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STUDY OF GENOTYPE - ENVIRONMENT INTERACTION IN TOMATO TRIPLE TEST CROSS 2. PHENOTYPIC STABILITY OF TRIPLE TEST CROSSES FAMILIES

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ABSTRACT: Phenotypic stability of the varieties or populations of stable genotypes were assessed under varied environments, in previous works. In this study , phenotypic stability of tomato genotypes (families) derived from two crosses,(Money Maker x Castle Rock and Carmeuco 200 x Peto 86), through triple test crosses were investigated. Family sets were developed by crossing each of P_1, P_2 and F_1 of each cross with a group of 11 cultivars to produce 33 families of each cross. Therefore, this study aimed to investigate the stability performance of those altered genotypes (33 families of each cross) under three micro -environments (30 , 45 and 60 cm plant spacings).

According to Finlay and Wilkinson (1963), and Eberhart and Russell (1966); stability parameters results showed that the eleven families set (L_{1i}, L_{2i} and L_{3i} for each cross) reflected highly significant differences among genotypes of each set in the two crosses under all environments, although they had a common tester. Stability performances changed with the change of genotypic composition, due to the backcross tester used; i.e. , P_1, P_2 and F_1 in each cross. Nevertheless, there were some families with average stability (b_i=1 and low S^2d), irrespective of the tester used for the studied trait . Those were the families derived from "Sun Drop" in cross 2 for plant height; from "Money Maker" in cross 2 for branch number ; from "Peto 86" and "Pearson Improved" in cross 1; from "Money Maker" in cross 2 for early fruit weight / plant; from "Carmeuco 200" and "UC 97-3" in cross 1; from "Castle Rock", "Super Marmande", "Carmeuco 201" and "Rutgers Select" in cross 2 for early fruit number ; from "Carmeuco 200" in cross 1 for early yield ; from "Super Strain-B" in cross 1 for average fruit weight; from "Carmeuco 200" and "Pearson improved" in cross 1 ; from "Super Marmande" and "Carmeuco 201" in cross 2 for total fruit number / plant ; and from "Money Maker", "Super Marmande" , "Strain B " and "Rutgers Select" in cross 2 for total yield / plant.

Key wards: Genotype-environment interaction (G x E), stability parameters, phenotypic stability, average stability, below average stability, above average stability.

INTRODUCTION

Tomato (*Lycoperiscon esculentum* Mill.) is grown overall the year, overall Egypt and under different cultural methods. A genotype may or may not do well under all environments and,therefore, changing the growing environment would affect the performance of the growing genotype. Phenotypic stability is often used to refer to fluctuations in the phenotypic expression, while the genotypic composition of varieties or populations remains stable. The basic cause of differences between genotypes in their phenotypic stability is the wide occurrence of genotype - environment interactions.

Genotype -environment interactions (GxE) of quantitative traits have been studied in several crops (Finlay and Wilkinson,1963 ;Eberhart and Russell, 1966, 1969 ;Baker, 1969 ; Breese,1969;Freeman, 1973; Tai *et al.,* 1982; Choo *et al.,*1984), including tomatoes (Cuartero and Cubero, 1982; Stoffella *et al.,*1984, 1988; Poysa *et al.,* 1986; Ismail, 1997). Finlay and Wilkinson (1963), using the regression coefficient (bi) as a stability parameter to evaluate adaptation, defined three classes of genotypes those were having above average (b_i<1),average (b_i=1), or below average (b_i>1) stability. Eberhart and Russell (1966) , proposed another stability parameter, that is S^2d (deviation from regression). They suggested that genotypes with b=1 and S^2d= 0 to be considered stable. Choo *et al.* (1984) used t-test to compare genotype means with the environment mean.

Since the tomato genotypes have varied growth habits, seeking for a suitable plant spacing (micro-environments) would affect plant growth and productivity. Stoffella *et al.* (1988) and Ghattas and Economakis (1993) reported that tomato plant growth traits increased with increasing plant spacing. Moreover, average fruit weight, fruit number /plant and total yield / plant in tomato increased also with high plant spacing (Moccia and Katcherian, 1997).While, increasing tomato plant density increased fruit yield / fed., fruit number /plot and early yield /plot (Cockshull and Ho, 1995; Moccia and Katcherian, 1997; Agele *et al.*, 1999).

The materials of the previous work on G x E used varieties or populations of stable genotypic compositions. In the present study, the used materials consisted of the families resulted from triple test cross (TTC) mating system; i.e., Ni- cultivars (11 ones) were crossed with three testers (P_1, P_2 and F_1). Therefore, three family sets were derived for each cultivar when crossed with the testers. This study aimed to evaluate the phenotypic stability of the families derived through triple test crosses, and to highlight the G x E of the changed genotypes of a cultivar according to the test cross used, under three micro-environments.

MATERIALS AND METHODS

Present study was carried out at the Experimental Farm at El-Khattara, Faculty of Agriculture, Zagazig University,on two tomato crosses; i.e., Money Maker (MM) x Castle Rock (CR), as cross 1, and Carmeuco 200 (C_{200}) x Peto 86 (Peto), as cross 2. The P_1, P_2 and F_1, of each cross, were crossed with a group of 11 cultivars (Schedule 1) to get three family sets (L_{1i}, L_{2i} and L_{3i}, 11 families for each), as a modified triple test cross mating system (Perkins and Jinks, 1971; Jinks and Virk, 1977).

The resultant 66 families were evaluated under three micro- environments (30, 45 and 60 cm plant spacing), in split - plots in a randomized complete blocks design, with three replicates. The main - plots were devoted for the three plant spacing treatments and the sub-plots contained the triple test crosses families. Seeds of the four parental cultivars were sown on Oct. 28, 1997 in speedling trays and the raised seedlings were transplanted on Dec. 21, 1997 under a plastic house to produce seeds of the F_1 for both crosses (MM x CR) and (C_{200} x Peto). Parents, F_1's and 11 Ni-cultivars seeds, for each cross, were sown on July 7, 1998 and transplanted on Aug. 10, 1998, in 30 cm pots and kept under a lath house during summer. At flowering, crosses started on Sept. 5 ,1998 between each Ni-cultivar with P_1, P_2 and F_1 of each cross to produce seeds of L_{1i}, L_{2i} and L_{3i} families, respectively. Crosses continued until Jan. 25, 2001 to compensate the shortage of some genotype seeds in TTC sets.

For evaluation trial, seeds of the 11 TTC families in sets (L_{1i}, L_{2i} and L_{3i}) for each cross (33 genotypes) were sown on Mar. 3, 2001 and the raised seedlings were distributed and transplanted in the field, according to the previously mentioned design, on Apr. 18, 2001.Sub-plot area was $4.5m^2$ (3m long x 1.5m wide) with uncultured space (1.5m) between each two adjacent sub-plots. Fertigation and other cultural practices were done as recommended for commercial tomato production in sandy soils.

Observations were taken from each sub-plot at the end of the season to measure plant height and branch number / plant. Early yield traits; i.e. , average early fruit weight, early fruit number / plant and early yield / plant. The first three pickings were considered as early yield, starting from 72-85 days after

Schedule 1. Appriviation and source of the two groups 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. Agrić., 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

transplanting. Total yield traits ; i.e., average fruit weight, fruits number / plant and total yield /plant were determined all-over the harvest season.

The obtained data were subjected to analysis of variance, according to Cochran and Cox (1957), following the used experimental design, and, also, to get the pooled error values.

Stability Analysis

Once a GxE is significantly occurred, for any studied character, stability analysis was performed. The joint regression model, proposed by Eberhart and Russell (1966), for assessing stability of tomato studied genotypes over environments and modified later by them (1969) was used. Stability parameters in their models were the regression of each genotype on an environmental index (bi) and the deviation from regression (S^2d). T-test was used to compare genotype means with the environment mean.

RESULTS

The behaviour of family sets; i.e., L_{1i}, L_{2i} and L_{3i} which were produced as line x tester, were assessed under different plant spacings (30,45 and 60cm). Analysis of variance and stability parameters; i.e., b_i and S^2d; were determined and their results will be presented below .

1. Results of the Analysis of Variance

Data in Tables 1, 2 and 3 showed highly significant mean squares for environments, genotypes and G x E of all studied tomato traits; viz., plant height, branch number, both early and total yields, and their components. When the genotype and genotype-environment variances were partitioned to their components, highly significant mean squares for L_{1i}, L_{2i} and L_{3i}, and for L_{1i} x env., L_{2i} x env. and L_{3i} x env. were also observed for all the studied traits. Off the partitioned components;L_{1i} x environment (in cross 1), L_{2i} x environment (in cross 2), both in early fruit weight, and genotype x environment residual (in cross 2), in average fruit weight over the whole harvesting season, showed insignificant values . Since the genotype x environment mean square for all the aforementioned tomato traits were significant, it facilitates to proceed for computing and

Table 1. Mean squares resulted from the analysis of variance for the triple test cross families (L_{1i}, L_{2i}, and L_{3i}), environments and their interactions, in the used crosses, for tomato plant height and branch number in the summer season of 2001.

SOV	d.f.	Cross 1: (MM[1] x CR[2])		Cross 2 : (C_{200} [3] x Peto 86[4])	
		Plant height (cm)	Branch No./plant	Plant height (cm)	Branch No./plant
Reps.	2	24.390	25.33	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.	32	1159.366**	555.770**	1043.597**	438.515**
L_{1i}	10	765.274**	281.759**	391.414**	181.126**
L_{2i}	10	534.162**	366.040**	100.344**	153.245**
L_{3i}	10	297.868**	136.771**	312.098**	76.228**
Residual	2	10563.355**	4969.482**	12678.272**	4963.243**
Gen. x Env.	64	118.765**	91.955**	64.165**	55.981**
L_{1i} x Env.	20	95.226**	71.682**	32.562**	81.208**
L_{2i} x Env.	20	84.970**	109.657**	12.264**	15.285**
L_{3i} x Env.	20	81.118**	54.488**	66.813**	48.932**
Residual	4	593.675**	292.149**	468.449**	168.737**
Error b	188	4.141	9.165	4.666	6.961

** ; Highly significant at 1% level of probability.
1:Money Maker cv, 2: Castle Rock cv , 3: Carmeuco 200 cv , and 4: Peto 86.

assessing the stability of the developed families in sets for those traits in the two crosses; i.e., MM x CR and C_{200} x Peto, according to Finlay and Wilkinson (1963), Eberhart and Russell (1966) and Perkins and Jinks (1971). Stability of tomato fruit yield were studied by Stoffella *et al.* (1984), Poysa *et al.* (1986) , Berry *et al.* (1988), Ortiz and Izquierdo (1994) and Ismail (1997). They found difference among tomato genotypes in their stability over different environments.

Table 2. Mean squares resulted from the analysis of variance for the triple test cross families (L_{1i} , L_{2i}, and L_{3i}) , environments and their interactions , in the used two crosses for tomato early yield triats in the summer season of 2001

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)	Fruit weight	Fruit No./ plant	Early Yield/ plant (gm)
Reps.	2	10.902	2.640	13848.101	66.226	0.493	934.303
Env.	2	92.883NS	239.167**	1040703.941**	150.986NS	109.488**	585696.928**
Error a	4	153.372	0.781	3014.781	57.298NS	0.349	455.957
Gen.	32	856.725**	4.631**	27512.994**	1793.049**	18.728**	95862.012**
L_{1i}	10	654.527**	1.658**	7562.579**	1275.962**	23.520**	79421.401**
L_{2i}	10	1413.583**	2.421**	17535.728**	3052.337**	17.312**	78436.457**
L_{3i}	10	656.356**	7.639**	49974.206**	1176.501**	15.237**	122592.750**
Residual	2	85.276**	15.505**	64845.326**	1164.784**	19.301**	131539.152**
Gen. x Env.	64	178.377**	1.901**	11795.921**	127.416**	1.981**	10620.489**
L_{1i} x Env.	20	25.872NS	1.546**	8691.578**	162.618**	1.708**	5090.969**
L_{2i} x Env.	20	190.083**	1.608**	11403.994**	64.274NS	1.110**	5174.118**
L_{3i} x Env.	20	151.186**	2.672**	14604.288**	160.501**	3.313**	22301.025**
Residual	4	1018.334**	1.282**	15235.433**	101.691**	1.041**	7097.294**
Error b	188	52.643	0.196	957.913	33.593	0.245	779.032

N.S., **; Insignificant, highly significant at 0.01 level of probability, respectively.

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

Table 3. Mean squares resulted from the analysis of variance for the triple test cross families (L_{1i} , L_{2i}, and L_{3i}) , environments and their interactions , in the used two crosses for tomato yield triats in the summer season of 2001

SOV	d.f.	Cross 1 :(MM[1] x CR[2])			Cross 2: (C_{200}[3] x Peto[4])		
		Fruit weight	Fruit No. / plant	Yield/ plant (gm)	Fruit weight	Fruit No./ plant	Yield/ plant (gm)
Reps.	2	6.831	12.362	103194.420	0.162	21.994	79829.629
Env.	2	50.703**	22482.358**	189050444.150**	9.855**	11669.993	54439317.088**
Error a	4	5.564	8.684	21457.337	1.749	5.246	57777.916
Gen.	32	1377.969**	542.452**	1802915.245**	1495.592**	462.867**	2905843.741**
L_{1i}	10	378.490**	450.710**	1059689.012**	641.870**	200.239**	1184046.626**
L_{2i}	10	2701.736**	431.953**	1709629.143**	3093.334**	727.881**	4167956.183**
L_{3i}	10	810.833**	557.861**	189216.089**	947.970**	375.331**	12865355.594**
Residual	2	2592.209**	1476.614**	5539207.699**	513.602**	888.587**	4906708.091**
Gen. x Env.	64	123.313**	89.505**	465096.301**	58.819**	36.073**	148595.437**
L_{1i} x Env.	20	32.977**	111.998**	51614.008**	25.563**	25.069**	92285.971**
L_{2i} x Env.	20	76.083**	75.706**	300467.653**	43.402**	18.150**	156121.897**
L_{3i} x Env.	20	176.827**	74.693**	531092.444**	119.002**	55.439**	147844.443**
Residual	4	543.573**	120.603**	701670.296**	1.156NS	83.878**	396265.436**
Error b	188	4.418	2.287	12867.675	3.364	4.854	18535.997

N.S., **; Insignificant, highly significant at 0.01 level of probability, respectively.

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

They , also, reported significant G x E.

2. Stability Parameters

2.1 Plant Growth Traits

2.1.1 Plant height

Results of plant height (Table 4) in the two crosses for L_{1i}, L_{2i} and L_{3i} show that, the families of each set differed in their mean performances and their stability parameters, that was due to the tester used. In cross 1, only one family of L_{1i} derived from SSB , four families of L_{2i} derived from Aledo, SSB, PI and BS, and three families of L_{3i} derived from C_{201},UC and PI were considered stable, since their b_i did not differ from unity and had insignificant S^2d. But, with considering their mean performances, the favourable environment for each could be specified. Therefore, families derived from SSB in L_{1i}; from SSB, PI and BS in L_{2i}; and from UC in L_{3i} could do well under good environment, since their means were larger than the average performance; nevertheless, only one family in L_{3i}; that is derived from PI could do well under all environments (its mean did not differ from the average). The rest two families ; i.e., those derived from Aledo in L_{2i} and C_{201} in L_{3i}, may favour low producing environments. In cross 2, the families that had b_i equal unity and insignificant S^2d and considered stable were; SD , RS and BS in L_{1i}; MM, CR, SM, C_{201}, SD , SSB and BS in L_{2i} ; and SD and PI in L_{3i} ; and all could do well under a specific environment, according to their mean performances. The other families in the two crosses that had significant values for both b_i and S^2d, were considered unstable.

2.1.2 Branch number

Results in Table 5 show that, within cross 1, the families derived from C_{201}, Aledo, UC and BS in L_{1i}; from Aledo, UC and BS in L_{2i}; and from Peto, C_{201} and SSB in L_{3i} of cross 1; while, within cross 2 the families of MM, SB and SSB in L_{1i}; MM, CR, SB, Aledo, SSB and RS in L_{2i}; and MM, CR, SD and RS in L_{3i}; were all considered stable. Moreover, all the mentioned families in the two crosses could do well under all environments, since their means did not differ from the respective grand average of each family set. However, there was only one family that may

Table 4 . Stability parameters for plant height in the two tomato triple test crosses in the summer season of 2001

Ni cultivars	L_{1i}			L_{2i}			L_{3i}		
	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d
Cross 1: Money Maker x Castle Rock(MM x CR)									
Carmeuco 200 (C_{200})	60.96	1.11	58.95**	67.67	0.48•	0.38	79.08	1.55•	14.89 *
Peto 86 (Peto)	70.67	1.08	21.13 *	75.81	1.63	86.68**	92.52	0.52•	5.06
Super Marmande(SM)	74.11	1.90•	1.75	68.41	0.94	57.40**	86.00	1.44•	4.14
Strain - B (SB)	78.33	0.46•	2.02	67.63	-0.11	60.39**	83.33	0.46	27.24**
Carmeuco 201 (C_{201})	58.74	2.02	42.40**	70.96	0.77•	0.39	80.08	1.23	9.02
Aledo VF(Aledo)	64.78	0.92	65.54**	69.89	0.94	0.53	82.00	0.90	27.48**
Sun Drop (SD)	65.41	1.84•	12.69	76.81	1.51•	5.29	81.15	1.17	18.60 *
Super Strain - B(SSB)	79.33	0.83	10.93	84.56	1.10	6.67	93.00	0.79	33.74**
UC - 97-3 (UC)	57.37	0.26•	61.10**	80.81	1.67•	10.46	92.33	1.27	4.86
Pearson Improved (PI)	85.56	0.44	26.01**	86.26	1.20	2.43	85.00	1.02	9.91
Beef Steak (BS)	74.26	-0.03•	23.69**	88.18	0.97	1.54	44.37	0.57•	7.71
Average	69.96			76.09			86.53		
LSD at 0.05	3.71			3.71			3.71		
Cross 2 : Carmeuco 200 x Peto 86 (C_{200} x Peto)									
Money Maker (MM)	63.00	1.15	37.92**	70.74	1.02	5.78	83.37	1.35•	6.47
Castle Rock (CR)	67.85	0.52•	0.16	67.48	1.05	1.68	96.15	0.60•	6.21
Super Marmande(SM)	73.07	0.90	10.72*	77.00	1.01	1.87	89.56	1.46•	9.81 *
Strain - B(SB)	82.74	0.31•	2.56	76.93	0.70•	1.50	87.30	0.53•	2.44
Carmeuco 201(C_{201})	77.07	1.81•	3.76	69.74	0.85	2.00	84.00	1.13	57.64**
Aledo VF (Aledo)	77.59	0.71•	0.92	68.44	0.72•	1.90	86.04	1.00	38.27**
Sun Drop (SD)	65.26	1.10	1.17	72.67	0.82	1.47	83.89	1.15	3.50
Super Strain - B (SSB)	78.67	0.68•	0.81	74.33	1.20	4.23	97.07	0.79	31.02**
Rutgers Select (RS)	70.33	0.89	5.43	74.81	0.78•	1.15	96.26	1.23•	4.34
Pearson Improved (PI)	74.26	0.79	1.83	75.44	1.55•	7.27	89.78	1.04	0.66
Beef Steak (BS)	82.07	1.13	0.71	71.07	1.22	3.06	98.93	0.72•	1.82
Average	73.81			72.60			90.21		
LSD at 0.05	4.18			4.18			4.18		

* and ** : Significant at the 0.05 and at the 0.01 levels of probability, respectively.

• : regression coefficient (bi) is significantly different from unity at 0.05 level of probability.

Table 5 . Stability parameters for branch number per plant in the two tomato triple test crosses in the summer season of 2001

Ni cultivars	L_{1i}			L_{2i}			L_{3i}		
	$\bar{X}$	bi	S^2d	$\bar{X}$	bi	S^2d	$\bar{X}$	bi	S^2d
Cross 1: Money Maker x Castle Rock(MM x CR)									
Carmeuco 200 (C_{200})	24.55	1.69	40.95**	34.07	-0.55•	2.79	41.63	1.62•	1.71
Peto 86 (Peto)	34.37	0.45	43.47**	36.59	0.67	120.66**	44.92	0.71	13.15
Super Marmande(SM)	31.52	1.45	23.05 *	28.26	1.29	51.27**	43.34	0.91•	7.92
Strain - B (SB)	34.85	-0.18	32.75 *	31.70	0.14•	1.86	47.74	0.04•	4.44
Carmeuco 201 (C_{201})	23.07	1.38	2.70	36.40	-0.06	162.20	44.60	1.21	7.52
Aledo VF(Aledo)	38.52	0.99	0.62	28.34	2.00	11.81	46.48	0.22	43.81**
Sun Drop (SD)	28.48	1.94•	2.01	37.41	2.27•	15.94	39.04	1.28•	0.16
Super Strain - B(SSB)	30.52	0.72	45.56**	42.26	1.32•	0.95	50.19	0.94	20.77
UC - 97-3 (UC)	25.93	0.85	4.44	41.11	2.03	20.56	44.93	1.20•	0.49
Pearson Improved (PI)	39.59	0.81	43.15**	47.08	0.67•	0.98	39.29	1.13•	0.06
Beef Steak (BS)	32.59	0.90	3.78	46.11	1.12	17.31	50.78	0.33•	2.01
Average	31.27			37.21			44.81		
LSD at 0.05	8.21			8.21			8.21		
Cross 2 : Carmeuco 200 x Peto 86 (C_{200} x Peto)									
Money Maker (MM)	24.82	1.54	9.01	33.22	2.12	12.20	41.41	1.71	16.92
Castle Rock (CR)	35.37	-0.07•	4.13	30.67	1.41	5.64	43.44	0.80	12.82
Super Marmande(SM)	33.26	1.39•	0.05	30.85	1.57•	0.32	44.48	2.03•	2.84
Strain - B(SB)	25.70	0.76	3.92	28.18	1.28	1.38	44.15	0.79•	0.42
Carmeuco 201(C_{201})	34.44	1.73•	114.27**	38.37	0.06•	1.71	44.74	1.39•	0.11
Aledo VF (Aledo)	26.41	2.05•	10.26	25.26	1.10	0.12	45.48	0.26	19.12*
Sun Drop (SD)	30.04	1.41•	4.88	29.74	0.59•	0.20	40.30	1.20	4.70
Super Strain - B (SSB)	26.81	0.97	0.15	29.59	1.04	0.60	47.22	0.49	25.33*
Rutgers Select (RS)	29.37	0.46•	0.16	30.63	0.96	8.57	44.26	1.16	1.99
Pearson Improved (PI)	38.22	0.41•	0.22	36.56	0.31•	0.71	40.00	0.84•	0.17
Beef Steak (BS)	33.15	0.34•	0.22	37.85	0.53•	0.23	49.89	0.41•	0.13
Average	30.69			31.90			44.12		
LSD at 0.05	6.21			6.23			6.23		

* and ** : Significant at the 0.05 and at the 0.01 levels of probability, respectively.
• : regression coefficient (bi) is significantly different from unity at 0.05 level of probability.

do well under unfavorable environments, that was derived from Aledo in L_{2i} of both crosses (its means were less than the average performances of L_{2i} in the 2 crosses). The other cases in the three family sets of the two crosses were considered unstable, since they had significant estimated values for b_i and S^2d.

2.2 Early Yield and Its Components

2.2.1 Average fruit weight

Regarding average fruit weight (Table 6), in the two crosses, the stability performances of the families differed from a set to another. However, there were three cases; when Peto and PI (in cross 1) and MM (in cross 2) were the common parent (crossed with P_1, P_2 and F_1) they gave three families, each that had equal performances, to be stable under all environments and to be in average stability. Moreover, most of the derived families; in L_{1i}, L_{2i} and L_{3i} ; had b_i that did not differ from unity and showed insignificant S^2d values, to be considered stable. However, there were only three families in L_{1i} (in cross 1) appeared stable, although L_{1i} x environment was not significant (Table 2). The other cases which had significant b_i values, could be considered sensitive to the environments or unstable. Some few other cases showed significant S^2d values that were also considered unstable.

2.2.2 Fruit number

Data in Table 7 illustrate that most of the derived families in L_{1i}, L_{2i} and L_{3i}, in the two crosses, had b_i values that did not differ from unity and insignificant S^2d estimated, to be considered stable, but the stability assessed for each Ni- cultivar differed according to the involved tester. However, in the six cases; C_{200} and UC (in cross 1), and CR, SM, C_{201} and RS (in cross 2); when they were crossed to the three testers, they gave three families, each, to be stable under all environments. There was an interesting case, when Peto 86 (P_2) was used as a tester for Ni-cultivars (in cross 2), all developed families were stable. Off these families, the MM and C_{201} x Peto 86 could do well under favourable environment, since their means were significantly larger than the corresponding set average. Only few cases, gave

Table 6. Stability parameters for average early fruit weight (gm) in the two tomato triple test crosses in the summer season of 2001

Ni cultivars	L_{1i}			L_{2i}			L_{3i}		
	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d
Cross 1: Money Maker x Castle Rock(MM x CR)									
Carmeuco 200 (C_{200})	63.59	-1.72	71.48	74.72	1.19	22.85	56.88	-0.57•	6.25
Peto 86 (Peto)	54.63	2.74	17.68	71.00	0.92	2.20	75.93	0.78	63.57
Super Marmande(SM)	62.75	2.14•	-0.47	62.39	-1.07	249.94**	61.79	0.70	1.58
Strain - B (SB)	72.36	-0.25	78.32	65.65	0.16	23.31	49.28	1.07	2.67
Carmeuco 201 (C_{201})	60.89	2.98•	5.66	71.69	-0.53•	4.38	73.16	0.44•	0.12
Aledo VF(Aledo)	37.43	7.18•	188.31	52.00	1.87•	1.98	61.15	0.01	31.81
Sun Drop (SD)	63.65	0.22•	0.43	53.38	0.13	17.47	57.14	1.62	38.41
Super Strain - B(SSB)	63.51	-2.43•	36.02	52.00	1.34	2.55	49.41	0.53	80.14
UC - 97-3 (UC)	59.88	-0.38	49.34	68.28	2.59	29.45	63.20	4.14•	19.14
Pearson Improved (PI)	71.34	0.91	11.06	86.95	0.68	222.89	66.18	1.28	131.43
Beef Stick (BS)	63.57	0.61	19.98	87.95	3.11•	9.65	56.23	-0.21•	8.01
Average	61.24			67.82			60.94		
LSD at 0.05	11.54			11.54			11.54		
Cross 2 : Carmeuco 200 x Peto 86 (C_{200} x Peto)									
Money Maker (MM)	70.55	-1.80	26.04	54.32	2.86	10.76	62.48	1.06	5.30
Castle Rock (CR)	64.51	9.67•	137.58 *	70.98	5.72	19.33	84.09	0.83	0.29
Super Marmande(SM)	71.67	-5.39	73.03	59.46	6.00•	0.41	64.65	9.31 •	126.40 *
Strain - B(SB)	71.82	-2.74	25.81	52.24	2.34	1.65	49.80	5.77 •	14.69
Carmeuco 201(C_{201})	70.19	11.12•	84.17	74.71	0.19	2.68	78.07	5.05 •	6.96
Aledo VF (Aledo)	99.40	1.08	96.06	49.40	1.47	5.97	53.55	0.54	1.28
Sun Drop (SD)	61.80	-0.90	725.44**	57.56	17.88•	76.21	55.90	10.88 •	17.07
Super Strain - B (SSB)	60.34	0.60	0.20	51.71	6.24	11.81	47.15	-0.51•	0.41
Rutgers Select (RS)	75.15	3.66	-1.97	61.39	2.15	4.91	70.58	-0.97	216.01**
Pearson Improved (PI)	70.00	-0.29	159.95 *	74.70	-16.15•	16.26	65.29	0.45	4.77
Beef Stick (BS)	51.81	-0.60	4.80	113.66	-16.78•	6.14	60.89	-0.89	2.58
Average	69.75			65.47			62.95		
LSD at 0.05	9.22			9.22			9.22		

* and ** : Significant at the 0.05 and at the 0.01 levels of probability, respectively.

• : regression coefficient (bi) is significantly different from unity at 0.05 level of probability.

Table 7. Stability parameters for early fruit number / plant in the two tomato triple test crosses in the summer season of 2001

Ni cultivars	L_{1i}			L_{2i}			L_{3i}		
	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d
Cross 1: Money Maker x Castle Rock(MM x CR)									
Carmeuco 200 (C_{200})	2.84	0.96	-0.05	2.78	1.07	0.17	4.47	0.95	0.12
Peto 86 (Peto)	3.59	0.67•	-0.02	3.10	0.73	0.12	4.09	0.64	0.41
Super Marmande(SM)	3.11	1.38•	-0.05	4.00	1.13	1.05	3.16	0.87	0.05
Strain - B (SB)	2.99	0.42	0.81	4.17	1.65 •	0.13	2.68	0.64	1.40*
Carmeuco 201 (C_{201})	3.22	1.43•	-0.04	2.93	0.92	0.31	4.07	1.00	0.11
Aledo VF(Aledo)	3.46	1.09	0.43	2.83	0.49 •	0.04	3.24	-0.21 •	1.05
Sun Drop (SD)	2.41	0.96	-0.03	3.52	1.86 •	0.30	5.77	2.37 •	0.44
Super Strain - B(SSB)	3.56	0.84	5.38**	2.82	0.73 •	0.03	2.51	0.80	0.20
UC - 97-3 (UC)	3.63	0.86	0.46	2.87	0.82	0.28	3.72	1.58	0.13
Pearson Improved (PI)	3.49	1.74•	-0.01	3.41	1.28	0.74	3.10	1.11	0.07
Beef Steak (BS)	3.92	0.05•	0.18	2.63	0.42 •	0.11	3.54	1.16	0.12
Average	3.29			3.19			3.67		
LSD at 0.05	0.71			0.71			0.71		
Cross 2 : Carmeuco 200 x Peto 86 (C_{200} x Peto)									
Money Maker (MM)	2.60	1.01	0.03	4.21	0.99	0.05	4.38	2.09 •	0.21
Castle Rock (CR)	2.23	1.03	0.01	2.98	1.54	-0.07	4.89	1.13	0.13
Super Marmande(SM)	3.79	1.56	0.01	5.66	1.97	0.15	5.16	1.35	0.15
Strain - B(SB)	2.17	0.89	0.52	3.42	-0.02	0.45	1.71	0.67	0.23
Carmeuco 201(C_{201})	1.83	1.15	0.07	4.74	1.17	-0.08	4.11	1.29	0.51
Aledo VF (Aledo)	3.59	0.84	0.04	2.13	0.11	0.09	2.29	0.46 •	0.05
Sun Drop (SD)	2.98	0.30	1.59**	1.78	0.87	-0.01	3.00	-0.69	7.96**
Super Strain - B (SSB)	3.53	2.61	1.04 *	2.62	0.91	0.05	1.74	-0.18 •	0.06
Rutgers Select (RS)	2.16	0.87	0.03	1.54	0.62	0.03	2.72	1.62	0.16
Pearson Improved (PI)	1.41	0.08	0.81 *	3.81	2.52	-0.10	1.76	0.89	0.07
Beef Steak (BS)	7.34	0.67	0.07	1.42	0.73	0.00	3.93	2.10	2.79**
Average	3.06			3.12			3.24		
LSD at 0.05	0.79			0.79			0.79		

* and ** : Significant at the 0.05 and at the 0.01 levels of probability, respectively.
• : regression coefficient (bi) is significantly different from unity at 0.05 level of probability.

significant b_i and S^2d, that could be considered unstable sensitive to a specific environment.

2.2.3 Early yield / plant

Regarding early yield (Table 8), of the families of L_{1i}, L_{2i} and L_{31}, in the two crosses, there were relatively low number of each could be considered stable, compared to its components; i.e., fruit weight and number. The families derived from C_{200} with the three testers (in cross 1) were stable under all environments, to be in average stability. The other cases that showed stability of performances were; SB, SD and UC of L_{1i} ; SM, SD , UC and BS of L_{2i}; and Peto, SM, SB, SSB, PI and BS of L_{3i} (in cross 1); and MM, SM, C_{201} and Aledo, of L_{1i}; MM, SD, SSB and BS of L_{2i}; and SB, RS and PI of L_{3i} (in cross 2) .However, there was a considerable number of the families that had significant b_i values, especially in L_{2i} set (in the two crosses) and some cases had significant S^2d estimated. These families were considered unstable and sensitive to the environments, especially those had significant b_i values.

3.Total yield and Its Components

3.1 Average fruit weight

Results in Table 9 , show that number of families which had a stable performance in this respect was not so high as in early yield. The families that had stable average fruit weight were; C_{200}, SSB and PI of L_{1i} ; SB, Aledo, SSB and UC of L_{2i} ; and C_{200}, SM, SSB , UC and BS of L_{3i} (in cross 1); and (in cross 2) they were; MM, CR, Aledo , SD and BS of L_{1i}; MM and Aledo of L_{2i} ; and CR, SB, C_{201}, SSB and BS of L_{3i}. The other interesting point was that the families of L_{1i} and L_{2i} (in the two crosses) had negative and / or significant b_i. This negative slope indicated that the decrease in plant spacing tended to increase the fruit size relative to the other genotypes in family set.

3.2 Fruit number / plant

Results in Table 10 revealed a wide range of mean performance among the families in sets in the two crosses. In cross 1, the range was from 27.9 - 46.3 in L_{1i} , from 29.1-46.2 in L_{2i} and from 32.4-55.9 ; and in cross 2, it was from 26.6- 42.7 in L_{1i}, from 27.5

Table 8 . Stability parameters for early yield / plant in the two tomato triple test crosses in the summer seasons of 2001

Ni cultivars	L_{1i}			L_{2i}			L_{3i}		
	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d
Cross 1: Money Maker x Castle Rock(MM x CR)									
Carmeuco 200 (C_{200})	194.94	1.03	557.82	206.78	1.78	10507.72	249.39	0.93	77.95
Peto 86 (Peto)	192.86	0.37•	84.81	208.07	1.25•	31.04	315.04	0.97	1938.04
Super Marmande(SM)	195.21	1.30•	226.72	267.10	2.84	3130.52	195.23	0.81	204.76
Strain - B (SB)	214.43	0.53	4891.20	269.07	2.59•	1928.80	134.51	0.57	3896.42
Carmeuco 201 (C_{201})	215.91	1.69•	14.42	211.61	2.01•	94.18	298.93	1.11•	17.46
Aledo VF(Aledo)	242.38	0.33	1305.30	142.50	0.49•	320.92	196.33	-0.21•	4576.50
Sun Drop (SD)	151.38	0.85	199.17	181.04	2.39	3679.36	366.68	2.41•	50.11
Super Strain - B(SSB)	196.67	1.77•	159.86	154.63	0.44•	36.35	126.08	0.74	1415.69
UC - 97-3 (UC)	219.60	0.92	2311.56	181.87	0.97	286.57	251.99	1.77•	424.09
Pearson Improved (PI)	250.69	2.38•	288.91	269.16	2.58•	1037.17	202.46	0.97	285.08
Beef Stick (BS)	244.98	0.26•	762.51	227.44	0.37	3307.46	198.60	0.94	800.11
Average	210.80			210.85			230.48		
LSD at 0.05	49.24			49.24			49.24		
Cross 2 : Carmeuco 200 x Peto 86 (C_{200} x Peto)									
Money Maker (MM)	180.90	0.89	131.11	225.62	0.64	836.44	274.74	2.13•	390.79
Castle Rock (CR)	137.01	0.54•	107.94	201.58	1.57•	316.80	418.40	-0.95•	88.08
Super Marmande(SM)	255.77	1.12	692.48	338.06	1.64•	221.94	367.24	3.44•	412.53
Strain - B(SB)	150.48	0.62	3290.99**	178.54	-0.02•	1147.07	93.62	1.04	219.12
Carmeuco 201(C_{201})	130.86	0.75	717.49	354.83	1.39•	54.10	333.58	1.78	3532.35**
Aledo VF (Aledo)	357.90	0.96	256.87	102.11	-0.10•	208.68	123.26	0.46•	86.88
Sun Drop (SD)	179.14	0.20	3885.41**	105.17	1.0	125.95	175.99	-1.32•	2466.79*
Super Strain - B (SSB)	202.40	1.47	1671.42*	130.62	0.67	200.75	82.81	-0.16•	97.34
Rutgers Select (RS)	159.76	0.58•	258.67	93.91	0.53•	179.33	176.23	1.58	572.11
Pearson Improved (PI)	82.69	0.23•	361.55	283.21	2.44•	198.99	115.17	0.99	153.41
Beef Stick (BS)	381.23	3.64•	4147.69**	161.42	1.13	52.81	237.89	2.02	9068.45**
Average	201.65			197.73			218.08		
LSD at 0.05	44.41			44.41			44.41		

* and ** : Significant at the 0.05 and at the 0.01 levels of probability, respectively.

• : regression coefficient (bi) is significantly different from unity at 0.05 level of probability.

Table 9. Stability parameters for average fruit weight (gm) in the two tomato triple test crosses in the summer seasons of 2001

Ni cultivars	L_{1i}			L_{2i}			L_{3i}		
	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d
Cross 1: Money Maker x Castle Rock(MM x CR)									
Carmeuco 200 (C_{200})	63.82	0.32	6.14	72.84	-0.01•	0.06	62.65	0.90	0.26
Peto 86 (Peto)	54.82	2.50 •	-2.58	72.14	-0.16	18.94*	82.74	4.66	213.08**
Super Marmande(SM)	68.01	-0.07 •	0.27	84.96	-0.21•	-0.54	56.84	1.73	4.47
Strain - B (SB)	67.35	-0.66 •	1.20	64.67	0.37	0.54	49.87	-0.11 •	0.88
Carmeuco 201 (C_{201})	65.08	-0.11 •	0.72	73.23	-0.01•	0.08	65.00	3.85	573.81**
Aledo VF(Aledo)	69.68	4.51 •	5.52	60.22	2.47	4.73	64.37	2.50	58.88**
Sun Drop (SD)	60.98	0.26	0.59	55.91	-2.39•	-1.72	51.33	-0.93	18.86*
Super Strain - B(SSB)	64.39	0.74	0.51	49.87	0.17	3.18	53.97	0.04	2.52
UC - 97-3 (UC)	61.14	-0.06 •	0.41	69.56	1.73	2.80	69.52	0.88	-0.96
Pearson Improved (PI)	79.38	2.22	5.12	99.64	7.56•	19.9*	68.76	-1.63	36.93**
Beef Stick (BS)	58.58	-0.16 •	0.34	105.86	0.27	19.20*	64.64	0.10	2.81
Average	66.48			73.54			62.70		
LSD at 0.05	3.53			3.53			3.53		
Cross 2 : Carmeuco 200 x Peto 86 (C_{200} x Peto)									
Money Maker (MM)	64.23	-0.89	0.30	53.64	2.37	5.59	63.73	0.71	11.28**
Castle Rock (CR)	71.14	0.39	6.07	74.01	2.83	8.89 •	82.45	1.88	4.65
Super Marmande(SM)	61.36	16.84	22.02**	58.04	-1.86•	-0.80	65.00	5.98	271.68**
Strain - B(SB)	66.51	-7.49•	1.08	50.74	-0.60 •	-0.03	50.82	1.56	1.97
Carmeuco 201(C_{201})	53.21	-1.90 •	0.28	72.07	-3.02 •	-1.59	74.74	0.07	1.91
Aledo VF (Aledo)	86.14	-2.27	-1.21	51.82	-2.47	-1.99	59.59	3.08	65.73**
Sun Drop (SD)	61.36	-2.80	-1.58	49.99	-3.21 •	-0.59	51.68	-2.87•	3.25
Super Strain - B (SSB)	62.27	-3.17 •	-0.05	49.95	-3.17 •	-2.06	50.05	0.88	2.60
Rutgers Select (RS)	71.69	-3.76	14.30**	61.27	8.15	73.92**	65.44	-1.38	25.94**
Pearson Improved (PI)	68.12	-6.67	9.79**	78.12	-14.26	-16.62**	71.29	-0.11	2.98
Beef Stick (BS)	61.23	-2.56	-1.46	110.99	10.60	36.05**	65.70	1.88	5.94
Average	66.14			64.60			63.68		
LSD at 0.05	2.92			2.92			2.92		

* and ** : Significant at the 0.05 and at the 0.01 levels of probability, respectively.

• : regression coefficient (bi) is significantly different from unity at 0.05 level of probability.

Table 10. Stability parameters for fruit number / plant in the two tomato triple test crosses in the summer season of 2001

Ni cultivars	L_{1i}			L_{2i}			L_{3i}		
	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d
Cross 1: Money Maker x Castle Rock(MM x CR)									
Carmeuco 200 (C_{200})	30.34	0.92	2.73	34.14	1.07	5.02	50.78	1.06	1.58
Peto 86 (Peto)	46.47	1.02	11.22	33.88	0.73•	5.10	34.23	0.74•	1.74
Super Marmande(SM)	27.89	0.83	4.65	32.19	0.78	5.58	32.38	0.79•	3.03
Strain - B (SB)	28.54	0.55	540.82**	46.23	1.16	6.26	38.86	1.03	11.05
Carmeuco 201 (C_{201})	29.14	1.53•	18.97 *	27.22	0.64•	0.91	43.14	0.83	5.32
Aledo VF(Aledo)	37.93	0.43•	28.32**	37.76	0.76•	5.50	33.36	0.90	2.93
Sun Drop (SD)	34.99	0.73	32.19**	43.43	1.72•	26.20**	55.98	2.01•	33.62**
Super Strain - B(SSB)	46.34	1.91•	1.40	44.98	1.01	8.64	33.56	0.71•	0.49
UC - 97-3 (UC)	41.61	1.45•	4.16	45.44	1.49•	7.65	36.00	1.09•	0.57
Pearson Improved (PI)	28.77	0.82	4.55	29.12	0.83	3.81	37.04	0.88	4.11
Beef Steak (BS)	33.86	0.73•	2.37	32.63	0.75•	1.83	37.22	0.98	0.25
Average	35.08			37.00			38.96		
LSD at 0.05	2.41			2.41			2.41		
Cross 2 : Carmeuco 200 x Peto 86 (C_{200} x Peto)									
Money Maker (MM)	30.34	1.25•	1.35	45.71	1.17•	0.27	42.81	1.19	2.35
Castle Rock (CR)	28.62	0.98	2.63	34.66	1.33•	3.96	33.18	1.35	15.81 *
Super Marmande(SM)	34.40	1.25	7.38	50.58	0.80	3.93	44.39	0.24•	5.50
Strain - B(SB)	26.58	1.08	3.07	35.21	1.08•	0.08	30.73	0.79	31.18 **
Carmeuco 201(C_{201})	28.63	1.16	2.70	49.99	1.22	2.74	42.77	0.94	0.51
Aledo VF (Aledo)	27.64	0.84	1.66	30.93	0.69•	0.73	28.81	1.02	0.38
Sun Drop (SD)	32.18	0.77	37.39**	32.11	0.82	3.02	36.67	1.92	64.94 **
Super Strain - B (SSB)	42.67	0.90	51.31**	31.11	1.05	2.02	31.96	0.72	3.25
Rutgers Select (RS)	27.51	1.07	11.63**	27.46	1.01	2.37	31.70	1.18	14.27 *
Pearson Improved (PI)	34.24	0.83	3.93	40.86	1.26•	2.83	24.70	0.81	4.99
Beef Steak (BS)	34.43	0.86	2.41	23.56	0.56•	0.75	30.02	0.86•	0.44
Average	31.57			36.56			34.96		
LSD at 0.05	3.51			3.51			3.51		

* and ** : Significant at the 0.05 and at the 0.01 levels of probability, respectively.

• : regression coefficient (bi) is significantly different from unity at 0.05 level of probability.

50.6 in L_{2i} and from 24.7- 44.3 in L_{3i} . Moreover, the differences among the means of each set were significant.

Regarding to stability of each family (Table 10), the quantitative effects of plant spacing depended on the genotype of the family, since b_i's were positive in all the cases and insignificant from unity. However, in some particular cases , the presence of positive significant b_i or S^2d values indicated that those families may need a specific environment to do well. The families which could do well under all environments, that had a common Ni with the three testers although their genotypes were different, were those derived with C_{200} and PI (in the cross 1), and with C_{201} (in cross 2). There were some other cases that could be considered stable under all environments, but the changes of the tester changed its response to the environments. These families were derived from Peto 86 and SM of L_{1i}; SM, SB and SSB of L_{2i}; SB, C_{201}, Aledo and BS of L_{3i} (in cross 1) ; and CR ,SM, SB, Aledo, PI and BS of L_{1i}; SM, SD, SSB and RS of L_{2i} ; and MM, Aledo, SSB and PI of L_{3i} (in cross 2). The other femilies which did well under high productive environments; whose b_i values were significant and different from unity, their x were larger than L_i average and may have high S^2d values; were Aledo, SSB and UC in L_{1i} ; Aledo , SD and UC in L_{2i} ; and SD in L_{3i} (in cross 1); and MM and PI of L_{2i}, and SM in L_{3i} (in cross 2). The rest of the families were considered unstable.

3.3 Total yield / plant

Data in Table 11 reflected wide ranges in mean performances of the families yields in the various sets of the two crosses. Such ranges were from 1.93 - 2.51 kg in L_{1i}, from 1.99-3.46 kg in L_{2i} and from 1.83 - 3.19 kg in L_{3i} (in cross 1); and (in cross 2) from 1.54 - 2.93 kg in L_{1i}, from 1.62 - 3.58 kg in L_{2i} and from 1.58 - 3.17 kg in L_{3i}.Therefore , there were , in each family set, some low and high performed families.

Regarding to the stability of the families performances (Table 11), the results reveal that b_i estimates were positive for all the families in the two crosses. Nevertheless, some few cases (in cross 1) had

Table 11 . Stability parameters for total yield / plant (gm) in the two tomato triple test crosses in the summer seasons of 2001

Ni cultivars	L_{1i}			L_{2i}			L_{3i}		
	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d	$\bar{x}$	bi	S^2d
Cross 1: Money Maker x Castle Rock(MM x CR)									
Carmeuco 200 (C_{200})	1925.74	0.92	35159.25	2485.59	1.14	16153.66	3186.58	1.14•	645.09
Peto 86 (Peto)	2509.42	0.73•	300.06	2404.22	0.68•	39567.11	2901.62	1.48•	9590.57
Super Marmande(SM)	1897.66	0.96	10279.44*	2736.34	0.98	1671.21	1854.51	0.81•	10457.39
Strain - B (SB)	1925.64	0.77	97200.53**	2969.57	1.10	1195.23	1931.64	0.83•	2057.30
Carmeuco 201 (C_{201})	2364.33	1.47	212545.33**	1986.72	0.67	6098.65	2728.59	0.06	57980.26**
Aledo VF(Aledo)	2017.62	0.23	288780.79	2245.83	0.55•	5143.42	2192.10	1.18	13658.60
Sun Drop (SD)	2133.18	0.79	68214.41	2478.22	1.56•	34927.65	2847.20	1.76	341495.01**
Super Strain - B(SSB)	2973.10	2.07•	25502.11	2245.24	0.77•	9146.79	1826.92	0.67•	16961.76
UC - 97-3 (UC)	2601.82	1.40	809.19	3124.70	1.40•	42457.11	2503.68	1.24•	13441.70
Pearson Improved (PI)	2291.49	0.78	583833.85**	2805.46	0.90	8394.82	2230.39	0.83	28480.45
Beef Stick (BS)	2032.71	0.62•	3179.72	3462.58	1.24•	1279.05	2406.26	0.98	14038.48
Average	2244.99			2631.32			2419.04		
LSD at 0.05	180.50			180.50			180.50		
Cross 2 : Carmeuco 200 x Peto 86 (C_{200} x Peto)									
Money Maker (MM)	1979.70	1.20	65159.91	2411.43	0.79	10558.89	2675.98	1.11	8092.79
Castle Rock (CR)	2011.32	0.96	2917.35	2451.22	1.26	15979.87	2752.89	1.61•	38721.59
Super Marmande(SM)	2120.86	1.11	2552.12	3074.34	1.06	18028.48	2846.60	1.24	49605.25
Strain - B(SB)	1747.93	0.98	1094.78	1807.16	0.84	11309.08	1576.52	0.78	49989.16
Carmeuco 201(C_{201})	1541.48	0.90	12932.86	3578.23	1.48•	11413.95	3172.06	0.94	60714.82
Aledo VF (Aledo)	2372.38	1.16	16252.02	1621.81	0.60•	1123.51	1729.93	1.01	75507.73
Sun Drop (SD)	2000.64	0.72	143314.20	1621.53	0.52	165686.98	1833.76	1.02	176529.06**
Super Strain - B (SSB)	2928.23	1.33	88058.36	2119.66	0.86	7309.48	1578.02	0.54•	12248.13
Rutgers Select (RS)	1973.78	0.89	620.21	1742.93	0.99	11728.88	2002.77	0.79	14372.88
Pearson Improved (PI)	2366.70	1.02	24069.70	3225.41	1.77•	6222.31	1756.30	0.86	29389.01
Beef Stick (BS)	2098.46	0.69•	7893.82	2581.97	0.63	45236.80	2000.41	1.08	20815.80
Average	1858.32			2385.06			2175.11		
LSD at 0.05	216.63			216.63			216.63		

* and ** : Significant at the 0.05 and at the 0.01 levels of probability, respectively.
• : regression coefficient (bi) is significantly different from unity at 0.05 level of probability.

insignificant values for both b_i (indifferent from unity) and S^2d ; to be regarded stable. Those families were derived from C_{200} , Aledo , SD and UC in L_{1i}; from C_{200}, SM, C_{201}, SB and PI in L_{2i} ; and from Aledo, PI and BS in L_{3i} (in cross 1). The families which were considered to need a specific environment (i.e., that had significant b_i's and had high mean performances , reflecting high productivity) were Peto and SSB in L_{1i} ; UC and BS in L_{2i}; and PI, and C_{200}, Peto and UC in L_{3i} . Other families in this cross sets were considered unstable, since they had significant values for both b_i and S^2d.

In cross 2 (Table 11), b_i values appeared positive and, mostly, insignificant; indicating that the environments effects depend on the family genotype. Therefore, plant yield was favoured by increasing the plant spacing. Moreover, all S^2d estimates were found to be insignificant, with only one exception in the case of SD in L_{3i} set. Therefore, all the derived families of this cross were considered stable , except those having significant b_i values in the three family sets. Moreover, the change of the tester did not change the stability performance of the four derived families; i.e., MM, SM, SB and UC. Considering the performance means of the families, the high performing ones were those derived from Aledo, SSB and PI in L_{1i} ; SM , C_{201} and PI in L_{2i} ; and MM, SM and C_{201} in L_{3i}.On the other hand, the families that need special environments to do well, which had high means, but significant b_i values were C_{201} and PI in L_{2i}, and CR in L_{3i}.

DISCUSSION

The stability parameters b_i and S^2d, suggested by Eberhart and Russell (1966) and modified later by them (1969), were used in the present study. The TTC, suggested by Kearsey and Jinks (1968), and modified by Jinks *et al.*(1969), Perkins and Jinks (1971), and Jinks and Virk (1977) to replace Ni- cultivar instead of F_2, was used to produce family sets; i.e., L_{1i}, L_{2i} and L_{3i}. Therefore, the L_{1i} and L_{2i} sets of families were developed by crossing P_1 and P_2 x Ni-cultivars and those of L_{3i} families by crossing F_1 x Ni-cultivars. The resultant families in sets, with different genotypes, were tested under different environments (plant spacings). These used plant spacings were 30 , 45 and 60 cm, which were classified as micro- environments (Comstock and Moll, 1963; and Verma and Gill, 1975).

Since the plant spacings is the environment factor in this study,plant height and branch number were measured, along with both early and total plant yield. The results showed that the variances of the environments, genotypes, and G x E and their components were highly significant, except that of L_{1i} x environment on average fruit weight in early yield. The presence of genotype - environment interaction would facilitate to determine and investigate the stability performances of the triple test cross families in sets of the two crosses.

The data clarified that the quantitative effects of environment depended on the genotype , because the estimated b_i's of the families of the three sets (L_{1i}, L_{2i} and L_{3i}), in the two crosses (MM x CR and C_{200} x Peto 86), differed in their values and signs. The estimates appeared positive in most cases of the families in the various sets, indicating that stability performance of the derived families differed according to the used tester or even among the three families of each L_i which had a common Ni- cultivar. Such differences could be due to the variation among Ni- cultivars and due to the change on the genotype according to the involved tester. Similar conclusions on tomato fruit yield and fruit chemical composition were reported by Stoffella *et al.*, (1984 , 1988), Poysa *et al.* (1986), Berry *et al.*(1988) and Ismail (1997).

On the other hand, b_i's were negative in few cases of plant height (for the families derived from BS in L_{1i} and SB in L_{2i} sets in cross 1) ; of branch number (for SB in L_{1i},and C_{200} and C_{201} in L_{2i} , in cross 1, and CR of L_{1i} in cross 2). For early and total yield , it was also negative in some cases of average early fruit weight and early yield, and it was mostly negative in average fruit weight of the total yield. The negative slope of these cases, whose the genotypes are dependent on environments (independent), illustrates that the decrease in the plant spacing increased the trait value relative to the other families in the same family set. Negative regression coefficients for some genotypes of dry bean, maize, and tomato were previously reported by Beaver *et al.* (1985), Hebert *et al.* (1995), and Ismail (1997), respectively.

Before assessing the stability performances of the families in sets, derived through the modified triple test cross, it should be noted that L_{1i} and L_{2i} families were considered as single hybrids (P_1 and P_2 x Ni-cultivars), and L_{3i} families as three- way hybrids. The families that had insignificant b_i's from unity and insignificant S^2d values were considered stable under all environments. The numbers of these families that showed stability performance among the 33 families of each cross were 8, 9 , 19 , 19, 16 , 12, 15 and 10 (in cross 1), and 13, 13, 18, 24, 11, 6, 17 and 25 (in cross 2) for plant height, branch number, fruit weight (early), fruit number (early), early yield , average fruit weight , fruit number and total yield; respectively. Therefore, the two plant growth traits had relatively low numbers of stable families , as well as early yield and average fruit weight (of the total yield) in the two crosses, and total yield in cross 1. While, relative high numbers of the stable families were observed for fruit weight and number of early yield, fruit number of total yield (in the two crosses) and for total yield (in cross 2). For breeding to plant growth traits and those having similar behaviour, the germplasm should be carefully examine to find out a good genotype of high recombining value of stable performance; or, carefully, adjust a plant spacing for a particular genotype. And for fruit weight and number in early yield, and those having similar trends, a good recombining genotype of high stability performance would be detected. Accordingly, breeding for stability performance for early yield should be based on its attributes; and, for total yield, to deal directly on yield / plant or through number of fruits / plant. The genotype grouping technique characterizes cultivars on a group basis and , thus, it's used in screening a large number of entries appears practical (Ntare and Aken'Ova, 1985 on cowpea). This procedure has been also found to be useful in soybeans (Funnah and Mak, 1980).

The change of the genotype for each Ni-cultivar through its crosses with the testers, for the differences among Ni-cultivars with a common testers, led to a high variability in stability performances of the recombinant families. Of the aforementioned stable families numbers, there were some genotypes (of Ni-cultivars) when crossed with the three testers (P_1,P_2 and F_1) in each cross, the resultant three families were in average stability. Those cases were derived from Peto and PI for early average fruit weight, C_{200} and UC for fruit number (early), C_{200} for early yield, SSB for average fruit weight (yield), and C_{200} and PI for total fruit number in cross 1; when crossed with MM , CR and their F_1 hybrid . In cross 2, those were derived from SD (for plant height), MM for branch number, MM and RS (for average early fruit weight, CR, SM, C_{201} and RS for early fruit number), C_{201} (for total fruit number), and MM , SM , SB and RS (for total yield); when crossed each with C_{200}, Peto 86 and their F_1 hybrid. These Ni-cultivars, for each of the mentioned traits, were considered good combiners, under this test for adaptation, and to be doners for stability gene-groups. However, there were some other cases, where a specific Ni-cultivar was crossed to produce L_{1i} and L_{2i} families, which are considered as F_1's, to be also in average stability. Those cases were derived from SSB (for plant height) ,UC and BS (for branch number), C_{200} (for early fruit weight), SD and UC (for early yield) , SM (for total fruit number) and C_{200} (for total yield), when crossed with MM and CR, the parents of cross 1. In cross 2, the families derived from BS (for plant height); SB and SSB (for branch number) ; SB and SSB (for early fruit weight); MM, Aledo and BS (for early fruit number); MM (for early yield); SM (for total fruit number); and CR , SD and SSD (for total yield); when crossed with C_{200} and Peto 86 (L_{1i} and L_{2i}, respectively); were stable under all environments. The rest families, which showed average stability, resulted as a specific interaction of Ni- cultivar with any of the testers of the two crosses.

These results clarified that the difference of stability depends on the family genotype, according to the change of the tester or due to the change of Ni- cultivars. These results were in general similarity with the findings of El-Mansi *et al.* (1986), Poysa *et al.* (1986) and Ismail (1997) on tomato fruit yield, and Stoffella *et al.*(1995), on bell pepper yield. The inheritance of the stability gene groups may have additive gene groups , as shown when Ni-cultivar was crossed with the three testers, or may also show non-additive (specific) action, as shown from certain families derived through crossing with L_{1i} and L_{2i} , and had specific interactions (specific combinations). Similar results were reported by Singh (1980), on spring wheat, using TTC under macro-environments.

The cases which had significant b_i and insignificant S^2d values , which were considered to be sensitive to the environments and could do well under the favourable environments (60 cm apart) were also detected from this study. Those were derived from PI and UC (in cross 1), and PI and C_{201} (in cross 2) both for early yield and total yield, when crossed with a specific tester of the two crosses. The rest of the families in the sets of the two crosses were considered unstable .

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دراسة التفاعل الوراثى البيئى فى التلقيح الإختبارى الثلاثى فى الطماطم
٢- الثبات المظهرى لعائلات الهجين الإختبارى الثلاثى

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أقيمت الدراسات السابقة لدراسة الثبات المظهرى على أصناف أو عشائر ذات تراكيب وراثية ثابتة تحت البيئات المختلفة . أما هذه الدراسة فقد أجريت لدراسة الثبات المظهرى لتراكيب وراثية من الطماطم (عائلات) ناتجة من خلال هجينين (مونى ميكر × كاسل روك و كارميكو ٢٠٠ × بيتو ٨٦) خلال نظام التلقيح الإختبارى الثلاثى ، وذلك بتهجين كل منهم مع ١١ صنفاً لإنتاج ٣٣ عائلة لكل هجين . لذلك ، تهدف هذه الدراسة

لتوضيح سلوك الثبات المظهرى للتراكيب الوراثية المحورة (الناتجة من تهجين كل صنف مع الأب الأول، والأب الثانى والجيل الأول ، لكل هجين) تحت ثلاث بيئات (٣٠ ، ٤٥ ، ٦٠ سم ، كمسافة زراعة) تحت ظروف الأراضى الرملية فى الموسم الصيفى لعام ٢٠٠١ فى مزرعة الخطارة - كلية الزراعة - جامعة الزقازيق .

طبقاً لفنلاى وولكنسون (١٩٦٣) وإبرهارت وراسيل (١٩٦٦)، توضح أدلة الثبات المظهرى أن العائلات الإحدى عشرة بكل مجموعة من L_{3i} , L_{2i} , L_{1i} لكل هجين وجود اختلافات معنوية عالية بين التراكيب الوراثية بكل مجموعة من مجموعات عائلات الهجينين تحت الظروف البيئية ، وذلك بالرغم من إختزال كل مجموعة فى مختبر عام . وقد تغير سلوك الثبات المظهرى مع التغير فى التركيب الوراثى للصنف الذى تغير بتغير الأب المختبر (الأب الأول أو الثانى أو الجيل الأول فى كل هجين). ورغماً عن ذلك كانت بعض العائلات فى نطاق الثبات الوراثى $b_i = 1$ و S^2d منخفضة ، بصرف النظر عن المختبر المستخدم فى الصفة قيد الدراسة ، من هذه العائلات تلك المشتقة من " صن دروب" لصفة ارتفاع النبات و " مونى ميكر" لصفة عدد الأفرع فى الهجين الثانى ومن "بيتو ٨٦ " و"بيرسون المحسن" فى الهجين الأول ومن " مونى ميكر" فى الهجين الثانى لصفة وزن الثمرة المبكرة / ثمرة ، ومن " كارميكو ٢٠٠" و " يوسى ٩٧-٣" فى الهجين الأول ومن " كاسل روك " و " سوبر مارمند " و" كارميكو ٢٠١" و " روتجرز المنتخب" فى الهجين الثانى لصفة عدد الثمار المبكرة ، و من " كارميكو ٢٠٠" فى الهجين الأول للمحصول المبكر ومن " سوبر سترين - بى " فى الهجين الأول لصفة متوسط وزن الثمرة ، ومن " كارميكو ٢٠٠" و" بيرسون المحسن " فى الهجين الأول و " سوبر مارمند " و"كارميكو ٢٠١" فى الهجين الثانى لصفة عدد الثمار الكلى للنبات ، و " مونى ميكر " ، " سوبر مارمند " ، سترين -بى " و " روتجرز المنتخب " فى الهجين الثانى لصفة المحصول الكلى للنبات.