific combining ability effect was associated with F_1 hybrid Balady Long Purple X Balady Long White (615.52). Such hybrid will give plants with high early yield followed by Belleza Nera X Baker (264.74), Violetta Lunga X Baker (248.74) and Balady Long Purple X Baker (112.92), (Table 4).

The results presented in (Table 7) indicated absence of one or more of the assumptions required for validity of Jinks- Hayman analysis for early yield per plant.

Since the Jinks-Hayman analysis was not valid, the broad and narrow sense heritability estimates were calculated using genetic components obtained from Griffing analysis (Table 8). The broad and narrow sense heritability estimates were 95.83% and 57.99%, respectively. These results indicated that the additive genetic variance components are relatively large comparing to the other types of genetic variance components. These results indicate the relatively high progress which can be achieved by selecting individual plants. Harbans and Nandpuri (1974) recorded also moderate to high value of heritability for number of days to first picking as a measure for early yield in eggplant.

Table 7. Tested hypothesis in the diallel eggplant crosses concerning early and total yield per plant for validity of Jinks- Hayman analysis.

Tested Hypothesis	Early yield/plant		Total yield/plant	
	Calc. t.0.05	Signif. [K]	Calc. t.0.05	Signif. [K]
Ho: Wr- Vr is homogeneous	0.89488	ns	0.2945111	ns
Ho:b=0(not significantly different from zero)	- 1.159821	ns	1.335555	ns
Ho:b=1(not significantly different from unity)	4.533823	**	1.381856	ns

[K]ns = Not significant
** = Significant at 1% level of significance

Table 8. Broad and narrow sense heritability estimates calculated using Griffing analysis for early and total yield per plant.

Characters	Heritability %	
	Broad sense (h^2_{bs})	Narrow sense (h^2_{ns})
Early yield/plant	95.83%	57.9?%
Total yield /plant	98.66%	12.96%

Total yield per plant:

The results presented in Tables 1 and 2 indicated significant differences among different parental genotypes and hybrids concerning total yield per plant. Plants of cultivar Black Beauty had the highest total yield per plant (3604.0 g) followed by Belleza Nera (2818.8 g), Violetta Lunga (2229.0 g), Balady Long White (1944.0 g), Baker (1788.8 g) and Balady Long Purple (1070.0 g). Significant differences in fruit yield per plant among eggplant genotypes have been reported (Aggour 1981, Khurana *et al* 1987, Rashid *et al* 1988, Patil and Shinde 1989, Vadivel and Bapu, 1990b, Chezhian *et al* 2000, Roman *et al* 2001, Antonini *et al* 2002, Prasad and Singh, 2003, Mahaveer *et al* 2004, Thangamani *et al* 2004). The F_1 hybrid Balady Long Purple X Black Beauty (4739.0g) exceeded the cultivar with the highest total yield, i.e., Black Beauty (Table 1). The superiority of the F_1 hybrid over one or the two parental genotypes was observed by Aggour (1981), Warade (1986), Parasath *et al* (1998), Kaur *et al* (2001), Aswani and Khandelwal (2003), Kanthaswamy *et al* (2003), Biswajit *et al* (2005b), Prabhu *et al* (2005) and Suneetha and Kathiria (2006).

The results presented in Table 2 showed significant general and specific combining ability effects which indicate the presence of both additive and non- additive type of gene actions. However, the calculated ratio of GCA/SCA was 0.77, i.e. less than unity, which indicates that the non- additive type of gene action was more important in the inheritance of this character. This result agreed with the results of many authors who reported that the non-additive gene action was predominant in the inheritance of fruit yield per plant in eggplant (Hani *et al* 1977, Singh and Singh, 2004, Bendale *et al* 2005, Biradar *et al* 2005, Suneetha *et al* 2005). In addition, Peter and Singh (1973), Joarder *et al* (1981) and Nualsri *et al* (1986) reported that out of the non-additive effects, the dominance effects were more important in the inheritance of yield/plant in eggplant. Moreover, Salehuzzaman and Alam (1983) reported that dominance and duplicate epitasis were most important in the inheritance of this character. On the other hand, the additive gene effects were found to be more important in the inheritance of this character (Vadivel and Bapu, 1990a, Omkar and Kumar, 2005). Such differences could be due to using different eggplant genotypes and/or different environments in evaluation. It has been reported by Warade (1986) and Baig and Patil (2002) that the estimates of both additive and non-additive gene actions were prone to change with the different environments and/or different eggplant genotypes.

The highest value of general combining ability effect was associated with the parental cultivar Black Beauty, which had the highest yielding capacity (447.53) (Table 3), The parental genotype which had the highest desirable general combining ability effect, i.e., Black Beauty, will be a good combiner for forming hybrids with high total yield/plant. Same results had been reached by Biradar *et al* (2005), who found that the eggplant cultivar Black Beauty was the best general combiner which produced significant GCA for fruit yield per plant. In addition, the results obtained in the present study in this respect agreed with the finding of Aswani and Khandelwal (2005), who mentioned that the parents which had the best *per se* performance were also the best general combiners, indicating a positive association between the two parameters.

The highest specific combining ability effect was associated with F_1 hybrid which included the best general combiner (Black Beauty), i.e., Balady Long Purple X Black Beauty (1684.8), (Table 4). Such F_1 hybrid will give plants with high total yield/plant. This result was confirmed by results and conclusions of Aswani and Khandelwal (2005), who found that the eggplant crosses would having high SCA effects and also involved at least one good general combiner parent were considered useful because such crosses provide transgressive type of segregants in the advanced generations more frequently than crosses with poor general combiner parents. On the other hand, Thakur *et al* (1968) found that the eggplant cultivar with the highest yield was not the best combiner. These differences can be explained by the findings of Warade (1986), who found that the eggplant crosses between parents with high GCA effects but had low magnitude of non-additive gene effects for certain characters, resulted in small degree of SCA effects and heterosis.

The results presented in Table 7 indicated absence of one or more of the assumptions required for validity of Jinks- Hayman analysis for total yield per plant. Since the Jinks- Hayman analysis was not valid, the broad and narrow sense heritability estimates were calculated using genetic components obtained from Griffing analysis (Table 8). The results presented in Table 8 showed very high broad sense heritability (98.66%) and low narrow sense heritability (12.96%). The relatively low value of the narrow sense heritability estimates indicated the high involvement of the non-additive and environmental effects on the expression of this character. Low estimates of heritability values for the same character were recorded by Sidhu *et al* (1980), Aggour (1981), Salehuzzaman and Alam (1983), Nualsri *et al* (1986) and Narendra and Ram (1989). On the other hand, moderate to high estimates for heritability were recorded for fruit yield/plant in eggplant (Mahaveer *et al* 2004, Omkar and Kumar, 2005). These differences could be due to evaluating different eggplant genotypes under different environmental conditions. The fact that the estimation of both the additive and non-additive gene actions are prone to change with the environments (Warade, 1986, Baig and Patil, 2002) may result in different calculations for the heritability values. In addition, using different criteria to evaluate total yield/plant in eggplant such as marketable yield/plant or total yield per plant may also cause such differences in the estimated heritability. According to the results obtained in the present study, selection for lines or hybrids with high productivity should be performed in replicated experiments to eliminate as much as possible the environmental effects on the expression of this character. In direct selection for high yield may also be investigated.

REFERENCES

Aggour, A.R. 1981. Effect of crossing on the inheritance of some economic characters in eggplant. M.Sc. Thesis, Zagazig Univ., Benha Branch, Egypt, PP.81.

Antonini, A.C.C., W.G.R. Robles, N.J. Tessarioli and R.A. Kluge. 2002. Yield potential of eggplant cultivars. Hort. Brasileira 20 (4): 646-648 (c.f. Data base of Agricola Internet).

Aswani, R.C. and R.C. Khandelwal. 2003. Hybrid vigour in brinjal (*Solanum melongena* L.) . Annals Agric. Res. 24 (4): 833-837

Aswani, R.C. and R.C. Khandelwal. 2005. Combining ability studies in brinjal. Indian J. Hort. 62(1): 37-40

Baig, K.S. and V.D. Patil. 2002. Combining ability over environments for shoot and fruit borer resistance and other quantitative traits in *Solanum melongena* L. Indian J. Genet. 62(1): 42-45.

Bendale, V.W., S.V. Mane, S.G. Bhave, R.R. Madav and S.B. Desai. 2005. Combination ability studies on growth and developmental characters in brinjal (*Solanum melongena* L.). International J. Agric. Sci. 1(1): 30-33.

Biradar, A.B., A.D. Dumbre and P.A. Navale. 2005. Combining ability studies in brinjal (*Solanum melongena* L.). J. Maharashtra Agric. Univ. 30(3): 342 (c.f. Data base of Agricola Internet).

Biswajit, P., Y.V. Singh and H.H. Ram. 2005a. Studies on heritability, genetic advance and genetic components of variation in round-fruited eggplant (*Solanum melongena L.*). Hort. J. 18(1): 46-50.

Biswajit, P., Y.V. Singh and H.H. Ram. 2005b. Manifestation of heterosis for certain economic characters in round- fruited brinjal (*Solanum melongena* L.) under Tarai conditions of Uttaranchal. India. J. Applied Hort. 7(2): 121-123.

Chezhian, P., S. Babu and J. Ganesan. 2000. Combining ability studies in Eggplant (*Solanum melongena* L.). Tropical Agric. Res. 12: 394-397.

Gomez, K.A. and A.A. Gomez. 1984. Statistical Procedures for Agricultural Research. 2nd Jhon Wiely and Sons. Inc New York. pp. 680.

Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Aust. J. Biol. Sci. 9:463-493.

Gulam, U.D., A.S. Arunachilla and M.I. Tanki. 1999. Diallel analysis of some economic traits in eggplant (*Solanum melongena* L.). Applied Biol. Res. 1(1): 83-84.

Hani, M.B., A.M. Khalf-Allah, M.A. El-Shal, M.M. Abd El-Kader and M.K. Doos. 1977. Estimation of heterosis in eggplant (*Solanum melongena* L.). Alex. J. Agric. Res. 25(3): 465-471.

Harbans, S. and K.S. Nandpuri. 1974. Genetic variability and correlation studies in eggplant (*Solanum melongena* L.). J. Res., Punjab Agric. Univ. 11(2): 150-157. (c.f. Plant Breed. Abstr. 45(7): 5907).

Hayman, B.I. 1954. Theory and analysis of diallel crosses. Genetics 39: 789-809.

Illangakoon, T.K., D.C. Bandara and H. Fonseka. 2004. Evaluation of physio-agronomic and chemical traits in relation to the productivity of eggplant (*Solanum melongena* L.). Tropical-Agric. Res. 16: 14-24.

Jinks, J.L. 1954. The analysis of continuous variation in a diallel cross of *Nicotiana rustica* varieties. Genetics, 39: 767-788.

Joarder, O.I., Q.N. Islam, M. Salehuzzaman and M.S. Alam. 1981. Inheritance of some quantitative characters in eggplant (*Solanum melongena* L.). Genetica Polonica 22 (1): 91-102 (c.f. Plant Breed Abstr. 52(1): 894).

Kanthaswamy, V., S. Natarajan, K. Srinivasan and A. Ananthalakshmi. 2003. Genetic studies in brinjal (*Solanum melongena* L.). South Indian Hort. 51(1/6): 144-148.

Kaur, J., J.A. Patel, M.J. Patel, A.S. Bhanvadia and R.R. Acharya. 2001. Heterosis for fruit yield and its components in brinjal (*Solanum melongena* L.). Capsicum and Eggplant Newsletter 20: 102-105 (c.f. Data base of Agricola Internet).

Khurana, S.C., G.R. Singh, K.K. Thakral, G. Kalloo, M.L. Pandita and U.C. Pandey. 1987. Phenotypic stability for fruit yield in brinjal. Haryana Agric. Univ. J. Res. 17(2): 189-191 (c.f. Data base of Agricola Internet).

Mahaveer, P., M. Nandan, S.N. Dikshit and S.S. Nichal. 2004. Genetic variability, genetic advance and heritability in brinjal (*Solanum melongena* L.). Orissa J. Hort. 32(2): 26-29. (c.f. Data base of Agricola Internet)

Mather, K. and J.L. Jinks. 1971. Biometrical genetics. Cornell Univ. Press, Ithaca, N.Y.

Narendra, K. and H.H. Ram. 1987. Combining ability and gene effect analysis of quantitative characters in eggplant. Indian. J. Agric. Sci. 57(2): 89-102.

Narendra, K. and H.H. Ram. 1989. Components of genetic variation in eggplant. Crop Improvement 16(1): 92-94. (c.f. Plant Breed. Abstr. 60 (12): 12616).

Nualsri, C., C. Dhanasobhon and P. Srinives. 1986. A study on the inheritance of some economically important characters in 4 cultivars of eggplant (*Solanum melongena* var. *esculenta* Nees.) II. Gene actions controlling the characters. Kasetsart J. 20(3): 239-248 (c.f. Data base of Agricola Internet).

Omkar, S. and J. Kumar. 2005. Variability, heritability and genetic advance in brinjal. Indian J. Hort. 62(3): 265-267.

Pandey, S. and E.T. Gritton. 1975. Inheritance of protein and other agronomic traits in a diallel cross of Pea. Amer. Soc. Hort. Sci. 100(1): 87-90.

Patil, H.S. and Y.M. Shinde. 1989. Combining ability in eggplant (*Solanum melongena* L.). Indian J. Genet. and Plant Breed. 49(2): 155-159.

Peter, K.V. and R.D. Singh. 1973. Diallel analysis of economic traits in brinjal. Indian J. Agric. Sci. 43(5): 452-455 (c.f. Plant Breed. Abstr. 44(11): 8231).

Prabhu, M., S. Natarajan and L. Pugalendhi. 2005. Studies on heterosis and mean performance in brinjal (*Solanum melongena* L.). Vegetable Sci. 32(1): 86-87 (c.f. Data base of Agricola Internet).

Prasad, V.S.R.K. and D.P. Singh. 2003. Biometrical relationship between F_1 potential and genetic distance in full diallel population of eggplant (*Solanum melongena* L.). Indian J. Hort. 60(4): 346-352.

Prasath, D., S. Natarajan and S. Thamburaj. 1998. Studies on heterosis in eggplant (*Solanum melongena* L.). South Indian Hort. 46(3-6): 247-250. (c.f. Data base of Agricola Internet)

Rashid, M.A., S.N. Mondal, M.S. Ahmed, S. Ahmad and D.K. Sen. 1988. Genetic variability, combining ability estimates and hybrid vigour in eggplant (*Solanum melongena* L.). Thai J. Agric. Sci. 21(1): 51-61 (c.f. Data base of Agricola Internet).

Roman, P.E., L.E. Rivera, A. Armstrong and G. Fornaris. 2001. Preliminary evaluation of commercial hybrids and open pollinated eggplant cultivars. J. Agric. Univ. Puerto Rico 85(1-2): 91-95 . (c.f. Data base of Agricola Internet).

Salehuzzaman, M. and M.S. Alam. 1983. Genetic analysis of yield and its components in the eggplant. SABRAO J. 15(1): 11-15 (c.f. Data base of Agricola Internet).

Sidhu, A.S., R.D. Bhutani, G. Kalloo and G.P. Singh. 1980. Genetics of yield components in brinjal (*Solanum melongena* L.). Haryana J. Hort. Sci. 9(3/4): 160-164 (c.f. Plant Breed. Abstr. 51(12): 11071).

Singh, B. and A.K. Singh. 2004. Gene effect for various quantitative traits in brinjal (*Solanum melongena* L.). Crop Research Hisar. 27(1): 109-110. (c.f. Data base of Agricola Internet).

Singh, S.N. and H.N. Singh. 1981. Genetic variability and heritability in brinjal (*Solanum melongena* L.). Progressive Hort. 12(4): 13-17 (c.f. Plant Breed. Abstr. 51(12): 11070).

Srivastava, O.P. and P.N. Bajpai. 1977. Combining ability in eggplant. Indian J. Agric. Sci. 47(4): 181-184 (c.f. Plant Breed. Abstr. 48(5): 4910).

Suneetha, Y. and K.B. Kathiria. 2006. Studies on combining ability for yield, quality and physiological characters in late summer brinjal. International J. Agric. Sci. 2(1): 193-197(c.f. Data base of Agricola Internet).

Suneetha, Y., K.B. Kathiria, P.K. Kathiria and T. Srinivas. 2005. Combining ability for yield, quality and physiological characters in summer grown brinjal. Vegetable Sci. 32(1): 41-43 (c.f. Data base of Agricola Internet).

Thakur, M.R., K. Singh and J. Singh. 1968. Hybrid vigour studies in brinjal (Solanum melongena L.). J. Res. Punjab Agric. Univ., Ludhiana 5: 490-495 (c.f. Plant Breed. Abstr. 40(2): 1937).

Thangamani, C., P. Jansirani and D. Veeraraghavathatham. 2004. Evaluation of F_1 hybrids of brinjal (*Solanum melongena* L.) for yield and quality. Capsicum and Eggplant Newsletter, (23): 141-144 (c.f. Data base of Agricola Internet).

Vadivel, E. and J.R.K. Bapu. 1990a. Variability and correlation coefficient in F_2 generation of eggplant. South Indian Hort. 38(3): 153-155 (C.F. Plant Breed. Abstr. 63(1): 701).

Vadivel, E. and J.R.K. Bapu. 1990b Genetic variation and scope of selection for yield attributes in eggplant (*Solanum melongena* L.). South Indian Hort. 38(6): 301-304.

Warade, S.D. 1986. Studies on heterosis and combining ability in brinjal (*Solanum melongena* L.). Unpubl. Ph.D. Thesis, Mahatma Phule Agric. Univ., Rahuri. (c.f. Data base of Agricola Internet).

دراسات وراثية على التبكير فى الإزهار والمحصول المبكر والمحصول الكلى فى الباذنجان

أحمد رضا عجور – لطفى عبدالفتاح بدر – فتحى أبو النصر أبو سديرة – منى عبدالكريم عياد

قسم البساتين – كلية الزراعة – جامعة بنها

استخدمت ستة أباء من الباذنجان في عمل تهجينات تبادلية غير رجعية بنظام Diallel وذلك خلال الموسم الصيفي لعام 2003 ، وكانت الأباء المستخدمة هي :

Balady Long Purple, Black Beauty, Balady Long White, Belleza Nera, Violetta Lunga and Baker

وذلك لدراسة توريث بعض الصفات في الباذنجان . وقد تم الحصول علي بذور الآباء من معمل حفظ الأصول الوراثية النباتية بكلية الزراعة بمشتهر بقسم البساتين، جامعة بنها.

وقد تم تقييم النباتات الفردية للأباء المختلفة وهُجن الجيل الأول الناتجة من التهجين بينها وذلك في الموسم الصيفى لعام 2004.

النتائج المتحصل عليها يمكن تلخيصها كالأتي :

- **وجد أن هناك اختلافات معنوية بين الاباء والهجن بالنسبة للصفات المدروسة وهى التبكير فى الإزهار والمحصول المبكر والمحصول الكلى.**
- **النتائج أشارت إلى اشتراك كل من التأثير الإضافي وغير الإضافي للجين في توريث هذه الصفات.**
- **النسبة GCA/SCA أشارت إلي أن التأثير غير الإضافي للجين كان أكثر أهمية في توريث صفتي المحصول المبكر/نبات والمحصول الكلي/نبات.**
- **النتائج أشارت إلي وجود سيادة جزئية (partial-dominance) تتحكم في توريث صفة ميعاد الإزهار.**

- بالنسبة لصفة ميعاد الإزهار أعطت الأبـاء Belleza Nera و Violetta Lunga و Baker و Balady Long White أعلي القيم لــ Vr و Wr وهذا يشير إلي أن هذه الأباء تحتـوي علـي معظـم الجينـات المتنحية بينما الصنفين Black Beauty و Balady Long Purple أعطيا أقـل القـيم وبالتـالي فهمـا يحتويان علي معظم الجينات السائدة التى تتحكم في هذه الصفة.
- أظهرت النتائج عدم تساوى نسبة الأليلات التى تقلل من تعبير صفة عدد الأيام من الـشتل حتـى تفـتح أول برعم زهرى مع الأليلات التى تزيد من تعبير هذه الصفات وذلك في الستة أباء المستخدمة في هذه الدراسة.
- درجة التوريث بمعناها الواسع والضيق بالنسبة لصفات عدد الأيام من الشتل حتى تفـتح أول بـرعم زهـرى والمحصول المبكر كانت 96.19%، 68.13% - 95.83% و57.99% علي التوالى - وهذا يشير إلـي دور كل من التأثير الإضافي والتأثير غير الإضافي للجين في توريث هذه الصفات. بالرغم من ذلـك فـإن تـأثير الإضافة كان أكثر أهمية من التأثير غير الإضافي.
- درجة التوريث بمعناها الواسع والضيق التى تم تقديرها لـصفة محـصول النبـات الكلـي كانـت 98.66% و12.96%. ومن ثم فإن الانتخاب لتحسين المحصول الكلى يجب أن يتم في تجارب ذات مكررات وذلك لتقليل تأثير البيئة علي تعبير هذه الصفة كلما أمكن ذلك.

مجلد المؤتمر الخامس لتربية النبات ـ الجيزة ٢٧ مايو ٢٠٠٧
المجله المصريه لتربية النبات ١١ (٢): ٩٦٩ ـ ٩٨٥ (عدد خاص)