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HETEROSIS AND COMBINING ABILITY IN MELON (*CUCUMIS MELO* L.)

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ABSTRACT: ***The purpose of this study was to estimate heterosis, general and specific combining ability in melon hybrids to identify the best combinations during the period from 2017 to 2019 at the Vegetable Research Farm, Horticultural Research Institute, Agricultural Research Center (ARC), Kaha and Dokki, Egypt. Six parents and their respective hybrids were evaluated in a randomized complete block design (RCBD) with three replications. The following traits were assessed of: main stem length, number of leaves, average fruit weight, fruit length, fruit diameter, flesh thickness, fruit cavity, fruit shape index, TSS and total yield/fed. The heterotic expression for total yield was the most important trait in this investigation. Potence ratio that measured the average of dominance confirmed the partial dominance for plant length and total yield but over-dominance appeared in the other characters. The range of both types of F_1 heterosis for studied characters indicated that the expression of heterosis varied according to different crosses and characters investigated. The results showed significant and highly significant mean squares for both GCA and SCA in all studied traits except fruit shape index, indicating the important role of both additive and non-additive gene effects in the expression of these traits. However, a greater ratio of GCA/SCA than unity as detected for number of leaves, fruit diameter, fruit weight, TSS and total yield revealing that the inheritance of these traits mainly was controlled by additive gene action. The estimates of GCA effects in individual parental genotypes of the F'_1s generation were significant and highly significant for the most studied traits. However, the crosses (P_1×P_3) and (P_2×P_4) achieved highly SCA effects for the most traits in this study, which means that GCA effects of the parents were reflected in the SCA effects in the crosses for the most studied traits.***

Key words: ***Cucumis melo, inbred lines, heterosis, potence ratio, GCA, SCA, Melon.***

INTRODUCTION

Melon is grown in Egypt as one of the most important vegetable crops for local consumption and exportation to many countries where it occupied an important position among the exported agricultural crops in many countries. In Egypt, the cultivated area of melon in 2017 according to the Ministry of Agriculture statistics, reached about 72173 feddan which produce 851194 tons with an average of 11.79 tons/fed. High yield, early maturity and uniform fruit shape and size as well as excellent quality are important objective in melon breeding programs. Yield associated with several traits including primary branch number, days to anthesis, fruit number and average fruit weight (Zalapa *et al., 2006*). The general combining ability (GCA) is relating to additive effects, representing the average parental performance in hybrid combinations while the specific combining ability (SCA) is relating to non-additive effects. Vashisht *et al.* (2010) on muskmelon stated results revealed that the importance of heterosis breeding for effective utilization of non-additive genetic variance. Barros *et al.* (2011) on melon found that total fruit number of melon, yield, flesh firmness and total soluble solids content were controlled by

additive and non-additive effects, while average fruit weight, longitudinal diameter, flesh thickness and internal cavity size were controlled by additive effects. Additive gene effects were most important with respect to average fruit weight, flesh thickness, days to fruit maturity and TSS, while genetic dominance effects mainly controlled total yield. The parent, Dastjerdi had the highest additive effect for fruit weight and days to fruit maturity while the parents Tiltorogh and Savei had the highest additive effects for flesh thickness and TSS, respectively.

Favorable heterosis over the better parent was found for total yield on Cantaloupe (Mohammadi *et al.* 2014). The estimates of GCA effects revealed that the line IL39B had considerable significantly positive effects for TSS providing to be a good combiner. Both parental lines IL43C and IL133K were the best general combiners for average fruit weight, leaf area index, total yield and one or two quality traits due to their significant desirable values of GCA effects for these traits. In cantaloupe, all studied crosses exhibited significantly positive SCA effects for total yield (Hussein and selim, 2014). Hatem *et al.* (2014) on melon found that both additive and non-additive gene effects were involved while the additive gene effects appeared to play the main role in the inheritance of all studied traits. Since estimated GCA: SCA ratio values ranged from 4.4 to 57.8. None of the parents were found to be good combiner for all characters. Hybrid vigor was detected for early and total yield as well as the most fruit characters.

In general, The main objectives of the present investigation were to estimate the magnitude of heterosis as well as general and specific combining ability in some economic traits in melon using a half diallel mating design.

MATERIALS AND METHODS

This study was conducted in three years 2017, 2018 and 2019.The used genetic materials were Kcl 1, Kcl 2, Kcl 3, Kcl 4, Kcl 5, and Kcl 6 (galia type, which green flesh, full netting). They were produced by the first author of the present study in breeding program by selfing and selection during four generations.

Six inbred lines of melon were crossed in half diallel design to produce 15 F_1 hybrids without reciprocal. The experiment was arranged in a randomized complete block design with three replications to evaluate 21 genotypes (six parents and 15 hybrids). Each plot consisted of two rows with 5 m long and 1.75 m width. Seeds were sown in hills at 50 cm apart. Three weeks later, seedlings were thinned to one plant per hill. The agricultural practices for melon production, i.e., irrigation, fertilization, weeding and pest control were practiced as recommended in the area.

The studied characters.

a. Main stem length (cm): main stem length was measured in centimeters from the cotyledon node to the top end.
b. Number of leaves: counting of leaves begun from the cotyledon node to the top end.
c. Fruit quality: (fruit length (cm), fruit diameter (cm), flesh thickness (cm), fruit cavity, fruit shape index and total soluble solids (TSS) by using a hand refractometer were determined in ripe fruits and average values were only represented.
d. Yield: total yield was measured as weight of all harvested fruits at the yellow-netted ripe, and average fruit weight was determined.

Statistical analysis

The obtained data were statistically analyzed and mean comparisons were based on the LSD test according to Gomez and Gomez (1984). The genetic analysis of half diallel crosses for general and specific combining abilities was done based on the method proposed by Griffing (1956), method (2) model (1). The relative potency of gene set (P) was used to determine the direction of dominance according to Smith (1952),

Potence ratio (P.R. %) = $$\frac{\overline{F_1} - \overline{MP}}{\frac{1}{2} \times (\overline{P_2} - \overline{P_1})}$$

Where: F_1 = First generation mean.

P_1 = Mean of the smaller parent.

P_2 = Mean of the larger parent.

MP = mid parent value = ½ ($\overline{P_1} + \overline{P_2}$).

Heterosis based on the mid (HMP) and better parent (HBP) values were estimated according to Sinha and Khanna (1975).

HMP (%) = $$\frac{\overline{F_1} - \overline{MP}}{\overline{MP}} \times 100$$

Where, $\overline{F_1}$ = mean performance of cross and $\overline{MP}$ = mean performance of mid-parent

HBP (%) = $$\frac{\overline{F_1} - \overline{BP}}{\overline{BP}} \times 100$$

Where, $\overline{F_1}$ = mean performance of cross and $\overline{BP}$ = mean performance of better parent

RESULTS AND DISCUSSION

Mean performances of the evaluated melon genotypes for the growth and fruit traits:

Mean performances of the six melon inbred lines and their 15 F_1 hybrids for some growth and fruit yield traits presented in Table (1). These results showed variations for plant length in the evaluated melon genotypes. The parental lines ranged from 162.42 cm (P_2) to 426.59 cm (P_4) while the plant length of the hybrids ranged from 210.84 cm (P_3×P_6) to 377.50 cm (P_1×P_5). Among parents, P_4 gave the greatest length meanwhile P_2 was the shortest. Regarding to crosses, cross (P_1×P_5) had the longest plants, but (P_3×P_6) had the shortest plants compared with the control. Regarding number of leaves among parents ranged from 23.20 (P_2) to 43.17 (P_4). Regarding to crosses, cross (P_2×P_4) gave the greatest number of leaves with no significant compared with the control while cross (P_3×P_6) gave the lowest number of leaves. These results are in agreement with Hussein and Selim (2014) on cantaloupe. The results indicated that, the parental lines for average fruit weight was ranged from 595.85g (P_4) to 1445.86g (P_2). The average fruit weight of the hybrids ranged from 698.35g (P_1×P_4) to 2420.01g (P_2×P_3). As well as, the hybrid (P_2×P_3) had the highest significantly average fruit weight among all evaluated genotypes compared with the control. For fruit length, the parents ranged from 11.23cm (P_1) to 15.80 cm (P_5). The fruit length of the hybrids ranged from 13.17 cm (P1×P6) to 19.21 cm (P_2×P_3). The parental range of fruit diameter was from 9.74cm (P_3) to 13.57 cm (P_2). The fruit diameter of the hybrids ranged from 9.37 cm (P_3×P_6) to 16.32 cm (P_2×P_3). Fruit shape index had narrow range between the inbred lines and among hybrids where all genotypes produced cylindrical fruits compared with the control. These results are in agreement with Hussein and selim (2014) on cantaloupe.

Table (2) shows that there is narrow range among inbred lines for flesh thickness where P_4 gave the greatest value while P_1 and P_3 gave the smallest value with no different with P_5 and P_6. As well as, the hybrid (P_2×P_6) gave the greatest value but (P_1×P_4) gave the smallest value with no different with Galia hybrid (control). Concerning fruit cavity, P_6 gave the smallest value over all evaluated parents with significant differences, while P_2 was the largest in this trait. The cross (P_3×P_6) gave the smallest value over all evaluated crosses with significant differences. On the other

hand, ($P_2 \times P_3$) was the largest in this trait with no significant differences with ($P_2 \times P_4$) compared with the control. The greatest TSS contents were recorded by the hybrid ($P_3 \times P_4$) and it was different significantly from all other evaluated genotypes. The hybrid ($P_3 \times P_6$) gave the lowest TSS content compared with Galia hybrid (control). The total yield trait was very important for breeders and growers, the parent P_2 gave the greatest value over all evaluated genotypes, on the contrary ($P_3 \times P_6$) hybrid gave the smallest value for this trait. These results are in agreement with Hussein and selim (2014) and Hatem *et al.* (2014) on cantaloupe.

Table 1. Mean performance of 15 F_1's and their six parents for plant length, number of leaves, average fruit weight, fruit length, fruit diameter and fruit shape index of melon (combined of 2017/2018 and 2018/2019).

Genotype	Plant length (cm)	Number of leaves	Average fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Fruit shape index (L/D)
(P_1)	191.09	23.67	608.21	11.23	9.90	1.13
(P_2)	162.42	23.20	1445.86	15.37	13.57	1.13
(P_3)	326.09	33.57	974.15	11.40	9.74	1.17
(P_4)	426.59	43.17	595.85	13.63	10.97	1.24
(P_5)	310.75	34.57	1086.66	15.80	10.98	1.44
(P_6)	329.75	34.63	764.15	14.37	11.00	1.31
$P_1 \times P_2$	305.84	34.76	1386.65	15.30	14.32	1.07
$P_1 \times P_3$	319.77	34.26	1439.35	18.14	13.52	1.34
$P_1 \times P_4$	290.84S	35.42	698.35	15.37	10.48	1.47
$P_1 \times P_5$	377.50	37.26	1210.00	15.66	13.20	1.19
$P_1 \times P_6$	306.00	35.33	1183.00	13.17	12.87	1.02
$P_2 \times P_3$	370.00	35.25	2420.01	19.21	16.32	1.18
$P_2 \times P_4$	320.84	40.92	1892.71	17.80	14.58	1.22
$P_2 \times P_5$	310.00	35.33	801.00	14.44	10.58	1.36
$P_2 \times P_6$	315.84	34.67	1908.65	16.90	15.28	1.11
$P_3 \times P_4$	319.50	33.67	1256.31	18.21	14.22	1.28
$P_3 \times P_5$	222.67	29.58	1346.37	16.20	14.13	1.15
$P_3 \times P_6$	210.84	22.76	645.01	13.28	9.37	1.42
$P_4 \times P_5$	320.00	35.00	807.50	13.24	11.45	1.16
$P_4 \times P_6$	330.18	34.50	812.35	12.52	11.32	1.11
$P_5 \times P_6$	305.67	34.58	1430.00	15.80	14.30	1.10
Control (galia)	372.29	40.37	788.72	13.66	10.83	1.26
LSD at 0.05%						
Inbred lines	5.85	2.98	57.61	0.42	0.16	0.04
Hybrids	1.84	1.04	51.74	0.77	0.15	0.05

Table 2. Mean performance of 15 F_1's and their six parents for flesh thickness, fruit cavity, TSS and total yield of melon-inbred lines (combined of 2017/2018 and 2018/2019).

Genotype	Flesh thickness (cm)	Fruit cavity (cm)	TSS	Total yield (ton/fed)
(P_1)	3.03	5.23	8.30	10.34
(P_2)	3.53	6.03	6.57	23.10
(P_3)	3.03	4.07	8.24	13.49
(P_4)	4.13	4.10	10.80	10.63
(P_5)	3.10	5.47	6.54	17.13
(P_6)	3.23	4.03	6.55	13.19
$P_1 \times P_2$	4.30	5.13	7.38	14.81
$P_1 \times P_3$	4.47	5.17	9.26	15.71
$P_1 \times P_4$	3.17	4.50	10.21	7.83
$P_1 \times P_5$	3.87	5.90	7.55	12.92
$P_1 \times P_6$	3.90	4.90	9.32	12.87
$P_2 \times P_3$	4.47	7.17	8.42	18.92
$P_2 \times P_4$	4.17	7.14	8.61	17.60
$P_2 \times P_5$	3.41	3.27	9.60	8.70
$P_2 \times P_6$	5.27	5.64	7.36	16.32
$P_3 \times P_4$	3.87	5.87	11.90	13.72
$P_3 \times P_5$	5.07	4.50	8.62	14.00
$P_3 \times P_6$	3.18	3.24	6.28	7.12
$P_4 \times P_5$	3.67	4.97	9.84	8.85
$P_4 \times P_6$	3.28	5.19	8.66	8.87
$P_5 \times P_6$	4.27	6.10	9.66	15.43
Control (galia)	3.12	5.95	9.65	12.68
LSD at 0.05%				
Inbred lines	0.21	0.16	1.23	0.80
Hybrids	0.11	0.12	0.25	0.45

Heterosis over mid-parent (MP-heterosis)

Mid parent heterosis for all studied traits are presented in Table (3). The results show clearly that all crosses showed highly significant heterosis except cross ($P_5 \times P_6$) which showed non-significant negative heterosis for plant length and number of leaves /plant. Mid parent heterosis for average fruit weight as positive highly significant but the crosses ($P_2 \times P_5$ and $P_3 \times P_6$) showed negative highly significant heterosis. On the other hand, the hybrid ($P_4 \times P_5$) was non-significant negative heterosis for this trait. Heterosis values over mid-parent for flesh thickness recorded positive significant heterosis among most of the crosses but crosses ($P_1 \times P_4$ and $P_4 \times P_6$) were negative significant but the crosses ($P_2 \times P_5$, $P_4 \times P_5$ and $P_3 \times P_6$) were not significant. The best crosses for fruit cavity trait were ($P_2 \times P_5$, -43.20) and ($P_3 \times P_6$, -20.04) while the crosses ($P_3 \times P_5$), ($P_1 \times P_4$), (P1×P_6) and ($P_4 \times P_5$) had non-significant heterosis.

Table 3. Heterosis values (%) over mid-parents (MP) of 15 F_1 hybrids for some melon characters.

Crosses	Plant length	Number of leaves	Average fruit weight	Flesh thickness	Fruit cavity	Fruit shape index(L/D)	TSS	Total yield
$P_1 \times P_2$	73.08**	48.33**	35.01**	31.02**	-8.84*	-5.42 NS	-0.65 NS	-11.40**
$P_1 \times P_3$	23.64**	19.70**	81.92**	47.32**	11.07*	16.48**	11.97**	31.90**
$P_1 \times P_4$	-5.86*	5.98*	15.99*	-11.59*	-3.55 NS	24.56**	7.00*	-25.26**
$P_1 \times P_5$	50.46**	27.94**	42.78**	26.13**	10.26*	-7.74*	1.77 NS	-5.89 NS
$P_1 \times P_6$	17.48**	21.21**	72.40**	24.52**	5.75 NS	-16.09**	25.62**	9.43*
$P_2 \times P_3$	51.60**	24.20**	100.00**	36.17**	41.83**	28.57**	13.71**	3.42 NS
$P_2 \times P_4$	8.98*	23.31**	85.40**	8.78*	40.96**	4.16 NS	-0.76 NS	4.40 NS
$P_2 \times P_5$	31.12**	22.32**	-36.74**	3.10 NS	-43.20**	6.45*	46.54**	-56.75**
$P_2 \times P_6$	28.42**	19.89**	72.72**	55.81**	12.06*	-9.47*	12.20**	-10.01*
$P_3 \times P_4$	-15.09*	-12.25*	60.03**	8.00*	43.66**	6.10*	25.06**	13.78**
$P_3 \times P_5$	-30.61**	-13.17*	30.66**	65.43**	-5.68 NS	-12.24**	16.65**	-8.54*
$P_3 \times P_6$	-35.72**	-33.26**	-25.78**	1.16 NS	-20.04**	14.66**	-15.00**	-46.59**
$P_4 \times P_5$	-13.19**	-9.96*	-4.01 NS	1.49 NS	3.87 NS	-12.385**	13.50**	-36.24**
$P_4 \times P_6$	-12.68*	-11.31*	19.46*	-10.78*	27.63**	-12.55**	-0.11 NS	-25.47**
$P_5 \times P_6$	-4.53 NS	-0.05 NS	54.52**	34.90**	28.52**	-19.51**	47.62**	1.80 NS

NS,*,**: insignificant and significant at 0.05 and 0.01 % probability levels.

The fruit shape index heterosis values over mid-parent showed highly negative significant values for seven crosses while the crosses ($P_1 \times P_2$ and $P_2 \times P_4$) were not significant. Concerning total soluble solids (TSS), desirable significantly positive MP heterosis were observed for most of crosses which revealing hybrid vigor in this trait where the cross ($P_5 \times P_6$) was the best (TSS). These results were in agreement with Sari *et al.* (2012). The heterotic expression for total yield percentage was the most important trait in this investigation. However, the values of MP heterosis were significant and highly significant for this trait ranging from -56.75 to 31.90 %, where the highest crosses for total yield / fed were ($P_1 \times P_3$, $P_3 \times P_4$ and $P_1 \times P_6$) (31.90, 13.78 and 9.43 %, respectively). These results were in agreement with Hussein and selim (2014) and Hatem *et al.* (2014) on cantaloupe.

Generally, the established MP heterosis values (Table 3) show that were significantly positive in most F_1 crosses for the studied traits, indicating dominance of the traits towards the highest parent. On the other hand, some crosses showed significant negative values indicating dominance towards the lowest parent in character. Insignificant values were shown by few crosses, suggesting no dominance for the character.

Heterosis values over better parent

HBP for all studied traits were presented in Table (4). Heterosis for Plant length ranged from -0.24 to 60.05. Most of hybrids were negative significant but hybrid $P_1 \times P_2$ was positive with highly significant for Plant length as well as for number of leaves. Heterosis for average fruit weight was positive with highly significant but the crosses ($P_2 \times P_5$, $P_3 \times P_6$ and $P_4 \times P_5$) showed negative highly significant heterosis. On the other hand, the hybrid ($P_1 \times P_2$) showed significant negative heterosis for this trait. Desirable significantly positive BP heterosis was observed in eight crosses, while the crosses ($P_1 \times$ P_4, $P_4 \times P_5$ and $P_4 \times P_6$) exhibited significantly negative BP heterosis for flesh thickness. Concerning fruit cavity, desirable significantly positive BP heterosis were observed for most of crosses which revealing hybrid vigor in this trait where the cross ($P_2 \times P_3$) was the best for this trait. Fruit shape index ranged from -15.42 % to 29.29 %. Six out 15 hybrids exhibited desirable significant heterosis over BP. The heterotic expression for TSS %, the most important trait in this investigation. So, six from 15 hybrids exhibited highly significant values of BP heterosis. Heterosis values for total yield recorded negative significant heterosis among most of the crosses but crosses ($P_1 \times P_3$) were positive significant but the crosses ($P_1 \times P_6$ and $P_3 \times P_4$) were not significant. These results were in agreement with Hussein and selim (2014) and Hatem *et al.* (2014) on cantaloupe. The estimated better parent heterosis (MPH) for the studied traits in each F_1 Cross showed that hybrid vigor was observed for plant length and number of leaves. In three crosses i. e. $P_1 \times P_2$, $P_1 \times P_5$, and $P_2 \times P_3$; for average fruit weight in most crosses; for cavity in most crosses; for shape index in seven crosses; for TSS content in six crosses and for total yield in the F_1 cross $P_1 \times P_3$ only. These crosses significantly exceed the better parent in the character. the remaining showed significant negative heterosis or not significant values indicating dominance towards the lowest parent or no- dominant for the trait. The estimated values of potence ratio (Table 5) showed that most F_1 crosses had positive nature for average fruit weigh, flesh thickness, fruit cavity and TSS. Suggesting dominance towards the highest parent in the character (partial, complete and over dominance). On the contrary, the estimated values of potence ratios in most F_1 hybrids were negative for plant length, number of leaves and total yield/fed. Indicated dominance towards the recessive parent. These results are in agreement with Hussein and selim (2014) and Hatem *et al*. (2014) on cantaloupe.

Analysis of variance and gene action of the studied traits

The results of Table (6) showed significant and highly significant mean squares for both GCA and SCA in all studied traits except fruit shape index revealing the importance of additive and non-additive gene effects in the inheritance of these traits. However, a greater ratio of GCA/SCA than unity were detected for number of leaves, fruit diameter, fruit weight, TSS content and total yield revealing that the inheritance of these traits was mainly controlled by additive gene effects. While the other characters were less than unity which mean that non-additive gene effects mainly control the inheritance of these traits.

Table 4. Better-parents heterosis value (BPH %) of 15 F_1 hybrids for some melon characters.

Crosses	Plant length	Number of leaves	Fruit weight	Flesh thickness	Fruit cavity	Fruit shape index(L/D)	TSS	Total yield
$P_1 \times P_2$	60.05**	46.85**	-4.10 NS	21.81**	-1.91 NS	-5.67*	-11.08**	-35.89**
$P_1 \times P_3$	-1.94 NS	2.06 NS	47.75**	47.52**	27.03**	18.28**	11.57**	16.46**
$P_1 \times P_4$	-31.82**	-17.95**	14.82**	-23.24**	9.76*	29.29**	-5.46*	-26.34**
$P_1 \times P_5$	21.48**	7.78*	11.35**	24.84**	12.81*	4.59*	-9.04*	-24.58**
$P_1 \times P_6$	-7.20*	2.02 NS	54.81**	20.74**	21.59**	-9.79*	12.29**	-2.43 NS
$P_2 \times P_3$	13.47**	5.00*	67.38**	26.63**	76.17**	3.92 NS	2.18 NS	-18.10**
$P_2 \times P_4$	-24.79**	-5.21*	30.91**	0.97 NS	74.15**	7.79*	-20.28**	-23.81**
$P_2 \times P_5$	-0.24 NS	2.20 NS	-44.60**	-3.40 NS	-40.22**	20.50**	46.12**	-62.34**
$P_2 \times P_6$	-4.22 NS	0.12 NS	32.01**	49.29**	39.95**	-2.35 NS	12.02**	-29.35**
$P_3 \times P_4$	-25.10**	-22.01**	28.96**	-6.30*	44.23**	9.41**	10.19**	1.70 NS
$P_3 \times P_5$	-31.72**	-14.43**	23.90**	63.55**	10.57**	-2.04 NS	4.61 NS	-18.27**
$P_3 \times P_6$	-36.06**	-34.28**	-33.79**	-1.55 NS	-19.60**	21.09**	-23.79**	-47.22**
$P_4 \times P_5$	-24.99**	-18.93**	-25.69**	-11.14**	21.22**	-6.93*	-8.89*	-48.34**
$P_4 \times P_6$	-22.60**	-20.08**	6.31*	-20.58**	28.78**	-10.98**	-19.81**	-32.75**
$P_5 \times P_6$	-7.30*	-0.14 NS	31.60**	32.20**	51.36**	-15.42**	47.48**	-9.92*

NS,*,**: in significant and significant at 0.05and 0.01 % probability levels.

Table 5. Potence ratio (P) for 15 F_1's for studied traits melon characters.

Crosses	Plant length	Number of leaves	Fruit weight	Flesh thickness	Fruit cavity	TSS	Total yield/fed
$P_1 \times P_2$	9.01	48.19	0.85	4.10	-1.24	-0.05	-0.29
$P_1 \times P_3$	0.90	1.13	3.54	89.85	0.88	33.00	2.41
$P_1 \times P_4$	-0.15	0.20	15.59	-0.75	-0.29	0.53	-17.95
$P_1 \times P_5$	2.11	1.49	1.51	26.04	4.67	0.14	-0.23
$P_1 \times P_6$	0.65	1.12	6.37	7.81	0.44	2.17	0.77
$P_2 \times P_3$	-1.53	-1.32	5.13	4.74	2.15	1.21	0.13
$P_2 \times P_4$	-0.19	-0.77	2.05	1.12	2.14	-0.03	0.11
$P_2 \times P_5$	-0.98	-1.13	-2.59	0.47	-8.74	23.23	-3.82
$P_2 \times P_6$	-0.83	-1.00	2.35	12.57	0.60	80.00	-0.36
$P_3 \times P_4$	-1.13	-0.97	2.49	0.52	42.60	1.86	1.16
$P_3 \times P_5$	-0.59	-0.31	0.65	2.03	-0.58	0.76	-0.30
$P_3 \times P_6$	-63.88	-21.30	-2.13	0.36	-40.58	-1.31	-41.42
$P_4 \times P_5$	0.84	0.90	-0.13	0.10	0.27	0.55	-1.54
$P_4 \times P_6$	0.99	1.03	1.57	-0.88	34.53	-0.01	-2.37
$P_5 \times P_6$	-1.53	-0.66	3.12	16.35	1.88	23.00	0.14

Table 6. Mean squares of variance for combining ability (GCA and SCA) and GCA/SCA ratio for some economic traits in half-diallel cross in melon.

Traits	Mean squares			GCA/SC
	GCA	SCA	Error	
Plant length	11214.8**	11531.2**	4.00	0.97
Number of leaves	99.22**	72.69**	0.97	1.36
Fruit cavity	1.40*	3.24**	0.00	0.43
Flesh thickness	0.38*	1.60*	0.00	0.23
Fruit length	10.70**	15.86**	0.15	0.67
Fruit diameter	14.61**	11.60**	0.00	1.25
Fruit shape index	0.001	0.007	0.00	0.14
Fruit weight	1077590**	563788**	740.67	1.91
TSS	14.02**	4.42*	0.13	3.17
Total yield	5651316**	2071227**	649133	2.72

GCA = General combining ability, SCA = Specific combining ability. *, **: significant, highly significant at 0.05 and 0.01 % probability levels.

The estimates of GCA effects of individual parental genotypes in the F_1's generation were significant and highly significant for the most studied traits (Table 7). It is well known that GCA is a function of additive gene effect and the additive portions of epistatic variance, while SCA is the function due to non-additive gene effects and the remainder of epistatic variance (Matzinger *et al.* 1959). The P_2 was good combiner for all studied traits and P_1 was good combiner for all studied traits except total soluble solid (TSS) and total yield. It is clear that the two parents (P_1 and P_2) could be considered as the best combiner for breeding to most traits. Meanwhile, P_3 was good general combiner for number of leaves, fruit weight, fruit diameter, fruit length and total yield. P_4, P_5 and P_6) were good general combiners for most studied traits. These results are agree with those obtained by Damarany *et al.* (1999), Hussein and selim (2014) and Hatem *et al*. (2014) on melon.

The potentiality of crossing between specific parents was detected by estimating specific combining ability effects (SCA) of each F_1 cross for all studied traits (Table 8). The crosses (P_2×P_4), (P_2×P_5) and (P_3×P_6) achieved highly (SCA) effects for all traits in this study which means comparing the general combining ability effects (GCA) of the parents to their corresponding crosses (SCA) indicating that the GCA effects of the parents were reflected in the (SCA) effects of the crosses for the most studied traits. Several researchers reported the importance of both additive and non-additive effects in the genetic control of yield components in melon (Vashisht *et al.* 2010, Barros *et al*. 2011 and Hussein and selim 2014).

Table 7. Estimates of general combining ability effects of six melon inbred lines for some characters.

Genotypes	Plant length	Number of leaves	Fruit weight	Fruit shape index	Fruit diameter	Fruit length	Flesh thickness	TSS	Fruit cavity	Total yield
(P_1)	-17.60**	-1.35**	-134.27**	-0.03**	-0.24**	-0.68**	-0.12**	0.05 ^{NS}	0.40**	-290.16 ^{NS}
(P_2)	-22.03**	-0.93**	382.01**	-0.05**	1.50**	1.09**	0.23**	-0.67**	0.10**	890.58**
(P_3)	-3.79*	-1.67**	100.63**	0.01^{NS}	0.11**	0.26**	0.03 ^{NS}	0.13 ^{NS}	0.05 ^{NS}	92.82 ^{NS}
(P_4)	38.86**	3.78**	-195.81**	0.01 ^{NS}	-0.26**	-0.16 ^{NS}	-0.04 ^{NS}	1.38**	-0.14**	-489.16 ^{NS}
(P_5)	4.00*	0.71**	-61.73**	0.06**	-0.52**	0.16 ^{NS}	-0.04 ^{NS}	-0.20 ^{NS}	-0.16**	23.08 ^{NS}
(P_6)	0.55 ^{NS}	-0.53 ^{NS}	-90.81**	0.01 ^{NS}	-0.58**	-0.65**	-0.05 ^{NS}	-0.69**	-0.25**	-227.15 ^{NS}
S.E. ($\hat{g}i$- $\hat{g}j$)	0.57	0.28	7.85	0.01	0.02	0.11	0.02	0.10	0.02	232.58

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

Table 8. Estimates of specific combining ability (SCA) effects of 15 F_1hybrids for some melon characters.

Crosses	Plant length	Number of leaves	Fruit weight	Fruit shape index	Fruit diameter	Fruit length	Flesh thickness	Fruit cavity	TSS	Total yield
$P_1 \times P_2$	42.12**	3.47**	-27.19*	-0.07 NS	0.73*	-0.19 NS	0.36**	-0.40**	-0.55*	-339.74 NS
$P_1 \times P_3$	37.81**	3.72**	301.84**	0.14 NS	1.33**	3.47**	0.72**	0.17**	0.50*	713.344**
$P_1 \times P_4$	-33.77**	-0.57 NS	-134.36**	0.26 NS	-1.31**	1.13**	-0.48**	-0.47**	0.31 NS	-570.00**
$P_1 \times P_5$	87.74**	4.32**	226.55**	-0.08*	1.67**	1.07**	0.20*	0.70**	-0.89**	159.08 NS
$P_1 \times P_6$	19.70**	3.57**	233.63**	-0.19**	1.39**	-0.60**	0.25*	0.02 NS	1.33**	323.98 NS
$P_2 \times P_3$	92.47**	4.29**	741.22**	-0.01	2.38**	2.75**	0.36*	1.87**	0.37*	401.92 NS
$P_2 \times P_4$	0.65 NS	4.99**	527.01**	0.03*	1.03**	1.78**	0.15*	-0.10**	-0.64*	567.910**
$P_2 \times P_5$	24.67**	1.89**	-695.40**	0.11*	-2.70**	-1.90**	-0.62*	-2.22**	1.90**	-2047.00**
$P_2 \times P_6$	33.96**	2.48**	441.34**	-0.08*	2.04**	1.37**	1.26**	0.46**	0.16 NS	20.56 NS
$P_3 \times P_4$	-18.91**	-2.92**	183.05**	0.02	2.06**	2.91**	0.05 NS	1.14**	1.84**	442.26 NS
$P_3 \times P_5$	-82.56**	-3.02**	114.63**	-0.16**	2.25**	0.69**	1.24**	-0.44**	0.10 NS	12.09 NS
$P_3 \times P_6$	-89.27**	-8.60**	-535.94**	0.16**	-2.45**	-1.42**	-0.64**	-1.39**	-1.70**	-1353.67**
$P_4 \times P_5$	-26.21**	-2.98**	-111.90**	-0.15**	-0.06*	-1.84**	-0.07*	0.04 NS	0.08 NS	-637.25**
$P_4 \times P_6$	-12.59**	-2.40**	-78.15*	-0.15**	-0.13*	-1.75**	-0.45**	0.59**	-0.58**	-374.88 NS
$P_5 \times P_6$	-2.24 NS	0.83*	398.09**	0.17**	-0.61**	1.21**	0.53**	1.27**	1.99**	626.73**
SE(Sij-Sik)	1.52	0.75	20.78	0.028	0.06	0.30	0.06	0.06	0.28	615.35
SE (Sij-Skl)	1.41	0.69	19.24	0.026	0.05	0.27	0.05	0.05	0.26	569.70

NS,*, **: insignificant and significant at 0.05 and 0.01 % probability levels respective.

Conclusion

It could be concluded that, parent (P_2) could be considered as the best combiner for breeding to most traits. The crosses ($P_2 \times P_4$), ($P_2 \times P_5$) and ($P_3 \times P_6$) achieved highly (SCA) effects for all studied traits. Comparing general combining ability effects (GCA) to their corresponding (SCA) effects indicated that the GCA effects of the parents were reflected in the SCA effects of the crosses for the most studied traits. All degree of dominance i.e. over dominance, partial dominance, complete dominance and no- dominance were defected in this study concerning the evaluated characters.

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قوة الهجين والقدرة علي التآلف في الشمام

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الملخص العربى

أجريت هذه الدراسة في مزرعة بحوث الخضر في قها وأقسام بحوث الخضر بالدقي في الفترة من ٢٠١٧ الي٢٠١٩ بهدف الحصول على المزيد من الايضاحات والمعلومات عن وراثة بعض الصفات في الشمام للمساعدة في اعداد برامج التربية وتحسين الشمام . أستخدم في هذه الدراسة ستة سلالات من الشمام من قسم تربية الخضر والنباتات الطبية بمصر حيث أجرى التهجين بينهم للحصول على بذور الجيل الأول اللازمة للدراسة ثم زرعت الأباء والهجن الناتجة في تجربة مصممة بطريقة القطاعات الكاملة العشوائية في ثلاث مكررات وأخذت القياسات اللازمة على : طول النبات، عدد الاوراق ومتوسط وزن الثمرة وقطر الثمرة وسمك اللحم وقطر الفجوة ودليل شكل الثمرة والمواد الصلبة الذائبة الكلية والمحصول الكلى.

وبعد تحليل البيانات المتحصل عليها بالطرق المناسبه كانت أهم النتائج :

1- ظهرت أنواع مختلفة من السيادة الجينيه ذات التأثير علي الصفات حيث كانت السياده الجزئيه هي المؤثره في طول النبات والمحصول الكلي بينما كانت السيادة فائقه في الصفات الأخري.

2- من دراسة قوة الهجين ف الصفات المختلف تبين أنها اختلفت بين الهجن والصفات تحت الدراسة.

3- كان التباين لكل من القدرة العامة والخاصة على الائتلاف معنويا لكل الصفات المدروسة مما يؤكد على أهمية كل من الفعل المضيف وغير المضيف للجينات في وراثة هذه الصفات.

4- أظهرت النتائج وجود ثبات وراثي لجميع السلالات في الصفات المدروسة حيث لم تظهر فروق معنوية بين موسمي الزراعة ولكن كان الاختلاف بين السلالات وبعضها البعض.

5- اختلفت الآباء في تأثيرات القدرة العامة على الائتلاف وعموماً فإن الاب (P_2) كانا أفضل الأباء حيث اعطى تأثيرات عامة على الائتلاف لجميع الصفات المدروسة.

6- أظهرت حسابات تأثيرات القدرة الخاصة على الائتلاف للهجن المختلفة أن أفضل الاتحادات للصفات المدروسة كان في الهجن الآتية: ($P_2\times P_4$).(‏ و($P_2\times P_5$) و($P_3\times P_6$) حيث أظهرت تأثيرات معنوية في جميع الصفات المدروسة ويلاحظ أن هذه الهجن يدخل في تكوينها أحد الآباء الذي أعطى قيم معنوية في القدرة العامة على الائتلاف ولهذا يمكن الاستفادة بها في برامج التربية لتحسين الشمام. كما يمكن تتبع بعض الهجن وتقييمها لتحل محل الهجن المستوردة.

أسماء السادة المحكمين

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