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Genetic Analysis to Identify Suitable Parents for Development and Relase of New Cantaloupe (*Cucumis melo*, var Cantaloupnsis)

Cross Mark

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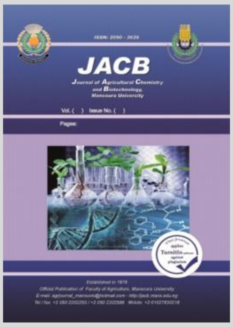

ABSTRACT

This research was achieved during the summer seasons 2018 and 2019 at El Baramoon Horticulture Research Farm, Dakahlia Governorate. Four parental lines of cantaloupe (*Cucumis melo*, L) were evaluated in this investigation to genetic analysis to identify suitable parents for development and relase of new cantaloupe. The results found that some F_1 hybrids exhibited highly significant for mid parents and better parents heterosis for traits. High estimated heterosis was reflected by four F_1 and F_{1r} hybrid, i.e., P_1 X P_4, P_1 X P_2, P_3 X P_4 and P_2 X P_1 for most traits. GCA, SCA and reciprocal effects were significant for studied traits. Parent P_4 was the better combiner for all traits exclude days to anthesis of first female flower. However, parent P_1 was the better combiner for days to anthesis of first female flower. The values of additive genetic variance o^2A were higher than those of non - additive genetic variance (o^2D) for all studied traits exclude days to anthesis of first female flower, pointing to the additive gene effect played the important role in the inheritance of studied traits. In addition, the values of broad sense heritability were higher than narrow sense heritability for studied traits. Genotypic and phenotypic correlations were positive and significant among total yield and some related traits such as fruit flesh thickness, average fruit weight and number of fruits per plot exhibited that each trait could be used indirectly to selection of yield. Hence, it could be suggested that these hybrids may be desirable parents for development new promising hybrids of cantaloupe.

***Keywords*:** Cantaloupe, Cucumis melo, heterosis, combining ability, heritability, correlation, yield.

INTRODUCTION

Cantaloupe (*Cucumis melo*, L.) a member of genus *Cucumis* and *Cucurbitaceae* family is grown at temperate, tropical and sub-tropical areas from the world. It is a rich source of dietary fiber, vitamins and minerals such as calcium, phosphorus and iron (Pitrat 2008). High yield and quality of fruits are major aims of cantaloupe breeding programme (Tanaka *et al.*, 2006; Elbekkay *et al.*, 2008). In cantaloupe, economical traits including early yield, total soluble solids, flesh thickness, average fruit weight, number of fruits and total yield are quantitative characters influenced by the environment, genotypes and genotypes x environment interaction. Productivity of cantaloupe should be increased by improving the genetic architecture over hybridization among variant lines or over selection of large yielding varieties. Knowledge of type and amount of genetic influences will improve an efficient use genetic variability. Beside, some of those major cultivars are not well acclimatized to local environmental conditions and consumer (Abdelmohsin and Pitrat, 2008 ; Glala *et al.*, 2010). Therefore, improving local varieties, large yielding genotypes and quality of fruits may be a useful practical solution for these problems. In addition, breeding desirable local cultivars might decrease the cultivation costs and illustrated that developing improved cantaloupe F_1 hybrids, acclimatized to local conditions, perhaps achieved successfully from diallel cross programs (Glala 2007). Some of the models such as Griffing methods of complete diallel mating design (Griffing 1956), have been excessively used by vegetable breeders to supply reliable data for genetic improving of various crops (Feyzian *et al.*, 2009). Amanullah *et al.* (2011) reported that the values of hybrid vigour can be used as one major consideration for selecting genotypes and new F_1 hybrids. The data of heterosis magnitude on sure selected genotypes can be greatly beneficial for expansion hybrid new cultivar. Heterosis for days to anthesis of first female flower, shape index of fruit, average fruit weight and yield and its correlated components has been observed (Ibrahim 2012; Hatem *et al.*, 2014). Some information can be obtained from diallel analysis i.e. general combining ability (GCA) and specific combining ability(SCA) from crossing parents and measurement of plant genotype ability in crossing to produce superior plants. Cruz and Vencovsky (1989) reported that the vegetable breeder must be choosing a cross with large specific combining ability and with at youngest one parent with a large general combining ability estimate. Baihaki (2000) reported that the analysis of diallel mating design crossing is demanded to expecting the additive and non - additive effects from a certain genotypes that can be utilized further to predict the genetic variation and heritability. Mohammadi *et al.* (2014) on melon, found that the additive (o^2A) and non – additive (o^2D) genetic variances governing TSS trait. On the contrary, Monforte *et al.* (2004) reported that non-additive (dominance) gene actions controlling TSS trait. Type of gene action and heritability are qualifications for starting a breeding programme of cantaloupe. Many authors noticed that additive genetic variances (o^2A) play important part in conditioning fruit yield. Large heritability connected with large genetic advance in traits i.e., days to anthesis of first female flower, fruit flesh thickness and yield (Veena *et al.*, 2012). In slicing

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melon, the magnitude of heritability in broad sense percentage (*$h^2_{b.s}$ %)* for shape index of fruits was 88% (Pornsuriya *et al*., 2014). Abou Kamer *et al.* (2015) showed that high heritability in broad sense for TSS and fruit flesh thickness and showed the magnitudes of heritability in broad sense percentage (*$h^2_{b.s}$ %)* for F_1´s hybrids ranged from 32.79 to 81.39%. Also, indicated that traits were mostly controlled by additive genetic effect. Abo Sedera *et al.* (2016) found that heritability in broad sense percentage (*$h^2_{b.s}$ %)* was very high and ranged from 95 to 99% for plant length and total yield, consequently, while the heritability in narrow sense percentage (*$h^2_{n.s}$ %)* ranged from 22 to 61 % for number of fruits and total yield, respectively . Ratnakar *et al.* (2018) recorded that the characteristics that have a heritability of over 60 % and governed by additive effects can play a major role in vegetables breeding programs. Selection of desirable breeding methods for better exploitation of the potential of various traits in a plant depends on the type of gene effect and heritability. Correlation estimates between traits are beneficial in developing desirable selection criteria for selecting demand plant types or developing large yielding varieties. Whenever there is a positive correlation of great yield traits, component breeding would be very influent but when the traits are negatively correlated, it would be complicated to exercise simultaneous selection for them in development a cultivar. El-Tahawey *et al.* (2015) found that significant and positive correlation of plant length, number of fruits and average fruit weight with total yield. Deepa *et al.* (2018) showed that the best positive correlation between average fruit weight with flesh thickness traits. Murtadh and Sanni (2018) revealed that the largest significant and positive correlation between average fruit weight with total yield followed by plant length, number of fruits and fruit flesh thickness. Ene *et al.* (2019) noticed that total yield was correlated with days to anthesis of first female flower, plant length, number of fruits per plant and average fruit weight. On the contrary, negative correlations were determined among some traits. Zalapa *et al.* (2008) showed negative association among total yield and days to anthesis of first female flower. Therefore, this research was conducted to investigate the prospect of breeding new promising local Egyptian F_1 hybrids based on Egyptian genetic resources and measurements their competitive potentiality against commercially dominant hybrids.

MATERIALS AND METHODS

The genotypes used in this study involved four cantaloupe lines belong to *Cucumis melo*, L. The lines obtained from Vegetable Research Department, Hort. Res. Inst., Agri. Res. Center. During the summer season of 2018, seeds were cultivated at El-Baramoon Horticulture Research Farm, Dakahlia Governorate, Egypt. At the flowering time all possible hybridization including reciprocals were made between the four parental lines agreements to a complete diallel mating design. Also, the four parental lines were self pollinated to get sufficient seeds from either line. In the summer season of 2019, all genotypes (six F_1 hybrid, six F_{1r} hybrid and four parents) were estimated in the open field. All genotypes were grown under open field condition in a randomized complete block design, with three replications. The experimental unit was 5 meters in length and 1.50 meter width, the plot area was 7.5 m^2 and the plants were spaced 0.50 m apart. All agricultural practices i.e., irrigation, fertilization, pest, disease control and weed removal were applied in compliance with those traditionally adopted in Egypt.

Data were recorded measurements on the following traits, plant length; number of leaves / plant; days to anthesis of first female flower; fruit shape index; fruit flesh thickness; total soluble solids; average fruit weight (kg); number of fruits / plot and total yield / plot (kg).

Tests of significance between the differences of genotype means were made using the least significant difference method LSD at both 5% and 1% levels of probabilities.

Statistical analysis:

The mean performances of all genotypes (four parents, six F_1 hybrids and sixF_{1r} hybrids) for studied traits were described by Mather and Jinks, (1971).

Heterosis versus mid – parents and heterosis versus better – parents were estimated.

The estimates of analysis of variance for general, specific combining ability and reciprocal effects and its effect were computed by Method 1 of Griffing (1956).

Significance test for general, specific combining ability and reciprocal effect were described by Cochran and Cox (1950). General (g_i), specific combining ability (s_{ij}) and reciprocal effect (r_{ij}) calculated as:

$$\textbf{GCA effect} = 1/2n\,(Yi. + Y.i) - 1/n^2\,Y..$$

$$\textbf{SCA effect} = 1/2\,(Yij + Yji) - 1/2n\,(Yi. + Y.i + Yj. + Yij) + 1/n^2\,Y..$$

$$\textbf{Reciprocal effect} = 1/2\,(Yij - Yji)$$

The estimates of components are obtained as:

$$\sigma^2 g = 1/2n\,[Mg - Me + n\,(n-1)\,Ms / n^2 - n + 1],$$

$$\sigma^2 s = n^2 / 2\,(n^2 - n + 1)\ X\ (Ms - Me) \text{ and } \sigma^2 r = 1/2\,(Mr - Me).$$

Predicted values of $\sigma^2 g$ and $\sigma^2 s$ were computed to estimate $\sigma^2 A$; $\sigma^2 D$; $\sigma^2 e$; $h^2_{b.s}$ and $h^2_{n.s}$.

$\sigma^2 A$ and $\sigma^2 D$ were recorded accordance to Matzinger and Kempthorne, (1956).

Determines of heritability in broad sense percentage ($h^2_{b.s}$ %) and heritability in narrow sense percentage ($h^2_{n.s}$ %) were recorded accordance to the equations:

$$h^2_{b.s}\% = \frac{\sigma^2 A + \sigma^2 D}{\sigma^2 A + \sigma^2 D + \sigma^2 E} \text{ X } 100$$

$$h^2_{n.s}\% = \frac{\sigma^2 A}{\sigma^2 A + \sigma^2 D + \sigma^2 E} \text{ X } 100.$$

Genotypic and phenotypic correlations for pair of traits could be recorded accordance to Singh and Chaudhary, (1985).

RESULTS AND DISCUSSION

Analysis of variances:-

Genotypic variations for four parental lines, their crosses for studied traits are listed in (Table 1). Mean squares of all genotypes were found to be largely significant for all studied traits. The obtained results exhibited that purveys evidence for entity of considerable value of genetic diversity between all genotypes. These results were predicted where the genotypes in this study included variable genetic lines, their F_1 and F_{1r} hybrids**.**

Table 1. Analysis of variance and mean squares for various studied traits of cantaloupe.

Traits Parameters	d.f	Plant length (cm)	Number of leaves / plant	Days to anthesis of first female flower (day)	Fruit shape index (cm)	Fruit flesh thickness (cm)	Total soluble solids (%)	Average fruit weight (kg)	Number of fruits / plot	Total yield / plot (kg)
Replication	2	5.65^{ns}	2.85^{ns}	1.13^{ns}	0.0002^{ns}	0.007^{ns}	0.043^{ns}	0.004^{*}	0.360^{ns}	0.552^{ns}
genotypes	15	134.19^{**}	904.03^{**}	35.60^{**}	0.048^{**}	0.374^{**}	10.91^{**}	0.059^{**}	69.73^{**}	112.42^{**}
Error	28	5.69	4.10	0.62	0.007	0.010	0.046	0.001	0.619	0.364

***, ** = significant at 0.05 and 0.01 levels of probabilities, consequently.**

Means of all genotypes:

In this study, the performances of all genotypes (four parental lines, F_1 and F_{1r} hybrids) for studied traits are listed in (Table 2). Mean values of the four parental lines exhibited that the parent (P_4) was the highest parental line for studied traits exclude for days to anthesis of first female flower. Also, parent (P_2) was the lowest parental line for various studied traits exclude days to anthesis of first female flower. On the other side, parent (P_3) was the poorest parent for aforementioned trait. Therefore, obtained results elucidate the variations among the mean performances of the largest and poorest parental lines were always significant indicating the existence of variations among the four used parents for studied traits. In addition, data in Table 2 revealed that the highest F_1hybrid for total yield / plot was F_1 hybrid P_1 x P_4 (30.40 kg) followed by the F_1hybrid P_3 x P_4 (25.16 kg). While, the largest F_{1r} hybrid was P_4 x P_1 (24.25 kg) followed by P_2 x P_1 (18.22 kg). In contrast, F_1hybrid P_2 x P_3 was lower most F_1 hybrid for the same trait (11.40 kg). Whereas, the cross P_3 x P_2 was the poorest mean aforementioned trait. The obtained results exhibited that the cross P_1 x P_4 was the largest means magnitude for number of leaves per plant, days to anthesis of first female flower (day), fruit shape index(cm), flesh thickness (cm), total soluble solids (%), average fruit weight (kg) and total yield per plot (kg) in comparison with other F_1 hybrids in this study. Meanwhile, the hybrid P_3 x P_4 was the largest means magnitude for plant length (cm) and number of fruits / plot (kg). While, the hybrid P_2 x P_3 exhibited the lowest means magnitude for plant length (cm), number of leaves / plant, fruit shape index (cm), number of fruits / plot (kg) and total yield / plot (kg), respectively. In addition, F_1hybrid P_1 x P_3 revealed the lowest means magnitude for days to anthesis of first female flower (day), fruit flesh thickness (cm), total soluble solids (%) and average fruit weight (kg) traits, consequently. For six F_{1r} hybrids, the obtained results revealed that the mean values exhibited that there was no F_{1r}hybrid superiority over other crosses for all studied traits. The good combination for all studied traits excluding plant length (cm) and number of leaves per plant were P_4 x P_1. While, the cross P_4 x P_3 was the largest mean magnitudes for plant length (cm) and number of leaves per plant. Therefore, these promising crosses between F_1 hybrids and F_{1r} hybrids combination could be utilized for support breeding studies to improve the economical traits in cantaloupe.

Table2. Means of all genotypes (four parental lines, sixF_1 hybrids and sixF_{1r} hybrids) for studied traits in cantaloupe.

Traits Genotypes	Plant length (cm)	Number of leaves / plant	Days to anthesis of first female flower (day)	Fruit shape index (cm)	Fruit flesh thickness (cm)	Total soluble solids (%)	Average fruit weight (kg)	Number of fruits / plot	Total yield / plot (kg)
					Parents				
P_1	127.27	98.53	43.27	0.99	2.63	8.03	0.502	26.77	13.43
P_2	95.76	61.57	41.00	0.75	2.53	7.20	0.400	19.17	7.67
P_3	113.17	76.23	48.10	0.85	2.90	9.77	0.460	23.97	11.03
P_4	151.53	103.13	47.60	1.04	3.23	11.03	0.653	30.67	20.04
				F_1 hybrids					
P_1 X P_2	136.63	103.57	39.73	0.85	2.97	11.03	0.612	28.83	17.65
P_1 X P_3	142.43	94.90	41.20	0.92	2.87	8.03	0.540	29.80	16.09
P_1 X P_4	169.13	126.87	36.87	1.08	3.80	13.33.	0.968	31.40	30.40
P_2 X P_3	121.63	84.40	40.60	0.75	2.87	8.50	0.583	19.53	11.40
P_2 X P_4	160.67	111.90	37.63	1.02	3.37	10.18	0.742	27.90	20.69
P_3 X P_4	170.40	117.50	40.07	1.01	3.17	11.90	0.770	32.67	25.16
				F_{1r} hybrids					
P_2 X P_1	131.23	97.57	41.60	1.03	2.97	8.10	0.662	27.53	18.22
P_3 X P_1	139.90	96.73	43.27	1.02	2.97	8.87	0.565	23.63	13.35
P_4 X P_1	158.67	106.43	36.76	1.08	3.57	12.81	0.790	30.70	24.25
P_3X P_2	126.83	68.00	41.90	0.81	2.53	7.90	0.572	16.93	9.68
P_4X P_2	152.60	97.978	45.03	0.88	2.73	8.10	0.715	21.40	15.30
P_4 X P_3	161.73	107.13	45.43	0.97	3.07	10.57	0.627	25.27	15.85
LSD 1%	5.357	4.546	1.764	0.048	0.231	0.481	0.023	1.767	1.354
LSD 5%	3.978	3.376	1.310	0.046	0.171	0.358	0.017	1.312	1.006

Heterosis:-

Heterosis over mid - parents:

Heterosis versus mid parents ($H_{M.P. \%}$) of the six F_1 hybrids and six F_{1r} hybrids from the mid- parents for aforementioned traits were listed in (Table 3). Obtained data exhibited the magnitudes of (hybrid vigour) heterosis versus mid parents from six cross hybrids ranged from 16.43% (P_2 X P_3) to 29.94 % (P_2 X P_4) for plant length; 8.61 % (P_1 X P_3) to 35.88 % (P_2 X P_4) for number of leaves per plant; - 5.71 % (P_1 x P_2) to -18.85 % (P_1 X P_4) for days to anthesis of first female flower (day); - 6.25 % (P_2 X P_3) to 13.97 % (P_2 X P_4) for fruit shape index; 3.43 % (P_3 X P_4) to 29.69 % (P_1 X P_4) for fruit flesh thickness; - 9.78 % (P_1 X P_3) to 44.85 % (P_1 X P_2) for T.S.S. %; 18.94 % (P_1 X P_3) to 67.62 % (P_1 X P_4) for average fruit weight; - 9.46 % (P_2 X P_3) to 25.51 % (P_1 X P_2) for number of fruits / plot and 21.93 % (P_2 X P_3) to 81.66 % (P_1 X P_4). On the other side, the magnitudes of heterosis versus mid parents (M.P) for F_{1r} hybrids ranged from 13.82 % (P_4 X P_1) to 23.42 % (P_4 X P_2); -1.31 % (P_3 X P_2) to 21.89 % (P_2 X P_1); 1.65 % (P_4 X P_2) to -19.09 % (P_4 X P_1); -1.68 % (P_4 X P_2) to 18.39 % (P_2 X P_1); - 6.81 % (P_3 X P_2) to 21.84 % (P_4 X P_1); - 11.14 % (P_4 X P_2) to 34.42 % (P_4 X P_1); 12.67 % (P_4 X P_3) to 46.78 % (P_2 X P_1); - 21.51 % (P_3 X P_2) to 19.85 % (P_2 X P_1) and 2.03 % (P_4 X P_3) to 72.70 % (P_2 X P_1) for plant length (cm), number of leaves per plant, days to anthesis of first female flower (day), fruit shape index (cm), fruit flesh thickness (cm), total soluble solids (%), average fruit weight (kg), number of fruits per plot and total yield per plot(kg), consequently. Positive heterosis of total yield / plot might be the reflection of heterosis of number of fruits / plot whereas the negative heterosis was obtained from negative heterosis of days to anthesis of first female flower (day). This result suggested the successive way to improve total yield of F_1 hybrid through average fruit weight and number of fruits / plot. Pornsuriya (2005) found that positive heterosis and heterosis on these traits in many F_1 hybrids of slicing melon. The magnitudes of heterosis versus mid parents exhibited largely significant values for various traits in squash (Abd El-Hadi *et al.*, 2014). Same obtained results were accordance to (Tamilselvi *et al.*, 2015; Othman, 2016; Chaudhari *et al.*, 2017; Selim 2019).

Table 3. Heterosis percentage versus to mid parents (M.P) of six F_1hybrids and six F_{1r} hybrids for different studied traits of cantaloupe.

Traits Hybrids	Plant length (cm)	Number of leaves / plant	Days to anthesis of first female flower (day)	Fruit shape index (cm)	Fruit flesh thickness (cm)	Total soluble solids (%)	Average fruit weight (kg)	Number of fruits / plot	Total yield / plot (kg)
P_1 X P_2	22.52**	29.38**	-5.71**	-2.30	15.12**	44.85**	35.70**	25.51**	67.30**
P_1 X P_3	18.47**	8.61**	-9.82**	0.00	3.80	-9.78*	18.94*	17.46**	31.56**
P_1 X P_4	21.33**	25.83**	-18.85**	6.40	29.69**	39.87**	67.62**	9.33**	81.66**
P_2 X P_3	16.43**	22.50**	-8.87**	-6.25	5.71*	0.18	35.58**	-9.46**	21.93**
P_2 X P_4	29.94**	35.88**	-15.06**	13.97*	17.01**	11.68**	40.93**	11.96**	49.33**
P_3 X P_4	28.75**	31.02**	-16.26**	6.88	3.43	14.42**	38.36**	19.58**	61.96**
P_2 X P_1	17.68**	21.89**	-1.27	18.39**	15.12**	6.37**	46.78**	19.85**	72.70**
P_3 X P_1	16.37**	10.70**	-5.29**	10.87**	7.41**	-0.34	24.45**	-6.86**	9.16*
P_4 X P_1	13.82**	5.55**	-19.09**	6.40**	21.84**	34.42**	36.80**	6.89**	44.91**
P_3 X P_2	21.41**	-1.31	-5.95**	1.25	-6.81**	-6.39**	33.02**	-21.51**	3.53**
P_4 X P_2	23.42**	18.97**	1.65	-1.68	-5.21**	-11.14**	35.80**	-14.13**	10.43**
P_4 X P_3	22.20**	3.88*	-5.06**	2.65**	0.16*	1.63**	12.67**	-7.50**	2.03*
LSD 1%	14.670	3..936	1.527	0.162	0.194	0.417	0.061	1.529	1.173
LSD 5%	10.893	2.923	1.134	0.120	0.144	0.309	0.045	1.136	0.871

***, ** = significant at 0.05 and 0.01 levels of probabilities, consequently.**

Heterosis over better parents (B.P):

Heterosis versus better parents ($H_{B.P.\ \%}$) of F_1 and F_{1r} hybrids from the better parents (B.P) for aforementioned traits are listed in (Table 4). The obtained results revealed that the magnitudes of heterosis versus better parents (B.P) from F_1hybrids ranged from 6.03 % (P_2 x P_4) to 12.45 % (P_3 x P_4); 3.68 % (P_1 x P_3) to 23.02 % (P_1 x P_4); 0.98 % (P_2 x P_3) to – 15.82 % (P_3 x P_4); -14.14 % (P_1 x P_2) to 3.85 % (P_1 x P_4); -1.86 % (P_3 x P_4) to 17.65 % (P_1 x P_4); -17.81 % (P_1 x P_3) to 37.36 % (P_1 x P_2); 7.57 % (P_1 x P_3) to 48.24 % (P_1 x P_4); -18.52 % (P_2 x P_3) to 11.32 % (P_1 x P_3) and 3.24 % (P_2 x P_4) to 51.70 % (P_1 x P_4) for plant length (cm), number of leaves per plant, days to anthesis of first female flower (day), fruit shape index (cm), fruit flesh thickness (cm), total soluble solids (%), average fruit weight (kg), number of fruits per plot (kg) and total yield per plot traits, consequently.

Table 4. Heterosis percentage versus better parents (B.P) of six F_1hybrids and six F_{1r} hybrids for studied traits of cantaloupe.

Traits Hybrids	Plant length (cm)	Number of leaves / plant	Days to anthesis of first female flower (day)	Fruit shape index (cm)	Fruit flesh thickness (cm)	Total soluble solids (%)	Average fruit weight (kg)	Number of fruits / plot	Total yield / plot (kg)
P_1 X P_2	7.35	5.12**	-3.10*	-14.14*	12.93**	37.36**	21.91**	7.70**	31.42**
P_1 X P_3	11.91*	-3.68*	-4.78**	-7.07	-1.03	-17.81**	7.57*	11.32**	19.81**
P_1 X P_4	11.61**	23.02**	-14.79**	3.85	17.65**	20.85**	48.24**	2.38	51.70**
P_2 X P_3	7.48**	10.72**	-0.98	-11.76	-1.03	-13.00**	26.74**	-18.52**	3.35
P_2 X P_4	6.03	8.50**	-8.22**	-1.92	4.33	-7.71**	13.63**	-9.03**	3.24
P_3 X P_4	12.45**	13.93**	-15.82**	-2.88	-1.86	7.89**	17.92**	6.52**	25.55**
P_2 X P_1	3.11	-0.97	1.46	4.04	12.93**	0.87	31.87**	2.84	35.67**
P_3 X P_1	9.92*	-1.83	0.00	3.03	2.41	-9.21**	12.55**	-11.73**	-0.60
P_4 X P_1	4.71	3.20	-15.05**	3.85	10.53**	16.14**	20.98**	0.10	21.01**
P_3 X P_2	12.07*	-10.80**	2.20	-4.71	-12.73**	-19.14**	24.35**	-29.37**	-12.24**
P_4 X P_2	0.71	-5.00**	9.83**	-15.38*	-15.48**	-26.56**	9.49*	-30.22**	-23.65**
P_4 X P_3	6.73	3.88*	-4.56**	-6.73	-4.95	-4.17*	-3.98	-17.61**	-20.91**
LSD 1%	16.940	4.545	1.763	0.187	0.224	0.481	0.071	1.766	1.354
LSD 5%	12.578	3.375	1.309	0.139	0.166	0.357	0.052	1.311	1.005

***, ** = significant at 0.05 and 0.01 levels of probabilities, consequently.**

Meanwhile, the magnitudes of heterosis over better parents for F1r hybrids ranged from 0.71 % (P_4 x P_2) to 12.07 % (P_3 x P_2) for plant length; -10.80 % (P_3 x P_2) to 3.88 % (P_4 x P_3) for number of leaves / plant; 0.00 % (P3 x P1) to -15.05 % (P_4 x P_1) for days to anthesis of first female flower; - 6.73 % (P_4 x P_3) to 4.04 % (P_2 x P_1) for fruit shape index; -15.48 % (P4 x P_2) to 12.93 % (P_2 x P_1) for fruit flesh thickness; -26.56 % (P_4 x P_2) to 16.14 % (P_4 x P_1) for T.S.S %; -3.98 % (P_4 x P_3) to 31.87 % (P_2 x P_1) for average fruit weight; -30.22 % (P_4 x P_2) to 2.84 % (P_2 x P_1) for number of fruits / plot and -23.65 % (P_4 x P_2) to 35.67 % (P_2 x P_1) for total yield / plot. The magnitudes of heterosis over the better parents (B.P) appeared that highly significance for generality of studied traits in squash. None of crosses showed high hybrid vigour for studied traits, nevertheless significant and favorable level of heterosis percentage over mid parents (M.P) and better parents (B.P) was recorded in crosses for the variant traits (Abd El-Hadi *et al.* (2014)). In addition, Saha *et al.* (2018) found that higher value of heterosis was observed for the number of fruits per plant, average fruit weight and total yield in muskmelon. This is in agreement with (Monforte *et al.*, 2004; 2005; Al-Ballat 2008; Abo Kamer *et al.*, 2015; Abdein *et al.*, 2017; El - Sharkawy *et al.*, 2018; Ene *et al.*, 2019).

Analysis of variance for combining abilities:

Analysis of variance for general, specific combining ability and reciprocal effects of the all genotypes for studied traits are listed in (Table 5). The obtained data exhibited that mean squares due to general, specific combining ability and reciprocal effects were significant for all studied traits. The obtained data indicate both general and specific combining ability was more major in the inheritance of all studied traits. Values of general combining ability mean squares were larger than those of specific combining ability for studied traits, it connotes that the predominance of the additive genetic variance. In addition, the results exhibited that significant reciprocal genetic effects were noticed for mentioned traits, indicating that these traits were governed by nuclear factor. Abd El-Hadi *et al.* (2013) and Hussien (2015) reported that the values of GCA were higher than those of SCA for studies traits and indicating the importance of GCA variances in squash. Hatem (2009) in melon, noticed that GCA was higher than SCA for yield, suggesting that additive gene effect was most importance than non-additive gene effect one. Significant effects of GCA and SCA obtained in this investigate on the aforementioned traits were also reported by Bayoumy *et al.* (2014) and Selim, (2019).

Table 5. Analysis of variance and mean squares for combining abilities of studied traits in cantaloupe.

S. O. V	d.f.	M. S								
		Plant length (cm)	Number of leaves / plant	Days to anthesis of first female flower (day)	Fruit shape index (cm)	Fruit flesh thickness (cm)	Total soluble solids (%)	Average fruit weight (kg)	Number of fruits / plot	Total yield / plot (kg)
GCA	3	1451.79**	952.08**	18.28**	0.047**	0.392**	11.13**	0.046**	71.92**	100.87**
SCA	6	364.80**	191.68**	12.77**	0.011**	0.084**	2.19**	0.021**	10.14**	29.55**
Reciprocal	6	26.03**	85.64**	7.75**	0.006**	0.032**	1.34**	0.005**	12.00**	13.70**
Error	30	18.973	1.370	0.206	0.002	0.003	0.015	0.003	0.206	0.121

***, ** = significant at 0.05 and 0.01 levels of probabilities, consequently.**

General combining ability effects *(gi)*:-

Estimates of general combining ability effects of each parent for studied traits presented in (Table 6). General combining ability effects were positive and largely significant for the parent (P_4) for all characters. However, parent (P_4) was the good general combiner for all characters exclude days to anthesis of first female flower. Also, the parent (P_1) was good general combiner for studied traits. While, the parent (P_2) was good general combiner for days to anthesis of first female flower (day). On the other hand, the parent (P_3) was good general combiner for fruit flesh thickness trait. In general, the obtained results exhibited the parent (P_1) and (P_4) were the good general combiners for all traits under the study. It could be proposed that these genotypes own desirable genes to improve F_1 hybrids for traits. This is in accordance to (Aravindakumar *et al.*, 2005 on muskmelon; El – Ballat, 2008 on summer squash; El-Tahawey 2015 on pumpkins).

Table 6. General combining ability (GCA) effects (*gi*) of each parental line for studied traits in cantaloupe.

Genotypes	Plant length (cm)	Number of leaves / plant	Days to anthesis of first female flower (day)	Fruit shape index (cm)	Fruit flesh thickness (cm)	Total soluble solids (%)	Average fruit weight (kg)	Number of fruits / plot	Total yield / plot (kg)
P_1	0.343	5.86**	-1.13**	0.054**	0.04*	0.07*	0.01	2.17**	1.46**
P_2	-13.59**	-11.21**	-0.82**	- 0.09**	- 0.20**	- 1.18**	- 0.05**	-3.45**	- 3.35**
P_3	-5.07**	-6.89**	1.71**	- 0.04*	0.10**	- 0.30**	- 0.07**	-1.54**	- 2.69**
P_4	18.31**	12.23**	0.25*	0.07**	0.26**	1.41**	0.11**	2.82**	4.58**
S.E.(gi)	1.886	0.506	0.196	0.019	0.023	0.053	0.008	0.196	0.150

***, ** = significant at 0.05 and 0.01 levels of probabilities, consequently.**

Specific combing ability effects (*Sij*):-

Estimated specific combing ability (SCA) effects *(Sij)* of F_1 hybrid for studied traits are listed in (Table7). Mean performances of the most crosses were fluctuated among their parental lines for studied traits. Data elucidated that there was no specific parental line, which was superior for all studied traits. F_1 hybrids P_2 x P_4 and P_3 x P_4 showed those highly significant magnitudes of 10.69 and 11.60 for plant length, consequently. Meanwhile, P_4 x P_1 and P_4 x P_3 exhibited positive and highly significant effects for plant length (cm). In addition, P_3 x P_4 and P_1 x P_2 recorded the largest and largely significant magnitudes for number of leaves / plant of (9.9 4 and 8.89), consequently. Whereas, the cross P_4 x P_1 and P_3 x P_2 showed that positive and largely significant effects for aforementioned trait. On the other side, P_1 x P_4 and P_2 x P_3 exhibited those largely significant negative magnitudes of (- 4.176 and -1.516) for days to anthesis of first female flower (day), consequently. Whilst, F_{1r} hybrid P_4 x P_2 and F_{1r} hybrid P_4 x P_3 exhibited largely significant negative effects for aforementioned trait. For fruit shape index (cm), F_1hybrid P_1 x P_2 and P_3 x P_4 gave significant magnitudes (0.03 and 0.02), consequently. The crosses P_4 x P_2 and P_4 x P_3 exhibited those positive and largely significant effects for aforementioned trait. Also, crosses P_1 x P_4 and P_1 x P_2 recorded highly significant magnitudes of (0.38 and 0.12), respectively for fruit flesh thickness. However, F_{1r} hyb rid P_4 x P_2 and F_{1r} hybrid P_3 x P_2 recorded significant value for fruit flesh thickness. As TSS %, F_1 hybrid P_1 x P_4 and P_1 x P_2 exhibited largely positive significant magnitudes of (1.88 and 0.70), consequently. While, F_{1r} hybrids P_2 x P_1 and P_4 x P_2 recorded significant magnitude (1.47 and 1.04) for TSS %. Crosses P_1 x P_4 and P_2 x P_3 showed that positive and highly significant magnitudes of 0.132 and 0.055, consequently for average fruit weight. While, P_4 x P_1 and P_4 x P_3 recorded significant value 0.09 and 0.07, respectively for average fruit weight. Concerning to number of fruits / plot, P_1 x P_2 and the cross P_3 x P_4 recorded highly significant magnitudes of 3.45 and 1.67, respectively. While, P_4 x P_3 and P_4x P_2 recorded significant value for aforementioned trait. The crosses P_1 x P_4 and P_1 x P_2 recorded highly significant magnitudes (4.39 and 2.94), respectively for total yield / plot. While, P_4 x P_1 and P_4 x P_3 and recorded significant value (3.08 and 4.66), respectively for total yield / plot. Results reported that no F_1 hybrid and F_{1r} hybrid was the good for all studied traits. Therefore, it is not essential that parental lines having evaluates of large general combining ability effects *(gi)* would too gave large evaluates of specific combining ability effects in their specific cross combination. Results propose the major role of dominance gene effect in the inheritance of studied characters. These findings agree with Hatem *et al.* (2014); Ene *et al.* (2019) and Selim (2019).

Table7. Specific combining ability (SCA) effects *(Sij)* of F_1 hybrid for studied traits in cantaloupe.

Traits Hybrids	Plant length (cm)	Number of leaves / plant	Days to anthesis of first female flower (day)	Fruit shape index (cm)	Fruit flesh thickness (cm)	Total soluble solids (%)	Average fruit weight (kg)	Number of fruits / plot	Total yield / plot (kg)
P_1 X P_2	5.95**	8.89**	0.736**	0.03**	0.12**	0.70**	0.034**	3.45**	2.94**
P_1 X P_3	4.67**	- 0.19	-0.216**	0.018	- 0.03	- 1.04**	- 0.028**	0.08	- 0.943**
P_1 X P_4	4.03**	1.53**	-4.176**	0.011	0.38**	1.88**	0.132**	0.05	4.39**
P_2 X P_3	1.66	- 2.73**	-1.516**	- 0.03**	-0.01	-0.04	0.055**	- 2.79**	- 0.31**
P_2 X P_4	10.69**	6.89**	0.024	0.02	- 0.02	- 0.80**	0.038**	- 0.73**	- 0.12
P_3 X P_4	11.60**	9.94**	-1.079**	0.02	-0.05**	0.42**	0.022**	1.67**	1.73**
S.E.(Sij)	1.778	0.477	0.185	0.018	0.022	0.050	0.007	0.185	0.142

***, ** = significant at 0.05 and 0.01 levels of probabilities, consequently.**

Table8. Specific combining ability (SCA) effects *(Sij)* of F_{1r} hybrid for studied traits in cantaloupe.

Traits Hybrids	Plant length (cm)	Number of leaves / plant	Days to anthesis of first female flower (day)	Fruit shape index (cm)	Fruit flesh thickness (cm)	Total soluble solids (%)	Average fruit weight (kg)	Number of fruits / plot	Total yield / plot (kg)
P_2 X P_1	2.7	3.00**	- 0.94**	- 0.09**	0.00	1.47**	- 0.03*	0.65**	- 0.29*
P_3 X P_1	1.27	- 0.92**	- 1.04**	- 0.05**	- 0.05*	- 0.42	- 0.04**	3.09**	1.37**
P_4 X P_1	5.23**	10.22**	0.06	0.00	0.12**	0.26**	0.09**	0.35*	3.08**
P_3X P_2	- 2.65	8.20**	- 0.65**	- 0.03*	0.17**	0.30**	0.01	1.30**	0.86**
P_4X P_2	4.04**	6.97**	- 3.70**	0.07**	0.32**	1.04**	0.01	3.25**	2.70**
P_4 X P_3	4.34**	5.19**	-2.68**	0.02	0.05*	0.665**	0.07**	3.70**	4.66**
S.E. (rij)	3.080	0.827	0.320	0.031	0.038	0.086	0.012	0.320	0.245

***, ** = significant at 0.05 and 0.01 levels of probabilities, consequently.**

Types of gene effect and heritability:-

The obtained results of (Table 9) revealed that genetic parameters (gene effects) and heritability. The obtained results revealed the additive *(δ^2A)* and non- additive genetic variance *(δ^2D)* were positive and large in magnitudes for traits. Also, values of δ^2A were positive and larger than those of *(δ^2D)* for studied traits exclude days to anthesis of first female flower. The data illustrated that the magnitudes of reciprocal effects variances *(δ^2r)* were noticed and smaller than (δ^2A) for studied traits, pronounced the important role of cytoplasmic factors in genetic manifestation of characters. Obtained results indicate that the additive effects δ^2A play important part in the manifestation of studied traits, meanwhile, dominance effects δ^2D had a great part. These results may elucidate the absence of hybrid vigour (heterosis) in most studied traits. With these respect, the obtained results inquiring the predominance of δ^2A in the inheritance of these aforementioned traits. Broad sense heritability $h^2_{BS}\%$ evaluates was exceeded 80 % and larger than the heritability in narrow sense percentage $h^2_{NS}\%$ for studied traits. However, magnitudes of the heritability in broad sense ranged from 88.89 to 99.67 % for fruit shape index and total yield / plot, consequently. On the other side, the magnitudes of heritability in narrow sense percentage $h^2_{NS}\%$ ranged from 16.95 to 71.23 % for days to anthesis of first female flower and number of fruits per plot, consequently. (Abd El-Hadi *et al.*, 2013) elucidate the σ^2D were the most major source of genetic variation. In addition, σ^2A were very serious. Also, reciprocal effects *(σ^2r)* were noticed for studied traits, nevertheless their evaluates were lesser than the non - additive (dominance) σ^2D and additive δ^2A genetic effects. Paris *et al.* (2008) noticed that significant effect for combining abilities and the presence of additive and dominance effects of total soluble solids and flesh thickness traits on melon. Ajay *et al.* (2012) illustrated that inter-allelic interactions play a great part in the expressiveness of a trait and additive – dominance single is not enough. Ibrahim (2012) on sweet melon reported that the heritability in broad sense percentage evaluates among characters were very large and the large heritability estimates indicate the existence of a large number of fixable additive factors and hence these traits perhaps improved by selection. In melon, Mohammadi *et al.* (2014) found that the heritability in narrow sense percentage $h^2_{NS}\%$ was low for flesh thickness, average fruit weight and total yield, but they were high for total soluble solids. The heritability in narrow sense percentage $h^2_{NS}\%$ was large in magnitudes for all melon characters exclude fruit diameter and total soluble solids (Javanmard *et al.*, 2018). Selim, (2019) found that the characteristics that have a heritability of over 60% and governed by additive gene actions, can play a major role in vegetable breeding programs. Also, they showed that selection of desirable breeding methods for best exploitation of the potential of various agronomic characters in a plant depends on the type of gene effect and heritability. These results reported that the selection may be more efficient for improving characters of genotypes at early generations in cantaloupe.

Table 9. Genetic parameters and heritability percentage in broad $h^2_{BS\%}$ and narrow $h^2_{NS\%}$ sense for studied traits in cantaloupe

Traits Genetic parameters	Plant length (cm)	Number of leaves / plant	Days to anthesis of first female flower (day)	Fruit shape index (cm)	Fruit flesh thickness (cm)	Total soluble solids (%)	Average fruit weight (kg)	Number of fruits / plot	Total yield / plot (kg)
δ^2A	279.14	193.76	1.62	0.010	0.079	2.28	0.015	15.64	18.36
δ^2D	212.82	117.11	7.73	0.006	0.050	1.34	0.013	6.11	18.11
δ^2r	3.53	42.14	3.77	0.002	0.015	0.66	0.002	5.90	6.79
δ^2E	18.97	1.37	0.206	0.002	0.003	0.015	0.003	0.206	0.121
$h^2_{B.S}\%$	96.29	99.56	97.85	88.89	97.73	99.59	98.45	99.06	99.67
$h^2_{N.S}\%$	54.63	62.05	16.95	55.56	59.85	62.70	31.09	71.23	50.18

Genotypic and phenotypic correlation coefficients:-

The information about the degree of correlation between pairs of traits in cantaloupe is of major importance and utilize as index for improvement of other traits over the selection programme. Phenotypic and genotypic correlation coefficients between studied traits were evaluated. Significant positive or negative and non – significant values were recorded as shown in (Table 10). These evaluates are an important aspects which should be utilized for planning better selection programme. The correlation between the studied traits may be due to either a pleiotropic effects of a gene on different parts of plant of the plants or the linkage. It is noticed that the genotypic correlation coefficients (r_g) for a pair of traits were mostly larger than phenotypic correlation coefficients (r_{ph}) which indicated that the conspicuous correlation might be due to genetic cause. Significant and desirable positive correlations found among total yield per plot with each of all studied traits expect for days to anthesis of first female flower trait. The same trait showed significant negative correlations with each of fruit shape index (cm), fruit flesh thickness (cm), average fruit weight (kg), number of fruits per plot and yield per plot. Negative and highly significant correlation was observed among total yield / plot and days to anthesis of first female flower. Desirable positive and significant correlations were detected among number of fruits / plot with each of plant length (cm); number of leaves per plant and total soluble solids. Also, positive and highly significant correlations were detected among average fruit weight and plant length; fruit shape index (cm) and fruit flesh thickness (cm). On the other side, non- significant correlation coefficients were noticed among some traits. Genotypic correlation (r_g) was larger than phenotypic correlation (r_{ph}) for fruit flesh thickness; number of fruits / plot; average fruit weight (kg) and total yield (Akter *et al.*, 2013). In the same time, Shivananda *et al.* (2013) noticed that positive and highly significant correlation of total yield / plot with fruit weight followed by plant length (cm), flesh thickness of fruit (cm) and number of fruits / plot. Naik *et al.* (2015) recorded highest yield was mainly correlated with increasing number of fruits / plot, fruit weight (g) and fruit flesh thickness. The obtained data indicated the worth of these traits in the improvement of fruit weight, number of fruits / plot and yield of cantaloupe and would be regarded in selection programme. Positive and desirable significant associations were found for aforementioned traits by many authors among of them were Babu *et al.* (2013); Deepa *et al.* (2018); Habib, (2018) and Ratnakar (2018).

Table 10. Genotypic and phenotypic correlation coefficient between pairs of studied traits in cantaloupe.

Traits		Number of leaves / plant	Days to anthesis of first female flower (day)	Fruit shape index (cm)	Fruit flesh thickness (cm)	Total soluble solids (%)	Average fruit weight (kg)	Number of fruits / plot	Total yield / plot (kg)
Plant length	r_g	0.79**	- 0.59**	0.82**	0.40*	0.40*	0.54**	0.84**	0.86**
(cm)	r_{ph}	0.77**	- 0.55**	0.81**	0.39	0.36	0.48*	0.87**	0.80**
Number of	r_g		-0.80**	- 0.65**	0.31	0.20	0.19	0.72**	0.44*
leaves / plant	r_{ph}		-0.76**	0.64**	- 0.28	0.18	0.25	0.86**	0.42*
Days to anthesis of first	r_g			-0.80**	-0.82**	0.01	-0.73**	-0.01	-0.95**
female flower (day)	r_{ph}			-0.79**	-0.80**	0.01	-0.66**	-0.10	-0.83**
Fruit shape index (cm)	r_g				0.66**	0.69**	0.81**	-0.44*	0.71**
	r_{ph}				0.65**	0.63**	0.75**	0.49*	0.63**
Fruit flesh thickness	r_g					0.47*	0.86**	-0.23	0.91**
(cm)	r_{ph}					0.43*	0.79**	-0.32	0.81**
Total soluble	r_g						-0.56**	0.89**	0.41*
solids (%)	r_{ph}						-0.47*	0.79**	0.11
Average fruit weight	r_g							-0.27	0.88**
(kg)	r_{ph}							-0.30	0.82**
Number of	r_g								0.84**
fruits / plot	r_{ph}								0.81**

***, ** = significant at 0.05 and 0.01 levels of probabilities, consequently.**

CONCLUSION

The used genotypes differed in significance indicating the existence of genetic variations between them. Most studied traits were primely controlled by additive effect and cytoplasmic factor; meanwhile non - additive effect cannot be ignored. So, selection must be taking placed in the segregated generations. Positive and significant genotypic and phenotypic association among yield / plot and some related traits (plant length (cm); flesh thickness (cm); average fruit weight (cm) and number of fruits / plot) exhibited that each trait could be used indirectly to selection of yield. Thus the genotypes could be used for hybridization for producing promising hybrids to development economical traits in cantaloupe.

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التحليل الوراثى لتحديد آباء مناسبة لإنتاج بعض الهجن الجديدة فى الكنتالوب

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أجري هذا البحث بالمزرعة البحثية بالبرامون ، محافظة الدقهلية بالحقل المكشوف فى العروة الصيفية خلال عامى ٢٠١٨ و ٢٠١٩. تم في هذا البحث التحليل الوراثى لتحديد آباء مناسبة لإنتاج بعض الهجن الجديدة فى الكنتالوب. كما هدفت الدراسة إلى تقديرقوة الهجين عن طريق متوسط الأبوين و أحسن الآباء ، والقدرة العامة والخاصة على الخلط ، وكذلك التأثير الإضافى والغير إضافى ، ودرجة التوريث و حساب معامل الأرتباط بين أزواج الصفات المختلفة محل الدراسة. أظهرت النتائج التي تم الحصول عليها أن:جميع التراكيب الوراثية أظهرت فروق معنوية عالية لجميع الصفات تحت الدراسة. أظهرت بعض الهجن إختلافات معنوية كبيرة سواء عن طريق متوسط الأبوين أو أحسن الآباء لبعض الصفات محل الدراسة.وقد أظهرت الهجن P_1 x P_4 و P_1 x P_2 و P_3 x P_4 و P_2 x P_1 تفوقا عالياً فى صفات المحصول ومعظم الصفات محل الدراسة. قيم القدرة العامة والخاصة على الخلط معنوية جداً للصفات تحت الدراسة مما يدل أهمية التأثير الجينى الإضافى والتأثير الجينى الغير إضافى فى وراثة الصفات محل الدراسة. أوضحت النتائج أن الأب P_4 كان ذات قدرة عالية على الخلط لكل الصفات محل الدراسة ماعدا صفة عدد الأيام لتفتح أول زهرة مؤنثة. أيضا أظهر الأب P_1 قدرة عالية على الخلط لصفة عدد الأيام لتفتح أول زهرة مؤنثة. أظهرت النتائج أيضاً أن الهجن P_1 x P_4 و P_1 x P_2 و P_3 x P_4 و P_2 x P_1 ذات قدرة خاصة عالية على الخلط لصفات المحصول الكلى. القيم المقدرة للتباين الوراثى الإضافى أعلى من القيم المقدرة للتباين الوراثى الغير إضافى للصفات محل الدراسة ما عدا صفة عدد الأيام لتفتح أول زهرة مؤنثة، مشيرة إلى أن الفعل الجينى الإضافى لعب دوراً مهماً في وراثة هذه الصفات. قيم معامل التوريث فى المدى الواسع أعلى من قيم معامل التوريث فى المدى الضيق للصفات محل الدراسة حيث تراوحت القيم المقدرة لمعامل التوريث فى مداة الواسع من ٨٨,٨٩٪ إلى ٩٩,٦٧٪ لصفة معامل شكل الثمرة وصفة المحصول الكلى للقطعة التجريبية على التوالي. بينما تباينت قيم معامل التوريث فى المدى الضيق من ١٦,٩٥٪ إلى ٧١,٢٣٪ لصفة عدد الأيام لتفتح أول زهرة مؤنثة وصفة عدد الثمار للقطعة التجريبية على التوالي. أوضحت النتائج أيضاً وجود إرتباط وراثياً ومظهرياً موجبا وعالى المعنوية بين صفة المحصول الكلى للقطعة التجريبية وبعض الصفات ذات الصلة بالمحصول مثل سمك اللحم وعدد الثمار للقطعة التجريبية ومتوسط وزن الثمرة. أشارت هذه الإرتباطات الإيجابية والعالية المعنوية إلى أن اختيار برنامج التربية يعتمد على أن الأُنتخاب لأي صفة من الصفات تحت الدراسة سيؤدي إلى زيادة المحصول الكلى للكنتالوب. عموما يمكن استخدام هذة الهجن و هي P_1 x P_4 و P_1 x P_2 و P_2 x P_1 و P_3 x P_4 كهجن مبشرة وواعدة للحصول على أعلى محصول وجودة من الكنتالوب.