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INHERITANCE OF PERCENTAGE SET, FIRMNESS AND β-CAROTENE AND LYCOPENE CONTENTS OF TOMATO FRUITS

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ABSTRACT

This investigation was conducted in the research facilities of the Horticulture Research Institute during the period from 1997 to 2000 to study the inheritance of some characters of importance to winter tomato production under low tunnels. Based on former evaluation studies on these characters in 15 true-breeding tomato cvs, five crosses were made for genetic studies, *viz.*, Supermarmande × Apex 1000 and Supermarmande × 506 Bush for studies on fruit set (FS) percentage, Apex 1000 × Siletz and Mountain Gold VFF × Siletz to study the inheritance of fruit firmness (FF), and Scotia (red fruits) × Mountain Gold VFF (tangerine fruits) to study the inheritance of fruit β-carotene and lycopene contents. Parental, F_1, F_1r, F_2 and backcross populations of each cross were planted in a RCBD with 4 replicates in the 1999/2000 winter season for evaluation under low tunnels using drip irrigation system. Percentage FS was found to be controlled by one and 4 pairs of genes in the crosses Supermarmande × Apex 1000 and Supermarmande × 506 Bush, respectively, with over dominance of high FS percentage in the first cross and partial dominance of the low FS percentage in the second one. Mid and better parent heterosis values were 39.1% and 13.4%, respectively, in the first cross, while it had negative values in the second one. BSH estimates were 73.6% and 23.7% in the two crosses, respectively. Fruit firmness was found to be controlled by 8 and 3 pairs of genes in the crosses Mountain Gold VFF × Siletz and Apex 1000 × Siletz, respectively, with partial dominance of the low FF character. Mid and better parent heterosis values were negative in the two crosses. BSH estimates were 74.9% and 85.6% in the two crosses, respectively. Fruit β-carotene and lycopene contents were found to be controlled by 2 pairs of genes for each pigment in the cross Scotia × Mountain Gold VFF with partial dominance of low over high content of each. They had negative values for both mid and better parent heterosis. Inheritance of fruit lycopene content was affected maternally. BSH estimates were 78.5% and 82.7% for fruit β-carotene and lycopene contents, respectively.

Key words: ***Lycopersicon esculentum, Fruit set, Fruit firmness, β-carotene and lycopene.***

INTRODUCTION

Fruit set (FS) percentage, fruit firmness (FF) and β-carotene and lycopene contents of tomato fruits are important characters in tomato production under polyethylene low tunnels. Knowledge about the inheritance of such characters are important for tomato breeders in their programs for producing new hybrids suitable for production under low tunnel conditions.

According to Kemp (1965), the ability for fruit set to occur in cv. Earlinorth at 4.4 C was found to be recessive and simply inherited. Ibrahim (1984) found partial dominance of low percentage FS under cold stress; broad sense heritability (BSH) was 34%, narrow sense heritability was 15% and mid-parent heterosis was - 100%.

The soft fruit character was reported by Kanno and Kamimura (1981) to be partially dominant. Khalil *et al* (1988) found no dominance of FF in some crosses, partial dominance towards the low or high parent in others and dominance for softness in one cross. Also, Hatem (1994) observed no dominance for FF in 10 hybrids and complete dominance for firm fruit in one hybrid. Mohammed (1998) found partial dominance of the high firmness. Abdel-Ati (1992) reported absence of dominance of FF in the cross Castlong × K. Korai Konzerv, whereas firmness was dominant in the cross Castlong × Housny. Also, Ramadan (1982) indicated that the low firmness (softness) was dominant. Complete dominance for the soft fruit character was reported by EL-Sayed *et al* (1966).

Fruit firmness was found to be controlled by a single major gene (EL-Sayed *et al* 1966). In another study, Ramadan (1982) suggested a 3 gene model to explain the inheritance of this trait. Three genes were also found by Yoshikawa *et al* (1982) to control FF. Abdel-Ati (1992) found that one pair of genes governed FF in the cross Castlong × K. Korai Konzerv with absence of dominance. Fruit firmness was dominant over softness in the cross Castlong × Housny. Two pairs of genes with cumulative effect were evident as segregation in the F_2 was 9 firm : 6 intermediate: 1 soft. Also, Rau *et al* (1994) and Mohammed (1998) reported that fruit fiirmness was controlled by 14 pairs of genes.

Heritability of FF was estimated by Ramadan (1982) as 51%, whereas Mochizuki *et al* (1986) mentioned that it was 74%. Markovic *et al* (1993) found that heritability was 70.7% in the broad sense. Also, Mohammed (1998) reported that estimates of BSH was low, being 22.55%.

Abani and Uzo (1985) estimated BSH for β-carotene content as 51.78%. Stommel and Haynes (1994) reported that segregation patterns for

fruit pigmentation and percentage β-carotene in F_1, F_2 and BC populations of a cross between an orange-fruited accession of *Lycopersicon cheesmanii* and *L. esculentum* fitted expected models for a single dominant gene conditioning a high percentage of β-carotene and resulting orange fruit pigmentation. Variation in coloured carotenoid content indicated a parental influence on total lycopene and β-carotene content and suggested independent genetic control of these carotenoid levels.

Amaral *et al* (1997) found the β-carotene content of Santa Clara × Floradade approached that of Floradade, whilst that of Angela I.5100 × Floradade exceeded that of Floradade (nearly 0.7 μg/100 g).

Aggour (1999) studied the inheritance of yellow versus red fruit color in the tomato crosses CAL 951/88 × Yellow Pear, Yellow Pear × CAL 951/88 and Yellow Pear × Edkawi. Segregation in the F_2 populations fitted a two gene pairs segregation ratio of 9 red : 3 orange : 4 yellow.

Rego *et al* (1999) reciprocally crossed a naturally occurring yellow tomato fruit mutant cv. Santa Clara with the red wild type. Plants from F_1 generation produced all fruits with a homogeneous deep red color when ripe. F_2 plants showed a 3:1 red: yellow segregation of fruit color. Based on reciprocal crosses, fruit color was unlikely to be determined by maternal genes.

This research was conducted to study genetics of some characters of importance to winter tomato production under low tunnels *viz.*, fruit set, fruit firmness and fruit β-carotene and lycopene contents.

MATERIALS AND METHODS

This study was conducted during the period from 1997 to 2000. Seeds of different genetic populations were produced and transplants were raised in the greenhouse facilities of Kaha Vegetable Research Farm (KVRF), Kalubia, while genetic studies were conducted using a drip-irrigation system under low tunnels during the winter season at Ali Mubarak Village Research Farm (AMVRF), South El-Tahrir Horticulture Research Station (STHRS), Behairah.

Based on an evaluation trial of 15 true-breeding tomato cvs. during the 1997/1998 planting, 6 cvs. were selected to serve as parents for 5 crosses to study the genetics of 3 characters. Seeds of all possible crosses and their reciprocals among the 15 evaluated cvs were produced during the 1997/1998 winter season. Seeds of the F_2 and backcross (BC) populations to both

parents and additional F_1 seeds were produced during the 1998/1999 winter season in KVRF, Kalubia.

The 6 genetic populations of each cross, *viz.*, parents, F_1, F_1r, BCs and F_2 , were evaluated in a RCBD with 4 replicates. Each replicate consisted of 15 plants of each of the non-segregating populations (*viz.*, parents and F_1's), 40 plants of each BC and 50 plants of the F_2 . The study was conducted during the 1999/ 2000 winter season under low tunnels using a drip-irrigation system. Seed sowing was on October 14 and transplanting on November 21, 1999. Plant beds were 1 m wide and plants were spaced 50 cm apart.

Fruit set percentage was measured in the crosses Supermarmande × Apex 1000 and Supermarmande × 506 Bush. Average monthly minimum and maximum temperatures both under the low tunnels and in the open air are presented in Table (1) . Fruit firmness was measured in red-ripe fruits of the crosses Apex 1000 × Siletz and Mountain Gold VFF × Siletz. Fruit lycopene and β-carotene contents were measured in ripe fruits of the cross Scotia × Mountain Gold VFF. Measurements of each character were made on individual plants of each genetic population. Percentage of FS was based on all flowers produced per plant. Measurements of FF were made on 5 red-ripe fruits of each plant using a needle type pocket penetrometer. Five readings were taken for each fruit by pushing the penetrometer needle slowly at 5 different sites ; one reading being near the shoulder, another one at the blossom end and 3 readings at the equatorial plane, then the mean of the 5 readings was calculated. For the measurement of fruit lycopene and β-carotene contents, 1 ripe fruit from each plant was taken and its content of both lycopene and β-carotene was determined (AOAC 1990).

Table 1. Average minimum and maximum temperatures (C) during the experimental period of the genetic study both under low tunnels and in the open air.

	Low tunnels		Open air*	
Month	**Min**	**Max**	**Min**	**Max**
December 1999	**7.9**	**28.8**	**8.9**	**18.3**
January 2000	**8.5**	**24.8**	**9.9**	**14.8**
February 2000	**9.5**	**31.1**	**9.0**	**19.2**
March 2000	**10.3**	**34.3**	**9.3**	**20.4**

***Source : Central Laboratory of Climate, Ministry of Agriculture, Dokki, Giza.**

Maternal effect was estimated by measuring the significance of difference between F_1 means and their reciprocals, using the t test. Potence ratio, i.e., the relative potency of gene set (P), was used to determine the direction of dominance according to the formula (Smith 1952):

$$P = \frac{F_1 - MP}{\frac{1}{2}(P_2 - P_1)}$$

where : F_1 = first generation mean, P_1 = mean of the smaller parent, P_2 = mean of the larger parent and MP = mid parent value = $\frac{1}{2}(P_1 + P_2)$. The absence of dominance was assumed when the difference between the parents was significant and F_1 - MP was not significant. Complete dominance was assumed when potence ratio equaled to or did not differ from $\pm$ 1.0. Meanwhile, partial dominance was considered when potence ratio was between + 1.0 and – 1.0, but was not equal to zero. Over dominance (Heterosis) was assumed when potence ratio exceeded $\pm$ 1.0 .

Heterosis based on the mid and better parent was estimated according to the following equation (Sinha and Khanna 1975):

$$\text{Mid-parent heterosis} = \frac{F_1 - MP}{MP} \times 100$$

where : MP: mean of the mid-parent and F_1 : mean of the first hybrid generation.

$$\text{High-parent heterosis} = \frac{F_1 - HP}{HP} \times 100$$

where HP : mean of the high or better-parent.

The minimum number of genes controlling the character in each cross was calculated using Castle-Wright equation (Castle and Wright 1921) as follow:

$$N = \frac{D^2}{8(V_{F2} - V_{F1})}$$

where : N = number of genes controlling the character in each cross, D = difference between parental means and V_{F1} and V_{F2} = variances of the F_1 and F_2 populations, respectively.

Broad sense heritability was calculated using the equation (Allard 1960):

$$BSH = \frac{V_G}{V_P} \times 100$$

where : V_G = genetic variance which was calculated by subtracting the environmental variance (V_E) from the phenotypic variance (V_P) and V_E was measured as the geometric mean of variances of the non-segregating populations, i.e., parents and F_1s.

RESULTS AND DISCUSSION

Fruit Set Percentage

Data obtained on FS percentage under low temperature of parental, F_1, F_1r, F_2, and backcrosses populations of the crosses Supermarmande × Apex 1000 and Supermarmande × 506 Bush are presented in Table (2).

In the two crosses, parents were distinctively different in FS percentage under low temperatures. In the first cross, F_1 and F_2 means were higher than the higher parent, meanwhile, in the second cross, F_1 mean was very close to the mid-parent, but F_2 mean was high and exceeded that of the higher parent. F_2 plants were widely distributed between the two parents with a high tendency towards the higher one. In the two crosses, plants of the backcross to cv. Supermarmande were widely distributed with a high tendency towards this parent. Plants of the backcross to cv. Apex 1000, in the first cross, were very close to it, while plants of the backcross to cv. 506 Bush, in the second cross, were widely distributed between the two parents. No significant differences were observed between the F_1 and its reciprocal, in the two crosses in FS percentage under low temperature indicating no maternal effect.

Quantitative genetic parameters obtained for FS percentage under low temperature in the two crosses are presented in Table (6). The high positive P value (1.72) in the first cross indicated over dominance (heterosis) for FS percentage under low temperature over high parent. Meanwhile, in the second cross, P value was negative (- 0.08) indicating partial dominance of the low over the high percentege of FS under low temperature. Results obtained on potence ratio in the second hybrid are in agreement with that of Ibrahim (1984) as she found partial dominance of low FS percentage. Meanwhile, Kemp (1965) reported complete dominance of low FS percentage.

Mid and better parent heterosis values were 39.1% and 13.4%, respectively, in the first cross, while it had negative values in the second one. Results of the second hybrid are in accordance with that of Ibrahim (1984) as she reported negative mid-parent heterosis for this character.

Percentage of FS under low temperature was found to be controlled by one pair and 4 pairs of genes in the two crosses, respectively. The estimated number in the first cross (one pair of genes) was similar to that obtained by Kemp (1965).

Table 2. Distribution, mean and variance of fruit set percentage of parental, F_1, F_1r, F_2, BCP_1 and BCP_2 populations of the crosses Supermarmande × Apex 1000 and Supermarmande × 506 Bush.

Population	Frequency of fruit set percentage in class [a]									Total No. of plants	Mean ($\bar{x} \pm S_{\bar{x}}$)	Variance (S^2)
	24.7	32.8	40.9	49.0	57.1	65.2	73.3	81.4	89.5			
Supermarmande × Apex 1000												
Supermarmande (P_1)		3	10	12	21	9	3			58	53.47 ± 1.32	101.69
Apex 1000 (P_2)	15	19	19	1						54	33.70 ± 0.93	46.22
F_1				6	20	28	1			55	60.63 ± 0.78	33.45
F_1r			2	8	19	22	5			56	59.99 ± 1.04	60.67
F_2	15	5	6	26	48	53	29	4	3	189	58.04 ± 1.04	204.31
BCP_1			1	19	55	51	18	8		152	61.90 ± 0.69	71.57
BCP_2	22	30	36	41	22					151	41.49 ± 0.84	107.69
Supermarmande × 506 Bush												
Supermarmande (P_1)		3	10	12	21	9	3			58	53.47 ± 1.32	101.69
506 Bush (P_2)	1	19	23	12						55	39.57 ± 0.86	40.74
F_1	3	6	14	19	14					56	45.96 ± 1.23	84.85
F_1r	1	9	19	25	3					57	43.74 ± 0.94	50.36
F_2			2	24	61	54	34	13	2	190	63.11 ± 0.70	92.47
BCP_1	1	7	27	48	30	29	7	4		153	53.29 ± 0.91	126.95
BCP_2	6	9	21	44	44	26	5			155	51.82 ± 0.89	121.50

[a] Each class represents a fruit set % range of 8.1 and class values indicated represent class centers.

Estimates of BSH in the first cross was high, being 73.6%. Conversely, BSH estimates in the second cross were low (23.7%) which agree with that obtained by Ibrahim (1984).

Fruit Firmness

Data obtained on FF of parental, F_1, F_1r, F_2 and backcrosses populations of the crosses Mountain Gold VFF × Siletz and Apex 1000 × Siletz are presented in Table (3).

In the two crosses, parents were distinctively different in FF. F_1 mean was close to that of the lower parent and mid-parent in the two crosses, respectively. F_2 plants were widely distributed between the two parents with a high tendency towards the low parent in the first cross and towards the high parent in the second one. Plants of the backcrosses to cv. Mountain Gold VFF in the first cross, and to cv. Apex 1000 in the second one were widely distributed. In the second cross, plants of the backcross to cv. Siletz were very close to it. A significant difference, in the first cross, was observed between the F_1 and its reciprocal in FF indicating the presence of maternal effect.

Quantitative genetic parameters obtained for FF in the two crosses are presented in Table (6). In the two crosses, the negative P value indicated partial dominance of the low FF character. These results are in agreement with results of Kanno and Kamimura (1981) and Khalil *et al* (1988) who found partial dominance for soft fruit. Different cases of dominance for this character were reported including complete dominance for firm fruit (Abdel-Ati 1992; Hatem, 1994), partial dominance of the high fruit firmness (Khalil *et al* 1988; Mohammed 1998), dominance of soft fruit (El-Sayed *et al* 1966; khalil *et al* 1988, Ramadan 1982) and absence of dominance (Abdel-Ati 1992, Hatem 1994, Khalil *et al* 1988).

In the two crosses, both mid and better parent heterosis had negative values.

Minimum number of genes estimated to control FF character in the cross Apex 1000 × Siletz was 3 pairs. These results coincided with that of Ramadan (1982) and Yoshikawa *et al* (1982) as they estimated 3 pairs of genes to control this trait. Eight pairs of genes were estimated in the cross Mountain Gold VFF × Siletz indicating that this trait was under polygenic control. These results are agree partially with that of Rau *et al* (1994) and Mohammed (1998) as they found that this character was under the control of at least 14 pairs of genes.

Table 3. Distribution, mean and variance of fruit firmness of parental, F_1, F_1r, F_2, BCP_1 and BCP_2 populations of the crosses Mountain Gold VFF × Siletz and Apex 1000 × Siletz.

Population	Frequency of fruit firmness in class [a]								Total No.	Mean	Variance
	306	483	660	837	1014	1191	1368	1545	of plants	($\bar{x} \pm S_{\bar{x}}$)	(S^2)
Mountain Gold VFF × Siletz											
Mountain Gold VFF (P_1)					2	20	38		60	1296.42 ± 12.7	9773.37
Siletz (P_2)	54	6							60	324.57 ± 6.88	2854.17
F_1	18	34							52	422.22 ± 11.72	7178.67
F_1r	52	7							59	328.29 ± 7.53	3286.62
F_2	32	83	47	17					179	531.96 ± 11.44	23438.79
BCP_1		6	39	41	38	18	4		146	879.78 ± 17.21	43158.51
BCP_2	22	46	39	28	6	1			142	601.71 ± 16.74	39698.91
Apex 1000 × Siletz											
Apex 1000 (P_1)					3	18	29	10	60	1326.18± 18.04	19460.25
Siletz (P_2)	54	6							60	324.57 ± 6.88	2854.17
F_1		10	32	15	3				60	692.85 ± 17.58	18508.86
F_1r		3	41	16					60	698.43 ± 11.90	8562.51
F_2		3	16	24	38	48	39	20	188	1127.16 ± 19.34	70316.37
BCP_1	37	60	35	19	2				153	531.96 ± 14.42	31741.83
BCP_2	132	16							148	326.43 ± 4.56	3027.15

[a] Each class represents a fruit firmness range of 177 g/cm^2 and class values indicated represent class centers.

BSH estimates in the crosses Mountain Gold VFF × Siletz and Apex 1000 × Siletz were 75.0% and 85.6%, respectively. These moderate to high estimates are in agreement with those of Mochizuki *et al* (1986) and Markovic *et al* (1993) whose estimates were 74% and 70.7%, respectively.

Fruit β-Carotene Content

Data obtained on fruit β-carotene content of parental, F_1, F_1r, F_2 and backcross populations of the cross Scotia (red fruits) × Mountain Gold VFF (tangerine fruits) are presented in Table (4).

Parents were distinctively different in their fruit β-carotene content. F_1 and F_2 means were close to that of the lower parent. F_2 plants were widely distributed between the two parents with a high tendency towards the low parent. Plants of the backcross to cv. Scotia were very close to it, while plants of the backcross to cv. Mountain Gold VFF were widely distributed with a slight tendency towards this parent. No significant difference was observed between F_1 and its reciprocal in fruit β-carotene content indicating no maternal effect. This result is in agreement with Rego *et al* (1999) who found that fruit color is unlikely to be determined by maternal genes.

Quantitative genetic parameters obtained for fruit β-carotene content are presented in Table (6). The negative P value (– 0.73) indicated partial dominance of the low over the high fruit β-carotene content.

Mid and better parent heterosis had negative values being – 38.8% and – 60.0%, respectively. These results are in contradiction with those of Amaral *et al* (1997) as they reported that β-carotene content of Santa Clara × Floradade approached that of the high parent, while Angela I.5100 × Floradade exceeded that of the high parent.

Fruit β-carotene content was found to be controlled by 2 pairs of genes. This result disagree with that previously estimated as a single dominant gene conditioning a high percentage of β-carotene (Stommel and Haynes 1994).

Estimates of BSH was high, being 78.8%, while Abani and Uzo (1985) estimated it as 51.78%. High BSH estimates indicate the minor role the environment plays on this character.

Fruit Lycopene Content

Data obtained on fruit lycopene content of parental, F_1, F_1r, F_2 and backcross populations of the cross Scotia (red fruits) × Mountain Gold VFF (tangerine fruits) are presented in Table (5).

Table 4. Distribution, mean and variance of fruit β-carotene content of parental, F_1, F_1r, F_2, BCP_1 and BCP_2 Populations of the cross Scotia × Mountain Gold VFF.

Population	Frequency of fruit beta carotene content in class [a]								Total No.	Mean	Variance
	0.40	0.61	0.82	1.03	1.24	1.45	1.66	1.87	of plants	$(\bar{x} \pm S_{\bar{x}})$	(S^2)
Scotia (P_1)	31	24							55	0.49 ± 0.014	0.011
Mountain Gold VFF (P_2)				14		2	15	27	58	1.60 ± 0.045	0.116
F_1		51	9						60	0.64 ± 0.010	0.006
F_1r		45	15						60	0.66 ± 0.012	0.009
F_2	63	61	41	9	4	3	3	3	187	0.67 ± 0.022	0.093
BCP_1	39	112							151	0.56 ± 0.008	0.009
BCP_2			1	125	23	11			160	1.09 ± 0.010	0.016

[a] Each class represents a fruit β-carotene content range of 0.21 mg/100 g fresh weight and class values indicated represent class centers.

Table 5. Distribution, mean and variance of fruit lycopene content of parental, F_1, F_1r, F_2, BCP_1 and BCP_2 populations of the cross Scotia × Mountain Gold VFF.

Population	Frequency of fruit lycopene content in class [a]								Total No.	Mean	Variance
	0.42	0.75	1.08	1.41	1.74	2.07	2.40	2.73	of plants	$(\bar{x} \pm S_{\bar{x}})$	(S^2)
Scotia (P_1)				3	16	17	12	7	55	2.094 ± 0.05	0.136
Mountain Gold VFF (P_2)	45	13							58	0.494 ± 0.018	0.019
F_1		10	23	27					60	1.174 ± 0.031	0.059
F_1r		9	41	10					60	1.086 ± 0.024	0.035
F_2	12	30	33	25	58	18	6	5	187	1.415 ± 0.041	0.307
BCP_1				40	111				151	1.653 ± 0.012	0.021
BCP_2	31	129							160	0.686 ± 0.010	0.017

[a] Each class represents a fruit lycopene content range of 0.33 mg/100 g fresh weight and class values indicated represent class centers.

Table 6. Quantitative genetic parameters obtained for FS percentage, FF and fruit β-carotene and lycopene contents of some tomato crosses.

Cross	Potence ratio (P)	Mid-parent heterosis (%)	High-parent heterosis (%)	Minimum number of genes	Broad sense heritability (%)
			Fruit set percentage		
Supermarmande × Apex 1000	1.72	39.1	13.4	0.29	73.6
Supermarmande × 506 Bush	- 0.08	- 1.2	- 14.1	3.17	23.7
			Fruit firmness		
Mountain Gold VFF × Siletz	- 0.80	47.9	- 67.4	7.26	75.0
Apex 1000 × Siletz	- 0.26	16.1	- 47.8	2.42	85.6
			Fruit β-carotene content		
Scotia × Mountain Gold VFF	- 0.73	- 38.8	- 60.0	1.77	78.8
			Fruit lycopene content		
Scotia × Mountain Gold VFF	- 0.15	- 9.3	- 43.9	1.29	82.6

Parents were distinctively different in fruit lycopene content. F_1 and F_2 means were close to that of the mid-parent. F_2 plants were widely distributed between the two parents. Plants of the backcross to cv. Scotia were close to it; also, plants of the backcross to cv. Mountain Gold VFF were very close to it. A significant difference was observed between the F_1 and its reciprocal in fruit lycopene content indicating the existence of maternal effect. This result agree with that obtained by Stommel and Haynes (1994) who reported parental influence on total lycopene and β-carotene content.

Quantitative genetic parameters obtained for fruit lycopene content are presented in Table (6). The low, negative P value indicated partial dominance of the low over the high fruit lycopene content.

Both mid and better parent heterosis had negative values of –9.3% and – 43.9%, respectively.

Fruit lycopene content was found to be controlled by 2 pairs of genes. This result partially agree with Aggour (1999) who estimated 2 gene pairs for fruit color.

Estimates of BSH for fruit lycopene content were high, being 82.6% indicating the minor role of the environment on this character.

REFERENCES

Abani, M.S.C and J.O. Uzo (1985). Estimates of genetic and environmental variability in beta- carotene and ascorbic acid in processing tomato (*Lycopersicon esculentum* Mill.) in southern Nigeria. J. Japanese Soc. Hort. Sci. 53 (4): 438-443. (c.a. Plant Breed. Abstr. 56: 9186; 1986).

Abdel-Ati, K.E.A. (1992). Inheritance of some economic characters in tomato, *Lycopersicon esculentum* Mill. Ph. D. Thesis. Fac. Agric., Cairo University.

Aggour, A.R. (1999). Inheritance of some fruit quality characteristics in tomato. Annals Agric. Sci., Moshtohor 37 (1): 555-573.

Allard, R.W. (1960). Principles of Plant Breeding. John Wiley & Sons, Inc. New York.

Amaral, J. , A.T. Do., V.W.D. Casali, F. L. Finger and R.F. Daher (1997). Heterosis in tomato for content of carotenoids with medicinal end-use. (In Portuguese). SOB Informa 15/16 (1): 20. (c.a. Plant Breed. Abstr. 68: 2954; 1998).

AOAC, Association of Official Agricultural Chemists (1990). Official methods of analysis. 15th ed, Washington. D.C., USA.

Castle, W.E. and S. Wright (1921). An improved method of estimating the number of genetic factors concerned in cases of blending inheritance. Science 54: 233.

El-Sayed, M.N.K., H. T. Erickson and M.L. Tomes (1966). Inheritance of tomato fruit firmness. Proc. Amer. Soc. Hort. Sci. 89: 523-527.

Hatem, M.K. (1994). Heterosis and nature of gene action in tomato. M. Sc. Thesis. Fac. Agric., Minufiya University.

Ibrahim, M.A. (1984). Genetic and physiological studies on heat and cold tolerance in tomato. Ph. D. Thesis. Fac. Agric., Cairo University.

Kanno, T. and S. Kamimura (1981). Fruit structure, firmness and quality, and relationships between these factors in varieties and F_1 hybrids of tomatoes, pp. 99-119. In: J.Philouze (Ed.) Genetics and Breeding of Tomato. INRA, Versalilles, France.

Kemp, G.A. (1965). Inheritance of fruit set at low temperature in tomatoes. Proc. Amer. Soc. Hort. Sci. 86: 565-568.

Khalil, R.M., A.A. Midan and A.K. Hatem (1988). Studies on heterosis of earliness and yield components in intervarietal crosses of tomato, *Lycopersicon esculentum* Mill. Zagazig J. Agric. Res. 15 (1): 184-208.

Markovic, Z., D. Stevanovic, M. Damjanovic, B. Kandic, R. Djordjevic and L. Stamova (1993). Estimation of inheritance and combining abilities of fruit firmness in tomatoes by partial diallel analysis, pp. 131-134. In Proceedings of the XIIth Eucarpia meeting on tomato genetics and breeding, Plovdiv, Bulgaria, 27-31 July 1993. (c.a. Plant Gene CD 1989-5/1998).

Mochizuki, T., S. Kamimura and K. Ito (1986). Studies on the inheritance of fruit firmness and acidity. Assessment of the F_2 of tomato lines differing in fruit shape. (In Japanese with English summary). Bulletin, Vegetable and Ornamental Crops Research Station, B. 6: 17-29. (c.a. Plant Breed. Abstr. 56: 9188; 1986).

Mohammed, A.A. (1998). Studies on the production of tomato hybrids. M.Sc. Thesis. Fac. Agric., Cairo University.

Ramadan, M.M. (1982). The biochemistry and genetics of tomato firmness. Dissertation Abstr. International, B42 (8): 3118 B. (c.a. Plant Breed. Abstr. 52: 8006; 1982).

Rau, G.A., C.E. McCulloch and M.A. Mutschler (1994). Evaluation of parental-type classification for the inbred –backcross method of estimating gene number. J. Heredity 85: 105-111.

Rego, E.R. Do., F.L. Finger, V.W.D. Casali and A.A. Cardoso (1999). Inheritance of fruit color and pigment changes in a yellow tomato (*Lycopersicon esculentum* Mill.) mutant. Genet. Molec. Biol. 22 (1): 101-104. (c.a. Plant Breed. Abstr. 69: 7891; 1999).

Sinha, S.K. and R. Khanna (1975). Physiological, biochemical and genetic basis of heterosis. Adv. Agron. 27: 123-174.

Smith, H.H. (1952). Fixing transgressive vigour in *Nicotiana rustica*. Iowa State College Press, Ames, Iowa.

Stommel, J.R. and K.G. Haynes (1994). Inheritance of beta carotene content in the wild tomato species *Lycopersicon cheesmanii*. J. Heredity 85 (5): 401-404.

Yoshikawa, H., S. Kamimura and K. Ito (1982). Fruit firmness in F_1 tomato hybrids. (In Japanese with English summary). Bull. Veg. & Ornamental Crops Res. Sta., B No. 4: 1-14. (c.a. Plant Breed. Abstr. 53: 2620; 1983).

وراثة نسبة العقد و الصلابة ومحتوى البيتا كاروتين والليكوبين في ثمار الطماطم

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أجرى هذا البحث فى معهد بحوث البساتين خلال الفترة من ١٩٩٧ إلى ٢٠٠٠ لدراسة وراثة بعض الصفات الهامة لإنتاج الطماطم تحت الأنفية المنخفضة. بناءً على دراسة سابقة أجرى فيها تقييم لـ ١٥ صنفاً من الطماطم لهذه الصفات فقد أجريت خمسة تلقيحات للدراسات الوراثية وهى Supermarmande × Apex 1000، و Supermarmande × 506 Bush لدراسة النسبة المئوية لعقد الثمار و Apex 1000 × Siletz ، و Mountain Gold VFF × Siletz لدراسة وراثة صلابة الثمار و Mountain Gold VFF (ثماره برتقالية) × Scotia (ثماره حمراء) لدراسة وراثة محتوى الثمار من كل من البيتا كاروتين والليكوبين . زرعت نباتات كل من الآباء، والجيل الأول، والجيل الأول العكسى، والجيل الثانى ، والتلقيحات الرجعية لكلا الأبوين لكل هجين فى أربعة مكررات فى قطاعات كاملة العشوائية فى العروة الشتوى ١٩٩٩/٢٠٠٠ للتقييم تحت الأنفاق مع استخدام نظام الرى بالتنقيط .

وجد أن صفة النسبة المئوية لعقد الثمار يتحكم فى وراثتها زوج واحد، وأربعة أزواج من العوامل الوراثية فى التلقيحين Supermarmande × Apex 1000 ، و Supermarmande × 506 Bush ، على التوالى، مع وجود سيادة فائقة لنسبة العقد العالية فى

التلقـيح الأول، و سيادة جزئية لنسبة العقد المنخفضة فى التلقيح الثانى. قدرت قوة الهجين بالمقارنة بكل من متوسط الأبوين، والأب الأفضل وكانت ٣٩,١ % ،و ١٣,٤ % على التوالى فى التلقيح الأول، بينما أخذت قيما سالبة فى التلقيح الثانى. قدرت درجة التوريث على النطاق العريض بـــ ٧٣,٦ % ،و ٢٣,٧ % فى التلقيحين، على التوالى.

وجـد أن صـفة صـلابة الـثمار يتحكم فى وراثتها ٨، و ٣ أزواج من العوامل الوراثـية فـى التلقيحيـن Mountain Gold VFF × Siletz ،و Siletz × Apex 1000 ، على الـتوالى مع سيادة جزئية لصفة صلابة الثمار المنخفضة. أخذت قوة الهجين بالمقارنة بكل من متوسط الأبويـن، و الأب الأفضل قيماً سالبة فى كلا التلقيحين. قدرت درجة التوريث على النطاق العريض بـــ ٧٤,٩ % ، و ٨٥,٦ % فى التلقيحين، على التوالى.

وجد أن صفة محتوى الثمار من كل من البيتا كاروتين والليكوبين يتحكم فى وراثتها زوجين مـن العوامل الوراثية لكل صبغة فى التلقيح Mountain Gold VFF × Scotia ، مع سيادة جزئية للمحتوى المنخفض على العالى لكل منها. قدرت قوة الهجين بالمقارنة بكل من متوسط الأبوين، والأب الأفضـل فكانت سالبة لكلا الصبغتين. تأثرت وراثة محتوى الثمار من الليكوبين بالوراثة الأمية . قدرت درجـة التوريـث على النطاق العريض بـــ ٧٨,٥ % ، و ٨٢,٧ % لمحتوى الثمار من كل من البيتا كاروتين والليكوبين ، على التوالى.