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BREADING NEW LOCAL TOMATO HYBRIDS AT WEST-DELTA REGION OF EGYPT

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ABSTRACT

During successive late summer seasons of 2007 to 2010, this study was conducted at Burg El-Arab area, West-Delta region, Egypt. A 7 x 7 half-diallel mating design was used to determine combining ability as well as top and standard heterosis for six characters in tomato. Preponderance of the non-additive gene action was evident in controlling number of branches, leaves per plant and total yield. While, the analysis of variance revealed the predominance of additive gene action for average fruit weight and fruit firmness. Top heterosis was noticed for number of branches, leaves and total yield, while appreciable amount of standard heterosis was detected for all traits studied. The promising hybrids “S.15 x RIG-10”, “S.60 x S.2” and “S.106 x RIG.10” were selected on the basis of their performances and standard heterosis manifested in them. These three crosses could be used commercially to improve yield in tomato in Burg El-Arab, West-Delta region in Egypt as local hybrids. The hybrid breeding method and the actual high productivity which depended on standard heterosis amount can be used efficiently to improve yield in tomato by breeding local hybrids.

INTRODUCTION

Combining ability estimates are important and vital parameters to mould the genetic makeup of tomato crop. This important information could prove an essential strategy to tomato breeders in the screening of better parental combinations for further enhancement. Griffing (1956) stated that general combining ability (GCA) effects were due to additive type of gene action, while specific combining ability (SCA) effects were due to non-additive gene action. Studies of Hannan *et al.* (2007), Kansouh and Zakher (2011), Izge and Garba (2012) and Shende *et al.* (2012) reported the prevalence of a non-additive gene action in the inheritance of number of branches, leaves per plant and total yield in tomato. While, the predominance of additive gene action was established earlier in the inheritance of average fruit weight and fruit firmness by Thakur and Kohli (2005), Mehdi *et al.* (2008) and Ravindra *et al.* (2013). According to Bhatt *et al.* (2001), Patel *et al.* (2010) and Raju *et al.* (2012), the additive and non-additive variance approximately play same roles in the inheritance of early and total yield.

The hybrid breeding method can be used efficiently to improve yield and quality in tomato. However, the recommendable F_1 tomato for commercial production must be depended on its actual high productivity not on its normal average degree of heterosis, since the obtained heterosis value in any hybrid based on mid-parents or better parent (normal heterosis) mainly depended on the behavior of its two parents only. Then, the overall evaluation must be depended on the mean performance and higher heterotic expression based on top parent (top heterosis)and commercial hybrid (commercial or standard heterosis). Heterosis over the top parent and commercial hybrid on tomato was reported for plant height, number of branches per plant and yield by Bhatt *et al.* (2001), Makesh *et al.* (2003) and Akhilesh and Gulshan (2004). Top and standard heterosis for number of branches, leaves, early and total yield and fruit firmness also previously detected by Kansouh and Masoud (2007). Standard heterosis for total yield and average fruit weight was also reported by Dhadde *et al.* (2009) and Ravindra *et al.* (2012).

Keeping these points in mind, the present investigation was planned to obtain more information on combining ability and gene action to identify breeding lines having good combining ability effects for some plant and fruit characters. Also, to explore the possibility of developing high yielding local tomato hybrids based on the mean performance as top and standard heterosis, suitable to Burg El-Arab area, West Delta region, Egypt.

MATERIALS AND METHODS

The present study was carried out at Burg El-Arab area, Nubaria district, Alexandria governorate, West Delta region during successive late summer seasons of 2007 to 2010. Seven breed lines of tomato (*Solanum lycopersicum* L.) comprised S.15, S.60, S.80, S.106, G.8, S.2 and RIG.10, which chosen from a breeding programme (Kansouh, 2002). In the season of 2007, a 7 x 7 half-diallel cross was made to obtain 21 F_1 hybrids. The obtained F_1 hybrids and their parents with the commercial hybrid Atlas pride (as a control) were evaluated in the two successive summer seasons of 2008 and 2009. According to data obtained , three superior F_1 hybrids were chosen and grown again with the commercial F_1 hybrid Atlas pride in large scale experiments in the late summer season of 2010. The seedlings were transplanted on June 5^{th} in a randomized complete blocks design with three replicates. In the two seasons of 2008 and 2009 each plot consisted of three rows (54 m^2), 1.50 m width and 12 m length, while in the season of 2010 each plot consisted of 37 rows (660 m^2), 1.50 m width and 12 m length and the plants were spaced at 50 cm apart. Routine cultural practices, similar to those used in tomato commercial production in this location were done as needed.

Data were recorded for plant height, number of branches and leaves per plant at the end of flowering stage from ten plants per plot; early yield as the yield of the first three harvest; total yield as the total weight of all harvested fruits. In this respect, early and total yield were recorded as kg/plant in 2008 & 2009 seasons, while as ton/fed. in 2010 season. Average fruit weight (gm) was also recorded; fruit firmness (g/cm^2) was measured by using a needle type pocket penetrometer. The percentage of total soluble solids (TSS%) content in fruit juice was determined by a hand refractometer. Data of plant height and TSS% content were additional recorded only on season 2010. Data were recorded during the two seasons of 2008 and 2009, then the combined data over the two seasons were calculated. Means were compared based on the LSD test. Analysis of variance, combining ability analysis, component of genetic variance (additive, σ^2A, and dominance, σ^2D) were done as reported according to method II model I of Griffing (1956) and Singh and Chaudhary (1995); degree of dominance $(\sigma^2D/2\sigma^2A)^{0.5}$ was made according to Patel *et al.* (2004). The average degree of heterosis (ADH%) was calculated only as top heterosis and standard heterosis based on top parent (TP) and commercial hybrid (CH), respectively as follows:

$$H(TP)\% = \frac{\overline{F_1} - \overline{TP}}{\overline{TP}} \times 100$$

$$H(CH)\% = \frac{\overline{F_1} - \overline{CH}}{\overline{CH}} \times 100$$

Where:

H(TP) and H(CH), heterosis from top parent (top heterosis) and commercial hybrid (standard heterosis), respectively.

$\overline{F_1}$, $\overline{TP}$ and $\overline{CH}$ = The means of F_1 generation, top parent and commercial hybrid (control), respectively. In the season of 2010, data were recorded on three promising hybrids only with the commercial hybrid Atlas pride for the previous traits.

RESULTS AND DISCUSSION

A.Components of genetic variance:

The analysis of variance for combining ability (Table 1) showed highly significant mean square values for both general and specific combining ability (GCA & SCA) effects, suggesting the importance of both additive (σ^2A) and non-additive (σ^2D) gene actions in the inheritance of all studied traits.

Table (1):Mean squares and components of genetic variance for some plant and fruit characteristics.

S.O.V	No. of branches	No. of leaves	Early yield	Total yield	Average fruit weight (g)	Fruit firmness (g/cm^2)
Mean squares						
GCA	0.953**	392.07**	0.141**	0.228**	4915.30**	25121.71**
SCA	0.644**	125.73**	0.034**	0.307**	105.59**	182.50**
Components of genetic variance						
σ^2GCA	0.097	42.90	0.016	0.024	543.53	2786.20
σ^2SCA	0.567	119.73	0.032	0.295	82.03	136.57
σ^2GCA/σ^2SCA	0.170	0.36	0.500	0.080	6.63	20.40
σ^2A	0.194	85.80	0.032	0.048	1087.05	5572.40
σ^2D	0.567	119.73	0.032	0.295	82.03	136.57
σ^2A/σ^2D	0.340	0.72	1.00	0.160	13.25	40.80
Degree of dominance	1.21	0.84	0.71	1.75	0.19	0.11

**** Significant at 0.01 level of probability**

For number of branches and leaves/plant, the variance due to specific combining ability (σ^2SCA) was higher than those of general combining ability (σ^2GCA) and the ratio of σ^2GCA/σ^2SCA were found less than 0.50, which revealed the preponderance of non-additive variance in the inheritance of these traits. The prevalence of the non-additive variance was further confirmed by calculated the ratio of additive and dominance variance (σ^2A/σ^2D) which also found less than one (0.34 and 0.72, respectively). The estimated average degree of dominance also supported the predominance of non-additive gene action in the inheritance of these two traits, where found more than one (1.21) for number of branches per plant, indicating over-dominance for the trait. Meanwhile, complete dominance was detected for number of leaves, since average degree of dominance value was found between 0.75-1.0.

For early and total yield, additive and non-additive variance play approximately the same role in the inheritance of early yield. This suggestion was detected by estimating the components of genetic variance, since the ratio of σ^2GCA/σ^2SCA and σ^2A/σ^2D were found 0.50 and 1.00, respectively. Also, the degree of dominance value (0.71) found between 0.50-0.75, indicating partial dominance for this trait. On the other hand, these parameters of genetic variance values showed the prevalence of the non-additive gene in the inheritance of total yield. The estimated of σ^2GCA/σ^2SCA ratio which found 0.08 (less than 0.50) and σ^2A/σ^2D recorded 0.16 value (less than one), supported the non-additive suggestion. Also, the degree of dominance which found more than one (1.75) indicated over-dominance for this trait.

Regarding average fruit weight and fruit firmness characters, data obtained (Table 1) revealed the preponderance of the additive portion of genetic variance in the inheritance of the two traits. This opinion was confirmed by the calculating σ^2GCA/σ^2SCA ratio which found more than one (6.63 and 20.40, respectively), and also supported by σ^2A/σ^2D ratio values which found more than one (13.25 and 40.80, respectively). The estimation of average degree of dominance reflected no-dominance for these two traits, since recorded values of 0.19 and 0.11, respectively (less than 0.50).

Generally, these information regarding components of genetic variance pointed out that number of branches, leaves and total yield characters could be improved through heterosis breeding since the non-additive gene action play the main role in the inheritance of these traits. On the contrary, average fruit weight and fruit firmness could be improved through selecting promising lines from superior hybrids since the additive genetic variance was prevalence and play the main role in the inheritance of these two traits. Meanwhile, early yield characters could be improved through the two methods, where both additive and non-additive genetic variances approximately play the same role.

Several previous studies in tomato also reported the significance of additive and non-additive genetic variances with predominance of non-additive effects in the inheritance of number of branches, leaves and total yield. Among those were Hannan *et al.* (2007), Kansouh and Zakher (2011), Izge and Garba

(2012). Our results also agree with those of Thakur and Kohli (2005), Shahabuddin *et al.* (2009) and Ravindra *et al.* (2013) who reported the prevalence of additive gene action in the inheritance of average fruit weight and fruit firmness in tomato. Studies of Bhatt *et al.* (2001), Patel *et al.* (2010) and Raju *et al.* (2012) for tomato early yield trait supported our obtained results since additive and non-additive gene action were significant and approximately play same role.

B.General and specific combining ability effects:

The estimates of GCA of the parents for different characters are presented in Table (2). The good combiner parents for the studied traits were S.106, S.2 for number of branches; S.106, S.2, and RIG.10 for number of leaves' S.2 and RIG.10 for early yield; S.60, S.2 and RIG.10 for total yield; S.15, S.60, S.80 and S.106 for average fruit weight and G.8, S.2 and RIG.10 for fruit firmness, since they showed significant positive GCA values. The highest significant positive GCA values among the lines for the various traits were: S.2 for number of branches and leaves (0.630 and 8.94, respectively);RIG-10 for early yield and fruit firmness (0.244 and 80.13, respectively); S.60 for total yield (0.182)and S.106 for average fruit weight (36.11), and they considered the best combiner parent for these traits. Generally, the line S.2 was found to be the most desirable general combiner. It possesses dominant for five traits, followed by the lines RIG-10, S.106 and S.60 which were good general combiners for four, three and two traits, respectively. As previously known, the general combining ability (GCA) effects is considered as an indicator of additive (σ^2A) and additive x additive (σ^2AA + σ^2AAA +…)portions of genetic variance and represents the fixable components of genetic variance, then, these characters could be improved by using these lines in hybrid breeding programmes for the accumulation of favorable genes. In this respect, Garg *et al.* (2008), Mondal *et al.* (2009) and Kansouh and Zakher (2011) mentioned that, the GCA effects are mainly attributed to additive and additive x additive interactions, which are fixable and parent lines/cultivars with high GCA may be recommended for utilization in genetic improvement in tomato through varietal breeding.

Table (2):General combining ability (GCA) effects of parental lines for some plant and fruit characteristics.

Lines	No. of branches	No. of leaves	Early yield	Total yield	Av. fruit weight	Fruit firmness
S.15	-0.030	-0.32	-0.053	0.039	13.33**	-32.94
S.60	-0.245	-6.58	-0.112	0.182**	8.01**	-44.26
S.80	-0.087	-1.05	-0.016	-0.158	7.94**	-19.54
S.106	0.182*	6.48**	-0.104	-0.225	36.11**	-55.37
G.8	-0.358	-9.52	-0.039	-0.092	-10.04	60.93**
S.2	0.630**	8.94**	0.080**	0.129**	-23.50	11.06**
RIG.10	-0.092	2.05**	0.244**	0.125**	-31.85	80.13**
LSD 5%	0.170	1.50	0.024	0.066	3.00	4.18
1%	0.226	2.00	0.032	0.088	3.99	5.56
var (g_i-g_j) 5%	0.262	2.30	0.036	0.100	4.58	6.38
1%	0.384	3.08	0.048	0.133	6.09	8.49

***, ** Significant at 0.05 and 0.01 levels of probability, respectively**

Regarding specific combining ability (SCA) effects, data of the various studied traits are presented in Table (3) . The highest significant SCA values were reflected by the cross S.60 x S.2, for number of branches, number of leaves and fruit firmness (1.35, 25.16 and 19.64, respectively); S.60 x G.8, for early yield; S.106 x G.8, for total yield (0.915) and S.15 x S.106, for average fruit weight (13.54), and could be considered the best combinations for each trait. As a whole, the cross combinations S.15 x RIG.10, S.80 x RIG.10 and S.106 x RIG.10 could be considered the best combinations, since they showed significant SCA values for five traits, followed by the combination S.60 x S.2 which showed good SCA effects for four traits.

Table (3):Specific combining ability (SCA) effects of the cross combinations for some plant and fruit characteristics.

Crosses	No. of branches	No. of leaves	Early yield	Total yield	Av. fruit weight	Fruit firmness
S.15 x S.60	-0.67	-2.74	-0.121	-0.063	-3.28	-1.63
S.15 x S.80	0.22	-1.42	-0.171	-0.227	-1.66	5.51
S.15 x S.106	-0.11	-3.95	-0.002	-0.211	13.54**	1.30
S.15 x G.8	0.42	3.55	0.133**	0.262**	-2.11	6.47
S.15 x S.2	0.18	3.40	0.138**	0.303**	-0.22	13.06
S.15x RIG.10	1.17**	15.72**	0.291**	0.666**	8.18	17.45**
S.60 x S.80	-0.15	-12.72	0.084*	-0.116	5.20	-4.89
S.60 x S.106	0.17	0.65	-0.087	-0.276	-4.52	6.22
S.60 x G.8	0.88**	8.27**	0.355**	0.159	6.86	1.57
S.60 x S.2	1.35**	25.16**	0.011	0.902**	-5.21	19.64**
S.60 x RIG.10	-0.12	-3.24	0.117**	0.198*	-6.31	-2.85
S.80 x S.106	-0.49	-8.23	-0.059	-0.367	-1.21	-12.13
S.80 x G.8	0.05	2.89	0.154**	0.565**	-3.51	10.10
S.80 x S.2	0.17	2.97	0.195**	0.202*	8.50	1.65
S.80 x RIG.10	0.79**	17.50**	0.119**	0.453**	5.41	12.21
S.106 x G.8	-0.25	5.83*	0.148**	0.915**	3.45	-0.89
S.106 x S.2	0.69**	3.15	0.093**	-0.075	-21.52	5.67
S.106 x RIG.10	1.33**	14.06**	0.164**	0.634**	-24.84	13.39
G.8 x S.2	0.47	3.18	-0.067	0.185	4.91	10.79
G.8 x RIG.10	-0.07	-1.61	-0.245	-0.106	1.63	-11.22
S.2 x RIG.10	-0.59	-9.85	-0.170	-0.049	0.08	8.23
LSD 5 %	0.50	4.40	0.068	0.188	8.70	14.16
1 %	0.66	5.85	0.090	0.250	11.57	17.17

***, ** Significant at 0.05 and 0.01 levels of probability, respectively**

It is noticed that these crosses involved the line RIG-10 or S.2 as one parent. Generally, since the SCA effects are considered as indicator for heterosis effects, the high amount of heterosis could be expected for early and total yield, followed by number of branches and leaves which showed, respectively, significant SCA values for twenty, ten and six crosses among 21 studied ones. While, the low amount of heterosis could be expected for average fruit weight and fruit firmness, since only one and two crosses, respectively, showed significant SCA values. This suggestion was agree with the previously estimated degree of dominance value (Table 1) which were more than one (1.21 and 1.75) for number of branches and total yield (over dominance) and dominance (complete and partial) for number of leaves and early yield, respectively. Meanwhile, average fruit weight and fruit firmness which recorded degree of dominance values of 0.19 and 0.11, respectively (no dominance) confirmed the low amount of heterosis for these two traits. Then, the heterosis breeding method (hybrid development) could be used as effective method for breeding number of branches, leaves, early and total yield characters, while, varietal breeding by selection method could be used for both average fruit weight and fruit firmness. These results are in agreement with those of Bhatt *et al.* (2001), Hannan *et al.* (2007), and Kansouh and Zakher (2011).

C.Mean performances and average degree of heterosis:

High significant differences among the parental lines and crosses were observed for all studied traits (Table 4). For number of branches per plant, the lines ranged from 5.96 to 7.57 with a mean of 6.66 branches/plant, while the crosses ranged from 6.50 to 9.17 with a mean value of 7.71 branches/plant . Among the lines S.2 followed by S.106 showed the highest number of branches per plant (7.57 and 7.13, respectively). In this respect, the four crosses S.15 x RIG, S.60 x S.2, S.106 x S.2 and S.106 x RIG recorded number of branches per plant of 8.50, 9.17, 8.96 and 8.87, respectively and significantly exceeded the top parent (S.2) with top heterosis values of 12.29, 21.14,18.36 and 17.17%, respectively. Compared with the commercial hybrid (CH) Atlas pride, all the obtained crosses, except S.15 x S60, produced plants with branches significantly higher than that of Atlas pride with standard heterosis values ranged from 14.93% (in the cross G.8 x RIG.10) to 52.07% (in the cross S.60 x S.2)

For number of leaves per plant, the parental lines S.106 and S.2 recorded the highest number (90.33 and 87.01 leaves/plant). Among the studied crosses, S.60 x S.2 and S.106 x RIG.10 showed the highest number of leaves per plant (110.64 and 105.70, respectively). However, the overall mean value of the crosses (86.09) significantly exceeded that of the parental lines (74.19) by 16.04%. Compared with the top parent (S.106), five crosses, i.e., S.15 x RIG.10, S.60 x S.2, S.80 x RIG.10, S.106 x S.2 and S.106 x RIG.10 showed top heterosis values of 11.33, 22.48,12.49, 12.58 and 17.02%, respectively. Also, of the studied 21 F_1's 18 hybrids showed significant standard heterosis values ranged from 10.48% (in the cross S.60 x G.8) to 62.37% (in the cross S.60 x S.2).

Generally, the obtained results indicated that the lines S.106 and S.2 as well as the crosses S.15 x RIG.10, S.60 x S.2, S.80 x S.2 , S.106x S.2 and S.106 x RIG-10 showed vigorous growth, since they recorded relatively high values for number of branches and leaves. This results agreed with those of Makesh *et al.* (2003), Akhilesh and Gulshan (2004) and Kansouh and Masoud (2007); who obtained significant positive top and standard heterosis for number of branches and leaves per plant in some F_1 tomato hybrids.

Table (4):Mean performances (M) and average degree of heterosis (ADH%) based on top parent (TP) and commercial hybrid (CH) of the evaluated F_1 hybrids and their parents for number of branches, number of leaves and early yield.

Entries	No. of branches			No. of leaves			Early yield (kg/plant)		
	M	ADH%		M	ADH%		M	ADH%	
		TP	CH		TP	CH		TP	CH
Lines									
S.15	6.77			75.21			1.275		
S.60	6.23			62.28			1.142		
S.80	6.96			80.54			1.325		
S.106	7.13			90.33			1.200		
G.8	5.96			53.03			1.227		
S.2	7.57			87.01			1.595		
RIG.10	6.00			70.94			1.885		
Mean	6.66			74.19			1.378		
Crosses									
S.15 x S.60	6.50	-19.21**	7.79	73.47	-18.66**	7.82	1.252	-33.58**	-23.98**
S.15 x S.80	7.56	-0.13	25.37**	80.32	-11.08**	17.88**	1.33	-29.28**	-19.06**
S.15 x S.106	7.50	-0.92	24.38**	85.33	-5.53	25.23**	1.378	-26.90**	-16.33**
S.15 x G.8	7.50	-0.92	24.38**	76.82	-14.96**	12.74*	1.578	-16.29**	-4.19
S.15 x S.2	8.23	8.72	36.48**	95.14	5.32	39.62**	1.703	-9.65**	3.40
S.15x RIG.10	8.50	12.29**	40.96**	100.56	11.33**	47.58**	2.020	7.16*	22.65**
S.60 x S.80	6.97	-7.93	15.59*	62.76	-30.52**	-7.90	1.495	-20.69**	-9.23**
S.60 x S.106	7.56	-0.13	25.37**	83.67	-7.37	22.79**	1.235	-34.48**	-25.02**
S.60 x G.8	7.73	2.11	28.19**	75.28	-16.66**	10.48*	1.722	-8.65**	4.55
S.60 x S.2	9.17	21.14**	52.07**	110.64	22.48**	62.37**	1.518	-19.47**	-7.83*
S.60 x RIG.10	7.00	-7.52	16.09*	75.34	-16.59**	10.57*	1.788	-5.15	8.56*
S.80 x S.106	7.06	-6.73	17.08**	80.31	-11.09**	17.86**	1.360	-27.85**	-17.43**
S.80 x G.8	7.06	-6.73	17.08**	75.43	-16.50**	10.70*	1.637	-13.16**	-0.61
S.80 x S.2	8.17	7.92	35.49**	93.98	4.04	37.92**	1.798	-4.62	9.17**
S.80 x RIG.10	8.07	6.61	33.83**	101.61	12.49**	49.12**	1.886	0.05	14.51**
S.106 x G.8	7.03	-7.13	16.58*	85.91	-4.89	26.08**	1.543	-18.14**	-6.31
S.106 x S.2	8.96	18.36**	48.59**	101.69	12.58**	49.24**	1.608	-14.69**	-2.37
S.106 x RIG.10	8.87	17.17**	47.10**	105.70	17.02**	55.12**	1.843	-2.23	11.90**
G.8 x S.2	8.20	8.32	35.98**	85.72	-5.10	25.80**	1.512	-19.79**	-8.20*
G.8 x RIG.10	6.93	-8.45	14.93*	74.03	-18.04**	8.64	1.498	-20.53**	-9.05**
S.2 x RIG.10	7.40	-2.25	22.72**	84.26	-6.72	23.66**	1.693	-10.19**	2.79
Mean	7.71			86.09			1.590		
Top parent (TP)	S.2 = 7.57			S.106= 90.33			RIG.10 = 1.885		
Atlas pride (CH)	6.03			68.14			1.647		
LSD 5 %	0.78			6.92			0.110		
1 %	1.03			9.20			0.146		

***, ** Significant at 0.05 and 0.01 levels of probability, respectively**

Highly significant differences among the evaluated lines and crosses were observed in early yield means (Table 4). The recorded early yields ranged from 1.142 to 1.884 with a mean of 1.378 kg/plant in the lines. The highest early yield of the lines (1.885 kg/plant) was produced by the line RIG.10 which considered as the top parent for this trait followed by the line S.2 which produced an early yield of 1.595 kg/plant. Regarding the studied crosses, their early yield means ranged from 1.235 kg/plant (in the cross S.60x S.106) to 2.020 kg/plant (in the cross S.15 x RIG.10) with a mean value of 1.590 kg/plant and this mean value significantly exceeded that of the parental lines (1.378 kg/plant) by 15.39%. Compared with the top parent, only the cross S.15 x RIG.10 significantly exceeded that of the top parent by 7.16%. While, compared with Atlas pride hybrid (CH), the five crosses S.15 x RIG.10, S.60 x RIG.10, S.80 x S.2, S.80 x RIG.10 and S.106 x RIG.10 significantly exceeded that of the control and reflected standard heterosis values of 22.65, 8.56, 9.17, 14.15 and 11.90%, respectively.

Total yield reflected also a great variations among the studied entries (Table 5). The lines produced total yield values ranged from 4.138 kg/plant (in the line G.8) to 5.276 kg/plant (in the line S.60) with a mean of 4.749 kg/plant. While, the studied crosses produced total yields higher than those of the parental lines, since they showed yield values ranged from 4.562 kg/plant (in cross S.80 x S.106) to 6.145 kg/plant (in cross S.60 x S.2) with overall mean of 5.502 kg/plant and significantly exceeded the overall mean of lines by 15.86%. Relative to the top parent (S.60), eight crosses significantly exceeded the top parent and showed top heterosis values ranged from 6.67% (in the cross S.80 x G.8) to 23.71% (in the cross S.60 x S.2). Also, the four crosses “S.15 x IRG.10”, “S.60 x S.2”, “S.106 x G.8: and “S.106 x RIG.10” outyielded the commercial hybrid (CH) and showed standard heterosis values of 11.12, 18.03, 6.87 and 5.73%, respectively.

The forgoing results of early and total yield traits were generally in a good agreement with those reported by Bhatt *et al.* (2001), Makesh *et al.* (2003), Kansouh and Masoud (2007 and Dhadde *et al.* (2009) who found top and standard heterosis in some crosses.

For average fruit weight (Table 5), the parental lines varied widely in this trait, since their means ranged from 105.03 gm (in the line RIG.10) to 250.58 gm (in the line S.106) with an average of 163.19 gm. Also, a wide range was also observed among the crosses. Their range was from 105.56 gm (in the cross S.2 x RIG.10) to 223.83 gm (in the cross S.15 x S.106) with an average of 160.03 gm. Compared with the top parent (S.106) and the commercial hybrid (CH) Atlas pride, none of the tested crosses showed superiority relative to the top parent, while nine F_1’s significantly exceeded the commercial hybrid by values ranging from 11.64%(in the cross S.15 x G.8) to 54.23% (in the cross S.15 x S.106).

For fruit firmness, obtained data (Table 5) showed that, the line RIG.10 considered the top parent, since showed the firmest fruits (640.76 g/cm^2), followed by the line G.8 which showed value of 612.55 g/cm. On the other hand, the line S.106 showed the least fruit firmness value (381.58 gm/cm^2). Regarding the studied crosses, they varied widely in this trait, since showed fruit with firmness values ranging from 405.68 gm/cm^2 (in the cross S.60 x S.106) to 628.93 gm/cm^2 (in the cross G.8x RIG.10). Relative to the top parent (RIG.10) and the commercial hybrid (Atlas pride), no top heterosis was detected, since no superiority was observed over the top parent (TP); while, nine crosses produced firmest fruits than that of Atlas pride (CH) and recorded standard heterosis values ranging from 6.21% (in the cross S.60x RIG.10) to 25.53% (in thecross G.8 x RIG.10).

Table (5): Mean performances (M) and average degree of heterosis (ADH%) based on top parent (TP) and commercial hybrid (CH) of the evaluated F_1 hybrids and their parents for total yield, average fruit weight and fruit firmness.

Entries	Total yield , kg/plant			Average fruit weight			Fruit firmness		
	M	ADH%		M	ADH%		M	ADH%	
		TP	CH		TP	CH		TP	CH
Lines									
S.15	5.028			180.28			412.15		
S.60	5.276			180.48			401.55		
S.80	4.743			170.32			453.79		
S.106	4.553			250.58			381.58		
G.8	4.138			135.10			612.55		
S.2	4.838			120.53			491.70		
RIG.10	4.667			105.03			640.76		
Mean	4.749			163.19			484.87		
Crosses									
S.15 x S.60	5.471	3.70	-1.07	178.83	-28.63**	23.22**	420.26	-34.41**	-16.12**
S.15 x S.80	4.967	-5.86*	-10.18**	180.45	-27.98**	24.34**	452.13	-29.44**	-9.76**
S.15 x S.106	4.916	-6.82*	-11.10**	223.83	-10.67**	54.23**	412.08	-35.69**	-17.75**
S.15 x G.8	5.522	4.66	-0.14	162.02	-35.34**	11.64*	533.56	-16.73**	6.49**
S.15 x S.2	5.786	9.67**	4.62	150.45	-39.96**	3.67	490.28	-23.48**	-2.15
S.15x RIG.10	6.145	16.47**	11.12**	150.50	-39.93**	3.70	563.74	-12.02**	12.52**
S.60 x S.80	5.221	-1.04	-5.59*	181.98	-27.38**	25.39**	430.40	-32.83**	-14.10**
S.60 x S.106	4.993	-5.36	-9.71**	200.43	-20.01**	38.10**	405.68	-36.69**	-19.03**
S.60 x G.8	5.562	5.42	0.58	165.65	-33.89**	14.14**	517.33	-19.26**	3.25
S.60 x S.2	6.527	23.71**	18.03**	140.12	-44.08**	-3.45	485.54	-24.22**	-3.09
S.60 x RIG.10	5.820	10.31**	5.24	130.68	-47.85**	-9.96*	532.12	-16.95**	6.21**
S.80 x S.106	4.562	-13.53**	-17.50	203.68	-18.72**	40.34**	412.05	-35.69**	-17.76**
S.80 x G.8	5.628	6.67*	1.77	155.22	-38.06**	6.95	550.58	-14.07**	9.89**
S.80 x S.2	5.487	4.00	-0.78	153.77	-38.63**	5.95	492.27	-23.17**	-1.75
S.80 x RIG.10	5.735	8.70**	3.71	142.33	-43.20**	-1.93	571.90	-10.75**	14.14**
S.106 x G.8	5.910	12.02**	6.87*	190.35	-24.04**	31.16**	503.76	-21.38**	0.55
S.106 x S.2	5.142	-2.54	-7.02*	151.92	-39.37**	4.68	460.45	-28.14**	-8.10**
S.106 x RIG.10	5.847	10.82**	5.73*	140.25	-44.03**	-3.36	537.24	-16.15**	7.23**
G.8 x S.2	5.536	4.93	0.11	132.20	-47.24**	-8.90	581.88	-9.18**	16.14**
G.8 x RIG.10	5.240	-0.68	-5.24	120.57	-51.88**	-16.92**	628.93	-1.85	25.53**
S.2 x RIG.10	5.520	4.62	-0.18	105.56	-57.87**	-27.26**	598.52	-6.59**	19.46**
Mean	5.502			160.03			503.84		
Top parent (TP)	S.60 = 5.276			S.106 = 250.58			RIG.10 = 640.76		
Atlas pride (CH)	5.530			145.13			501.03		
LSD 5 %	0.296			13.72			19.16		
1 %	0.393			18.24			25.48		

***, ** Significant at 0.05 and 0.01 levels of probability, respectively**

In this respect, similar results were obtained by Patgaonkar *et al.* (2003) and Kansouh and Masoud (2007), since no heterosis was detected for both tomato average fruit weight and fruit firmness relative to the top parent. Generally, this behavior was expected since the top parent produced the largest and firmest fruits among all the parents, and heterosis over the better parent (over-dominance) was absent for tomato average fruit weight (Abdel-Ati *et al.*, 2000; Hatem, 2003) and fruit firmness (Khalil, 2004 and Kansouh and Masoud, 2007). Also, the additive gene action which found predominant and play the main role in the inheritance of these two traits, as mentioned before (Table 1) and previously reported by Thakur and Kohli (2005), Mehdi *et al.* (2008) and Ravindra *et al.* (2013) supported again the absence of heterosis over the top parent. Regarding standard heterosis for average fruit weight and fruit firmness, our results are in agreement with Kansouh and Masoud (2007), and Ravindra *et al.* (2012) who found heterosis over the commercial hybrid for these two traits in their studied.

Generally, the obtained results indicated that, the crosses “S.15 x RIG.10”, “S.60 x S.2”, “S.106 x G.8” and “S.106 x RIG.10” considered the best hybrids. They outyielded the commercial hybrid Atlas pride for total yield and vigorous growth and could be used commercially for high yield after additional experimental evaluation.

D.Promising hybrids evaluation:

As mentioned before, among the superior crosses three ones, i.e., “S.15x RIG.10”, “S.60 x S.2” and “S.106 x RIG.10” were chosen and evaluated again with the commercial hybrid (CH) Atlas pride on a large scale experiment. Obtained data (Table 6) showed that, these three crosses showed plant height values of 68.26, 75.01 and 70.67 cm, respectively, compared with 52.33 cm of Atlas pride (CH) with significant standard heterosis of 30.44, 43.33 and 35.05%, respectively. Also, they significantly exceeded the commercial hybrid for number of branches per plant. They showed values of 8.77, 10.33 and 9.10 branch/plant, respectively, compared with 6.80 branch/plant in the control (Atlas pride) with standard heterosis values of 28.79, 51.91 and 33.82%, respectively. The same behaviour was detected for number of leaves per plant, since the evaluated superior crosses recorded values of 103.86, 115.02 and 106.17 leaf/plant compared with 88.50 leaf/plant in Atlas pride (CH) and showed commercial heterosis values of 16.79, 29.97 and 19.97%, respectively. The obtained results indicated that, the evaluated promising crosses had vigorous growth compared with the commercial hybrid Atlas pride.

For early yield (ton/fed.), the two crosses “S.15 xRIG.10” and “S.106 x RIG.10” produced early yield of 8.512 and 7.887 ton/fed., respectively, and significantly surpassed that of Atlas pride (CH) by 26.42 and 17.14%, respectively. Meanwhile, no significant difference was detected between the third cross “S.60 x S.2”and the commercial hybrid Atlas pride for early yield. Regarding total yield (ton/fed.), the obtained data (Table 7) showed that, the three cross combinations produced total yield as 28.735, 29.693 and 27.145 ton/fed. compared with 22.687 in Atlas pride hybrid (CH) and showed significant standard heterosis values of 26.66, 30.88 and 19.65%, respectively.

Table (6): Mean performances (M) and standard heterosis (SD%) of the superior hybrids for plant height, number of branches, leaves and early yield.

Hybrids	Plant height (cm)		No. of branches		No. of leaves		Early yield (ton/fed.)	
	M	SD%	M	SD%	M	SD%	M	SD%
S.15 x RIG.10	68.26	30.44**	8.77	78.79**	103.86	16.79**	8.512	26.42**
S.60 x S.2	75.01	43.33**	10.33	51.91**	115.02	29.97**	6.305	-6.35
S.106 x RIG.10	70.67	35.05**	9.10	33.82**	106.17	19.97**	7.887	17.14*
Atlas bride (CH)	52.33		6.80		88.50		6.733	
LSD 5 %	8.33		1.06		9.68		0.977	
1 %	10.40		1.55		11.73		1.223	

***,** significant at 0.05 and 0.01 levels of probability, respectively.**

Table (7):Mean performances (M) and standard heterosis (SD%) of the superior hybrids for total yield (ton/fed),average fruit weight, fruit firmness and TSS% content.

Hybrids	Total yield, ton/fed.		Average fruit weight, g		Fruit firmness (g/cm^2)		TSS %	
	M	SD%	M	SD%	M	SD%	M	SD%
S.15 x RIG.10	28.735	26.66**	147.13	4.16	583.65	9.07**	4.86	0.62
S.60 x S.2	29.693	30.88**	135.68	-3.94	525.17	-1.86	5.07	4.96
S.106 x RIG.10	27.145	19.65**	145.25	2.83	571.19	6.74**	4.87	0.83
Atlas bride (CH)	22.687		141.25		535.12		4.83	
LSD 5 %	2.493		12.75		20.01		0.34	
1 %	3.015		17.16		29.33		0.46	

***,** significant at 0.05 and 0.01 levels of probability, respectively.**

For average fruit weight, no significant differences were observed among the evaluated crosses and the commercial hybrid Atlas pride. The average fruit weight in the crosses was 147.13, 135.68 and 145.25 gm, while it was 141.25 gm in the hybrid control. The same behaviour was detected for total soluble solids (TSS%) content, since the cross combinations recorded TSS% values of 4.86, 5.07 and 4.87% compared with 4.83% in Atlas pride hybrid. Lastly, the crosses “S.15 x RIG.10”and “S.106 x RIG.10” produced firmest fruits compared with those of the commercial hybrid, since they recorded firmness values of 583.65 and 571.19 gm/cm^2, respectively, compared with 535.12 gm/cm^2 in Atlas pride (CH) and recorded significant standard heterosis values of 9.07 and 6.74%, respectively. While, no significant differences was observed between the third cross “S.60 x S.2” and the control in this trait.

Generally, from this study, we can see that, the new three evaluated crosses significantly surpassed the commercial hybrid Atlas pride (the common hybrid in this area) for growth traits (plant height, number of branches and leaves) and showed vigorous growth compared with this hybrid. Also, they produced early and total yield significantly higher than those of Atlas pride with firmest fruits. It is very good when the local hybrids exceeded the commercial imported hybrid for growth and yield. Then, it could be concluded that, these three hybrids are good as local hybrids and can be used efficiently to improve tomato yield in Burg El-Arab area, West-Delta region, Egypt. However, the three crosses “S.15 x RIG.10”, “S.60 x S.2” and “S.106 x RIG.10” are succeeded in the general evaluation at the central administration for seed certification, Ministry of Agriculture. These hybrids under recognize by names of “Rima lady”, “Sara star” and”Wessam”.

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تربية هجن طماطم محلية جديدة بإقليم غرب الدلتا ـ مصر

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أجريت هذه الدراسة خلال الموسم الصيفى المتأخرفى الفترة من ٢٠٠٧ وحتى ٢٠١٠ فى منطقة برج العرب بإقليم غرب الدلتا ـ إستخدم فى الدراسة سبعة سلالات من الطماطم فى نظام نصف دائرة تلقيحية لتقدير كل من القدرة على التآلف وكذلك قوة الهجين القمية (أحسن الأباء) وقوة الهجين القياسية وذلك لصفات عدد الفروع والأوراق ـ المحصول المبكر والكلى ـ متوسط وزن الثمرة وصلابة الثمار.

أظهرت النتائج أن الفعل الإضافى والفعل الغير أضافى للجينات معنوى فى كل الصفات ، لكن الفعل الغير إضافى سائد ويلعب الدور الأساسى فى وراثة عدد الفروع والأوراق والمحصول الكلى ، بينما الفعل الإضافى للجينات أكثر أهمية وسيادة ويلعب الدور الأساسى فى وراثة متوسط وزن الثمرة وصلابة الثمار.

قوة الهجين القمية (على أساس أحسن الأباء) ظهرت فى صفات عدد الفروع والأوراق والمحصول الكلى ـ بينما ظهرت قوة الهجين التجارية (القياسية) على أساس الهجين التجارى فى كل الصفات تحت الدراسة وأظهرت الدراسة تفوق الهجن الثلاثية "اس١٥ × أر أى جى١٠" ، "اس ٦٠ × اس ٢" و"اس١٠٦ × ار أى جى١٠" على الأب القمى والهجين التجارى وأعطت قوة هجين قمية وقياسية فى معظم الصفات ومن ثم تم إختيارها كهجن جديدة محلية يمكن بها تحسين الإنتاج فى منطقة برج العرب ـ إقليم غرب الدلتا فى مصر ـ طريقة تربية الهجن على أساس المحصول العالى والذى يعتمد على قياس قوة الهجين القياسية (التجارية) تعتبر طريقة نافعة وذات كفاءة لتحسين المحصول عن طريق إنتاج هجن محلية. وفى النهاية قدمت الدراسة ثلاث هجن محلية للتسجيل تعادل بعض الهجن المستوردة وهذا يشجع على إنتاج الهجن المحلية والإستغناء التدريجى عن إستيراد بذورالهجن من الخارج.