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PRODUCTION OF LOCAL TOMATO HYBRIDS SHOW HIGH YIELDING ABILITY AND HEAT TOLERANCE

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ABSTRACT

The objective of the present investigation was to identify desired parents and cross combinations show high yielding ability under heat stress conditions in Egypt as well as to gather information on genetic behavior of some traits associated with yield and its components under heat stress conditions.

Nine parents diallel crosses, involving Egyptian and exotic tomato germplasm were done. Then the parents and their 36 F_1's were evaluated during the late summer season 2002.

The results revealed that both general and specific combining abilities were highly significant for all studied traits. Therefore, both additive and non-additive gene actions were important in the expression of these traits. The magnitudes of additive genetic variances were larger than those of the non-additive variances for number of branches / plant, total yield and TSS%. However for other traits, the dominance gene effects play the major role in the inheritance of these traits.

Heterosis over mid-parents or better parents was present in most of crosses for these traits. Edkaway, CLN 1355 and CLN 2026D, were good combiners for vegetative traits. The parental lines CLN 1355, Tolalakheen and EM9 were considered good combiners for fruit set percentage. Talalakheen, CLN 1355, CLN 2025C and EM9, were good combiners for early and total yield. FM9, Castle Rock and LHT 24 were good combiners for average fruit weight. FLa 7156 was the best combiner for fruit firmness, TSS% and ascorbic acid content.

In addition both broad and narrow-sense heritabilities values were high for all studied traits, indicating that all traits were highly heritable.

Out of the present study, there were some desirable genotypes appeared high yielding ability and quality traits under heat stress conditions in late summer in Kafr El-Shiekh, Egypt, these genotypes were FM9 as cultivar and the hybrid Castle Rock x FM9.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is the most important vegetable crop grown in Egypt for fresh consumption and processing. According to Ministry of Agriculture Statics (2002), the cultivated area of tomato was 454.988 feddans that produced 6.777.875 tons.

Tomato is grown in most parts of the world from the tropics to within few degrees of the Arctic Cycle (Rick, 1976). It is adapted to a wide range of climates, however, fruit set is limited to somewhat narrow ranges. In Egypt, tomato production is always limited and prices are high during October. This is due to the unfavorable high temperature prevailing during flowering in the preceding months, which seriously reduces fruit set. This happen during June, July and August , when night and day temperature became unfavorably high for fruit set (Metwally *et al.*, 1990 and 1996). Therefore, the heat-tolerant cultivars capable of setting fruits during this particular period are urgently needed.

MATERIALS AND METHODS

Inbred lines of nine tomato cultivars namely; CLN 1355, CLN 2026C, CLN 2026D, FLa 7156, LHT 24, FM 9, Talalakheen, Edkawy and Castle Rock were included. All cultivars are belonging to the species *Lycopersicon esculentum* Mill. The first three lines were obtained from Asian Vegetable Research and Development Center (AVRDC) in Taiwan. These cultivars differed greatly in their traits, i.e., fruit set percentage under high temperature conditions, fruit weight, fruit firmness and growth habit.

In 2000/2001 season, the nine parents were crossed in all possible combinations without reciprocals to produce 36 F_1 hybrids. All parental lines were also self pollinated to increase their seeds.

In late summer season (2002), 45 entries, which included nine parental lines and 36 F_1 hybrids were grown in a randomized complete block design with four replications.

Each block contained 45 plots. The plot consisted of two ridges, each one 5 m long and 1.3 m wide, thus making an area of 13 m^2.

Seeds of 45 genotypes were sown in a nursery in seedling trays on April 15th of 2002. The 40 days tomato seedlings were transplanted on 20 May 40 cm apart. Each plot contained 24 plants. The experiment was conducted at a private farm in Disuq district, Kafr El-Sheikh governorate.

Routine culture practices were done similar to those used in tomato production at Disuq district. The average monthly maximum and minimum temperature and relative humidity from May to October, 2002 are shown in Table 1.

Table 1. Average maximum and minimum temperatures and relative humidity % during the growing season (2002).

	Temperature (°C)		RH (%)	
	Maximum	Minimum	Maximum	Minimum
May	30.2	13.6	71.0	39.5
June	32.3	18.4	75.0	51.6
July	34.4	21.0	83.0	52.3
August	33.6	20.3	82.3	48.3
September	34.0	19.8	79.0	43.8
October	28.9	16.0	88.4	48.4

Source: Sakha Agriculture Research Station, Kafr El-Shekh governorate.

Measurements:

Five plants from each experimental unit (plot) were randomly chosen, where the following data were recorded:

- Vegetative traits; i.e., plant height, number of branches / plant and plant size (plant height x plant wide x 40 cm apart plants).
- Fruit set percentage: Number of the flowers that set fruit in the first three inflorescences / total number of flowers that anthesis in the first three inflorescences x 100.
- Yield components; i.e., early yield (fruit weight in the first two harvests) and total yield (weight of all harvested fruits).

- Some fruit characteristics; i.e., average fruit weight, fruit firmness, total soluble solids (using hand refractometer) and ascorbic acid content (mg/100g fresh weight) (AOAC, 1970).

Data were subjected to the analysis of variance in order to test the significance of the differences among the nine parents and their F_1 hybrids. A regular analysis of variance of a complete randomized block design was conducted. LSD test was used for the comparison among genotype means. Half diallel crosses analysis was done to provide the information about general and specific combining ability, and at the same time to estimate various types of gene effects (Griffing, 1956).

The amount of heterosis was expressed as the deviation percentage of F_1 mean performance from the mid-parent (MP) or better parent (BP) average values.

Heritability was estimated according to the following formula (Mather and Jinks, 1971).

Heritability:

$$\text{Broad sense} = \frac{\frac{1}{2}D + \frac{1}{2}H_1 - \frac{1}{4}H_2 - \frac{1}{2}E}{\frac{1}{2}D + \frac{1}{2}H_1 - \frac{1}{4}H_2 - \frac{1}{2}F + E} \times 100$$

$$\text{Narrow sense} = \frac{\frac{1}{2}D + \frac{1}{2}H_1 - \frac{1}{2}H_2 - \frac{1}{2}E}{\frac{1}{2}D + \frac{1}{2}H_1 - \frac{1}{4}H_2 - \frac{1}{2}F + E} \times 100$$

RESULTS AND DISCUSSION

The performance of parents and their F_1 hybrids:

Means of plant height, number of branches / plant, plant size, fruit set percentage, early yield / plot, total yield / plot, average fruit weight, fruit firmness, TSS% and ascorbic acid content of the nine parental lines and their hybrids are given in Tables 2 and 3.

As the analysis of variance (Table 3) revealed that highly significant differences among the genotypes for all studied traits. This indicates that the planned comparison could be made as well as the variability among the populations was existed.

The results of diallel analysis and the mean squares of the F_1 hybrids and their parents for all studied traits are presented in Table 3. Mean square due to GCA and SCA were highly significant. This indicates that both additive and non-additive gene action are involved in the inheritance of all studied traits.

This fact was confirmed by many investigators among them; Omar *et al.* (1988), Sherif and Hussein (1992), Metwally *et al.* (1988, 1990 and 1996) and Bayomy (2002).

Data in Table 2 show that the parent Edkaway (8) and its hybrids combinations (2 x 8, 3 x 8, 5 x 8 and 6 x 8) had highest values for vegetative traits (plant height, number of branches / plant and plant size). These traits are very important in late summer season for protecting the fruits from sunscald.

Table 2. Mean performance for plant height, number of branches / plant, plant size, fruit set % and early yield of parents and their F_1 hybrids in tomato.

No.	Genotypes	Plant height (cm)	No. of branches / plant	Plant size (dm^3)	Fruit set (%)	Early yield (kg/plot)
1	CLN 1355	89.0	10.3	234	53.6	3.2
2	CLN 2026C	70.0	9.7	217	49.3	8.4
3	CLN 2026D	61.0	10.0	177	50.1	16.0
4	FLa 7156	74.0	16.0	238	34.1	16.0
5	LHT 24	79.0	14.3	251	35.3	6.6
6	FM 9	72.0	16.3	238	52.9	4.8
7	Talalakheen	64.0	18.0	200	53.7	17.2
8	Edkawy	99.0	21.3	434	21.3	1.4
9	Castle Rock	73.0	16.7	247	39.1	2.2
10	1 x 2	85.0	12.3	293	59.7	8.6
11	1 x 3	88.0	12.0	350	68.4	17.6
12	1 x 4	90.0	12.3	353	47.9	6.4
13	1 x 5	88.0	7.3	333	48.9	9.2
14	1 x 6	86.0	9.3	321	53.7	11.2
15	1 x 7	88.0	10.7	328	55.3	13.2
16	1 x 8	70.3	10.0	288	59.1	0.4
17	1 x 9	89.0	11.0	369	42.4	4.4
18	2 x 3	77.3	13.3	303	49.0	8.4
19	2 x 4	93.8	13.3	395	48.8	5.2
20	2 x 5	72.8	9.3	301	63.3	23.6
21	2 x 6	70.0	11.3	276	50.9	5.8
22	2 x 7	76.0	15.7	326	34.3	17.6
23	2 x 8	96.0	15.0	460	35.1	4.6
24	2 x 9	82.0	11.3	302	34.6	4.2
25	3 x 4	76.0	10.0	247	49.5	2.0
26	3 x 5	72.0	8.7	244	46.7	13.0
27	3 x 6	70.0	12.7	249	52.9	8.6
28	3 x 7	72.0	12.0	263	54.8	14.6
29	3 x 8	93.0	14.7	371	47.4	5.2
30	3 x 9	69.0	15.0	242	28.1	6.2
31	4 x 5	65.0	11.3	232	37.9	2.0
32	4 x 6	58.0	14.7	179	53.3	2.4
33	4 x 7	54.0	11.7	172	72.6	10.6
34	4 x 8	80.0	16.7	280	30.8	2.4
35	4 x 9	56.0	16.3	173	45.9	5.0
36	5 x 6	61.0	15.3	163	51.3	5.2
37	5 x 7	58.0	19.7	180	46.0	4.6
38	5 x 8	90.0	19.0	307	34.7	2.2
39	5 x 9	66.0	22.7	243	43.4	5.4
40	6 x 7	72.0	23.0	276	47.2	14.2
41	6 x 8	102.0	24.3	468	37.5	1.2
42	6 x 9	64.0	17.3	210	50.0	6.0
43	7 x 8	91.0	19.7	496	49.2	7.2
44	7 x 9	66.0	18.3	253	38.3	9.2
45	8 x 9	96.0	20.7	501	40.8	3.6
F test		**	**	**	**	**
LSD	5%	3.47	1.13	27.12	5.83	3.22
	1%	4.89	1.58	38.15	8.20	4.54

Table 3. Mean performance for fruit yield and some fruit traits of parents and their F_1 hybrids in tomato.

No.	Genotypes	Total yield (kg/plot)	Average fruit weight (g)	Fruit firmness	TSS (%)	V.C. mg/100g fresh weight
1	CLN 1355	26.4	62.8	630.0	6.0	27.1
2	CLN 2026C	36.6	47.1	722.5	5.8	30.0
3	CLN 2026D	33.6	52.8	857.5	6.0	25.0
4	FLa 7156	24.8	58.2	572.5	6.5	25.0
5	LHT 24	33.0	61.5	760.0	5.6	23.6
6	FM 9	45.2	71.3	887.5	5.0	25.7
7	Talalakheen	57.2	35.1	630.0	6.0	25.0
8	Edkawy	21.2	66.8	712.5	7.0	25.0
9	Castle Rock	28.0	86.7	882.5	6.8	25.0
10	1 x 2	64.8	62.6	667.5	6.5	28.6
11	1 x 3	63.4	47.5	612.5	7.0	25.0
12	1 x 4	41.8	43.7	972.5	7.0	28.6
13	1 x 5	45.0	45.1	872.5	6.8	27.1
14	1 x 6	57.6	60.4	960.0	6.5	30.7
15	1 x 7	57.0	44.6	495.0	6.8	35.7
16	1 x 8	44.2	40.9	742.5	6.4	30.0
17	1 x 9	41.2	58.0	945.0	6.8	28.6
18	2 x 3	38.0	50.1	700.0	7.0	28.6
19	2 x 4	35.4	60.5	742.5	7.0	28.6
20	2 x 5	60.8	67.5	657.5	6.0	21.4
21	2 x 6	49.8	58.8	810.0	5.5	27.1
22	2 x 7	49.6	52.8	555.0	6.4	35.7
23	2 x 8	28.8	40.0	520.0	6.4	35.7
24	2 x 9	24.2	41.0	995.0	7.0	30.3
25	3 x 4	20.2	35.6	910.0	7.5	27.9
26	3 x 5	24.8	49.9	822.5	6.5	25.0
27	3 x 6	30.4	56.3	960.0	6.5	25.0
28	3 x 7	38.6	39.0	920.0	6.8	24.3
29	3 x 8	24.8	43.0	487.5	6.5	24.3
30	3 x 9	18.2	52.0	975.0	6.8	29.3
31	4 x 5	20.0	56.2	847.5	6.5	25.0
32	4 x 6	20.8	44.6	587.5	6.5	32.1
33	4 x 7	32.2	40.0	707.5	6.4	25.7
34	4 x 8	21.0	47.6	707.5	6.5	25.0
35	4 x 9	31.0	58.2	940.0	7.0	30.7
36	5 x 6	35.0	62.8	705.0	5.5	20.0
37	5 x 7	28.8	53.7	517.5	6.5	28.6
38	5 x 8	24.4	42.5	485.0	6.8	28.6
39	5 x 9	35.8	59.9	620.0	6.5	25.0
40	6 x 7	48.4	73.9	450.0	5.8	27.1
41	6 x 8	34.0	66.1	397.5	6.0	25.0
42	6 x 9	49.4	80.4	920.0	6.0	21.4
43	7 x 8	32.6	51.7	462.5	6.0	25.0
44	7 x 9	36.6	51.3	787.5	6.5	23.6
45	8 x 9	30.4	52.4	870.0	7.0	21.4
F test		**	**	**	**	**
5%		10.40	5.41	80.91	0.24	0.27
LSD	1%	14.62	7.61	113.8	0.33	0.38

Table 4. Half diallel analysis of variance and the mean squares of the F_1 hybrids and their parents for plant height, number of branches / plant, plant size, fruit set % and early yield.

S.O.V.	D.F.	Plant height (cm)	No. of branches / plant	Plant size (dm^3)	Fruit set (%)	Early yield (kg/plot)
Replication	3	1163.487**	127.038**	56762.139**	3689.244**	70.427**
Genotype	44	641.811**	71.537**	31270.539**	397.886**	24.386**
Error	132	12.203	1.282	743.931	34.387	2.631
GCA	8	484.733**	62.292**	23064.694**	235.512**	18.199**
SCA	36	88.447**	8.047**	4430.255**	69.065**	3.415**
GCA/SCA		5.480	7.741	5.206	3.410	5.329

Table 5. Half diallel analysis of variance and the mean squares of the F_1 hybrids and their parents for total yield, and some fruit traits.

S.O.V.	D.F.	Total yield (kg/plot)	Average fruit weight (g)	Fruit firmness	TSS (%)	Ascorbic acid mg/100g fresh weight
Replication	3	1823.625**	290.365**	481388.704**	0.673**	0.296
Genotype	44	160.727**	538.093**	113242.980**	1.081**	70.422**
Error	132	27.310	29.563	6625.067	0.057	0.074
GCA	8	117.033**	333.135**	55636.994**	0.8651	26.289
SCA	36	23.123**	90.489**	22238.244**	0.1402	15.669
GCA/SCA		5.061	3.681	2.502	6.170	1.677

*** and ** significant at P = 0.05 and P = 0.01, respectively**

In this concern, many investigators among them; Salib (1999) and Bayomy (2002) reported that F_1 hybrids were more vigorous in vegetative traits than their parents. Concerning fruit set percentage, it is the limited factor for any entries grown in this time (late summer season).

Data presented in Tables 4 and 5 show that entries under studied divided into three groups, the first group (1, 2, 3, 6, 7) give average fruit set percentage about 50%, the second group (4, 5, 9) show average fruit set percentage about 35%, the third group give lowest average fruit set percentage (about 20%). Generally, F_1 crosses had fruit set percentage more than parents, the hybrid 4 x 7 had the largest value of fruit set % (72%), this hybrid produced from two different parents for fruit set % (medium x high). This fact was confirmed by many investigators among them; Sherif and Hussein (1992), Hegazi *et al.* (1995).

Concerning early and total yield, data presented in Table 2 show that the parent Talalakheen gave the highest early yield (17.2 kg/plot). However, the parent Edkawy produced the lowest early yield (1.4 kg/plot). The cross 2 x 5 produced highest early yield (23.6 kg/plot). Total yield for parents ranged from 21.4 kg/plot in Edkawy cultivar to 57.2 kg/plot in Talalakheen cultivar, but the crosses exceeded to parents, the cross 1 x 2 produced 64.8 kg/plot and the cross 1 x 6 produced 57.6 kg/plot. In general, F_1 crosses produced higher fruit yield (early and total yield) than their parents.

This fact was confirmed by many investigators among them; Sherif and Hussein (1992), Srivastava *et al.* (1998) and Salib (1999). For about fruit characteristics, data in Table 3 show that Castle Rock cv. had the largest average fruit weight (86.79 g/fruit), while the Talalakheen parent had the smallest average fruit weight (35.1 g/fruit). The cross 6 x 9 had the highest average fruit weight (80.4 g/fruit).

Concerning fruit firmness, cultivars FM 9 and FLa 7156 had the highest (887.5) and lowest (572.5) values of fruit firmness, respectively. Edkawy cv had the highest values of TSS% (7.0%) in their fruits, however, FM 9 cv had the lowest value (5.0%) from TSS% in their fruits.

CLN 2026 cv had the largest value of V.C (30 mg/100g fresh weight) in their fruits. In general, F_1 hybrids produced fruits with more quality characters than their parents. Many investigators among them; Youssef (1997), Bhatt *et al.* (1998), Salib (1999) and Bayomy (2002) confirmed this fact.

Heterosis:

The estimation of mid and better parent heterosis for all studied traits are present in Tables 6, 7, 8 and 9 for plant height, heterosis ranged from -25.21 to 30.01 and -28.99 to 26.24% over MP and BP, respectively. Eighteen and five hybrids showed significant and positive heterosis over MP and BP, respectively. The hybrid 2 x 4 had the highest values (30.0 and 26.24%) over MP and BP, respectively.

For about number of branches / plant heterosis ranged from -40.65 to 46.45% and -53.93 to 35.93% over MP and BP, respectively. Ten and seven hybrids showed significant and positive heterosis over MP and BP, respectively. The hybrid 5 x 9 had the largest values (46.45 and 35.93%) over MP and BP, respectively.

For plant size, heterosis ranged from -33.10 to 73.60% and -35.50 to 65.76% over MP and BP, respectively. Twenty one and sixteen hybrids showed significant and positive heterosis over MP and BP, respectively. The hybrid 2 x 4 had the largest value (73.60 and 65.76%) over MP and BP, respectively.

For about fruit set %, heterosis ranged from -37.0 to 65.38% and -29.82 to 35.20% over MP and BP, respectively. Fourteen and three hybrids showed significant and positive heterosis over MP and BP, respectively. Heterosis over MP and BP, the hybrid 4 x 7 had the largest values (65.38 and 35.20%), respectively.

Concerning early and total yield, data in Tables 4 and 5 show that in early yield, heterosis ranged from -57.14 to 370.0% and -75.00 to 193.55% over MP and BP, respectively. Nine hybrids showed significant and positive heterosis over MP, while three hybrids showed significant and positive heterosis over BP. The cross 1 x 8 had the largest values (370.0 and 193.55%) over MP and BP, respectively.

In total yield, data show that heterosis over the MP ranged from -40.57 to 111.33%, while heterosis over the BP ranged from -53.98 to 88.69%. Ten and five hybrids showed significant and positive heterosis over MP and BP, respectively. The best hybrids over the BP (1 x 3) produced 88.69% total fruit yield over his better parent. This is in agreement with the results obtained by

Metwally *et al.* (1990 and 1996), who found for tomato grown under high temperature that heterosis over MP and BP was significant in some crosses and non-significant or absent in the other crosses for the total yield / plant.

Table 6. Estimations of heterosis as percentage of mid-parents for plant height, number of branches / plant, fruit set % and early yield.

Crosses	Plant height (cm)	No. of branches / plant	Plant size (dm^3)	Fruit set (%)	Early yield (kg/plot)
1 x 2	7.30**	23.00**	30.37**	16.03*	48.28
1 x 3	16.83**	18.23**	70.82**	31.92**	83.33**
1 x 4	10.59**	-6.46	49.60**	9.24	166.67**
1 x 5	5.24*	-40.65**	37.31**	10.01	87.76*
1 x 6	6.63*	-30.08**	36.89**	0.85	180.00**
1 x 7	16.08**	-24.38**	51.34**	3.08	57.14*
1 x 8	-25.21**	-36.71**	-13.68**	47.93**	370.00**
1 x 9	10.01**	-18.52**	53.57**	-8.52	62.96*
2 x 3	17.75**	35.03**	53.98**	-1.41	-31.15
2 x 4	30.01**	3.50	73.60**	17.03*	4.00
2 x 5	-2.82	-22.50**	]28.69**	39.01**	214.67**
2 x 6	-1.62	-13.08*	21.90**	-0.39	-12.12
2 x 7	13.43**	13.36**	56.52**	-33.40**	14.55
2 x 8	13.61**	-3.23	41.26**	-7.14	0.00
2 x 9	14.85**	-18.18**	29.80**	-21.72**	-20.75
3 x 4	11.80**	-23.08**	27.68**	17.58*	-54.55
3 x 5	3.21	-28.40**	13.90	9.37	15.04
3 x 6	4.49	-3.42	8.67	2.72	-17.31
3 x 7	14.60**	-14.29**	39.67**	5.59	-1.35
3 x 8	15.78**	-6.07	21.36**	24.08*	-38.10
3 x 9	2.61	12.36*	14.27	-37.00**	-31.87
4 x 5	-14.70**	-25.41**	-5.17	9.22	-51.22
4 x 6	-20.87**	-8.98*	-24.47**	22.53**	-25.00
4 x 7	-21.48**	-31.18**	-21.43**	65.38**	39.47
4 x 8	-7.91**	-10.46**	-16.70**	1.99	100.00
4 x 9	-24.13**	-0.31	-29.12**	25.41	163.16
5 x 6	-19.52**	0.00	-33.10**	16.33	-5.26
5 x 7	-18.35**	21.98**	-20.51**	3.37	-54.46**
5 x 8	1.01	6.74	11.37*	12.66	-40.54
5 x 9	-12.93**	46.45**	4.21	16.67	22.73
6 x 7	5.36	34.11**	26.57**	-11.44	54.35*
6 x 8	18.86**	29.26**	39.68**	-5.30	-57.14
6 x 9	-11.37**	4.85	-13.18	8.70	71.43
7 x 8	11.66**	0.25	66.50**	29.25**	0.00
7 x 9	-3.51	5.48	12.95	-17.46*	16.46
8 x 9	12.11**	8.95*	46.97**	24.77*	140.00
5%	4.24	1.37	33.07	7.11	1.97
LSD 1%	5.60	1.82	43.76	9.41	2.60

* and ** significant at P = 0.05 and P = 0.01, respectively

Table 7. Estimations of heterosis as percentage of mid-parents for total yield and some fruit traits.

Crosses	Total yield (kg/plot)	Average fruit weight (g)	Fruit firmness	TSS (%)	Ascorbic acid mg/100g fresh weight
1 x 2	105.71**	13.92*	2.89	10.17**	0.18
1 x 3	111.33**	-17.68**	-14.49*	16.67**	-4.05**
1 x 4	63.28*	-27.77**	69.50**	12.00**	9.79**
1 x 5	51.52*	-27.76**	43.03**	17.24**	6.90**
1 x 6	60.89	-10.58*	-5.64	18.18**	16.29**
1 x 7	36.36**	-8.89	-17.84*	13.33**	36.52**
1 x 8	84.94**	-36.88**	15.34*	-1.54	15.61**
1 x 9	51.47*	-22.41**	41.84**	0.74	10.21**
2 x 3	8.26	0.30	-11.39*	18.64**	4.38**
2 x 4	15.31	14.72*	14.67	13.82	4.00**
2 x 5	74.71**	23.94**	-3.84	5.26*	-19.78**
2 x 6	21.76	-1.84	0.62	1.35	-2.69**
2 x 7	3.62	28.71**	-17.98*	8.47**	29.35**
2 x 8	-0.69	-29.76**	-27.53**	0.00	30.29**
2 x 9	-25.08	-38.71**	34.46**	5.26*	9.49**
3 x 4	-30.82	-35.74**	27.27**	20.00**	12.05**
3 x 5	-25.53	-12.53**	9.48	12.07**	4.13**
3 x 6	-22.84	-9.85	10.03	18.18**	2.18**
3 x 7	-14.98	-11.06	23.70**	10.00**	-2.80**
3 x 8	-9.82	-27.97**	-37.90**	0.00	-2.02**
3 x 9	-40.91	-25.34**	-20.74**	0.74	18.15**
4 x 5	-32.87	-6.10	39.22**	7.44**	2.88**
4 x 6	-40.57*	-32.11**	-19.52**	13.04	26.63**
4 x 7	-19.02	-14.04	19.75*	2.40	2.39**
4 x 8	-9.09	-23.34**	10.12	-3.70	0.400
4 x 9	17.42	-18.70**	41.35**	0.00	3.29**
5 x 6	-10.49	-6.13	-7.79	3.77	-18.86**
5 x 7	-36.14*	11.18	-18.82*	12.07**	17.21**
5 x 8	-10.29	-33.75**	-28.55**	6.35**	18.18**
5 x 9	17.38	-19.16**	-11.59	-3.82	3.31**
6 x 7	-5.47	37.62**	-40.69**	5.45*	6.48**
6 x 8	2.10	-4.82	-50.63**	0.00	-0.99
6 x 9	34.97*	0.75	-9.42	-4.00	-15.25
7 x 8	-17.05	1.47	-31.20**	-7.69**	0.00
7 x 9	-14.08	-15.76**	13.51*	-3.70	-65.00**
8 x 9	23.08	-31.73**	18.37**	-6.21**	-54.03**
5% LSD	6.34	6.59	98.69	0.29	0.33
1%	8.38	8.72	130.59	0.38	0.44

* and ** significant at P = 0.05 and P = 0.01, respectively

Concerning fruit characteristics, data in Tables 6, 7, 8 and 9 show that in average fruit weight, heterosis over MP ranged from -38.71 to 37.62%,

while heterosis over the BP ranged from -52.71 to 22.60%. Five and one crosses out of 36 ones had positive and significant values of heterosis over MP and BP, respectively. Therefore, heterosis over the MP was absent in 31 crosses from 36, while heterosis over the BP was absent in 35 crosses from 36. Cross 6 x 7 had the highest value (37.62%) over MP, while cross 7 x 8 had the highest value (22.60%) over BP. All crosses under the applied mating system were between (heat-tolerant with small-fruited and heat-sensitive with large-fruited) genotypes. Accordingly, both heterosis over MP or BP under the present study, most crosses had negative values. In this concern, Scott *et al.* (1986) and Metwally *et al.* (1990 and 1996), who found for tomato grown under high temperature that both heterosis over MP or BP was absent in most crosses for average fruit weight.

For about fruit firmness, heterosis ranged from -50.63 to 69.50% and -55.49 to 69.13% over MP and BP, respectively. Twelve and six crosses out of 36 ones of each showed significant and positive values heterosis over MP and BP, respectively. The cross 1 x 4 had the highest value over MP and BP. For TSS%, heterosis ranged from -7.69 to 20.0% and -20.0 to 16.67% over MP and BP, respectively. Eighteen and fourteen crosses exhibited significant and positive heterosis over MP and BP, respectively.

For about fruit contents of V.C, heterosis ranged from -65.0 to 36.52 and -54.03 to 31.73% over MP and BP, respectively. Twenty-three hybrids showed significant and positive heterosis over MP, while fourteen hybrids showed significant and positive heterosis over BP. These results are in agreement with those reported by Khalil *et al.* (1987).

Combining ability:

Estimates of general combining ability effects (gi) for each parental lines of all studied traits under heat stress conditions are given in Tables 10 and 11. The obtained high positive values would be of interest in all studied traits. Edkaway cv had the greatest GCA effect for the vegetative traits (plant height, 13.249 ± 0.496; No. of branches / plant, 3.4 ± 0.16 and plant size 110.263 ± 3.877) followed by line CLN 1355 (plant height, 8.521 ± 0.496 and plant size, 18.363 ± 3.877) and then line CLN 2026D (plant height 2.058 ± 0.496 and plant size, 17.208 ± 0.16). While, the other cultivars were poor combiners for these traits under heat stress conditions. For fruit set percentage, the parental line CLN 1355 had the greatest GCA effect (6.854 ± 0.833) followed by Talalakheen cv (3.672 ± 0.833), while the other cultivars were poor combiners. Regarding early and total yield, Talalakheen cv was the best combiners among the parental set, which has highest positive and significant GCA values for early yield (1.775 ± 0.231) and total yield (3.30 ± 0.742) followed by CLN 1355, CLN 2026 C and then FM 9.

About the average fruit weight, the estimation of GCA effects shows clearly that FM 9 had the greatest GCA effects (9.678 ± 0.772) followed by Castle rock (7.872 ± 0.772) and then LHT 24 (1.769 ± 0.772). It is clear that such parents are good combiners, while the other parents had negative GCA effects indicating that such parents are poor combiners.

Concerning fruit characteristics, FLa 7156 cv was the best combiner among the parental set, which has highest positive and significant GCA

values for fruit firmness, TSS% and V.C content, followed by CLN 1355, Castle Rock for fruit firmness and TSS% and CLM 2026D for fruit firmness and TSS%.

Table 8. Estimations of heterosis as percentage of better parents for plant height, number of branches / plant, plant size, fruit set % and early yield.

Crosses	Plant height (cm)	No. of branches / plant	Plant size (dm^3)	Fruit set (%)	Early yield (kg/plot)
1 x 2	-4.16	19.42*	25.75**	11.38	2.38
1 x 3	-1.35	16.50*	50.21**	27.61**	10.00
1 x 4	1.46	-23.13**	48.03**	-10.63	100.00
1 x 5	-0.79	-48.95**	32.31**	-8.77	39.39
1 x 6	-3.37	-42.94**	36.02**	0.19	133.33**
1 x 7	-0.22	-40.56	40.56**	2.98	-2.34
1 x 8	-28.99**	-53.05**	-33.66**	10.26	193.75**
1 x 9	0.00	-34.13**	49.13**	-20.90**	37.50
2 x 3	10.43**	33.00**	39.86**	-2.20	-47.50**
2 x 4	26.24**	-16.88**	65.76**	-1.01	-38.10
2 x 5	-3.26	-34.97**	19.78*	19.27	180.95**
2 x 6	-3.18	-30.67**	16.86*	-3.78	-30.95
2 x 7	8.58	-12.78**	50.48**	-36.13**	-7.35
2 x 8	-3.03	-29.58**	5.88	-28.80**	-45.24
2 x 9	12.64**	-35.33**	21.71**	-29.82**	-50.00
3 x 4	2.02	-37.50**	11.26	-1.20	-75.00**
3 x 5	-3.25	-39.16**	-2.98	-6.79	-18.75
3 x 6	-3.46	-22.09*	-4.96	0.00	-46.25**
3 x 7	12.19	-33.33**	31.63	2.05	-8.75
3 x 8	-6.26*	-30.99**	-14.59**	-5.39	-67.50**
3 x 9	-5.49	-10.18*	-2.02	-43.91**	-61.25**
4 x 5	-17.13**	-29.38**	-7.68	7.37	-69.70*
4 x 6	-21.94**	-9.82*	-24.79**	0.76	50.00
4 x 7	-26.92**	-35.00**	-27.73**	35.20**	-22.06
4 x 8	-19.39**	-21.60**	-35.50**	-9.68	50.00
4 x 9	-24.90**	-2.40	-30.45	17.39	127.27
5 x 6	-22.84	-6.13	-35.14**	-3.02	-18.18
5 x 7	-26.02**	9.44*	-28.66**	-14.34	-66.18**
5 x 8	-9.29**	-10.80**	-12.06**	-1.70	-66.67
5 x 9	-16.24**	35.93**	3.38	11.00	-18.18
6 x 7	-0.69	27.78**	16.36	-12.00	4.41
6 x 8	2.83	14.08**	7.84	-29.11**	75.00
6 x 9	-11.68**	3.59	-15.16	-5.48	25.00
7 x 8	-8.08**	-7.51*	14.29	-3.72	-47.06**
7 x 9	-9.34**	1.67	2.10	-28.68**	-32.35
8 x 9	-2.73	-2.82	15.38**	4.35	63.64
LSD 5%	4.89	1.59	38.19	8.21	2.27
LSD 1%	6.47	2.10	50.53	10.86	3.01

* and ** significant at P = 0.05 and P = 0.01, respectively

Table 9. Estimations of heterosis as percentage of better parents for total yield and some fruit traits.

Crosses	Total yield (kg/plot)	Average fruit weight (g)	Fruit firmness	TSS (%)	Ascorbic acid mg/100g fresh weight
1 x 2	77.05**	-0.32	-7.61	8.33**	-4.67**
1 x 3	88.69**	-24.36**	-28.57**	16.67**	-8.12**
1 x 4	58.33*	-30.41**	69.13**	7.69**	5.84**
1 x 5	36.63	-28.50**	35.27**	13.33**	0.00
1 x 6	27.43	-16.46*	-22.25**	8.33**	13.28**
1 x 7	-0.53	-28.98**	-21.43**	13.83**	31.73**
1 x 8	67.42*	-38.77**	4.21	-8.57**	10.70**
1 x 9	47.14	-3.10**	24.75**	-9.33**	5.54**
2 x 3	3.83	-4.49	-18.37**	16.67**	-4.64**
2 x 4	-3.28	3.78	2.77	7.69**	-4.67**
2 x 5	66.12**	9.43	-9.0	3.45	-28.33**
2 x 6	10.18	-18.95**	-8.73	-5.17	-9.67**
2 x 7	-15.03	12.31	-23.18**	6.67*	19.00**
2 x 8	-21.31	-40.12**	-28.03**	-8.57**	19.00
2 x 9	-33.88	-52.71**	31.35**	-6.67	0.00
3 x 4	-39.88	-38.33**	6.12	15.38**	11.60**
3 x 5	-26.19	-18.86**	-4.08	8.38**	1.61*
3 x 6	-32.74*	-22.13**	8.17	8.33**	0.39
3 x 7	-32.53*	-25.36**	7.29	10.00**	-3.57**
3 x 8	-26.19	-35.63**	-43.15**	-7.14**	-2.02**
3 x 9	-45.83	-40.02**	13.70*	-9.33**	18.15**
4 x 5	-41.21	-8.62	48.03	0.00	0.00
4 x 6	-53.98**	-38.73**	-33.80**	0.00	24.90*
4 x 7	-41.96**	-31.10**	14.29	-1.54	1.98*
4 x 8	-15.32	-23.74**	-0.70	-7.14**	0.00
4 x 9	10.71	-32.06**	24.09**	6.67**	22.80
5 x 6	-22.57	-13.14*	-20.50*	-1.79	-22.18**
5 x 7	-49.65**	-12.68*	-19.77	8.33**	13.49**
5 x 8	-26.06	-36.38	-31.93**	-4.29	15.32*
5 x 9	8.48	-30.71**	18.15*	-16.00**	0.81
6 x 7	-15.38	2.21	-49.30	-3.33	5.45**
6 x 8	-24.78	-8.44	-55.49**	-14.29**	-2.72**
6 x 9	2.29	-7.61	-16.06*	-20.00*	-16.73**
7 x 8	-43.01**	22.60**	-35.09**	-14.29**	-0.79
7 x 9	36.01**	-40.83**	3.96	-13.33**	-6.35**
8 x 9	8.57	-39.56**	14.85	-9.33**	-54.03**
5% LSD	7.32	7.61	113.96	0.33	0.38
1%	9.68	10.07	150.79	0.44	0.50

* and ** significant at P = 0.05 and P = 0.01, respectively

Table 10. Estimates of general combining ability effect (gi) of each parental lines for plant height, number of branches / plant, plant size, fruit set % and early yield.

Parents	Plant height (cm)	No. of branches / plant	Plant size (dm^3)	Fruit set (%)	Early yield (kg/plot)
1. CLN 1355	8.521**	-3.540**	18.363**	6.854**	0.547*
2. CLN 2026C	2.058**	-2.186**	17.208**	0.244	0.702**
3. CLN 2026D	-2.824**	-2.168**	-27.256**	2.717**	1.602**
4. FLa 7156	-4.397**	-0.559**	-35.756**	-1.111	-1.507**
5. LHT 24	-3.579**	-0.231	-27.401**	-2.619**	0.193
6. FM 9	-3.906**	1.460**	-28.037**	3.226**	-0.153
7. Talalakheen	-5.824**	2.32**	-18.692**	3.672**	1.775**
8. Edkawy	13.249**	3.478**	110.263**	-7.037**	-1.679**
9. Castle Rock	-3.297**	1.194**	-8.692*	-5.947**	-1.179**
SE	0.4965	0.161	3.877	0.833	0.231

* and ** significant at P = 0.05 and P = 0.01, respectively

Table 11. Estimates of general combining ability effect (gi) of each parental lines for total yield and some fruit traits.

Parents	Total yield (kg/plot)	Average fruit weight (g)	Fruit firmness	TSS (%)	Ascorbic acid mg/100g fresh weight
1. CLN 1355	4.65**	-1.139	17.29	0.125**	1.907**
2. CLN 2026C	2.64**	-1.248	-12.24	-0.092**	2.579**
3. CLN 2026D	-1.81*	-5.657**	79.57**	0.179**	-0.683**
4. FLa 7156	-4.23**	-3.412**	31.39**	0.271**	0.561**
5. LHT 24	-1.15	1.769*	-37.24**	-0.220**	-1.747**
6. FM 9	2.28**	9.678**	14.57	-0.556**	-0.620**
7. Talalakheen	3.30**	-5.757**	-96.34**	-0.129**	0.788**
8. Edkawy	-3.74**	-2.075**	-102.9**	0.079*	-1.165*
9. Castle Rock	-1.93*	7.842	105.93**	0.343**	-1.620**
SE	0.742	0.772	11.57	0.033	0.038

* and ** significant at P = 0.05 and P = 0.01, respectively

Specific combining ability effect (Sij) for all possible combinations with respect to the studied traits are presented in Tables 12 and 13. Results revealed that 17, 12, 14, 7, 4, 8, 14, 12 and 16 crosses showed significant or highly significant positive SCA effects values of plant height, No. of branches / plant, plant size, fruit set %, early yield, total yield, average fruit weight, fruit firmness, TSS% and V.C content, respectively. It was worthily to notice that these crosses of good x poor general combiners (1 x 3, 1 x 4, 1 x 5, 1 x 6, 1 x 7, 2 x 4, 2 x 9 and 8 x 9) and good x good combiners (1 x 9 and 2 x 8), while the crosses 3 x 4, 3 x 7 and 6 x 7 were poor x poor general combiners.

With respect to number of branches / plant, five crosses were poor x poor general combiners, five crosses were poor x good general combiners. For plant size, the crosses involved three types of combinations poor x poor, poor x good and good x good general combiners. The highest SCA effect for this trait was presented in the cross CLN 2026 C x FLa 7156, which involves one good (CLN 2026C) and one poor (FLa 7156) general combiners.

Table 12. Estimations of specific combining ability effects for each cross (Sij) for plant height, number of branches / plant, plant size, fruit set % and early yield.

Crosses	Plant height (cm)	No. of branches / plant	Plant size (dm^3)	Fruit set (%)	Early yield (kg/plot)
1 x 2	-2.285	3.582**	-32.26**	5.89*	-0.667
1 x 3	5.96**	3.464**	69.70**	12.12**	2.932**
1 x 4	9.169**	1.955**	80.00**	-4.55*	0.441
1 x 5	6.351**	-3.373**	51.85**	-2.04	0.141
1 x 6	4.378**	-3.064**	40.98**	-3.09	1.787**
1 x 7	9.096**	-2.236**	48.14**	-2.04	0.56
1 x 8	-28.47**	-4.382**	-130.52	12.57**	2.114**
1 x 9	6.77*	-1.818**	69.44**	-5.22	-0.885
2 x 3	1.06	3.409**	23.16*	-0.67	-1.821**
2 x 4	19.13**	1.600**	123.36**	2.09	-0.31
2 x 5	-3.13*	-2.727**	21.50	14.46**	7.187**
2 x 6	-5.16	-2.418**	-3.06	0.72	-1.067
2 x 7	2.76	1.409**	87.59**	-16.33**	0.105
2 x 8	3.69*	-0.736	42.14**	-4.82*	-0.411
2 x 9	6.23**	-3.372*	2.79	-6.41**	-1.14
3 x 4	6.01**	-1.518**	20.12	1.18	-1.812**
3 x 5	1.70	-3.145**	8.76	-0.11	0.987
3 x 6	-0.43	-0.836	-10.09	0.24	-0.567
3 x 7	3.44*	-2.109**	19.26	1.70	0.205
3 x 8	5.37**	-0.855	-2.99	5.01*	-1.04
3 x 9	-2.08	1.009*	-11.44	-15.38**	-1.04
4 x 5	-3.73**	-2.355**	5.46	-5.08*	-1.403*
4 x 6	-10.70	-0.645	-46.89**	4.47	-0.558
4 x 7	-12.48**	-4.218**	-63.24**	23.33**	1.314*
4 x 8	-6.05	-0.664	-85.19**	-7.76**	0.669
4 x 9	-13.51	0.500	-73.24**	6.24**	1.469*
5 x 6	-8.72**	-0.373	-71.25**	3.98	-0.758
5 x 7	-9.30**	3.455**	-64.29**	-1.76	-3.385**
5 x 8	3.12*	1.309**	8.94	-2.35	-1.13
5 x 9	-4.13**	6.573**	6.20	5.25*	-0.030
6 x 7	4.52**	5.064**	32.83**	-6.41**	2.06**
6 x 8	15.45**	4.918**	95.88**	-5.40*	-0.985
6 x 9	-5.50**	-0.518	-43.96	6.01*	0.914
7 x 8	6.57**	-0.255	114.53**	8.35**	-0.212
7 x 9	-1.88	-0.091	-9.81	-6.14*	0.287
8 x 9	9.34**	0.864	109.24**	7.07**	0.941
SE	1.413	0.458	11.033	2.372	0.656

*** and ** significant at P = 0.05 and P = 0.01, respectively**

Similar trend was observed in other traits. Thus, it could be reported that it is not necessary that parents having high general combining ability effects would also contribute to high specific combining ability effects. In the cross CLN 1355 x CLN 2026C in the cases plant height, plant size, early yield / plot, fruit firmness and V.C content both the parents involved have high GCA effect, but gave comparatively very low SCA effects. Jinks and Jones (1958) are of the opinion that low SCA effects in such cases might be to some internal conciliation of favorable factors to genetic similarity of the involved parents. In contrast, the cross CLN 2026C x FLa 7156 involved parents with very low GCA effects for average fruit weight gave highest SCA effect value, which might be due to high genetic diversity among the parents.

Table 12. Estimations of specific combining ability effects for each cross (Sij) for total yield and some fruit traits.

Crosses	Total yield (kg/plot)	Average fruit weight (g)	Fruit firmness	TSS (%)	V.C. mg/100g fresh weight
1 x 2	6.83**	10.915**	-60.27	0.025	-2.62**
1 x 3	10.58**	0.223	-207.09**	0.253**	-3.06**
1 x 4	2.20	-5.821**	201.09**	0.161	-0.61**
1 x 5	0.73	-9.803**	169.72**	0.453**	0.19
1 x 6	3.58	-2.212	205.41**	0.489**	2.67**
1 x 7	2.26	-2.576	-148.68**	0.362**	6.26**
1 x 8	2.92	-9.958**	105.41**	-0.247**	2.52**
1 x 9	-0.38	-2.776	99.04**	-0.111	1.57**
2 x 3	-0.10	2.832	-90.04**	0.471**	-0.03
2 x 4	1.01	10.99**	0.64	0.38**	-1.28**
2 x 5	10.64**	12.705**	-15.72	-0.129	-6.07**
2 x 6	1.69	-3.903	84.95*	-0.293**	-1.60**
2 x 7	0.07	5.832**	-59.14	0.18	5.58**
2 x 8	-2.76	-10.749**	-87.54**	-0.029	7.54**
2 x 9	-6.87**	-19.667	178.59**	0.307**	2.29**
3 x 4	-2.13	-9.403	76.32*	0.607**	1.28**
3 x 5	-2.90	-0.285	57.45	0.098	0.88**
3 x 6	-3.54	-1.794	143.14**	0.434**	0.36**
3 x 7	-0.46	-3.658	214.04**	0.107	-2.54**
3 x 8	-0.31	-3.34	-211.86**	-0.202*	-0.59**
3 x 9	-5.42	-4.258	66.77*	-0.165	4.86**
4 x 5	-3.18	3.769	130.63**	0.007	-0.55**
4 x 6	-5.93**	-16.04**	-181.18**	0.343**	5.42**
4 x 7	-0.74	-4.803*	62.22	-0.183	-2.39**
4 x 8	-0.20	-0.985	56.32	-0.292	-1.14**
4 x 9	3.39	0.396	79.95*	-0.056	5.01**
5 x 6	-1.90	-2.721	4.95	-0.165	-4.37**
5 x 7	-6.02**	3.614	-71.63*	0.407**	2.82**
5 x 8	-1.16	-11.267**	-97.54**	0.398**	4.77**
5 x 9	2.72	-3.785	-171.40**	-0.265**	1.62**
6 x 7	0.33	15.905**	-190.95**	0.043	0.18
6 x 8	0.187	4.523*	-239.36**	0.034	0.04
6 x 9	6.07**	8.505**	-98.22**	-0.229*	-3.10**
7 x 8	-1.53	5.46*	-60.95	-0.392	-1.36**
7 x 9	-1.34	-4.858*	55.18	-0.156	-2.31**
8 x 9	2.61	-7.44	144.27**	-0.065	-12.55**
SE	4.185	2.199	32.925	0.096	0.109

* and ** significant at P = 0.05 and P = 0.01, respectively

Heritability:

The estimates of additive (σ^2 A), non-additive (σ^2D) genetic variances, degree of dominance $(\sigma^2D / \sigma^2A)^{1/2}$ and heritabilities in broad (h^2b) and narrow ($h^2n\%$) senses with respect to all studied traits are presented in Tables 14 and 15. The results revealed that the magnitude of additive variance (σ^2A) were positive and larger than those of non-additive (σ^2D) variance for number of branches / plant, total yield and TSS%. However for other traits, the dominance (non-additive) gene effects played the major role in their inheritance. These could be verified by the ratio $(\sigma^2D / \sigma^2A)^{1/2}$, which were less than one, revealing the importance of partial dominance and that the additive effects played the major role in the inheritance of these traits. Whereas, the traits which the ratio were higher than one, revealing the

importance of over dominance in the genetic control of these traits. This finding might explain the presence of heterosis over the better parent in most of crosses for these traits.

Table 14. The estimation of genetic parameters and heritabilities in narrow (h^2n) and broad (h^2b) senses for plant height, number of branches / plant, plant size, fruit set % and early yield.

Parameters	Plant height (cm)	No. of branches / plant	Plant size (dm^3)	Fruit set (%)	Early yield (kg/plot)
σ^2A	72.052	9.862	3388.079	30.263	2.687
σ^2D	85.397	7.726	4244.272	60.468	2.758
σ^2e	3.0507	0.320	185.982	8.596	0.657
$(\sigma^2D / \sigma^2A)^{1/2}$	1.089	0.885	1.119	1.413	1.006
0.657	44.892	55.069	43.350	30.467	44.035
h^2b %	98.099	98.210	97.621	91.345	89.223

Similar trend was observed by Omar *et al.* (1988), Metwally *et al.* (1996) and Bayomy (2002).

Concerning heritability, it is likely to mention that broad sense heritability (h^2b%) was high and exceeded 90% for most studied traits, while narrow sense heritability (h^2n%) ranged from 43.35 to 55.069% for vegetative traits (plant height, No. of branches / plant and plant size), while heritability in narrow sense in the other traits ranged from 10.97% for ascorbic acid content to 44.036% for early yield. These suggested that all traits were highly heritable.

Table 15. The estimation of genetic parameters and heritabilities in narrow (h^2n) and broad (h^2b) senses for total yield and some fruit traits.

Parameters	Total yield (kg/plot)	Average fruit weight (g)	Fruit firmness	TSS (%)	Ascorbic acid mg/100g fresh weight
σ^2A	17.074	44.117	6072.5	0.1318	1.9308
σ^2D	16.296	83.098	20581.978	0.1259	15.6513
σ^2e	6.827	7.390	1656.266	0.0142	0.0184
$(\sigma^2D / \sigma^2A)^{1/2}$	0.977	1.372	1.841	0.030	2.848
h^2n %	42.476	32.775	21.449	48.451	10.970
h^2b %	83.015	94.509	94.149	94.754	99.895

Out of the present study, there were some desirable genotypes which appeared high yielding ability and quality traits under heat stress conditions in late summer season in Egypt. These genotypes were CLN 2026C, FM 9 and Talalakheen as cultivars and the hybrids 1 x 2, 1 x 6, 2 x 5, 2 x 6, 6 x 7 and 6 x 9. The cultivar FM 9 and the hybrid (Castle Rock x FM 9) promising for used in commercial production in Egypt under heat stress conditions.

REFERENCES

A.O.A.C. (1970). Official Methods of Analysis. 11th ed. Washinghton, D.C.

Bayomy, K.E.M. (2002). Heterosis and gene action in varietal crosses under North Sinai conditions. M.Sc. Thesis, Faculty of Environ. Agric. Sci., Suez Canal Univ., Egypt.

Bhatt, R.P.; M.R. Biswas; H.K. Pundy; G.S. Nerma and N. Kumar (1998). Heterosis for vitamin C in tomato (*Lycopersicon esculentum* Mill.). Indian J. Agric. Sci., 68:176-178.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crosses systems. Aust. J. Biol. Sci., 9:436-493.

Hegazi, H.H.; H.M. Hassan; A.G. Moussa and Wahab-Allah (1995). Heterosis and heritability estimation for some characters of tomato cultivars and their hybrid combinations. Alex. J. Agric. Res., 40:265-276.

Jinks, J.L. and R.M. Jones (1958). Estimation of components of heterosis. Genetics, 43:223-234.

Khalil, R.M.; A.A. Midan and A.K. Hatem (1987). Breeding studies of some characters in tomato (*Lycopersicon esculentum* Mill.). Acta Horticulturae, 220:77-83.

Mather, K. and J.L. Jinks (1971). Biometrical Genetics. (2nd Ed.). Chapman and Hall, New Fetter Lane, London.

Metwally, E.I.; G. El-Fadaly and A.Y. Mazrouh (1988). Inheritance of fruit set under heat stress conditions. In Tomato Proc. 2nd Hort. Sci. Conf., Tanta Univ., 11:521-530.

Metwally, E.I.; G. El-Fadaly and A.Y. Mazrouh (1990). Inheritance of yield and yield components in the tomato (*Lycopersicon esculentum* Mill.). Assiut J. Agric. Sci., 19:227-238.

Metwally, E.I.; A. El-Zawily; N. Hassan and O. Zanata (1996). Inheritance of fruits set and yield of tomato under high temperature conditions in Egypt. 1st Egypt. Hung. Hort. Conf., Kafr El-Sheikh, Egypt, 1:112-122.

Omar, M.K.; S.E.A. Younis; T.H.I. Sherif; S.M.Y. Hussein and H.M. El-Aref (1988). A genetic analysis of yield and yield components in the tomato (*Lycopersicon esculentum* Mill). Assuit J.Agric.Sci.,9:227-238.

Rick, C.M. (1976). Natural variability in wild species of *Lycopersicon esculentum* and its bearing on tomato breeding. Genet. Agric., 30:242-259. (C.F. Hort. Abst., 47:761).

Salib, F.S. (1999). Genetical studies on some morphological and physiological characters of tomato varieties (*Lycopersicon esculentum* Mill.). Ph.D. Thesis, Ain Shams Univ., Egypt.

Scott, J.W.; R.B. Volin; H.H. Bryan and S.M. Olson (1986). Use of hybrids to develop heat tolerant tomato cultivars. Proc. Fla. State Hort. Soc., 99:311-314.

Sherif, T.H.I. and H.A. Hussein (1992). A genetic analysis of growth and yield characters in tomato (*Lycopersicon esculentum* Mill.) under heat stress of late summer in Upper Egypt. Assuit J. Agric. Sci., 23:3-28.

Srivastava, J.P.; B.P. Srivastava; H.P. Verma and H. Singh (1998). Heterosis in reaction to combining ability in tomato. Veget. Sci., 25:43-47.

Youssef, S.M.S. (1997). Studies on some international crosses and hybrid vigor in tomato. M.Sc. Thesis, Ain Shams Univ., Egypt.

إنتاج هجن من الطماطم مرتفعة المحصول وتتحمل الحرارة المرتفعة

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أجريت هذه الدراسة بغرض تحديد الآباء وكذلك الإتحادات الوراثية الجديدة التى تظهر إنتاجية عالية تحت ظروف الحرارة العالية فى مصر (العروة الصيفية المتأخرة) علاوة على ذلك معرفة السلوك الوراثى لبعض الصفات المساهمة فى المحصول تحت ظروف الحرارة العالية من خلال التهجين بنظام التزاوج النصف دائرى لتسعة آباء من الطماطم الشاملة تراكيب وراثية محلية وأخرى مستوردة. وقيمت الآباء والهجن الناتجة منها فى العروة الصيفية المتأخرة موسم ٢٠٠٢ وأوضحت النتائج الآتى:-

- كانت كلا من القدرة العامة والخاصة على التآلف عالية المعنوية لكل الصفات التى درست وهذا يدل على أهمية كل من التأثير المضيف والسيادى فى وراثة هذه الصفات.
- كانت قيمة التباين الإضافى أكبر من قيمة التباين السيادى لصفات عدد الأفرع / النبات ، المحصول الكلى ، محتوى الثمار من فيتامين ج ، بينما باقى الصفات فقد كان الفعل السيادى له الدور الرئيسى فى وراثتها.
- أشارت النتائج إلى أن الآباء Edkaway, CLN 1355, CLN 2026 D التى أظهرت قيما موجبة لتأثير القدرة العامة على التآلف للصفات الخضرية تعتبر أحسن التراكيب ضمن الآباء المستخدمة فى هذه الدراسة وذلك بغرض تحسين تلك الصفات تحت ظروف الحرارة المرتفعة ، بينما الآباء CLN 1355, FM 9, Talalakheen تعتبر أحسن الآباء من حيث قدرتها العامة على التآلف بالنسبة لصفة النسبة المئوية لعقد الثمار تحت ظروف الحرارة العالية والآباء FM 9 ، Talalakheen, CLN 1355, CLN 2026C تعتبر أحسن الآباء من حيث القدرة العامة على التآلف بالنسبة لصفات المحصول المبكر والكلى. أما بالنسبة لصفات متوسط وزن الثمرة فكان أعلى الآباء بالنسبة للقدرة العامة على التآلف الآباء FM9, Castle Rock, HT 24 وبالنسبة لدرجة صلابة الثمار ومحتواها من فيتامين ج والمواد الصلبة الذائبة الكلية فكانت أعلى الآباء بالنسبة للقدرة العامة على التآلف هى: FLa 7156, CLN 1355, CLN 2026D.
- كان معامل التوريث فى مداه الواسع والضيق مرتفعا لكل الصفات التى درست.
- كانت قوة الهجين على أساس متوسط الأبوين أو الأب الأفضل موجود لكل الصفات تحت الدراسة.
- كان الأب FM 9 والهجين FM 9 x Castle Rock من أفضل التراكيب الوراثية التى أعطت أعلى محصول وجودة تحت ظروف العروة الصيفية المتأخرة فى كفر الشيخ ، مصر.