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Combining Ability and Heritability in Round Eggplant (*Solanum melongena* L.) for Vegetative Traits, Yield and its Component

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ABSTRACT

Present investigation was carried out during two summer seasons of 2018 and 2019 on a private farm in Gharbia Governoratethe with 15 genotypes including 5 lines and 10 $F_{1's}$ of eggplant. The experiment was laid out in Randomized Block Design with four replications. The observations were recorded for 10 characters. The obtained results cleared that both GCA and SCA were highly significant in vegetative traits, earliness and fruit characteristics. The ratio between GCA / SCA were more than one in all studied traits under study. The estimates of General combining Ability effects (gca) indicated that parent 1 was best general combiner for fruit yield as number and weight of fruits, whereas the best specific crosses were cross 3 ×4 for number of fruits per plant and crosses 1 × 4 and 3 × 5 were best specific combiners for total fruit weight. Heritability estimates in broad sense were high for all studied traits, while heritability estimates in narrow sense were low for all studied traits except for chlorophyll content it was moderately high.

Keywords: Eggplant, Combining ability, Heritability, Half diallel.

INTRODUCTION

Eggplant (*Solanum melongena* L.) is one of the important Solanaceous vegetable crops. It is widely cultivated in both temperate and tropical region of the world. Its immature fruits are generally used as vegetable and other culinary preparations. Eggplant contains a higher content of free reducing sugars, anthocyanin, phenols, glycoalkaloids (solasodine) and amide proteins. Eggplant is well known for its medicinal properties (Pramila *et al*., 2020). Combining ability is prerequisite in any plant breeding programme either for varietal improvement or for evolving a hybrid. The knowledge of general combining ability and specific combining ability help to choose better parents and better hybrids respectively. The present investigation formulated to investigate the combining ability effects. In this investigation we have to identify potential parental combination in order to have superior hybrids with high yield potential.

MATERIALS AND METHODS

The experiments were carried out at a private farm in Gharbia Governorate, during 2018 and 2019 to produce promising hybrids of eggplant suitable to local condition. Five lines of eggplant (*Solanum melongena* L.) were used as genetic materials, viz., P1, P2, P3, P4 and P5. These lines were obtained from the local cultivars Black Beauty by using individual selection after several generations of inbreeding and selection. In the summer season of 2017, the parental seeds were sown, at flowering stage, crosses among these parents were done in all possible combinations excluding reciprocals to produce 10 $F_{1's}$. In summer seasons of 2018 and 2019, all populations viz., 5 parents and 10 $F_{1's}$ were evaluated in field trails.

The experimental design used was a randomized complete block design with four replications. Each replicate contained 15 plots or experimental units (5 parents and 10 F1's). Each plot was a single row (7.0 m length and 0.85 m width), therefore the plot area was 5.95 m2. The distance between plants was 50 cm apart the number of plants/plot was 14 plants. Drip irrigation system was used. Fertigation was carried out according to recommendations. Routine cultural practices were done as needed and were similar to those used in commercial eggplant production.

Data recorded

1. Vegetative traits

After 2 months from transplanting, 5 plants were chosen randomly from each plot to measure the following parameters:

Plant height (cm), number of branches / plant, number of leaves / plant, Leaf area (cm^2) and total chlorophyll content: Total chlorophyll content in the fourth leaf from the plant tip was determined by using the SPAD-501, a portable leaf chlorophyll meter (Minolta Corp) that used for greenness measurements (Marqurad and Timpton, 1987) on fully expended leaves without destroying them.

2. Days to flower flowering

Days from transplanting to 50% flowering were determined.

3. Total yield / plant

Number of fruits: Total fruit number / plant were calculated from all harvested fruits. Fruit weight: It was calculated from all harvested fruits for the whole season.

4. Fruit characteristics:

Five fruits from each parent and F1 hybrids were taken randomly and the following data were recorded: Average fruit weight (g), fruit length (cm) and fruit diameter (cm).

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Statistical procedures

Statistical procedures used in this study were done according to the analysis of variance for a randomized complete block design as outlined by Cochran and Cox (1957). Duncan's Multiple Range Test was used for the comparison among genotype means (Duncan, 1955).

In order to estimate the different genetic parameters in terms of additive and dominance genetic variances, the F_1 hybrids were analyzed according to the analysis of the half diallel crosses mating system as outlined by Griffing (1956) method 2 model II. Heritability estimates were obtained as described by Burton and Devan (1953).

RESULTS AND DISCUSSION

The results will be presented as follows:

1- Combining ability.

2- Heritability in broad and narrow sense.

1. Combining ability

Success of any crop improvement programs is mainly dependent upon the selection of parents together with the information regarding nature and magnitude of gene effect controlling quantitative traits of economic importance.

The knowledge of gene effect and combining ability not only provides information on the inheritance of characters but also helps in selection of suitable parents for hybridization and development of promising hybrids for further exploitation.

General combining ability (GCA) is the average performance of a parent in hybrid combinations, and specific combining ability (SCA) is the deviation of a particular cross from the expectation based on the average performance of the lines involved. Mean squares for GCA and SCA of the traits under the study are given in Table 1. Estimates of general combining ability effects (gi) for individual parent and specific combining ability effects (sij) for individual cross of each trait are presented in Tables 2 and 3. Theoretically, an estimate of GCA effect of a parent is not an absolute value. It actually depends upon the group of parents to which this particular parent was crossed in the crossing system. If the parent has exactly the same average in its combinations as the general average performance of the parents in their combinations, the expected estimate (gi) would be zero. Significant departure from zero, wherever the direction, would indicate that the parent is such better or much poorer than the overall average of the parents involved in the test. High positive values would be interesting for all traits in question except the earliness traits, viz., Days to first flower anthesis, where high negative ones would be useful from the breeder's point of view.

Vegetative traits

Data presented in Table 1 show that in both years each of GCA and SCA were highly significant for plant height, number of branches / plant, chlorophyll content and leaf area / plant. This result indicates that both additive and none additive genetic variances were important for inheritance of these traits. The estimated ratio between the mean squares of GCA and SCA were more than one in all vegetative traits indicating that the additive gene effects are more than the none additive effects of inheritance in these traits. These results confirm by Suneetha *et al*.(2006), Umaretiya *et al*.(2008) and Zyada (2009).

Analysis of variance for number of days from transplanting to 50% flowering presented in Table 1, data show highly significant differences for both GCA and SCA in both years. These results indicated that both additive and none additive genetic variances were important in the inheritance of this trait. Additive gene effects (GCA) played the major role in the inheritance of number of days to opening first flower than none additive gene effects (SCA). Ratio between GCA/SCA mean squares was estimated as about 8.14 and 4.78 in the first and second year, respectively. These results coincide with the results obtained by Umaretiya *et al* (2008).

The estimates of gca effects (gi) for parents and sca effects (sij) for crosses are given in Table 2. The results show that in both years parent 1 had the greatest gca effects for plant height, number of branches / plant, chlorophyll content and leaf area / plant therefore parent 1 was good combiner for these traits. Parent 2 had negative values gca effects (gi) for these traits therefore, parent 2 was poor combiners for these traits. Parent 3 had positive and significant values for plant height and total chlorophyll content in both years, therefore parent 2 consider good combiner for these traits. Parent 4 and 5 had negative or insignificant values for vegetative traits, therefore these two parents were poor combiners.

Regarding to sca effects in both years 2 crosses (1x2 and 1x3) gave highly significant sca effects for plant height, number of branches / plant, chlorophyll content and leaf area / plant. On the other hand, the other crosses reflected the lowest sca effects values.

Table 1. Mean squares for general combining ability (GCA) and specific combining ability (SCA) for studied vegetative, earliness and fruit yield and its components traits of eggplant grown in 2018 and 2019.

Source of variation	Plant height (cm)		No. of branches / plant		Days to 50 % flowering		Total chlorophyll		Leaf area (cm^2)		Average fruity weight (g)		Average fruity length (cm)		Average diameter (cm)		No. of fruit / plant		Total weight of fruit / plant(kg)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
Genotypes	281.95 **	270.10 **	3.25 **	366 **	127.50 **	83.02 **	691.07 **	337.44 **	4972981.91 **	2980792.11 **	5734.23 **	2097.37 **	6.53 **	4.56 **	5.75 **	2.47 **	96.52 **	30.80 NS	0.04 NS	0.12 NS
GCA	41.84 **	88.04 **	0.61 **	1.55 **	6.27**	7.26 **	114.57 **	39.84**	1642319.94 **	1252710.13 **	1823.80 **	941.21 **	1.77**	1.45 **	1.44 **	0.88 **	27.94 NS	12.72 NS	0.01 NS	0.05 NS
SCA	4.80 **	2.48 **	0.13 **	0.06 **	0.77 **	1.52 **	1.32**	4.17**	212145.23 **	156116.21 **	15.86**	196.55 **	0.06 **	0.14 **	0.07 **	0.12 **	1.02**	3.01NS	0.01 NS	0.02 *
GCA / SCA	8.72	35.50	4.69	25.83	8.14	4.78	86.80	9.55	7.74	8.02	114.99	4.79	29.50	10.36	20.57	7.33	27.39	4.23	1.00	2.50

***, ** = significant at 0.05 and 0.01, probability levels, respectively**

Table 2. Estimates of general combining ability effects (gca) for studied vegetative, earliness and fruit yield and its components traits in the parents of eggplant grown in 2018 and 2019.

Parents	Plant height (cm)		No. of branches / plant		Days to flowering		Total chlorophyll		Leaf area (cm)		Average fruity weight (g)		Average fruity length (cm)		Average diameter (cm)		No. of fruit / plant		Total weight of fruit / plant (kg)	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
1	8.68**	3.19**	0.58**	0.21**	7.45**	5.78**	9.54**	9.18**	794.01**	175.00^{NS}	29.92**	-1.24^{NS}	-0.01^{NS}	-0.62**	0.84**	0.34**	-3.56**	-1.01**	0.01^{NS}	0.07*
2	-5.23**	-3.19**	-0.28**	0.11*	-0.93**	-1.55**	-10.03**	-3.68**	-422.51**	-132.47^{NS}	-9.46**	2.76^{NS}	-0.10^{NS}	0.14^{NS}	0.16*	-0.32**	1.25**	-0.44^{NS}	-0.04^{NS}	-0.03^{NS}
3	2.20**	4.14**	0.49**	0.07^{NS}	-2.89**	-1.46**	7.83**	2.47**	-160.32^{NS}	181.49*	-14.08**	-3.71^{NS}	0.85**	0.71**	-0.88**	-0.28**	2.87**	0.99*	0.10**	-0.03^{NS}
4	-4.37**	-4.10**	0.01^{NS}	-0.41**	-0.27^{NS}	-0.12^{NS}	-6.60**	-8.01	131.25^{NS}	-325.80**	-0.55^{NS}	-2.67^{NS}	0.28**	-0.24*	-0.26**	-0.04^{NS}	-1.23**	0.42^{NS}	-0.04^{NS}	0.02^{NS}
5	-1.28**	-0.05^{NS}	-0.80**	0.02^{NS}	-3.36**	-2.65**	-0.74*	0.04^{NS}	-342.42**	101.82^{NS}	-5.84**	4.86^{NS}	-1.01**	0.00^{NS}	0.46**	0.30**	0.68*	0.04^{NS}	-0.04^{NS}	-0.03^{NS}
LSD$_{0.05}$	1.34	0.69	0.16	0.10	0.39	0.54	0.52	0.92	208.63	178.98	1.79	6.33	0.11	0.16	0.11	0.15	0.45	0.77	0.05	0.06
LSD$_{0.01}$	2.04	1.46	0.24	0.16	0.60	0.83	0.79	1.40	317.62	272.48	2.73	9.64	0.17	0.25	0.17	0.23	0.69	1.18	0.07	0.09

***, ** = significant at 0.05 and 0.01, probability levels, respectively**

Days to 50% flowering

Analysis of variance for number of days from transplanting to 50% flowering presented in Table 1 show highly significant differences for both GCA and SCA in both years. These results indicated that both additive and none additive genetic variances were important in the inheritance of this trait. But additive gene effects (GCA) was important than none additive gene effects (SCA) in the inheritance of number of days to 50% flowering Ratio between GCA/SCA mean squares was estimated as about 8.14 and 4.78 in both years, respectively. These results coincides with the results obtained by Umaretiya *et al* (2008).

Concerning gca effects for each parent, the negative values are desirable values to this character. Data in Table 2 show that parents 2, 3, 4 and 5 had highly significant with negative values gca effects. These parents could be considered as good combiner for earliness in eggplant. Parent 1 had positive gca effects values (poor combiner).

Regarding sca effects, crosses 2x3, 2x5, 3x4 and 3x5 exhibited highly significant with negative sca effect values. The other crosses had positive or none significant sca effect values for this trait.

Total yield/plant

Number of fruits

Data presented in Table 1 show that in both years the analysis of variance for number of fruits/plant revealed highly significant differences for SCA in the first year only. However GCA were not significant in both years. Suggests that gene with none additive effects have the main role in the inheritance of the number of fruits in eggplant.

Concerning gca effects, data in table 2 and 3 show high significant positive values of gca effects were observed in parent 1 in both years, this parent was a good combiner for this trait. The other parents had negative or none significant values in one or in both years for gca effects (poor combiners). Data in Table 3 show that the crosses 3x4 had positive highly significant values of sca effects for number of fruits/plant in both years. Meanwhile, the other crosses had negative or none significant values of sca effects in one or in the two years. Similar results were reported by Suneetha and Kathiria (2006) and Umaretiya *et al.* (2008)

Fruit weight

Data presented in Table 1 show that in both years the analysis of variance for number of fruits/plant revealed significant differences for SCA in the second year only. However GCA was not significant in both years. Suggests that gene with none additive effects have the main role in the inheritance of the fruit weight in eggplant.

Concerning gca effects, data in table 2 and 3 show significant positive values of gca effects were observed in parent 1 in the second year and parent 3 in the first year. These parents were good combiners for this trait. The other parents had negative or none significant values in both years for gca effects (poor combiners). Data in Table 3 show that the crosses 1x4 and 3x5 had positive significant values of sca effects for fruit weight in second year only. Meanwhile, the other crosses had negative or none significant values of sca effects in both years. Similar results were reported by Suneetha and Kathiria (2006) and Umaretiya *et al*. (2008).

Fruit characteristics

Data of average fruit weight, length and diameter in Table 1 show highly significant differences for both GCA and SCA, indicating that genes with additive and none additive effects were involved in the inheritance of the three studied fruit characteristics. The estimated ratio between the mean squares of GCA and SCA were more than one show that the additive gene effects were more important than the none additive effects for fruit characteristics in eggplant. This agrees with the results obtained by Biradar (2005).

For general combining ability effects, (gi) data in table 2 and 3 show only parent 1 showed highly significant gca effects in the first year only with value of 29.92. It is clear that this parent was a good combiner for average fruit weight. Parent 3 showed highly significant gca effects (gi) for fruit length in both years. Parents 1 and 5 had highly significant gca effects (gi) for fruit diameter in both years.

Estimates of sca effects (sij) presented in Table 3 show that cross 2x4 had highly significant values of average fruit weight and diameter in both years and crosses1x3 and 2x3 exhibited positive highly significant values of sca effects in both years for fruit length. The other crosses exhibited negative or none significant values of sca effects in one or in two years.

Table 3. Estimates of specific combining ability effects (SCA) for studied vegetative, earliness and fruit yield and its components traits in the F_1 crosses of eggplant grown in 2018 and 2019.

Treatments		Plant height (cm)		No. of branches / plant		Days to flowering		Total chlorophyll		Leaf area (cm)		Average fruity weight (g)		Average fruity length (cm)		Average diameter (cm)		No. of fruit / plant		Total weight of fruit / plant (kg)	
No.	Crosses	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
1	P_1xP_2	7.40**	12.00**	1.43*	1.14**	2.51*	-1.32^{NS}	5.51**	2.10^{NS}	1848.1**	739.0*	22.67**	-23.97^{NS}	-0.29^{NS}	0.25^{NS}	0.86**	-0.84*	-1.84*	4.27*	-0.02^{NS}	0.21^{NS}
2	P_1xP_3	13.30**	17.33**	0.67*	1.19**	0.46^{NS}	0.59^{NS}	24.32**	4.62*	2097.6**	1660.1**	32.95**	22.17^{NS}	2.76**	1.68**	0.24^{NS}	0.44^{NS}	-3.46**	-1.83^{NS}	0.17^{NS}	-0.13^{NS}
3	P_1xP_4	0.54^{NS}	4.24*	0.48^{NS}	1.67**	3.84**	-0.75^{NS}	2.75*	8.10**	920.7*	1262.3**	4.43^{NS}	6.46^{NS}	0.67*	0.64^{NS}	-0.74*	0.21^{NS}	0.64^{NS}	0.41^{NS}	-0.02^{NS}	0.49**
4	P_1xP_5	2.44^{NS}	-2.14^{NS}	0.29^{NS}	-0.76**	2.94**	2.11^{NS}	-13.78**	4.71*	-171.0^{NS}	314.4^{NS}	58.71**	-16.73^{NS}	0.29^{NS}	-1.27**	2.57**	-0.13^{NS}	-4.60**	1.46^{NS}	-0.02^{NS}	-0.13^{NS}
5	P_2xP_3	-4.79*	-0.95^{NS}	-0.48^{NS}	0.29^{NS}	0.84^{NS}	-2.75*	-4.78**	6.14**	-665.2^{NS}	-463.8^{NS}	-35.00**	-23.16^{NS}	1.19**	1.25**	-0.76**	-1.22**	3.73**	1.94^{NS}	-0.11^{NS}	-0.03^{NS}
6	P_2xP_4	0.11^{NS}	-1.71^{NS}	0.00^{NS}	-0.90**	-0.44^{NS}	3.92**	1.32^{NS}	-4.05*	485.2^{NS}	220.1^{NS}	25.81**	63.79**	0.09^{NS}	-0.13^{NS}	0.95**	1.21**	-3.84**	-6.83**	0.03^{NS}	-0.08^{NS}
7	P_2xP_5	0.68^{NS}	1.24^{NS}	-0.19^{NS}	1.00**	-2.02*	0.78^{NS}	9.13**	1.91^{NS}	-70.8^{NS}	506.8^{NS}	29.76**	17.94^{NS}	0.71**	1.00*	-0.10^{NS}	0.54^{NS}	-4.75**	-2.78^{NS}	0.03^{NS}	-0.03^{NS}
8	P_3xP_4	-0.98^{NS}	4.62**	0.24^{NS}	0.81**	-0.16^{NS}	-3.84**	-1.54^{NS}	-2.19^{NS}	-456.0^{NS}	711.8*	-29.90**	-36.40*	-0.19^{NS}	0.64^{NS}	-0.33^{NS}	-1.51**	4.21**	3.41*	-0.11^{NS}	-0.08^{NS}
9	P_3xP_5	-1.08^{NS}	-2.43^{NS}	0.05^{NS}	0.38^{NS}	-0.73^{NS}	-2.32*	-3.40**	-2.57^{NS}	44.4^{NS}	103.5^{NS}	-51.95**	-5.92^{NS}	-0.90**	0.40^{NS}	-1.05**	-0.51^{NS}	9.30**	0.79^{NS}	-0.11^{NS}	0.30*
10	P_4xP_5	-0.84^{NS}	1.14^{NS}	-0.81*	0.52*	0.32^{NS}	1.68^{NS}	-2.30*	-9.10**	-504.9^{NS}	-93.8^{NS}	16.52**	16.37^{NS}	0.67*	0.35^{NS}	0.00^{NS}	0.25^{NS}	-2.27*	-2.97^{NS}	0.03^{NS}	-0.08^{NS}
$LSD_{0.05}$		3.84	2.76	0.62	0.42	1.53	2.17	2.01	3.58	810.09	694.93	6.99	24.64	0.42	0.65	0.45	0.6	1.77	3.04	0.20	0.25
$LSD_{0.01}$		6.42	4.61	1.04	0.69	2.55	3.62	3.36	5.98	1350.82	1158.7	11.65	41.09	0.71	1.08	0.76	1.00	2.95	5.07	0.34	0.43

***, ** = significant at 0.05 and 0.01, probability levels, respectively**

2. Heritability

Heritability estimates in both broad and narrow sense are very important and should be recognized as a first step before starting any breeding program. Heritability measures are the portion of the total genetic variance that is due to hereditary factors. Heritability in broad sense includes all types of genetic variances, consequently plant breeders count on the narrow sense heritability which estimate the portion of genetic variance due to additive gene action.

Vegetative traits

Data illustrated in Table 4 show that the estimates of heritability in broad sense were high, while its estimates in narrow sense were relatively low for plant height, number of branches and leaf area. This indicates that a major part of the total phenotypic variance is due to dominance and/or over-dominance, and the environmental factors influences the inheritance of this trait. For about chlorophyll content data show that heritability estimates in broad and narrow sense were high. The high value of heritability in narrow sense indicating that a major part of the total phenotypic variance is due to additive gene effect and less influence of the environment. Similar results obtained by Mishra *et al*. (2008) and Zyada (2009).

Table 4. Estimates of broad (h^2b.s.) and narrow (h^2n.s.) sense heritability for vegetative, earliness and total yield and fruit characteristics of eggplant grown in 2018/2019.

Characters	Seasons			
	2018		2019	
	H^2b.s.	H^2n.s	H^2b.s.	H^2n.s
Plant height (cm)	0.81	0.49	0.93	0.36
No. of branches / plant	0.66	0.43	0.89	0.05
Days to flowering	0.89	0.05	0.85	0.73
Total chlorophyll(mg/l)	0.98	0.59	0.86	0.61
Leaf area (cm^2)	0.72	0.34	0.60	0.07
Total yield / plant(No.)	0.93	0.44	0.38	0.00
Total yield / plant weight(kg)	0.68	0.29	0.25	0.00
Average fruit weight (g)	0.98	0.44	0.52	0.08
Fruit length (cm)	0.95	0.37	0.73	0.19
Fruit diameter (cm)	0.95	0.41	0.95	0.41

Days to flowering

Data presented in Table 4 show that heritability estimates in broad sense were high with a value of 89 and 85 % in the two years respectively, while heritability estimated in narrow sense was low with a value of 5 % in the first year. This indicates that a major part of total phenotypic variances are due to dominance and/or over-dominance. In this concern, Mishra *et al*. (2008) have similar result.

Fruit yield/plant

Data illustrated in Table 4 show that in the first year heritability estimates in broad sense were high for fruit yield as a number and weight of fruits/plant with values of 93 and 68%, respectively. However, heritability estimates in narrow sense for fruit yield as a number and weight of fruits/plant was moderate and low with values of 44 and 29 %, respectively. These results indicated that a major part of total phenotypic variances are due to dominance and/or over-dominance, and the environmental factor affects the inheritance of these characters. In this connection, Sherly and Shanthi (2009) and Zyada (2009).

Fruit characteristics

Heritability estimates in broad sense for all fruit characteristics were high. Meanwhile, it were low in narrow sense (Table 4). These results indicate that a major part of total phenotypic variances are due to dominance and/or over-dominance and the environmental influences affected these traits. In this connection, Mostafa (2011) found similar results on eggplant.

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دراسة القدره العامه والخاصه على التآلف ودرجه التوريث بمعناها الواسع والضيق للهجن الصنفيه فى محصول الباذنجان

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أجريت هذه الدراسة بمزرعة خاصه بمحافظة الغربيه خلال الفترة من ٢٠١٧ إلى ٢٠١٩م بهدف دراسة القدرة العامة والخاصة على التآلف وكذلك تقديردرجة التوريث بمعناها الواسع والضيق فى محصول الباذنجان. استخدمت في هذه الدراسة خمسة أباء من الباذنجان تم التهجين بينها فى اتجاه واحد لانتاج ١٠هجن جيل أول تم تقييم الأباء والهجن فى تجربه حقليه فى موسمى ٢٠١٨و٢٠١٩ باستخدام تصميم القطاعات الكاملة العشوائية فى أربعة مكرارت .وتم تقيم الصفات الآتية-:الصفات الخضرية وهى: ارتفاع النبات، عدد الأفرع / نبات، المحتوي الكلي للكلوروفيل في الأوراق وعدد الأيام حتى تزهير ٥٠ % من النباتات. المحصول الكلي : عدد ووزن الثمار/ نبات. وصفات الجودة في الثمار وهى: متوسط وزن الثمرة ، طول الثمرة ، قطر الثمرة. وأجرى تحليل القدرة العامة والخاصة على التآلف باستخدام طريقة جريفنج. ويمكن تلخيص أهم النتائج المتحصل عليها كالتالي- : كانت قيم القدرة العامة والقدرة الخاصة على التآلف عالية المعنوية لصفات النمو الخضرى والتبكير وصفات الثمار مما يبين أهمية كل من الفعل المضيف وغير المضيف للجين فى توريث هذه الصفات وكانت النسبة بين القدرة العامة على التآلف إلى القدرة الخاصه على التآلف أكبر من الواحد الصحيح مما يوضح أهمية الفعل المضيف عن الفعل غير المضيف للجين في توريث هذه الصفات في حين كان الفعل غير المضيف للجين أكثر أهمية من الفعل المضيف في توريث صفات عدد ووزن الثمارفى المحصول الكلي. وكان الأب P3 ذو قدرة ائتلافية عامة عالية لصفه عدد ووزن الثمار فى المحصول الكلى . أظهرت النتائج أن الهجين ٣×٤ كان الافضل بالنسبة لعدد الثمار لكل نبات وان الهجين ١×٤ و٣×٥ كان الافضل في المحصول الكلي. كانت درجة التوريث بمعناها الواسع مرتفعة لكل الصفات تحت الدراسة بينما كانت درجة التوريث بمعناها الضيق منخفضه لكل الصفات فيما عدا صفة التزهير فى العام الثانى فقط.