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DEVELOPING OF NEWLY LOCAL CANTALOUPE HYBRIDS FOR GROWING UNDER PLASTIC TUNNELS

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ABSTRACT

The planting of hybrid cultivars in cantaloupe played a great role in the improvement of production and quality of the crop. Thus, this study was conducted during the period from 2016 to 2018 for improving the productivity and fruit quality of cantaloupe crop under low tunnels in the winter seasons by enhancing the earliness and average fruit weight through crossing between five parental selected cantaloupe recombinant inbred lines (RILs) from a previous breeding program to produce 20 F_1 (10 crosses and 10 reciprocal F_1 crosses) hybrids. These 20 hybrids, their five parental RILs and two commercial F_1 hybrids (Yathreb 7 and Gold Stone) were used as controls for determining the best hybrid suitable to grow under low tunnels in the winter seasons. Besides, some genetic determinations of early yield and average fruit weight were done to identify the genetic nature of these two traits under low tunnels in the winter seasons. Results confirmed that the best hybrid for planting under low tunnel was RIL G16 × RIL G38 which ranked first and fifth in total and early yield, respectively, and had high fruit quality. The highest value of mid and better parents heteosis were 143.79 and 120.00% in hybrids RIL G42 × RIL G4 and RIL G42 × RIL G16, respectively for early yield. Also, the highest value of mid parent heterosis was 68.63% in hybrid RIL G16 × RIL G38 for average fruit weight, but non-significant heterobeltiosis (heterosis relative to the better parent) was shown in all hybrids for the same trait. The general combining ability effects of the parents were agreed with the specific combining ability effects of the hybrids for early yield and average fruit weight traits. Likewise, the coefficient of variance was 7.94 and 10.01% for average fruit weight and early yield, respectively. The, estimated genotypic coefficient of variance (GCV %) vs. phenotypic one (PCV %) were 19.658 vs. 21.201% for average fruit weight and 34.129 vs. 35.565% for early yield. Small difference were observed between GCV and PCV in average fruit weight and early yield, indicating the importance of the genetic effects in controlling the inheritance of these two traits. In addition, broad sense heritability (h^2_b) was high (85.975 and 92.086) for average fruit weight and early yield, respectively. So, the high value of (h^2_b) indicating that the cantaloupe can be improved through selection based on phenotypic observation. Finally, a highly positive correlation ($r = 0.93^{**}$) was detected between early yield and flowering in cantaloupe RILs, suggesting that the selection of early flowering could be associated with great early yield and this could save effort for the melon breeders.

Key words: ***Cantaloupe**, **Heterosis**, **Coefficient of variance**, **Heritability**, **Genotypic coefficient of variance**, **Correlation coefficients**, **General combining ability**, **Specific combining ability**.*

INTRODUCTION

Cantaloupe was grown in sunny weather and in fertile, well-drained sandy soils. Incorporate organic matter and a complete fertilizer into the area before planting should be done. Although the winter season is the main cantaloupe planting season in Egypt, Cantaloupe is very sensitive for low temperatures at any stage of its growth. So, transparent plastic tunnels are used to protecting the cantaloupe plants against frost injuries (Pardossi *et al* 2000).

The effect of interaction between a genotype and environmental conditions effects on the performance of the hybrid, either positive or negative, was investigated in Egypt (Selim and Alian 2018). So, the best hybrids suitable for the low tunnel planting could be obtained via studying the performance of these hybrids under plastic low tunnels (El-Aidy *et al* 2007). Also, Welles *et al* (1999) found that cultivar choice had the greatest impact on cucumber yield and fruit quality. The planting of hybrid cultivars has had a main role in the improvement of crop production and fruit quality during the tiny years ago (Duvick 1999). Likewise, Ranjan *et al* (2019) found that melon fruit yield/plant was 9.07 kg under low tunnels in India.

According to Dufault *et al* (2006) all cantaloupe growers prefer to grow the hybrids that contain great early yield, especially in the winter season. The early yield trait is the most important trait in cantaloupe hybrids performance (Refai *et al* 2008 and Duradundi *et al* 2018). Likewise, the earliness of cantaloupe harvest allows growers to harvest earlier, and get a great price for their production before vegetable prices begin to decline in mid-season and this result in improvement of profitability from cantaloupe production (Ranjan *et al* 2019). Under low tunnels, the low temperatures reduces the average fruit weight of melon, especially in the first four pickings, and this affects on marketable yield (Pardossi *et al* 2000). So, the study of some genetic parameters of early yield and average fruit weight (such as heterosis, genetic, phenotypic coefficient of variations and heritability) should be done to determine the ability of improvement these traits.

Hybrid vigour or heterobeltiosis was observed for many plant and fruit traits of melon by several researchers. From those were, Hatem (1992), Hatem *et al* (1995) and Hatem *et al* (2014) for early yield trait, total yield as fruit number and weight and average fruit weight. Greish *et al* (2005) for plant height, plant growth rates, fruit weight, fruit length, fruit width and total soluble solids (TSS). Feyzian *et al* (2009) for average fruit weight, total yield, and marketable yield.

The genotypic and phenotypic coefficient of variation are helpful in detecting the nature of variability in the breeding population. Whereas, the determine of heritability uses as indicator of transmissibility of traits. Burton (1952) stated that GCV together with heritability estimates would give best picture about the extent of advance to be expected by selection. So, Janghel *et al* (2018) found that the genetic (GCV, phenotypic (PCV) coefficient of variations and heritability in melon were 31.03, 32.77 and 89.6% for average fruit weight and 30.02, 30.86 and 94.6% for fruit yield/plot, respectively.

Negative correlation were reported by Zalapa *et al* (2008) between early pistillate flowering and fruit maturity in melon**.**

So, this study aimed to make crosses and reciprocal crosses between five cantaloupe inbred lines, which were produced from former breeding program. Then, to evaluate the produced hybrids beside two cultivars as controls under low tunnels to select the best ones. Also, estimate the heterosis and some genetic parameters for early yield and average fruit weight traits. Also, to estimate the genetic correlation between the number of days till first hermaphrodite flower and early yield.

MATERIALS AND METHODS

This experiment was conducted during the period from 2016 to 2018 and involved making crosses between five parental inbred lines in two directions to produce 20 F_1 hybrids and evaluation of these 20 hybrids, their five parental inbred lines and two controls. Crosses and transplant production were carried out in the greenhouse facilities, while evaluations of the 20 hybrids, their five parental inbred lines and the two controls were conducted using a drip-irrigation system under low tunnels during the 2016/2017 and 2017/2018 winter seasons at Kaha Vegetable Research Farm (KVRF), Kalubia.

Plant resources and seed sowing

Field trials were conducted under low tunnels of winter seasons at Kaha Vegetable Research Farm (KVRF), Kalubia during the period from 2016 to 2018. Five parental inbred lines of cantaloupe (RILs G4, G16, G38, G42 and G48) were crossed as parents to produce a 5 × 5 diallel crosses and their reciprocals to create 20 F_1 hybrids. These five parental inbred lines were produced by the second author of the present study from previous cantaloupe breeding program by selfing and selection during 12 generations. Crosses and transplant production were carried out in the greenhouse facilities, while the 20 hybrids were evaluated along with their parents, and 2 commercial F_1 hybrids, Yathreb 7 (HRI, Egypt) and Gold Stone

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(Nickerson-Zwaan company, Netherlands) as controls under low tunnels using the drip irrigation system during the 2016/2017 and 2017/2018 winter seasons at Kaha Vegetable Research Farm (KVRF), Kalubia.

The crosses among the five parental inbred lines were made during the 2016 early summer season. Regarding low tunnels evaluation, seedlings were transplanted on Dec. 5 th for both 2016/2017 and 2017/2018 winter seasons in a randomized complete block design with 3 replicates. Each replicate contained 27 experimental plots (EP) for 5 parents, 20 F_1s and 2 controls of the diallel cross experiment. Each plot was presented by a single bed covered with black plastic mulch, 1.5 m width and 10 m length (EP area = 15 m^2) and the plants were spaced at 50 cm. Land preparation, fertilizer application and other field practices were carried out according to recommendations of the Egyptian Ministry of Agriculture.

Measured characters

1. Leaf area index (LAI): The leaf area of each plant was determined after maturity of fruits by the area meter (LI-COR, model: LI 3050A/4,U.S.A) measured as an average of 3 randomly chosen plants per EP and the LAI was calculated by dividing average leaf area by the ground area occupied by the plant.
2. Flowering: Three plants were randomly chosen per EP to determine the number of days from transplanting to appearance of the first andromonocious flower on the plant.
3. Yield: Early yield (EY) was yield of the first 3 pickings and total yield (TY) was weight of all fruits harvested at the yellow-netted ripe stage from each EP. Marketable yield (MY) was determined after excluding cracked, rotten and infected fruits with diseases and pests and was calculated as percentage from the total yield.
4. Fruit quality: average fruit weight (AFW), seed cavity diameter (SCD) and flesh thickness were determined as the mean of 10 fruits randomly chosen from each EP. Fruit shape index (FSI) was calculated as the ratio of fruit length to fruit diameter and classified as: oblate FSI < 0.88, round FSI = 0.88 - 1.1, cylindrical FSI = 1.1 - 1.5 and oblong FSI > 1.5 (Rashidi and Seyfi 2007). The netting percentage was measured as a ratio of the netting covered fruit rind to full fruit rind as visual method and determined as the mean of 10 fruits randomly chosen from each EP.

Total soluble solids (TSS) was determined in the third and fourth pickings of 5 yellow-ripe fruits/picking of each EP using a hand refractometer.

5. The shelf life: It was measured as number of days till fruits decay for 5 ripe fruits from each experimental plot, which were stored at ambient temperature in non-controlled temperature with various air temperature between 20-25^{o}C.

Statistical analysis

Obtained data were statistically analyzed and mean comparisons were based on the LSD test according to Gomez and Gomez (1984). Also, the Bartlett's test (using Chi-square test) of the variance of error for inbred lines in both winter seasons (2016/2017 and 2017/2018) were homogeneous for all traits. So, the combined analysis of variance for the two winter seasons was computed for all traits according to Koch and Sen (1968).

The genetic analysis of diallel crosses for general and specific combining abilities were done based on the method proposed by Griffing (1956), method (2) model (1). Also, the correlation coefficients between flowering and early yield traits was estimated according to the Pearson formula (Rodgers and Nicewander 1988). Relative heterosis and heterobeltiosis were estimated as the deviation of F1 mean over the mid-parent (MP) and better parent (BP) in each cross, respectively.

RESULTS AND DISCUSSION

Mean performance of the F_1 hybrids and their parents

Mean performance of the F_1 hybrids, (galia type, whitish green flesh, full netting), their parents and commercial hybrids Yathreb7 and Gold Stone are presented in Tables (1 and 2). Among parents, RIL G42 gave the greatest LAI and was significantly different from all other evaluated parents. In contrast, RIL G38 had the lowest LAI, but it was not significantly different from RIL G4. With regard to crosses, hybrid RIL G16 × RIL G42 had the highest LAI, but it was not significantly different from its reciprocal cross and the crosses RIL G4 × RIL G42, its reciprocal cross, Gold Stone and Yathreb 7. Regarding the earliness of perfect flowers was shown by RIL G42, but it was not significantly different from RIL G4. On the other hand, the tardiness of perfect flowers was showed in RIL G38 and was significantly different from all other evaluated parents.

~~Table 1.~~ Leaf area index, flowering, yield and its components and average fruit weight of 20 local cantaloupe hybrids and two commercial hybrids (as control) evaluated during the combined 2016/2017 and 2017/2018 winter seasons under low tunnels.

Traits / G~~enotypes~~	Leaf area index	Flowering (days)	Early yield (ton/fed.)	Total yield (ton/fed.)	Marketable yield%	Average fruit weight (g)
RIL G4	0.83	44.46	0.65	6.95	73.84	589.95
RIL G16	0.94	46.53	0.86	8.46	68.38	479.23
RIL G38	0.73	52.07	0.44	10.69	90.30	397.18
RIL G42	1.16	41.25	0.97	11.12	77.82	562.18
RIL G48	0.98	48.51	0.53	7.81	90.14	366.21
Mean	0.93	46.56	0.69	9.00	80.10	478.95
RIL G4 × RIL G16	1.08	42.24	1.40	13.15	83.12	720.22
RIL G4 × RIL G38	0.88	49.43	1.04	13.76	93.20	539.26
RIL G4 × RIL G42	1.28	40.29	1.56	11.27	82.06	823.04
RIL G4 × RIL G48	0.90	47.27	1.18	11.33	95.90	534.32
RIL G16 × RIL G4	1.05	43.09	1.64	12.62	88.32	754.40
RIL G16 × RIL G38	0.97	47.16	1.31	14.23	86.75	738.96
RIL G16 × RIL G42	1.29	41.64	1.89	13.59	84.46	595.62
RIL G16× RIL G48	0.94	47.32	1.26	11.53	89.57	501.30
RIL G38 × RIL G4	0.91	49.16	0.97	13.94	95.21	594.24
RIL G38 × RIL G16	0.94	48.15	1.07	13.83	83.58	694.97
RIL G38 × RIL G42	1.05	43.06	1.19	11.71	90.58	701.43
RIL G38 × RIL G48	0.93	52.27	0.95	11.95	92.44	599.32
RIL G42 × RIL G4	1.26	39.62	1.98	10.76	81.74	793.59
RIL G42 × RIL G16	1.28	41.79	2.14	13.13	79.33	583.94
RIL G42 × RIL G38	1.04	41.59	1.25	12.36	82.37	677.50
RIL G42 × RIL G48	0.99	46.12	1.32	11.99	78.86	515.02
RIL G48 × RIL G4	0.92	47.14	0.98	11.82	86.01	566.55
RIL G48 × RIL G16	0.98	50.05	1.03	12.23	71.41	520.01
RIL G48 × RIL G38	0.93	52.84	0.73	12.34	90.08	533.98
RIL G48 × RIL G42	0.97	46.23	1.09	13.41	78.81	493.88
Mean	1.03	45.82	1.30	12.55	85.69	624.08
Gold Stone	1.16	47.33	1.47	12.88	87.38	738.86
Yathreb 7	1.19	49.89	1.17	10.02	94.15	439.97
L.S.D. (0.05)	0.17	4.22	0.19	1.46	8.07	77.35

~~Table~~ 2~~.~~ Some fruit quality traits of 20 local cantaloupe hybrids and two commercial hybrids (as control) evaluated during the combined 2016/2017 and 2017/2018 winter seasons under low tunnel.

Traits / Genotypes	Fruit shape index	Netting (%)	Flesh thickness (cm)	Seed cavity diameter (cm)	Tss (%)	Shelf life (days)
RIL G4	0.94	100.00	2.69	4.36	12.59	9.58
RIL G16	0.72	3.33	2.60	5.06	11.08	5.47
RIL G38	1.03	100.00	3.45	3.08	15.73	14.02
RIL G42	1.18	50.83	3.59	3.59	12.38	11.29
RIL G48	0.86	90.83	2.60	4.10	13.06	12.65
Mean	0.95	69.00	2.99	4.04	12.97	10.60
RIL G4 × RIL G16	0.86	87.98	3.04	4.07	11.08	9.44
RIL G4 × RIL G38	1.04	100.00	3.92	3.59	14.02	16.15
RIL G4 × RIL G42	1.06	79.40	3.13	3.47	13.34	12.24
RIL G4 × RIL G48	0.91	98.50	2.87	4.10	14.38	13.16
RIL G16 × RIL G4	0.87	90.50	2.93	4.38	10.94	8.38
RIL G16 × RIL G38	0.91	99.67	3.80	4.02	13.61	12.24
RIL G16 × RIL G42	1.02	62.5	3.90	4.00	10.33	8.38
RIL G16× RIL G48	0.82	88.00	2.92	5.04	11.36	10.53
RIL G38 × RIL G4	1.04	100.00	3.81	3.32	14.64	16.28
RIL G38 × RIL G16	0.97	87.75	3.73	4.34	12.93	12.02
RIL G38 × RIL G42	1.19	100.00	4.27	2.86	15.87	13.90
RIL G38 × RIL G48	0.92	100.00	3.16	4.10	14.77	15.59
RIL G42 × RIL G4	1.07	81.83	3.28	4.00	13.09	13.13
RIL G42 × RIL G16	0.99	67.33	3.69	3.83	10.60	9.71
RIL G42 × RIL G38	1.20	100.00	4.24	2.69	15.46	13.43
RIL G42 × RIL G48	0.93	87.67	3.59	3.39	12.79	12.41
RIL G48 × RIL G4	0.89	100.00	2.50	4.09	14.34	13.15
RIL G48 × RIL G16	0.86	87.50	2.62	5.26	11.30	9.85
RIL G48 × RIL G38	0.93	100.00	3.08	4.18	14.69	15.53
RIL G48 × RIL G42	0.97	87.88	3.52	3.57	12.97	12.73
Mean	0.97	91.20	3.40	3.92	13.13	12.40
Gold Stone	0.79	100.00	3.73	4.46	12.65	11.08
Yathreb 7	0.89	100.00	3.29	3.97	13.43	14.36
L.S.D. $_{(0.05)}$	0.08	8.31	0.45	0.42	1.00	1.4

Meanwhile, hybrid RIL G42 × RIL G4 was significantly the earliest in flowering of perfect flowers, but was not significantly different from its reciprocal and hybrids RIL G16 × RIL G42, its reciprocal, RIL G42 × RIL G38, its reciprocal, RIL G4 × RIL G16 and its reciprocal. In the meantime, hybrid RIL G48 × RIL G38 was tardy in flowering of perfect flowers, but was not significantly different from its reciprocal and hybrids RIL G48 ×

RIL G16, Yathreb 7, RIL G38 × RIL G4 and its reciprocal. Referring to the early yield, the RIL G42 produced the highest early yield and was significantly different from all other evaluated parents. On the contrary, the lowest early yield was recorded in the RIL G38, but was not significantly different from RIL G48. As for the crosses, hybrid RIL G42 × RIL G16 had the highest early yield, but was not significantly different from hybrid RIL G42 × RIL G4. On the other side, the least early yield was given in the hybrid RIL G48 × RIL G38 and was significantly different from all other evaluated hybrids. Also, the RIL G42 produced the highest total yield and was significantly different from all other evaluated parents. While, the least total yield was recorded in RIL G4, but was not significantly different from G48. In the case of crosses, hybrid RIL G16 × RIL G38 had the highest total yield, but was not significantly different from its reciprocal and hybrids RIL G38 × RIL G4, RIL G16 × RIL G42 and their reciprocals, beside hybrids RIL G4 × RIL G16, RIL G48 × RIL G42 and Gold Stone. In contrast, the least total yield was produced in the hybrid Yathreb 7, but was not significantly different from hybrids RIL G42 × RIL G4, its reciprocal and RIL G4 × RIL G48. Regarding the marketable yield, RIL G38 had the highest marketable yield, but it was not significantly different from RIL G48. On the contrary, RIL G16 gave the least marketable yield, but it was not significantly different from RIL G4. In the same trait, the hybrid RIL G4 × RIL G48 produced the greatest marketable yield, but was not significantly different from hybrids RIL G38 × RIL G4, its reciprocal, RIL G38 × RIL G48, its reciprocal, RIL G38 × RIL G42, RIL G16 × RIL G48 and RIL G16 × RIL G4. While the least marketable yield was obtained in hybrid RIL G48 × RIL G16 and was significantly different from all other evaluated hybrids. Concerning the average fruit weight, the parent RIL G4 produced the heaviest fruit, but it was not significantly different from the parent RIL G42. By contrast, the parent RIL G48 gave the lowest average fruit weight, but it was not significantly different from the parent RIL G38. As for the crosses, hybrid RIL G4 × RIL G42 produced the heaviest fruit, but it was not significantly different from its reciprocal and hybrid RIL G16 × RIL G4. Meanwhile the least average fruit weight was obtained in hybrid Yathreb 7 and was significantly different from all other evaluated hybrids.

Concerning fruit shape index, RIL G42 produced cylindrical fruits, RILs G38 and G4 had round fruits and RILs G16 and G48 gave oblate fruits. Meanwhile most of the hybrids produced round fruits as well as hybrid RIL G4 × RIL G42, but hybrids RIL G4 × RIL G16, its reciprocal, RIL G16 × RIL G48, its reciprocal and hybrid Gold Stone gave oblate fruits. Likewise, hybrid RIL G42 × RIL G38 and its reciprocal produced cylindrical fruits. With respect to netting percentage, the RIL G4 had the highest netting percentage without significant differences from RIL G38. In contrast, the least netting percentage was observed in RIL G16 and was significantly different from all other evaluated RILs. Meanwhile in the hybrids, the hybrid RIL G4 × RIL G38 had the greatest netting percentage without significant differences from the most other evaluated hybrids. On the contrary, the hybrid RIL G16 × RIL G42 had the lowest netting percentage without significant differences from its reciprocal. Regarding the flesh thickness, RIL G42 gave the greatest flesh thickness and was significantly different from all other evaluated RILs. While the least flesh thickness was measured in RIL G48 without significant differences from RIL G16. As for the hybrids, the hybrid RIL G38 × RIL G42 had the greatest flesh thickness without significant differences from its reciprocal, hybrids RIL G16 × RIL G42 and RIL G4 × RIL G38. In contrast, hybrid RIL G48 × RIL G4 gave the lowest flesh thickness, but it wasn't significantly different from its reciprocal, hybrids RIL G16 × RIL G4, RIL G16 × RIL G48 and its reciprocal. Concerning seed cavity diameter, RIL G38 had the narrowest seed cavity diameter and was significantly different from all other evaluated RILs. On the other hand, the RIL G16 had the largest seed cavity diameter and was significantly different from all other evaluated RILs. In the hybrids case, the hybrid RIL G38 × RIL G42 had the narrowest seed cavity diameter, without significant differences from its reciprocal. On the contrary, the hybrid RIL G16 × RIL G48 had the largest seed cavity diameter without significant differences from its reciprocal. With respect to TSS, RIL G38 and RIL G16 had the highest and the least TSS, respectively, and were significantly different from all other evaluated RILs. Meanwhile in the hybrids, hybrid RIL G38 × RIL G42 had the highest TSS without significant differences from its reciprocal. In contrast, hybrid RIL G16 × RIL G42 had the least TSS, but it wasn't significantly different from its reciprocal, hybrids RIL G16 × RIL G4, its reciprocal and RIL G48 × RIL G16. As for fruit shelf life, the RIL G38 and RIL G16 had the highest and lowest fruit shelf life, respectively, and were significantly different from all other evaluated RILs. In the hybrids case, the hybrid RIL G38 × RIL G4 had the greatest fruit shelf life, without significant differences from its reciprocal, hybrids RIL G38 × RIL G48 and RIL G48 × RIL G38. In contrast, the hybrid RIL G16 × RIL G4 had the least fruit shelf life, without significant differences from its reciprocal, hybrids RIL G16 × RIL G42 and RIL G42 × RIL G16.

All these previous results confirmed that the best hybrid for planting under low tunnel was RIL G16 × RIL G38 which ranked first and fifth in total and early yield, respectively, and had high fruit quality. These results are in agreement with El-Aidy *et al* (2007) which reported that the best hybrids suitable for the low tunnel planting could be obtained it by studying the performance of these hybrids under plastic low tunnels. Likewise, the findings illustrated that no significant differences between each hybrid and its reciprocal in all studied traits except early yield and marketable yield, and this indicated that no maternal effect in all studied traits except the formed two traits.

Genetic Estimations

The early yield and average fruit weight are important traits in cantaloupe fruit quality and its market, which may be affected by low temperatures in the low tunnel season. The determination of the best two parents and hybrid based on these two traits in most of cases. So, the genetic estimations of these two traits were studied to define the genetic performance of these two traits in the previous different genotypes.

Combining Ability

Data in Table (3) show the estimated values of general combining ability effects for early yield and average fruit weight traits. Regarding the early yield, RILs G16 and G42 showed positive significant and highly significant GCA effects, respectively, but RILs G48 and G38 had negative significant and highly significant GCA effects, respectively. Similarly, both of RILs G4 and G42 exhibited positive highly significant GCA effects in average fruit weight trait, while RIL G48 had negative highly significant GCA effect. So, the RIL G42 is the potential parent (good combiner for both traits) that could be used in selection program and would be effective for its efficient use in subsequent crossing for development of the earliness and average fruit weight in cantaloupe under low plastic tunnels which are very important traits for melon's farmers.

Table 3. Estimation of parental general combining ability effects (GCA) for early yield and average fruit weight traits during the combined 2016/2017 and 2017/2018 winter seasons under low tunnel.

RILs	Early Yield (ton/fed.)	Average fruit weight (g)
RIL G4	0.027	55.50**
RIL G16	0.169*	11.74
RIL G38	- 0.237**	-7.65
RIL G42	0.259**	35.79**
RIL G48	-0.218*	-95.37**
LSD 1%	0.230	33.76
LSD 5%	0.139	20.41

As for specific combing ability, data in Table (4) show the estimated values of specific combining ability effects for early yield and average fruit weight traits. The hybrids RIL G42 × RIL G16, its reciprocal and RIL G4 × RIL G42 exhibited positive highly significant SCA effects for early yield trait. A positively significant SCA effect was shown by hybrid RIL G42 × RIL G4. While negative and significant SCA effects was shown by the hybrids RIL G38 × RIL G16 and RIL G42 × RIL G4 for the same trait.
Referring to average fruit weight, the hybrids RIL G4 × RIL G42, RIL G16 × RIL G38, G42 × RIL G4 for the same trait. Referring to average fruit weight, the hybrids RIL G4 × RIL G42, RIL G16 × RIL G38, RIL G4 × RIL G16, RIL G38 × RIL G48 and RIL G38 × RIL G42 showed positive highly significant SCA effects and the hybrid RIL G48 × RIL G38 had positive and significant SCA effect. In contrast, negative highly significant SCA effects were detected in hybrids RIL G4 × RIL G38 and RIL G16 × RIL G42 and negative significant SCA effects were exhibited in hybrids RIL G42 × RIL G48 and RIL G38 × RIL G4 for the same trait.

Comparing the general combining ability effects (GCA) of the parents to their corresponding crosses (SCA) indicating that the GCA effects of the parents were agreed with the SCA effects of the hybrids for early yield and average fruit weight traits.

Table 4. Estimation of specific combining ability (SCA) effects of 20 local cantaloupe hybrids for early yield and average fruit weight traits during the combined 2016/2017 and 2017/2018 winter seasons under low tunnel.

Crosses	Early yield (ton/feddan)	Average fruit weight (g)
RIL G4 × RIL G16	0.15	75.02**
RIL G4 × RIL G38	0.04	-76.15**
RIL G4 × RIL G42	0.30**	121.98**
RIL G4 × RIL G48	0.09	-4.74
RIL G16 × RIL G4	0.12	-17.09
RIL G16 × RIL G38	0.08	117.83**
RIL G16 × RIL G42	0.41**	-52.79**
RIL G16× RIL G48	0.02	-0.76
RIL G38 × RIL G4	0.04	-27.49*
RIL G38 × RIL G16	-0.21*	21.99
RIL G38 × RIL G42	0.02	66.28**
RIL G38 × RIL G48	0.12	74.62**
RIL G42 × RIL G4	0.21*	14.72
RIL G42 × RIL G16	0.55**	5.84
RIL G42 × RIL G38	0.03	11.96
RIL G42 × RIL G48	-0.01	-31.02*
RIL G48 × RIL G4	0.10	-16.11
RIL G48 × RIL G16	0.11	-9.35
RIL G48 × RIL G38	0.11	32.67*
RIL G48 × RIL G42	0.11	10.57
LSD 1%	0.22	36.77
LSD 5%	0.16	25.87

For instance, the RILs G42 and G16 had the highest positively significance and positively significance of GCA in early yield trait, respectively, and their hybrid RIL G42 × RIL G16 had the highest positively significance of SCA in early yield. Thus, the crossing between both good combiners RILs could produce superior combinations. Also, the crossing between good combiner and other poor RILs and vice versa may be produced good specific combinations. In some cases, when two poor combiners were crossed, best combinations were observed to be produced. Similar results were reported by Gurav *et al* (2000) and Chaudhary *et al* (2006). Based on the present results, it could be concluded that the production of hybrids based on the parental performance was practically true. Such results were also reported by Dhaliwal *et al* (2003) on tomato. The cross combinations that were observed as good specific combiners can be utilized as genetic resources for heterosis breeding or in obtaining desirable recombinants/segregants in subsequent generations for such traits.

Heterosis

The heterosis of mid and better parents for the twenty hybrids are presented in Table 5. All the hybrids showed highly significant mid and better parents heterosis for the early yield trait indicating predominance of non-additive gene action in genetic control of this trait.

Table 5. Mid and better parents heterosis of early yield and average fruit weight in the 20 local cantaloupe hybrids evaluated during the combined 2016/2017 and 2017/2018 winter seasons under low tunnel.

Crosses	Early yield (ton/feddan)		Average fruit weight (g)	
	MPH (%)	BPH (%)	MPH (%)	BPH (%)
RIL G4 × RIL G16	85.52**	62.70**	34.72	22.08
RIL G4 × RIL G38	90.63**	61.38**	9.26	-8.59
RIL G4 × RIL G42	91.58**	59.65**	42.87	39.51
RIL G4 × RIL G48	100.58**	82.54**	11.76	-9.43
RIL G16 × RIL G4	117.19**	90.48**	41.12	27.88
RIL G16 × RIL G38	101.05**	52.38**	68.63*	54.20
RIL G16 × RIL G42	105.96**	94.04**	14.39	5.95
RIL G16× RIL G48	81.28**	46.03**	18.59	4.59
RIL G38 × RIL G4	77.50**	50.26**	20.40	0.73
RIL G38 × RIL G16	63.35**	23.81**	58.60*	45.02
RIL G38 × RIL G42	67.71**	22.11**	46.23	24.77
RIL G38 × RIL G48	95.77**	81.70**	57.02*	50.89
RIL G42 × RIL G4	143.79**	103.16**	37.76	34.52
RIL G42 × RIL G16	133.52**	120.00**	12.15	3.87
RIL G42 × RIL G38	76.87**	28.77**	41.24	20.51
RIL G42 × RIL G48	75.85**	35.44**	10.95	-8.39
RIL G48 × RIL G4	66.86**	51.85**	18.51	-3.97
RIL G48 × RIL G16	48.77**	19.84**	23.02	8.51
RIL G48 × RIL G38	51.41**	40.52**	39.90	34.44
RIL G48 × RIL G42	45.79**	12.28**	6.40	-12.15
LSD 1%	0.201	0.232	76.87	88.76
LSD 5%	0.139	0.161	53.36	61.62

NS, *, **: insignificant, significant and highly significant at 0.05 and 0.01 level, respectively

The hybrids RIL G42 × RIL G4, RIL G42 × RIL G16, RIL G16 × RIL G4 and RIL G16 × RIL G42 had highly significant, desirable positive heterosis and heterobeltiosis beside the greatest values of both of them for early yield. This result is coincided with Duradundi *et al* (2018) who reported that early yield had positive strong heterosis and farmers prefer to grow early and high yielding hybrids in order to catch early market to get higher prices and to avoid market glut. Therefore, earliness is an important trait in vegetables like muskmelon. In contrast, the average fruit weight showed significant heterosis in hybrids RIL G16 × RIL G38, its reciprocal and RIL G38 × RIL G48 only, while non-significant heterobeltiosis was shown in all hybrids for the same trait.

Heritability

The coefficient of variation, genotypic and phenotypic coefficient of variations and broad- sense heritability are presented in Table (6).

Table 6. Estimated genotypic and phenotypic variances (GCV and PCV) and broad-sense heritability (h^2_b) values of early yield and average fruit weight traits during the combined 2016/2017 and 2017/2018 winter seasons under low tunnel.

Genotypes	Average fruit weight (g)	Early yield(ton/feddan)
CV	7.94	10.01
$\sigma^2 e$	2228.900	0.014
$\sigma^2 g$	13663.967	0.165
$\sigma^2 p$	15892.867	0.179
GCV%	19.658	34.129
PCV%	21.201	35.565
h^2_b	85.975	92.086

The variance was varied from average fruit weight to early yield traits, since the coefficient of variance was 7.94 and 10.01% for average fruit weight and early yield, respectively. The average fruit weight variation was higher than early yield variation. Estimated genotypic coefficient of variance (GCV %) vs. phenotypic one (PCV %) were 19.658 vs. 21.201% for average fruit weight and 34.129 vs. 35.565% for early yield. The results are in disagreement with those obtained by Janghel *et al* (2018). Broad sense heritability (h^2_b) was 85.975 and 92.086 for average fruit weight and early yield, respectively. Small difference were observed between GCV and PCV in average fruit weight and early yield, indicating the importance of the genetic effects in controlling the inheritance of these two traits. So, the high value of (h^2_b) indicating that the cantaloupe can be improved through selection based on phenotypic observation. These results are in agreement with Burton (1952).

Finally, a highly positive correlation (r = 0.93) was detected between early yield and flowering in cantaloupe RILs, suggesting that the selection of early flowering could be associated with great early yield and this could save effort for the melon breeders. This result is disagreement with those of Zalapa *et al* (2008) who reported that negative correlation between early pistillate flowering and fruit maturity in melon**.**

In conclusion, The hybrid RIL G16 × RIL G38 was very suitable for cultivating under low tunnels during winter seasons which ranked first and fifth in total and early yield, respectively, and had high fruit quality, high positive better and mid parents heterosis for average fruit weight and early yield and ranked second in SCA for average fruit weight. The estimation of GCV, PCV and h^2_b for average fruit weight and early yield confirmed that the cantaloupe can be improved through selection in these two traits. Also, the selection for early flowering in cantaloupe was associated with high early yield.

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إستنباط هجن كنتالوب محلية جديدة للزراعة تحت الإنفاق البلاستيكية

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أُجريت هذه الدراسة خلال الفترة من ٢٠١٦ إلى ٢٠١٨ لتحسين الإنتاجية وصفات الجودة فى محصول الكنتالوب المزروع تحت الإنفاق البلاستيكية فى المواسم الشتوية لزيادة التبكير ومتوسط وزن الثمرة من خلال التلقيح بين خمسة سلالات آبوية من الكنتالوب منتخبة من برنامج تربية سابق فى اتجاهين (هجن وهجن عكسية) لإنتاج عشرون هجين. تم تقييم العشرون هجين وهجين عكسى بجانب آبائهم الخمس وهجنين تجاريين (يثرب ٧ وGold Stone) استخدموا ككنترول لتحديد انسب هذه الهجن للزراعة تحت الإنفاق البلاستيكية فى العروات الشتوية، بالإضافة لتقدير بعض التقديرات الوراثية لصفتى المحصول المبكر ومتوسط وزن الثمرة لمعرفة السلوك الوراثى لهاتين الصفتين تحت الإنفاق البلاستيكية فى المواسم الشتوية. اثبتت النتائج ان أفضل هجين للزراعة تحت الإنفاق البلاستيكية كان RIL G16 × RIL G38 والذى احتل المرتبة الأولى والخامسة فى المحصول الكلى والمبكر، على التوالى، كما احتوى على صفات جودة مرتفعة. وقد كانت أعلى قيمة لقوة الهجين لمتوسط وأفضل الآبوين ١٤٣,٧٩ و ١٢٠,٠٠٪ فى هجن RIL G4 ×RIL G42 و RIL G16 × RIL G42 ، على التوالى، لصفة المحصول المبكر. ايضاً كانت أعلى قيمة لقوة الهجين لمتوسط الآبوين ٦٨,٦٣ فى هجين RIL G16 × RIL G38 لصفة متوسط وزن الثمرة، ولكن لم تظهر اى اختلافات معنوية لقوة الهجين للأب الأفضل فى كل الهجن لنفس الصفة. توافقت نتائج القدرة العامة على الإئتلاف للآباء مع نتائج القدرة الخاصة على الإئتلاف التى ظهرت فى الهجن لصفتى المحصول المبكر ومتوسط وزن الثمرة. ايضاً كان معامل الإختلاف ٧,٩٤ و١٠,٠١٪ لمتوسط وزن الثمرة والمحصول المبكر، على التوالى. وصل معامل الإختلاف الوراثى والمظهرى إلى ١٩,٦٥٨ و٢١,٢٠١٪، على التوالى، لمتوسط وزن الثمرة، و٣٤,١٢٩ و٣٥,٥٦٥٪، على التوالى، للمحصول المبكر. لوحظ ان الفرق بين معامل الإختلاف الوراثى والمظهرى كان صغيراً لصفتى متوسط وزن الثمرة والمحصول المبكر، ويشير ذلك إلى أهمية التأثيرات الوراثية فى التحكم فى وراثة هاتين الصفتين. اما كفاءة التوريث على النطاق العريض فكانت ٨٥,٩٧٥ و ٩٢,٠٨٦ لصفتى متوسط وزن الثمرة والمحصول المبكر، على التوالى. لذلك اشارت القيم المرتفعة لدرجة التوريث على النطاق العريض ان تحسين الكنتالوب يمكن يتم من خلال الإنتخاب المظهرى. اخيراً، وجد ارتباط ايجابى معنوى جداً ($r= 0.93^{**}$) بين المحصول المبكر والتبكير فى التزهير فى الكنتالوب، مما يشير ان الإنتخاب للإزهار المبكر يصاحبة صفة المحصول المبكر المرتفع، مما يوفر الجهد على مربى الكنتالوب.

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