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STUDY OF GENOTYPE-ENVIRONMENT INTERACTION IN TOMATO TRIPLE TEST CROSS 1. MEAN PERFORMANCE OF THE TESTERS AND NI-CULTIVARS

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ABSTRACT : Two tomato crosses; i. e., Money Maker x Castle Rock (MM x CR) and Carmeuco 200 x Peto 86 (C_{200} x Peto), their parents and two cultivar groups (11 each) , which will be used for triple test cross, were evaluated under three micro-environments (30, 45 and 60 cm plant spacings) in sandy soils. They were tested in split-plot design with three replicates, in the summer season of 2000, at El-Khattara Farm, Zagazig University.

Highly significant values were observed for the mean squares of environments, genotypes (testers and Ni-cultivars) and genotype-environment interaction (tester x env. and cultivar x env.); for plant height, branch number/plant, early fruit number/plant, early yield/ plant, early yield/plot, total yield/plant and per plot, fruit weight/ fruit. and fruit number /plant; whereas, those for average early fruit weight of environments and all early yield traits of testers x environment were insignificant. Such differences among genotypes (testers and Ni-cultivars) and their interaction with the same environment and under different environments were assessed in both studied crosses. Therefore, the testers (P_1, P_2, and F_1) and Ni-cultivars group for each cross had sufficient variability among them, and responded differently to the examined environments. Peto cv gave the highest yield / plant, in environment 1, and C_{200} cv, in environments 2 and 3, in group 1, while, in group 2, MM gave the highest yield / plant of all environments.

Key wards : Micro-envirnments, testers, N_i - cultivars .

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is considered one of the most important vegetable crop in Egypt, for fresh consuption and processing. Althouth, tomato is a self pollinated crop,

hybrid vigour was earlierly reported by many authers and used as hybrid variety in economic agriculture (Khalf-Allah, 1970; Khalf -Allah and Kassem, 1985; Mahmoud and Gad El-Hak, 1988; Sherif and Hussein, 1993; Dev *et al.*, 1994; Zanata, 1994; Hegazi *et al.* 1995; Kumar *et al.* 1995; El-Sayed, 1997; Ismail, 1997; Youssef, 1997; Salib, 1999; Bayomy, 2002). Therefore, the breeding program for such a crop should aim to seek for obtaining high yield hybrid or to develop high performed cultivar (Ismail, 1997). The amount of heterosis depends upon the diversity of the parents involved in hybridization, so that when the parents are not closely related, a fairly large amount of heterosis would be expected (Bayomy, 2002).

Since the breeding program is a time and labor consumption, it should be well planned from the beginning. And/also the material (genotypes) should be carefully selected to acheive its aim to detect the cause of heterosis, a fair estimation of the genetic components of variation would be obtained(Jinks, 1983). Predection at each step of the program for obtaining lines superior than their good parent or even than the F_1-hybrid.

Triple-test cross (TTC) provides a fair estimates of genetic components of variations, if the used genotypes for this cross system are adequate. Therefore, the present work aimed to test the adequacy of the testers (P_1, P_2 and F_1) and Ni-cultivar two groups for TTC, through the evaluation of their general, under different environments (planting spaces).

MATERIALS AND METHODS

Four tomato cultivars; i.e., Money Maker (MM), Castle Rock (CR), Carmeuco 200 (C_{200}) and Peto 86 (Peto), were used to obtain two F_1 hyprids. The two crosses were MM x CR as cross 1, and C_{200} x Peto as cross 2 and 11 cultivar groups (Schedule 1) which will be used for TTC system in the next papers, were evaluate for their general performances under three environments. The three environments (plant spacings) were; 30 cm (env. 1), 45 cm (env. 2) and 60 cm (env. 3).

Seeds of the parents were sown on Oct. 28 ,1997 in plastic pots (15 cm). The growing medium consisted of peat moss and vermiculite 1:1 (v/v) . The pots were kept under a low plastic tunnul and the raised seedlings were transplanted on Dec.

21, 1997 under plastic house to produce seeds of the two F_1 crosses, and continoud up to 1999. Seeds of both F_1's and 11 Ni-cultivar groups were sown in speedling trays on Jan. 25, 2000 and kept under plastic house. The seedling were transplanted on Mar. 8, 2000 in the field. Seedlings were distributed in the field according to split-plot in randomized complete block design with three replicates. The main plots were devoted for the three different environments (30, 45 and 60 cm spacings between plants) in lines of about 150 cm wide. The fourteen genotypes (2 parents + an F_1 hybrid + 11 Ni-cultivars group) of each cross were randomly distributed in the sub-plots of each environments. Plot area was 4.5 m^2 (3 m lenght x 1.5 m wide) with an uncultured space (1.5 m) between every two plots. Fertigation and other cultural practices were done as recommended for sandy soil conditions in the district .

Data were recorded from each sub-plot at the end of the season for final plant height, branch number/plant, early yield traits; i.e., average early fruit weight, early fruit number/plant, early yield/plant and total early yield/plot. The first three

Schedule 1. Appriviation and source of the tomato Ni-cultivars.

Ni - cultivars		Appriv.	Source
Name	Group		
Super Marmande	1 and 2	SM	Daehnfeldt, Holland
Strain-B	1 and 2	SB	Sun Seeds, Parma, Idaho, USA
Carmeuco 201	1 and 2	C_{201}	Inter. Agric., Res., Argantina
Aledo VF	1 and 2	Aledo	Clause, France
Sun Drop	1 and 2	SD	Bruinsma, Holland
Super Strain-B	1 and 2	SSB	Sun Seeds, Parma, Idaho, USA
Pearson Improved	1 and 2	PI	Noord Scharwoude, Holland
Beef Stick	1 and 2	BS	American Seed, USA
Carmeuco 200	1	C_{200}	Inter. Agric., Res.,Argantina
Peto 86	1	Peto	Peto Seed, USA
UC 97-3	1	UC	Peto seed, USA
Money Maker	2	MM	Yates, New Zealand Ltd.
Castle Rock	2	CR	Castle Seed, USA
Rutgers Select	2	RS	American Seed, USA

pickings, starting from 72-85 days after transplanting were considered as early yield .Total yield traits; i.e., average fruit weight, total fruit number/plant and total yield/plot and plant, were recorded at the end of harvesting season.

Obtained data were statistically analyzed using the conventional two way analysis of variance of split-plot as illustrated by Sendecor and Cochran (1967). The comparisons of the means were done using LSD at 0.05 level of probability as mentioned by Cochran and Cox (1957).

RESULTS AND DISCUSSION

Mean performances of the TTC testers (P_1, P_2 and F_1) and a group of Ni-cultivars, to be used to establish family sets of TTC, were studied to high light on the differences among the testers and the variability among group of a random sample of Ni-tomato cultivar groups. Such differences among genotypes and their interaction with the environments will be assessed and discussed under the following topics.

1. Plant Growth Characters

Results of the analysis of variance (Table 1) for plant height and branch number/ per plant showed highly significant mean squares for environments, genotypes (testers and Ni-cultivars) and genotype- enivornment interaction (tester x env. and genotype x env.). These results indicate that the studied environments (plant spacings) had a sufficient variability among them to be valid to evaluate the genotypes under such environments. It suggests also that the testers (P_1, P_2 and F_1) and Ni-cultivars group were different in the two growth traits, and interacted differently with the environments. Increasing plant density caused an increase in plant height in tomato nutrient film techniques (Ghattas and Economakis, 1993).

In the present study, plant height and branch number were investigated at the end of the season, since the material was evaluated under different plant spacings; i.e. 30, 45 and 60 cm. The validity of such environments for assessing tomato genotypes was also reported by Ismail (1997).

The detected differences among P_1, P_2 and their F_1 in the two crosses (MM x CR as cross 1;C_{200} x Peto 86, as cross 2) and among the used tomato cultivar

Table 1.Mean squares of genotypes (testers and Ni-cultivars), environments and their interactions, in both tomato crosses, for the characters plant height and branch number, in the summer season of 2000

SOV	d.f.	Cross 1 (MM[1] x CR[2])		Cross 2 (C_{200}[3] x Peto[4])	
		Plant height (cm)	Branch No./plant	Plant height (cm)	Branch No./plant
Reps.	2	24.390	25.331	34.986	218.083
Env.	2	9355.868**	3997.329**	10637.574**	4214.940**
Error a	4	6.148	8.302	2.483	8.150
Gen.	13	1535.877**	790.488**	1736.544**	602.122**
Testers[5]	2	1873.562**	415.789**	2977.511**	560.897**
Ni[6]	10	581.360**	454.946**	413.101**	181.663**
Residual	1	10405.674**	4895.311**	12489.044**	4889.165**
Gen. x Env.	26	187.894**	110.040**	105.617**	94.963**
Testers x Env.	4	50.159**	84.473**	153.178**	91.613**
Ni x Env.	20	45.947**	97.378**	60.521**	88.508**
Residual	2	584.814**	287.789**	461.457**	166.218**
Error b	78	3.932	8.703	4.431**	6.961

** ; Highly significant at 1% level of probability

1 : Money Maker cv, 2 : Castle Rock cv, 3 : Carmeuco 200 cv , 4: Peto 86, 5 : (P_1,P_2 and F_1), and 6 : ith cultivars.

groups were general similar to those reported by many investigators; such as Zanata (1994), Ismail (1997), Salib (1999) and Bayomy (2002) on tomato plant height; and Mahmoud and Gad El-Hak (1988),El-Sayed (1997), Youssef (1997) and Bayomy (2002) on branch number per plant.

1.1 Average effects

In the two crosses (Tables 2 , 3), the highest significant values

for plant height and branch number, among testers and Ni-cultivar groups were obtained with 60 cm, followed significantly by 45 and 30 cm. Therefore, tomato plant height and branch number /plant were increased with increasing the plant spacing. Similar results were reported by Stoffella *et al.* (1988), when two tomato cultivars were evaluated (Harizon and Sunny) at 30.5, 61 and 91 cm within-row spacings at five locations during spring at Florida state.

Regarding to the testers, the F_1 hybrid in the two crosses gave the highest values for plant hieght and branch number, and reflected heterosis over their highest parent. Such a heterosis for plant height reached 19.2% in cross 1 (MM x CR) and 21.68% in cross 2 (C_{200} x Peto 86). For branch number it was 19.73% in cross 1, but not so clear in cross 2, and reached 14.54% over mid-parent. Moreover, P_1 in the two crosses (MM and C_{200}, P_1 for each) had higher plant heights than their P_2's. However, for branch number P_2 (CR) and P_1 (C_{200}) in cross 1 and 2, respectively gave higher values than the respective other parents (P_1 and P_2). Accordingly the testers of the two crosses appeared to be significantly different and provided to be valid to be testers for these two traits. Obtained results are in conformity with those of Sherif and Hussein (1993), Dev *et al.* (1994) and Kumar *et al.* (1995) for plant height and Hegazi *et al.* (1995) and Salib (1999) for branch number/plant. Moreover, Bayomy (2002) found that average heterosis over the mid-parents for all crosses was highly significant with values of 32.39% and 17.03% for tomato plant height and 12.56% and 15.28% for branch number in the first and second year, respectively.

The two groups of Ni-cultivars, of the two crosses, showed also some significant differences in values of these two traits (Tables 2, 3). The cultivars that gave the highest values of plant height and branch number were C_{200} and C_{201} for cross 1,and MM and C_{201} for cross 2 in the two traits. The lowest values,on the other hand, of Ni-cultivars were obtained by UC, in cross 1 the two traits, and RS for plant height and SD of branch number for cross 2.

1.2 Interaction effects

Concerning the testers x env.

Table 2. Mean performances of the triple test cross testers (P_1, $P_2$and F_1) and Ni-cultivars (ith cultivars), which will be used for generating the triple test cross, for plant height of tomato in the summer season of 2000

Genotype	Cross 1 (MM[1] x CR[2])			Avg. genotype	Genotype	Cross 2 (C_{200}[3] x Peto[4])			Avg. genotype
	Env. 1	Env. 2	Env. 3			Env. 1	Env. 2	Env. 3	
Testers					Testers				
Money Maker, $\bar{P}_1$	60.45	73.67	84.11	72.74	Carmenco 200, $\bar{P}_1$	67.22	72.78	89.56	76.52
Castle Rock , $\bar{P}_2$	50.11	59.33	64.22	57.89	Peto- 86 , $\bar{P}_2$	51.56	58.56	60.22	56.78
(MM x CR), $\bar{F}_1$	71.56	86.89	101.8	86.74	(C_{200} x Peto), $\bar{F}_1$	75.44	92.89	111.00	93.11
Avg. Env.	60.71	73.30	83.37		Avg. Env.	64.74	74.74	86.93	
Ni[4]-cultivars		Group 1			Ni[4]-cultivars		Group 2		
Carmeuco 200	67.45	70.89	89.00	75.78	Money Maker	60.11	73.78	85.67	73.19
Peto- 86	51.22	58.22	59.67	56.37	Castle Rock	49.67	54.67	64.44	57.93
Super Marmande	56.89	67.89	71.00	65.26	Super Marmande	57.44	68.89	71.44	65.92
Strain -B	59.56	58.44	66.78	61.59	Strain -B	60.67	54.33	67.89	62.63
Carmeuco 201	78.22	66.56	85.78	76.85	Carmeuco 201	79.00	67.89	86.44	77.78
Aledo VF	49.89	55.44	61.44	55.59	Aledo VF	51.10	56.22	62.33	56.55
Sun Drop	54.78	59.00	65.89	59.89	Sun Drop	56.44	60.67	66.89	61.33
Super Strain -B	49.56	54.33	67.67	57.19	Super Strain -B	50.00	56.56	68.67	58.41
UC-97/3	48.78	44.67	60.00	51.15	Rutgers Select	58.00	49.11	66.11	57.74
Pearson Improved	57.22	58.89	64.67	60.26	Pearson Improved	57.33	60.22	64.67	60.74
Beef Stick	57.00	57.78	66.22	60.33	Beef Stick	56.78	59.22	66.78	60.93
Avg.Env.	57.32	59.28	68.92		Avg.Env.	57.86	61.05	70.12	

1:Money Maker cv, 2 : Castle Rock cv, 3 : Carmeuco 200 cv and 4: Peto 86

LSD at 0.05 for comparing means in	testers		and	Ni - cultivars	
	Cross 1	Cross 2		Cross 1	Cross 2
Averages of environments	2.68	1.08		0.73	0.99
Averages of genotypes	1.35	1.52		1.24	1.39
Any two row values	2.44	2.31		4.10	4.09
Any two column values	4.04	4.55		3.71	4.18
Gen. x Env. interaction	3.24	3.44		3.24	3.44

Table 3. Mean performances of the triple test cross testers (P_1, $P_2$and F_1) and Ni-cultivars (ith cultivars), which will be used for generating the triple test cross, for branch number/plant of tomato in the summer season of 2000

Genotype	Cross 1 (MM[1] x CR[2])			Avg. genotype	Genotype	Cross 2 (C_{200}[3] x Peto[4])			Avg. genotype
	Env. 1	Env. 2	Env. 3			Env. 1	Env. 2	Env. 3	
Testers					Testers				
Money Maker, $\bar{P}_1$	13.67	30.00	34.78	26.15	Carmenco 200, $\bar{P}_1$	43.67	42.00	43.89	43.19
Castle Rock , $\bar{P}_2$	18.67	38.67	42.22	33.19	Peto- 86 , $\bar{P}_2$	16.89	33.67	35.22	28.59
(MM x CR), $\bar{F}_1$	36.67	39.18	42.78	39.74	(C_{200} x Peto), $\bar{F}_1$	38.33	40.22	44.78	41.11
Avg. Env.	23.00	36.15	40.93		Avg. Env.	32.96	38.63	41.30	
Ni[4]-cultivars		Group 1			Ni[4]-cultivars		Group 2		
Carmeuco 200	43.61	42.44	42.00	42.70	Money Maker	14.33	29.56	35.44	26.41
Peto- 86	16.89	30.33	35.11	27.44	Castle Rock	17.89	38.11	41.00	32.33
Super Marmande	19.78	34.89	41.00	31.89	Super Marmande	18.11	33.56	42.56	31.41
Strain -B	18.67	20.45	36.89	25.34	Strain -B	19.11	19.67	37.67	25.48
Carmeuco 201	37.78	40.00	40.22	39.33	Carmeuco 201	36.67	38.45	40.67	38.60
Aledo VF	26.00	21.78	34.33	27.37	Aledo VF	25.89	21.44	36.22	27.85
Sun Drop	14.67	21.22	33.11	23.00	Sun Drop	14.66	20.56	32.56	22.59
Super Strain -B	23.22	30.11	37.89	30.41	Super Strain -B	21.89	29.78	37.78	29.82
UC-97/3	16.44	19.89	19.89	18.74	Rutgers Select	24.00	24.55	31.45	26.67
Pearson Improved	18.11	23.67	28.89	23.56	Pearson Improved	18.67	22.67	30.89	24.08
Beef Stick	40.55	25.33	31.56	32.48	Beef Stick	34.78	24.78	31.89	30.48
Avg.Env.	25.07	28.19	34.63		Avg.Env.	22.36	27.56	36.11	

1:Money Maker cv, 2 : Castle Rock cv, 3 : Carmeuco 200 cv and 4: Peto 86

LSD at 0.05 for comparing means in	testers		and	Ni - cultivars	
	Cross 1	Cross 2		Cross 1	Cross 2
Averages of environments	3.62	3.56		0.99	0.97
Averages of genotypes	2.98	2.26		2.74	2.08
Any two row values	9.58	8.08		8.45	7.95
Any two column values	8.94	6.79		8.21	6.23
Gen. x Env. interaction	4.82	4.20		4.82	4.20

interaction (Table 2, 3), the results reveal that, the studied testers, in the two crosses, behaved differently under the environments in plant height and branch number,except C_{200} (P_1), in cross 2, which behaved similarily (insignificantly) in branch number under the studied environments. In this respect , the F_1 of the two crosses x 60 cm gave the highest values of both traits at 60 cm.

Moreover, Ni-cultivars of the two groups behaved differently under the same environment and so did, each cultivar under different environments. However, in some cases; i.e., SB, PI and BS in cross 1, in plant height, and SB, C_{201} and UC in the two crosses, in branch number; their behavior did not differ when they are planted at 30 cm or 45 cm. However, the highest values of plant height were obtained with C_{200} and C_{201} x 60 cm, in cross 1, and with MM and C_{201} x 60 cm; in cross 2. For branch number, the highest values were obtained with C_{200} x all environments, in cross 1, and with CR and SM x 60 cm, in cross 2.

2. Early Yield

Results in Table 4 showed highly significant environments mean squares for fruit number, early yield/ plant and early yield/plot in the two crosses, but it was insignificant for fruit weight. It revealed also highly significant mean squres for genotypes and its two portions; i.e., testers and Ni-cultivar groups, and for GxE and Ni-cultivars x environment for all early yield traits. But, it was insignificant of testers x environment . Ismail (1997) reported insignificant environment mean squares for early yield per plant .

Therefore, the testers and Ni-cultivar groups and Ni-cultivars x environment under such micro-environments,showed cnsiderable differences among them and also they responded differently to the growing environments. However, early fruit weight were did not affected by the studied environments.

2.1 Average effect

Data in Tables 5, 6, 7 and 8 clarify that the average weight of early fruits was not affected by the studied environments. However,fruit number/plant and early fruit yield/plant (Tables 6,7), of both the testers and Ni-cultivar groups, were affected by the environments and favoured 60 cm spacing. While, early yield/plot favoured 45 cm

Table 4.Mean squares of genotypes (testers and Ni-cultivars), environments and their interactions in both crosses of tomato early yield traits, in the season of 2000

SOV	d.f.	Cross 1 (MM^1 x CR^2)				Cross 2 (C_{200}^3 x Peto^4)			
		Fruit weight	Fruit No. plant	Early Yield/ plant (gm)	Early Yield/ plot (kg)	Fruit weight	Fruit No. plant	Early Yield/ plant (gm)	Early Yield/ plot (kg)
Reps.	2	10.902	2.640	13848.101	0.635	66.226	0.493	934.303	0.021
Env.	2	92.883$^{N.S.}$	239.167**	1090703.941**	0.437**	15.986$^{N.S}$	109.488**	585696.928**	2.928**
Error a	4	153.372	0.781	3014.781	0.042	57.298	0.349	455.957	0.021
Gen.	13	857.330**	4.443**	26099.209**	1.146**	957.448**	7.966**	32990.475**	5.890**
Testers^5	2	308.291**	6.855**	8970.044**	0.428**	1627.198**	6.896**	7638.775**	0.171**
Ni^6	10	1044.471**	2.877**	25747.215**	1.109**	804.566**	6.425**	28402.274**	1.244**
Residual	1	84.003**	15.274**	63877.485**	2.953**	1147.418**	19.013**	129578.885**	6.380**
Gen. x Env.	26	296.011**	1.272**	12981.657**	0.476**	93.889**	0.768**	4277.825**	0.156**
Testers x Env.	4	75.860$^{N.S.}$	0.340$^{N.S.}$	1440.748$^{N.S}$	0.064$^{N.S}$	21.996$^{N.S}$	0.321$^{N.S}$	1316.000$^{N.S}$	0.029$^{N.S}$
Ni x Env.	20	269.329**	1.460**	15837.603**	0.576**	107.639**	0.831**	4809.387**	0.148**
Residual	2	1003.135**	1.263**	15008.038**	0.599**	100.173**	1.032**	6991.365**	0.490**
Error b	78	49.458	0.187	909.534	0.028	33.593	0.245	779.032	0.027

N.S., **; Insignificant, highly significant at 0.01 level of probability, respectively.
1 : Money Maker cv., 2 : Castle Rock cv , 3 : Carmeuco 200 cv , 4: Peto 86, 5 : (P_1,P_2 and F_1) and 6: ith cultivars .

Table 5. Mean performances of the triple test cross testers (P_1, $P_2$and F_1) and Ni-cultivars (ith cultivars), which will be used for generating the triple test cross, for average early fruit weight of tomato in the summer season of 2000

Genotype	Cross 1 (MM[1] x CR[2])			Avg. genotype	Genotype	Cross 2 (C_{200}[3] x Peto[4])			Avg. genotype
	Env. 1	Env. 2	Env. 3			Env. 1	Env. 2	Env. 3	
Testers					Testers				
Money Maker, $\bar{P}_1$	48.98	51.90	55.61	52.16	Carmenco 200, $\bar{P}_1$	76.10	79.50	84.98	80.19
Castle Rock , $\bar{P}_2$	57.80	58.50	58.34	58.21	Peto- 86 , $\bar{P}_2$	56.15	57.03	57.01	56.73
(MM x CR), $\bar{F}_1$	71.64	59.28	60.67	63.86	(C_{200} x Peto), $\bar{F}_1$	76.32	77.34	85.85	79.84
Avg. Env.	59.47	56.56	58.21		Avg. Env.	69.52	71.29	75.95	
Ni[4]-cultivars	Group 1				Ni[4]-cultivars	Group 2			
Carmeuco 200	69.09	102.76	85.58	85.81	Money Maker	54.15	55.25	55.34	54.91
Peto- 86	58.38	57.43	60.97	58.83	Castle Rock	57.26	57.79	59.83	58.29
Super Marmande	73.13	74.53	47.92	65.19	Super Marmande	72.51	76.75	66.17	71.81
Strain -B	55.55	51.91	79.20	62.46	Strain -B	54.61	48.72	81.47	61.60
Carmeuco 201	80.57	83.96	88.20	84.24	Carmeuco 201	77.71	83.26	88.67	83.21
Aledo VF	47.47	54.47	56.98	52.97	Aledo VF	52.45	55.59	56.22	54.75
Sun Drop	58.30	60.63	57.53	58.82	Sun Drop	59.08	58.82	62.31	60.07
Super Strain -B	55.16	56.26	54.62	55.35	Super Strain -B	57.25	61.26	54.36	57.62
UC-97/3	62.34	63.63	73.17	66.38	Rutgers Select	63.36	54.07	69.56	64.00
Pearson Improved	51.23	67.31	77.72	65.42	Pearson Improved	70.66	73.37	79.25	74.43
Beef Stick	74.45	75.29	65.71	71.82	Beef Stick	74.64	69.74	78.10	74.16
Avg.Env.	62.33	67.99	67.96		Avg.Env.	63.06	63.60	68.30	

1:Money Maker cv, 2 : Castle Rock cv, 3 : Carmeuco 200 cv and 4: Peto 86

LSD at 0.05 for comparing means in testers and Ni - cultivars

	testers		Ni - cultivars	
	Cross 1	Cross 2	Cross 1	Cross 2
Averages of environments	NS	NS	NS	NS
Averages of genotypes	7.26	5.80	6.66	2.78
Any two row values	NS	NS	13.71	10.11
Any two column values	12.58	10.05	11.54	9.22
Gen. x Env. interaction	NS	NS	12.01	9.59

Table 6. Mean performances of the triple test cross **testers** (P_1, P_2 **and** F_1) and Ni-cultivars (ith cultivars), which will be used for generating the triple test cross, for **early** fruit number/plant of tomato in the summer season of 2000

Genotype	Cross 1 (MM[1] x CR[2])			Avg. genotype	Genotype	Cross 2 (C_{200}[3] x Peto[4])			Avg. genotype
	Env. 1	Env. 2	Env. 3			Env. 1	Env. 2	Env. 3	
Testers					Testers				
Money Maker, $\bar{P}_1$	3.60	5.50	6.20	5.10	Carmenco 200, $\bar{P}_1$	3.90	4.33	5.20	4.48
Castle Rock , $\bar{P}_2$	2.33	3.70	4.67	3.57	Peto- 86 , $\bar{P}_2$	4.70	5.07	6.67	5.48
(MM x CR), $\bar{F}_1$	2.27	3.37	5.20	3.61	(C_{200} x Peto), $\bar{F}_1$	3.57	3.23	4.40	3.73
Avg. Env.	2.73	4.19	5.36		Avg. Env.	4.06	4.21	5.42	
Ni[4]-cultivars		Group 1			Ni[4]-cultivars		Group 2		
Carmeuco 200	2.07	4.73	4.47	3.76	Money Maker	3.93	5.23	6.13	5.10
Peto- 86	3.93	5.50	5.80	5.08	Castle Rock	2.53	3.10	4.67	3.43
Super Marmande	1.97	3.10	5.07	3.41	Super Marmande	2.33	2.37	3.73	2.81
Strain -B	2.63	3.73	6.93	4.43	Strain -B	2.77	3.17	4.93	3.62
Carmeuco 201	2.77	4.57	5.67	4.33	Carmeuco 201	3.03	4.23	4.87	4.04
Aledo VF	2.90	3.47	4.13	3.50	Aledo VF	2.47	3.00	3.66	3.05
Sun Drop	2.20	4.10	6.70	4.30	Sun Drop	2.27	2.77	4.00	3.01
Super Strain -B	2.87	4.00	6.20	4.36	Super Strain -B	2.93	4.10	4.47	4.83
UC-97/3	3.13	3.30	4.67	3.70	Rutgers Select	1.73	2.93	4.27	2.98
Pearson Improved	2.03	4.30	4.13	3.49	Pearson Improved	2.80	3.20	4.93	3.64
Beef Stick	1.70	3.60	4.67	3.32	Beef Stick	1.63	2.53	2.93	2.37
Avg.Env.	2.65	4.04	5.32		Avg.Env.	2.59	3.33	4.69	

1:Money Maker cv, 2 : Castle Rock cv, 3 : Carmeuco 200 cv and 4: Peto 86

LSD at 0.05 for comparing means in testers and Ni - cultivars

	testers		Ni - cultivars	
	Cross 1	Cross 2	Cross 1	Cross 2
Averages of environments	1.16	0.77	0.60	0.40
Averages of genotypes	0.44	0.50	0.41	0.46
Any two row values	NS	0.83	0.89	0.84
Any two column values	0.77	0.86	0.71	0.79
Gen. x Env. interactions	NS	NS	0.70	0.79

Table 7. Mean performances of the triple test cross testers (P_1, $P_2$and F_1) and Ni-cultivars (ith cultivars), which will be used for generating the triple test cross, for early yield/plant (gm) of tomato in the summer season of 2000

Genotype	Cross 1 (MM[1] x CR[2])			Avg. genotype	Genotype	Cross 2 (C_{200}[3] x Peto[4])			Avg. genotype
	Env. 1	Env. 2	Env. 3			Env. 1	Env. 2	Env. 3	
Testers					Testers				
Money Maker, $\bar{P}_1$	176.63	285.43	344.40	268.82	Carmenco 200, $\bar{P}_1$	286.50	344.43	441.13	357.35
Castle Rock , $\bar{P}_2$	134.23	215.60	271.80	207.21	Peto- 86 , $\bar{P}_2$	263.37	287.97	412.93	321.42
(MM x CR), $\bar{F}_1$	162.23	198.07	317.87	226.06	(C_{200} x Peto), $\bar{F}_1$	272.07	250.60	336.33	299.67
Avg. Env.	157.70	233.03	311.36		Avg. Env.	273.98	294.33	410.13	
Ni[4]-cultivars		Group 1			Ni[4]-cultivars		Group 2		
Carmeuco 200	142.93	485.30	378.53	269.92	Money Maker	213.37	289.60	339.83	280.93
Peto- 86	229.70	300.47	352.53	294.23	Castle Rock	144.93	178.80	278.33	200.69
Super Marmande	143.80	277.70	236.20	219.23	Super Marmande	169.07	182.23	241.67	197.66
Strain -B	145.67	192.83	548.87	295.79	Strain -B	150.90	149.53	401.13	233.85
Carmeuco 201	220.67	383.27	449.47	367.80	Carmeuco 201	235.80	349.3	427.73	337.61
Aledo VF	137.67	186.03	227.20	183.63	Aledo VF	129.40	166.73	187.67	161.27
Sun Drop	129.77	225.40	384.53	246.57	Sun Drop	133.97	162.47	246.47	180.97
Super Strain -B	169.20	224.87	338.60	244.22	Super Strain -B	166.07	249.73	405.93	273.91
UC-97/3	205.10	209.27	336.20	250.19	Rutgers Select	108.60	174.37	294.27	192.41
Pearson Improved	104.53	285.03	331.80	240.45	Pearson Improved	196.27	237.40	389.33	241.00
Beef Stick	126.67	269.33	306.67	234.22	Beef Stick	121.90	175.57	226.27	174.58
Avg.Env.	159.61	276.32	358.24		Avg.Env.	160.93	210.52	312.60	

1:Money Maker cv, 2 : Castle Rock cv, 3 : Carmeuco 200 cv and 4: Peto 86

LSD at 0.05 for comparing means in	testers		and	Ni - cultivars	
	Cross 1	Cross 2		Cross 1	Cross 2
Averages of environments	71.84	27.94		37.52	14.59
Averages of genotypes	30.97	27.93		14.85	13.39
Any two row values	NS	NS		59.40	55.60
Any two column values	53.65	48.38		49.24	44.41
Gen. x Env. interaction	NS	NS		49.25	44.41

Table 8. Mean performances of the triple test cross testers (P_1, $P_2$and F_1) and Ni-cultivars (ith cultivars), which will be used for generating the triple test cross, for early yield/plot (kg) of tomato in the summer season of 2000

Genotype	Cross 1 (MM[1] x CR[2])			Avg. genotype	Genotype	Cross 2 (C_{200}[3] x Peto[4])			Avg. genotype
	Env. 1	Env. 2	Env. 3			Env. 1	Env. 2	Env. 3	
Testers					Testers				
Money Maker, $\bar{P}_1$	1.766	1.998	1.722	1.829	Carmenco 200, $\bar{P}_1$	2.865	2.078	2.206	2.383
Castle Rock , $\bar{P}_2$	1.342	1.509	1.359	1.403	Peto- 86 , $\bar{P}_2$	2.634	2.016	1.898	2.183
(MM x CR), $\bar{F}_1$	1.622	1.386	1.589	1.532	(C_{200} x Peto), $\bar{F}_1$	2.721	1.754	1.882	2.119
Avg. Env.	1.577	1.631	1.557		Avg. Env.	2.740	1.949	1.995	
Ni[4]-cultivars	Group 1				Ni[4]-cultivars	Group 2			
Carmeuco 200	1.429	3.397	1.893	2.240	Money Maker	2.134	2.027	1.698	1.953
Peto- 86	2.297	2.187	1.763	2.082	Castle Rock	1.449	1.252	1.392	1.364
Super Marmande	1.438	1.513	1.181	1.377	Super Marmande	1.691	1.277	1.208	1.392
Strain -B	1.463	1.350	2.744	1.844	Strain -B	1.509	1.047	1.996	1.517
Carmeuco 201	1.983	2.420	2.497	2.300	Carmeuco 201	2.045	2.465	2.139	2.213
Aledo VF	1.377	1.302	1.136	1.272	Aledo VF	1.294	1.167	0.938	1.133
Sun Drop	1.168	1.578	1.538	1.428	Sun Drop	1.340	1.137	1.232	1.236
Super Strain -B	1.581	1.574	1.693	1.616	Super Strain -B	1.661	1.748	2.030	1.813
UC-97/3	1.771	1.465	1.681	1.639	Rutgers Select	1.013	1.046	1.255	1.105
Pearson Improved	1.045	1.995	1.606	1.549	Pearson Improved	1.766	1.662	1.947	1.792
Beef Stick	1.267	1.885	1.533	1.562	Beef Stick	1.219	1.229	1.131	1.193
Avg.Env.	1.529	1.879	1.751		Avg.Env.	1.556	1.460	1.542	

1:Money Maker cv, 2 : Castle Rock cv, 3 : Carmeuco 200 cv and 4: Peto 86

LSD at 0.05 for comparing means in	testers		and	Ni - cultivars	
	Cross 1	Cross 2		Cross 1	Cross 2
Averages of environments	NS	0.190		0.140	0.099
Averages of genotypes	0.172	0.166		0.082	0.079
Any two row values	NS	NS		0.294	0.268
Any two column values	0.298	0.287		0.273	0.263
Gen. x Env. interaction	NS	NS		0.271	0.262

in cross 1 and 30 cm in cross 2. The differences in the results of early yield /plant and per plot could be related to the differences in number of growing plants, according to used plant spacing. On the other side, Cockshull and Ho (1995) reported that the early yield/plot of tomato from the crop grown at a high density (3.06plants/m^2) throughout were about 8% greater than that at low density (2.04 plants/m^2). Bayomy (2002) found, on tomato grown in winter season under North Sinai conditions,that parents produced more early yield than F_1's crosses.

For average performance of the testers, the results showed significant differences among the testers in average fruit weight, fruit number, early yield/ plant and early yield/plot. The highest fruit weight was obtained with F_1 , in cross 1, and P_1 (C_{200}), in cross 2, with insignificance between F_1 and P_1 in both the crosses (Table 5). However, the highest significant values for fruit number (Table 6) were obtained with P_1 (MM) in cross 1 and P_2 (Peto 86), in cross 2. For early yield/plant or per plot, the highest values were obtained with P_1 (MM or C_{200} in the two crosses,respectively) , but there were no clear differences between P_2 and F_1 in the two crosses for the later two cases (Tables 7, 8).

For Ni-cultivar groups, data in Table 5 showed high differences among the used cultivars of each group in fruit weight. The highest fruit weight in the two groups was obtained by C_{201} and the lowest one was cv Aledo. Moreover, Ni-groups of cultivars had significant differences within them in fruit number and total yield. The highest number of early fruits were obtained with cv Peto in group 1 and MM in group 2 and the lowest one was obtained with BS in the two groups. The results of early yield/plant, which is the combination between fruit weight and fruit number, and early yield/plot showed also high variability among the studied cultivar groups.The highest early yield in the two groups (Tables 7 and 8) was obtained with cv C_{201} and the lowest one was that of cv Aledo.

2.2 Interaction effects

Regarding the testers x environment data in Table 5 showed the absence of any clear effect of such an interaction on average fruit weight, even when compared row values. So, fruit

weight seems to be a stable trait in each genotype, it is a genotype dependent. Moreover, genotypes and environments in this study had indpendent effects on fruit weight.Similar results were also obtained for fruit number and early yield (per plant or per plot).

For Ni-cultivars x environments interactions, data in Table 5 showed that fruit weight was affected by this interaction, reflecting favourable and unfavourable effects. The best interaction that gave the highest fruit weight in group 1 was C_{200} x 45 cm and, in the group 2, it was C_{201}x60 cm. On the other hand, the lowest fruit weight was obtained with Aledo x 30 cm in the two cultivar groups. For fruit number (Table 6), most of the cultivars in the two groups gave different values of fruit number with the change in the environment. The best interaction was obtained with SD and SSB in group 1, and with SSB and MM, in group 2. While, the unfavourable one in the two groups was obtained with BS x 30 cm.

For early yield (Tables 7, 8), the interaction of Ni x environment had considerable effect on early yield (per plant and per plot), indicating that the two main factors did not independently act on early yield. Therefore, the change in the environment had a considerable change on early yield of each cultivar in each group. Due to such interactions, the interactions SB x 60 cm and C_{200} x 45 cm, in the group 1, gave the highest early yield per plant and per plot. While in group 2, C_{201}, SSB and SB x 60 cm, and C_{201} x 45 cm, MM x 30 cm and SSB x 60 cm gave the highest early yield per plant and per plot, respectivley. On the other hand, the lowest values of early yield per plant and per plot were obtained by PI x 30 cm in group 1 and by RS x 30 cm in group 2.

3. Total Yield

Results in Table 9 reflected highly significant mean squares for environments,genotypes and its two portions; i.e., testers and Ni-cultivars, and for GxE and its two portions; i.e., testers x env. and Ni-cultivars x environments interactions in all total yield traits. Therefore, the differences among environments, among genotypes and GxE (testers x env. and Ni-cultivars x env.) should be considered when assessing their general mean performances. Ismail (1997) reported that the genotypes mean squares were found highly significant for number of

Table 9.Mean squares of genotypes (testers and Ni-cultivars), environments and their interactions in both crosses of tomato yield traits, in the season of 2000

SOV	d.f.	Cross 1 : (MM^1 x CR^2)				Cross 2 : (C_{200}^3 x $Peto^4$)			
		Fruit weight	Fruit No. plant	Early Yield/ plant (gm)	Early Yield/ plot (kg)	Fruit weight	Fruit No. plant	Early Yield/ plant (gm)	Early Yield/ plot (kg)
Reps.	2	6.831	12.362	103194.420	2.955	0.162	21.994	79829.629	0.540
Env.	2	50.703**	22482.358**	89050444.150**	19.309**	9.855**	11669.993**	54439317.088**	143.452**
Error a	4	5.564	8.648	21457.337	0.782	1.749	5.247	57777.916	1.008
Gen.	13	1069.442**	376.175**	991940.774**	57.984**	957.498**	7.466**	32990.475**	1.474**
Testers[5]	2	369.953**	422.378**	2454627.888**	95.704**	1666.137**	585.492**	1553719.404**	85.034**
Ni[6]	10	1006.932**	259.095**	525770.781**	28.490**	909.953**	586.910**	1295548.911**	44.520**
Residual	1	2552.880**	1454.575**	2728266.479**	277.490**	1147.418**	19.013**	129575.885**	6.380**
Gen. x Env.	26	93.745**	45.980**	229089.126**	6.417**	93.889**	0.768^{NS}	4277.825**	0.156**
Testers x Env.	4	14.088**	40.202**	401660.278**	7.314**	2.739^{NS}	7.613^{NS}	22831.708$^{N.S}$	0.837$^{N.S}$
Ni x Env.	20	65.504**	39.859**	148364.048**	5.863**	39.195**	30.702**	88907.393**	2.497**
Residual	2	535.469**	118.802**	691197.605**	10.164**	100.173**	1.032$^{N.S}$	6991.365$^{N.S}$	0.490$^{N.S}$
Error b	78	4.670	2.172	12217.793	0.218	3.195	4.609	17599.836	0.579

N.S., **; Insignificant, highly significant at 0.01 level of probability, respectively.
1 : Money Maker cv., 2 : Castle Rock cv , 3 : Carmeuco 200 cv , 4: Peto 86, 5 : (P_1,P_2 and F_1) and 6: ith cultivars .

fruits./plant, fruit weight and yield/plant, but G x E was highly significant for yield/plant only.

3.1 Average effects

Results in Table 10 showed highly significant differences on average fruit weight among the environments, when averaged over testers or Ni-cultivars in the two groups of crosses. Such difference, found between the environments could be considered to be valid to be assessed them. However, the favourable environment seemed to differ according to genotype group. Accordingly; environment 1 for testers in cross 1, environment 3 for testers in cross 2, environment 3 for Ni-cultivars in group 1 and environment 1 for Ni-cultivars in group 2, appeared to be the favorable ones. Moccia and Katcherian (1997) found that increasing plant density increased fruit number and decreased the average fruit weight.

Regarding fruit number (Table 11) and total yield/ plant (Table 12), the results show that 60 cm in all cases gave the highest values of both traits and was considered the best environment. However, total yield /plot, which is the combination between yield/ plant and number of plants/plot according to specific environment, was mostly favoured by environment 1 (30 cm). Fruit yield/ha increased as plant density increased, although yield of the individual plant and their components were significantly reduced (Agele *et al.*, 1999).

For genotype average, fruit weight for the testers differed also significantly, and the F_1, in cross 1, was higher than its two parents, but, in the cross 2, it did not differ from P_1 (C_{200}). Such differences were also observed among testers on fruit number, with the highest value for P_1 (MM) in cross 1 and for F_1 in cross 2. However, the F_1 in the two crosses surpassed its highest respective parent in total yield per plant or per plot and showed heterosis, which valued 17.07%, in cross 1, and 26.30%, in cross 2, for yield/plant and 13.89%, in cross 1, and 26.57%, in cross 2, for yield/plot, over the better parent. These results are in conformity with those of Hegazi *et al.* (1995), Kumar *et al.* (1995), Singh *et al.* (1995), Dharmatti *et al.* (1997), Youssef (1997) and Bayomy (2002).

Regarding to Ni-cultivars, average fruit weight (Table 10) for the Ni-cultivar groups had higher variability of each group.

Table 10. Mean performances of the triple test cross testers (P_1, $P_2$and F_1) and Ni-cultivars (ith cultivars), which will be used for generating the triple test cross, for fruit weight/fruit of tomato in the summer season of 2000

Genotype	Cross 1 (MM[1] x CR[2])			Avg. genotype	Genotype	Cross 2 (C_{200}[3] x Peto[4])			Avg. genotype
	Env. 1	Env. 2	Env. 3			Env. 1	Env. 2	Env. 3	
Testers					Testers				
Money Maker, $\bar{P}_1$	56.56	52.33	55.64	54.84	Carmenco 200, $\bar{P}_1$	83.17	83.02	87.21	84.47
Castle Rock , $\bar{P}_2$	62.76	57.10	56.29	58.72	Peto- 86 , $\bar{P}_2$	57.18	56.45	58.28	57.30
(MM x CR), $\bar{F}_1$	67.01	66.82	68.27	67.36	(C_{200} x Peto), $\bar{F}_1$	71.04	72.24	73.56	72.28
Avg. Env.	62.11	58.75	60.06		Avg. Env.	70.46	70.57	73.02	
Ni[4]-cultivars		Group 1			Ni[4]-cultivars		Group 2		
Carmeuco 200	81.63	84.28	85.11	83.67	Money Maker	52.43	52.18	55.59	53.40
Peto- 86	58.85	57.38	58.14	58.12	Castle Rock	60.73	55.47	56.05	57.42
Super Marmande	68.83	59.69	60.29	62.94	Super Marmande	67.20	61.82	60.24	63.09
Strain -B	56.15	57.85	75.89	63.30	Strain -B	57.24	58.49	60.91	58.80
Carmeuco 201	76.00	78.08	78.21	77.43	Carmeuco 201	76.87	77.93	78.40	77.73
Aledo VF	52.11	52.36	49.31	51.26	Aledo VF	51.40	49.63	50.07	50.37
Sun Drop	59.98	62.39	64.57	62.31	Sun Drop	61.71	62.54	62.51	62.25
Super Strain -B	59.80	57.12	57.92	58.28	Super Strain -B	56.22	57.01	56.52	56.58
UC-97/3	83.78	82.24	84.02	83.34	Rutgers Select	79.09	80.85	80.54	80.16
Pearson Improved	69.92	77.15	79.75	75.61	Pearson Improved	75.36	75.18	74.60	75.04
Beef Stick	74.97	63.80	63.27	67.35	Beef Stick	75.62	63.44	63.66	67.57
Avg.Env.	67.45	66.58	68.77		Avg.Env.	64.90	63.14	63.55	

1:Money Maker cv, 2 : Castle Rock cv, 3 : Carmeuco 200 cv and 4: Peto 86

LSD at 0.05 for comparing means in testers and Ni - cultivars

	testers		Ni - cultivars	
	Cross 1	Cross 2	Cross 1	Cross 2
Averages of environments	3.09	1.73	1.61	0.90
Averages of genotypes	2.28	1.84	1.06	0.88
Any two row values	4.37	3.10	3.71	1.20
Any two column values	3.84	3.18	3.53	2.92
Gen. x Env. interactions	NS	NS	3.53	2.92

Table 11. Mean performances of the triple test cross testers (P_1, $P_2$and F_1) and Ni-cultivars (ith cultivars), which will be used for generating the triple test cross, for fruit number/plant of tomato in the summer season of 2000

Genotype	Cross 1 (MM[1] x CR[2])			Avg. genotype	Genotype	Cross 2 (C_{200}[3] x Peto[4])			Avg. genotype
	Env. 1	Env. 2	Env. 3			Env. 1	Env. 2	Env. 3	
Testers					Testers				
Money Maker, $\bar{P}_1$	34.80	52.43	63.80	50.34	Carmenco 200, $\bar{P}_1$	24.03	29.33	39.23	30.87
Castle Rock , $\bar{P}_2$	26.33	36.07	50.93	37.78	Peto- 86 , $\bar{P}_2$	34.43	41.40	55.33	43.72
(MM x CR), $\bar{F}_1$	30.00	48.90	67.47	48.79	(C_{200} x Peto), $\bar{F}_1$	36.43	44.57	56.20	45.73
Avg. Env.	30.38	45.80	60.73		Avg. Env.	31.63	38.43	50.26	
Ni[4]-cultivars		Group 1			Ni[4]-cultivars		Group 2		
Carmeuco 200	19.93	33.70	39.67	31.10	Money Maker	39.47	55.57	68.33	54.46
Peto- 86	31.13	45.27	52.83	43.08	Castle Rock	26.93	36.13	53.97	39.01
Super Marmande	23.87	35.50	46.00	35.12	Super Marmande	25.90	31.37	43.70	33.66
Strain -B	22.73	31.63	41.40	31.92	Strain -B	24.13	30.27	40.50	31.63
Carmeuco 201	21.50	30.47	38.53	30.17	Carmeuco 201	21.83	26.17	37.60	28.53
Aledo VF	26.43	37.27	52.50	38.70	Aledo VF	25.17	33.00	49.13	35.77
Sun Drop	21.97	28.13	51.30	33.80	Sun Drop	19.80	26.23	39.80	28.61
Super Strain -B	24.87	32.70	52.07	36.55	Super Strain -B	23.37	33.00	52.67	36.35
UC-97/3	21.73	30.63	32.20	28.19	Rutgers Select	21.77	34.70	43.30	33.26
Pearson Improved	17.67	23.70	31.13	24.17	Pearson Improved	20.57	23.17	33.70	25.81
Beef Stick	19.93	27.83	37.13	28.30	Beef Stick	18.47	24.60	34.03	25.70
Avg.Env.	22.89	32.44	43.16		Avg.Env.	24.31	32.20	45.16	

1:Money Maker cv, 2 : Castle Rock cv, 3 : Carmeuco 200 cv and 4: Peto 86

LSD at 0.05 for comparing means in testers and Ni - cultivars

	testers		Ni - cultivars	
	Cross 1	Cross 2	Cross 1	Cross 2
Averages of environments	3.86	3.00	2.01	1.57
Averages of genotypes	1.51	2.21	0.73	1.06
Any two row values	4.38	4.30	3.02	3.67
Any two column values	2.62	3.82	2.41	3.51
Gen. x Env. interaction	2.41	NS	2.44	3.50

Table 12. Mean performances of the triple test cross testers (P_1, $P_2$and F_1) and Ni-cultivars (ith cultivars), which will be used for generating the triple test cross, for yield/plant of tomato in the summer season of 2000

Genotype	Cross 1 (MM[1] x CR[2])			Avg. genotype	Genotype	Cross 2 (C_{200}[3] x Peto[4])			Avg. genotype
	Env. 1	Env. 2	Env. 3			Env. 1	Env. 2	Env. 3	
Testers					Testers				
Money Maker, $\bar{P}_1$	1966.37	2907.33	3550.13	2807.94	Carmenco 200, $\bar{P}_1$	1997.80	2423.80	3448.90	2623.50
Castle Rock , $\bar{P}_2$	1652.17	2209.87	2856.53	2242.86	Peto- 86 , $\bar{P}_2$	1968.30	2241.23	3492.73	2567.42
(MM x CR), $\bar{F}_1$	1992.50	3267.37	4598.53	3286.16	(C_{200} x Peto), $\bar{F}_1$	2584.37	3159.97	4196.10	3313.48
Avg. Env.	1870.35	2794.86	3671.73		Avg. Env.	2183.49	2608.33	3712.58	
Ni[4]-cultivars	Group 1				Ni[4]-cultivars	Group 2			
Carmeuco 200	1626.47	2835.80	3373.13	2611.80	Money Maker	2068.67	3069.13	3834.97	2990.92
Peto- 86	1832.10	2598.47	3061.93	2497.50	Castle Rock	1636.47	1949.13	3196.70	2260.77
Super Marmande	1642.60	2119.63	2770.33	2177.52	Super Marmande	1740.13	2099.50	2992.27	2277.30
Strain -B	1276.43	1829.30	3137.67	2081.13	Strain -B	1381.23	1709.90	2761.40	1950.84
Carmeuco 201	1635.23	2340.33	3013.73	2329.77	Carmeuco 201	1675.67	2046.83	2897.27	2206.59
Aledo VF	1377.30	1952.43	2584.20	1971.31	Aledo VF	1293.70	1760.90	2470.87	1841.82
Sun Drop	1317.27	1755.53	2975.97	2016.26	Sun Drop	1221.10	1679.63	2450.03	1783.59
Super Strain -B	1486.83	1868.53	3010.93	2122.10	Super Strain -B	1313.67	1832.33	2841.23	1995.74
UC-97/3	1821.03	2521.93	2697.00	2346.66	Rutgers Select	1719.30	2648.53	3486.67	2618.17
Pearson Improved	1247.53	1824.77	2476.27	1849.52	Pearson Improved	1547.70	1764.13	2711.27	2007.70
Beef Stick	1494.40	2021.83	2345.00	1953.78	Beef Stick	1390.47	1590.67	2237.03	1739.39
Avg.Env.	1523.38	2151.70	2858.74		Avg.Env.	1544.37	2013.70	2898.16	

1:Money Maker cv, 2 : Castle Rock cv, 3 : Carmeuco 200 cv and 4: Peto 86

LSD at 0.05 for comparing means in	testers		and	Ni - cultivars	
	Cross 1	Cross 2		Cross 1	Cross 2
Averages of environments	191.66	314.51		100.09	164.25
Averages of genotypes	113.52	136.25		54.42	65.31
Any two row values	248.19	366.49		197.40	260.87
Any two column values	196.63	235.99		180.47	216.61
Gen. x Env. interactions	180.50	216.63		180.50	216.63

The highest fruit weight in group 1 was obtained with C_{200}, in group 1, and with RS in group 2. On the other hand, cv Aledo, in the two groups, gave the lowest value of fruit weight.

Concerning fruit number (Table 11),the difference among the Ni-cultivars in each group reflected clear and significant differences among their means. The highest fruit number, in groups 1 and 2, were obtained with cvs Peto and MM, respectively; and the lowest ones were obtained with PI and BS in both groups. For yield/plant and per plot (Tables 12, 13), variability among Ni-cultivars productivity appeared so pronounced. The highest and the lowest total yield/plant and/or per plot were obtained with C_{200}, in group 1, and MM, in group 2; whereas the lowest values appeared to be those of BS in the two groups, respectively.

Among six tested tomato cvs, Bayomy (2002) showed that CLN 1355-23 TCIF 5-1 produced the highest yield/plot and average fruit weight. But, Bonner Baste cv had the highest fruit number and the smallest fruit weight; while VF 145-B-7879 (Strain-B) gave the lowest number of fruits / plant and yield/ plot.

3.2 Interaction effects

For testers, the average fruit weight differed from one environment to another environment and the best interaction was obtain with the F_1 x 60 cm, in cross 1, and C_{200} x 60 cm in cross 2. Moreover, the fruit number showed a similar response; but the F_1 x 60 cm in the two crosses gave the highest values. The lowest one was obtained with P_2 (CR) x 30 cm, in cross 1, and with P_1 (C_{200}) x 30 cm in cross 2. The total yield / plant and plot, it was of the testers were also affected by the environments, and the highest values of total yield/plant (Table 12) were obtained with F_1 x 60 cm in the two crosses. The unfavourable interaction, in this respect, was found with P_2(CR) x 30 cm, in cross 1, and with P_2 (Peto 86) in cross 2. Also the total yield / plot was also found high with F_1 x 60 cm and the lowest was P_2 (CR) x 60 cm in cross 1. In cross 2, the highest yield/plot was observed with F_1 x 30 cm and the lowest one was obtained with P_2 (Peto 86) x 60 cm .

Among three plant spacings; i.e., 30 x 45, 45 x 60 and 60 x 90 cm; Sawant *et al.* (1999)

Table 13. Mean performances of the triple test cross testers (P_1, $P_2$and F_1) and Ni-cultivars (its cultivars), which will be used for generating the triple test cross, for yield/plot of tomato in the summer season of 2000

Genotype	Cross 1 (MM[1] x CR[2])			Avg. genotype	Genotype	Cross 2 (C_{200}[3] x Peto[4])			Avg. genotype
	Env. 1	Env. 2	Env. 3			Env. 1	Env. 2	Env. 3	
Testers					Testers				
Money Maker, $\bar{P}_1$	19.664	20.350	17.751	19.255	Carmenco 200, $\bar{P}_1$	19.988	17.873	17.071	18.311
Castle Rock , $\bar{P}_2$	16.522	15.469	14.333	15.441	Peto- 86 , $\bar{P}_2$	19.683	16.588	16.199	17.490
(MM x CR), $\bar{F}_1$	19.925	22.872	22.993	21.930	(C_{200} x Peto), $\bar{F}_1$	25.844	22.645	21.041	23.177
Avg. Env.	18.714	19.564	18.359		Avg. Env.	21.838	19.035	18.104	
Ni[4]-cultivars		Group 1			Ni[4]-cultivars		Group 2		
Carmeuco 200	16.265	19.851	16.866	17.661	Money Maker	19.020	20.741	19.186	19.649
Peto- 86	18.326	18.189	15.311	17.274	Castle Rock	16.365	14.249	15.191	15.268
Super Marmande	16.426	14.060	13.852	14.779	Super Marmande	17.402	14.103	13.477	14.994
Strain -B	12.764	12.805	15.688	13.752	Strain -B	13.812	12.386	14.170	13.456
Carmeuco 201	14.717	14.757	15.069	14.484	Carmeuco 201	14.424	14.383	14.612	14.473
Aledo VF	13.773	13.667	12.921	13.454	Aledo VF	12.937	11.740	12.320	12.332
Sun Drop	11.855	12.289	13.237	12.460	Sun Drop	12.211	11.236	12.200	11.882
Super Strain -B	14.868	13.080	15.055	14.334	Super Strain -B	13.137	13.024	14.251	13.471
UC-97/3	16.389	17.654	13.485	15.843	Rutgers Select	16.032	16.169	15.575	15.925
Pearson Improved	12.345	12.773	12.381	12.500	Pearson Improved	13.929	12.869	12.978	13.259
Beef Stick	14.942	12.438	11.725	13.035	Beef Stick	13.905	11.338	11.237	12.160
Avg.Env.	14.788	14.688	14.145		Avg.Env.	14.834	13.840	14.109	

1:Money Maker cv, 2 : Castle Rock cv, 3 : Carmeuco 200 cv and 4: Peto 86

LSD at 0.05 for comparing means in	testers		and	Ni - cultivars	
	Cross 1	Cross 2		Cross 1	Cross 2
Averages of environments	1.157	1.314		0.604	0.686
Averages of genotypes	0.480	0.762		0.230	0.365
Any two row values	1.588	1.685		1.230	1.808
Any two column values	0.831	1.319		0.762	1.211
Gen. x Env. interaction	0.762	1.211		0.762	1.211

found that the highest tomato yield was recorded at a spacing of 45 x 60 cm. While, Moccia and Kacherian (1997) reported that cherry tomato yield per unit area increased linearly with planting density (2.7, 3.3, 4.4 and 6.7 plant/m^2); but the yield/ plant decreased. On the other hand, plant density of 12 plants /m^2 gave a higher tomato economic yield and a higher number of fruits /plant than plant density of 16 plants/m^2 (Sanchez *et al.*, 1998).

For Ni-cultivars; although, average fruit weight was affected by the changing the environment, there was mostly no difference between environments 1 and 2 on the two Ni-cultivars of the two groups. However, the highest fruit weights in group 1, were obtained with C_{200} x 60 or 45 cm and with UC x 60 cm. In group 2, the highest values were obtained with RS x 45 or 60 cm. The lowest values were given by Aledo x 30 cm in the two cultivar groups. For fruit number (Table 11), the change in environment had a marked effect on fruit number of the cultivar of the two groups. The highest fruit numbers were obtained with Peto, SSB and SD x 60 cm, in group 1, and with MM x 60 cm in group 2. While, the lowest ones was obtained with PI x 30 cm and BS x 30 cm in the two groups, respectively. Regarding total yield/plant and per plot, the environment had considerable effects on the productivity of tomato cultivars. So, the change in the environment had a concomitante change on yield. The best interaction found in this study was obtained with C_{200} and Peto x 60 cm in group 1 and with MM and RS x 60 cm, in group 2, for yield/plant. The lowest yield/ plant was observed with PI x 30 cm in group 1 and with SD x 30 cm in group 2. However, the highest yield/plot was obtained with C_{200} x 45 cm and Peto x 30 cm in group 1, and with MM x 45 and 60 cm in group 2, whereas, the lowest yield/plot, was obtained with SD x 30 or 45 cm in the two cultivar groups.

Therefore, the testers (P_1 , P_2 and F_1) of the two crosses had a considerable differences among them in all the studied traits. Also, the cultivars of the two groups, which represent a random sample of tomato cultivars, showed highly significant difference among them. The interactions of those GxE were also detected. Accordingly, the testers and Ni- cultivar groups proved to be valid to initiate

triple test cross, to study the genetic components of their mentioned traits and their interactions with the various environments (in the next two papers).

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دراسة التفاعل الوراثى البينى فى التلقيح الإختبارى الثلاثى فى الطماطم
١- سلوك التراكيب المختبرة والأصناف

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تم تقييم إثنين من هجن الطماطم، وهما مونى ميكر × كاسل روك (MMx CR) وكارميكو ٢٠٠ × بيتو ٨٦ (C_{200} x Peto) ، وأبائهم ،ومجموعتين من الأصناف (١١ صنفاً لكل مجموعة)، ،التى سوف تستخدم فى التلقيح الإختبارى الثلاثى . تحت ثلاث بيئات (٣٠ ، ٤٥ ، ٦٠ سم مسافات زراعة) فى الأراضى الرملية، فى الموسم الصيفى لعام ٢٠٠٠ بمزرعة الخطارة التابعة لجامعة الزقازيق .

أظهرت النتائج وجود معنوية عالية لمجموعة مربعات الانحراف الراجع للبيئات وللتراكيب الوراثية (المختبرات والأصناف) وللتفاعل الوراثى البيئى(المختبرات × البيئة والأصناف × البيئة) لبعض الصفات الكمية فى الطماطم وهى :ارتفاع النبات، وعدد الأفرع للنبات، وعدد الثمار المبكرة للنبات، والمحصول المبكر للنبات وللقطعة التجريبية، والمحصول الكلى للنبات والقطعة التجريبية، ومتوسط وزن الثمرة وعدد الثمار الكلى للنبات؛ ولكن مجموع مربعات الإنحراف الراجع للبيئات بالنسبة لصفة متوسط الثمرة المبكرة وتفاعل المختبرات × البيئة كانت غير معنوية . هذه الاختلافات وجدت أيضاً بين التراكيب الوراثية (المختبرات والأصناف) وتفاعلاتها ، عندما قورنت تحت نفس البيئة وتحت البيئات المختلفة فى كلا الهجنين ومجموعتى الأصناف المدروسة . وعلى ذلك وجدت إختلافات عالية بين المختبرات الثلاثة (الأب الأول - الأب الثانى والجيل الأول) ، وبين مجموعة أصناف كل هجين وإختلفت إستجاباتها للبيئات وأعطى الصنف بيتو ٨٦ أعلى محصول لكل نبات فى البيئة الأولى وأعطى الصنف كارميكو ٢٠٠ أعلى محصول للنبات فى البيئتين الثانية والثالثة فى مجموعة الهجين الأول بينما أعطى الصنف مونى ميكر أعلى محصول للنبات مع كل البيئات فى مجموعة الهجين الثانى.