Genotypic and Phenotypic Stability for New Lines of Tomato (*Solanum Lycopersicum* L.).

Mohamed, A.G., A. M. Ahmed and R.M. Galal
Vegetable Res. Dept., Horticulture Res. Institute, Agricultural Res. Center, Giza, Egypt.

Abstract:

Eight tomato genotypes (seven lines and Castle Rock cultivar) were evaluated for yield and growth characteristics. Also, their phenotypic and genotypic stabilities were determined over four environments (two locations during seasons, 2011 and 2012). Plant height, number of branches per plant, fruit length, fruit diameter, fruit flesh thickness, vitamin C, total soluble solids (T.S.S.), dry weight of fruit, weight of fruit, number of fruit per plant, early yield and total yield were studied. The results of the combined analysis of variance for the traits under study showed highly significant effects for genotypes (G),environments (E) and genotype x environment (G x E) interaction. The genotypes L-7, L-6 and L-2 were stable with higher mean compared to grand mean.

Key words: Tomato (*Solanum lycopersicum* L.), lines and stability analysis.

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Referees: **Prof**. Mohamed F. M. Abdalla **Prof**. Ahmed A. Hassan

Introduction:

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops widely grown all over the world. It is a self-pollinated crop and is a member of Solanaceae family.

Plant breeders, in developing improved cultivars, are often confronted with the problem of interpreting genotype x environment (G x E) compared over a series of environments. The main difficulty for the breeder is in demonstrating the superiority of any cultivar.

Eberhart and Russell (1966) stated that while stratification of environments has been used effectively to reduce G x E interactions, it was better to select stable genotypes that interact less with the environments in which they are grown. Statistical methods for determining stability and adaptation of crop cultivars in diverse environments (locations and years) are usually used to assist plant breeders in selecting superior genotypes. The genotype x environment (G x E) interaction is important to plant breeders. The effect of environmental variation on genotype performance suggests that genotype selection is not possible from one environment (either year or location) but that genotypes must be evaluated in diverse environments. A dynamic approach to the interaction of varietal adaptation to varying environments was developed by Finley and Wilkinson (1963). Hill (1975) indicated that the genotype classification varies according to the environment in which they are assessed. Genotypes with consistent yield over many environments are preferred to those with high yield in selected environments. Breeders must select cultivars adapted to unpredictable environmental fluctuations using replicated yield trials over locations and years, which allows the assessment of the G x E interaction and proper germplasm selecting. Phenotypic stability with respect to number of primary branches per plant in 25 tomato varieties was studied by Peter and Rai (1976).They found tomato varieties HS-101 and Marglobe were suitable for high yielding environments (bi > 1), whereas Pusa Early Dwarf, Roma and B-2247 were suitable for poor environments (bi < 1). Kalloo and Pandey (1979) studied G x E interaction for yield of eight varieties of tomato in five different seasons. They found highly significant differences among genotypes, environment and G x E interaction. Jinks and Pooni (1982) indicated that Genotype x environment interaction force the breeder to choose between developing widely adaptable cultivars or cultivars adapted to unfavorable environment. Stoffella *et al.* (1984) suggested that the selection of tomato genotypes with stable performance should be considered by tomato breeders because differences for yield stability were detected among tomato cultivars in yield trials evaluated in Florida. In contrast, Poysa *et al.* (1986) indicated that tomato genotypes with low yields had greater yield stability than genotypes with high but unstable yields in Ontario, Canada. Berry *et al.* (1988) stated that stability analysis as detected by Eberhart and Russell (1966) was a useful tool or identifying tomato cultivars adopted by the processing industry in Uruguay and the United States. Genotype by environment interaction exists whenever the differences between a numbers of genotypes change with changes in the environment (Ceccarelli, 1989). Effect of environmental variation on genotype performance suggests that genotype selection is not possible from one environment (either year or location) but the genotypes must be evaluated in diverse environments. Gull *et al.* (1989) evaluated 10 fresh market tomatoes for stability of soluble solids and dry weight when grown in different environments. Stable genotypes were less sensitive to environmental changes and more adapted to favorable and unfavorable conditions than unstable genotype. No genotype was found to be stable for every fruit quality trait in nine environments. Significant genotype x environment effects were observed in tomato for plant height and number of primary branches, when eighteen advanced generation lines of tomato, including 'Megha', were evaluated under four subset of environments (Patil, 1994). Selection-10 (L-15 X 79B 1390/2-6), Selection-13 (L-15 X 79B 1390/4-11-2) and Selectio-18 (Megha) were stable with regression coefficient near unity. Meanwhile, Selection-4 (UC 204B X 79B 1390/7-17-1) was stable for number of primary branches. Ortiz and Izquierdo (1994) found that alleles that confer broader adaptation might be required to achieve tomato yield stability across environments. Hence, it is possible to select for yield stability in tomato. Significant genotype x environment effects was observed in tomato for plant height, when advanced lines and varieties evaluated for 4 years. (Kalloo *et al*., 1998). Mandal *et al.* (2000) tested 20 tomato genotypes under three environments for stability analysis. They found that among the five characters (plant height, primary branch number, fruit number, fruit weight and yield) studied; only fruit yield recorded significant genotype by environment interaction. Pandey *et al.* (2000) tested fifteen tomato genotypes for their stability in yield and yield components. They found that genotype x environment interaction was significant for all the traits studied. None of genotypes were found to be stable for all traits. Aravindakumar *et al.* (2001) found that the mean squares for G x E and G x E (linear) were significant for flesh thickness, number of locules and total soluble solids in tomato genotypes. The genotypes S-72, NS-815, F1-124, Shivaji and Arka Ashish were found stable with high mean values for flesh thickness. The genotype Arka Ashish was identified as stable variety for total soluble solids. Upadhay *et al.* (2001) studied 30 tomato genotypes in 4 environments. They found that pooled analysis of variance exhibited significant mean of squares due to the genotypes for all the traits studied. The significant variations due to the environments were observed for all characters, except number of primary branches per plant. Significant mean squares due to genotype environment interaction were observed for all traits except number of marketable fruits per plant and marketable fruit yield per plant. Aravindakumar *et. al.* (2003) found that variance due to genotypes, environments, genotype x environment and G x E (linear) components were highly significant for average fruit weight, fruit polar diameter, fruit equatorial diameter, number of fruits per plant, yield per plant, early yield per plot and total yield per plot. The genotypes F1-124, Shivaji and 855–211 were found to be desirable and stable for total yield per plot, while genotypes 5–72 and Rashmi were suited for favorable environments. The genotype Megha was found stable for early yield. Mulge and Aravindakumar (2003) found that significant genotype x environment interaction was observed for plant height and number of primary branches in tomato genotypes. Hossain *et al.* (2006) found that the analysis after Eberhart and Russell (1966) indicated that most of the genotypes were affected by environmental changes, and performance of these genotypes could hardly be predicted. Alsadon and Wahb-allah (2007) found that tomato genotypes could be differentiated for phenotypic stability of yield and its components or for adaptability to diverse environments. Xian *et al.* (2007) studied the stability of the fruit quality traits, including contents of vitamin C and total soluble solids (TSS) of seven tomato lines using Eberhart and Russell model (1966). Two space mutation lines (YH02-2 and YH02-6) had good stability and high nutrient content. Lines having unstable contents of vitamin C and TSS had higher contents. Mane (2009) tested sixteen advanced breeding lines of tomato along with a check L-15 (Megha) and found that the pooled analysis of variance revealed significant difference among the genotypes and environments for all the characters, indicating that genotypes and environments tested were diverse in nature. Genotype x environment interaction was significant for most of the characters suggesting genotypes interacted significantly with environments. Thapliyal and Singh (2009) evaluated thirty three genotypes over three environments i.e., summer and winter of 2006 and winter of 2007. They found that highly significant differences were observed among genotypes for all 13 characters under observation. The differences among the environment were also highly significant for all characters except plant height where it was significant only. The analysis of variance revealed the presence of genotype-environment interaction for all characters. Mane *et al.* (2010) studied 16 tomato genotypes over three different locations. They found that genotype x environment interaction was significant for most of the yield related traits suggesting that genotypes interacted significantly with environments. None of the genotypes was stable for all the characters and stability for one character was independent of stability for other characters.

This study aims to:

1. Produce a new line of genetically stable.
2. To identify stable genotypes over different locations for growth, yield and yield.
3. Study stability parameters in the genotypes for yield and yield components.
4. Comparison between lines selected and Castle Rock cultivar.

Materials and Methods:

Field experiments were conducted at two locations. The first location was at Sids Horticultural Research Station, Beni-Sueif Governorate and the second location at Beni-Mazar, El-Minia Governorate during the growing seasons of 2011 and 2012 to study the genotypic and phenotypic stability of eight (seven lines and Castle Rock cultivar) tomato genotypes.

The soil of the experiment at both locations was clay loam. Calcium super phosphate (15.5 % P_2O_5) was added at the rate of 300 kg/fed., during preparation of the soil. Also, the other recommended agricultural practices were done as for commercial tomato productions.

Lines L-1, L-2, L-3, L-4, L-5, L-6 and L-7 were produced by (Mohamed, 2004). These lines were compared with Castle Rock cultivar. The genotypes were sown in the fall season (August. 9th, 11th and 10th, 9th in 2011 and 2012 at the two locations).

The genotypes were arranged in a randomized complete block design with four replicates. Seeds were planted in the nursery 40 days before transplanting in the open field. The seedlings of each genotype were planted in open field 35cm apart on beds 5m beds long and 120cm wide. Each experimental unit consisted of three rows.

The following data were recorded: plant height, number of branches/plant, fruit length, fruit diameter, fruit flesh thickness, vitamin C (V.C.), total soluble solids (T.S.S.), dry weight of fruit, weight of fruit, number of fruit /plant, early yield and total yield.

Pooled analysis of variance (ANOVA) was performed over environments. The genotypes were considered as the fixed factor and appropriate error terms were used to test the significance among environments, genotypes and the interactions between genotypes and environments as illustrated by Gomez and Gomez (1984).

The phenotypic stability of the genotypes was measured using, the mean performance over environments, the linear regression (bi), the deviation from regression function(Eberhart and Russell ,1966) and their genetic counterparts α and λ (Tai, 1971).

Results and Discussion:

The response and stability performance of each of the eight genotypes over the two seasons and tow locations for 2011 and 2012 were determined. The phenotypic stability of the genotypes was measured using the means over environments, the linear regression (bi) and the deviation from regression (S_2d) (Eberhart and Russell, 1966) and their genetic stability counterparts α and λ (Tai, 1971). The deviation from linear regression mean square was tested using the pooled error mean square. The regression coefficient (bi) and genotype mean yield were used together as a measure of adaptation (Bilbro and Ray, 1976). Genotype with b = 1.0 was considered adapted for all environments, genotype with b < 1.0 was considered adapted for low yielding environments and genotype with b > 1.0 was considered better adapted for high yielding environments, depending upon the genotype mean yield.

Eberhart and Russell (1966) suggested that the mean coupled with the regression coefficient values and deviation from regression would provide useful parameters for studying the adaptation of genotypes and in their interpretations for the analysis of adaptation in plant breeding programs, Finlay and Wilkinson (1963) reported that regression coefficient values of up to 1.0 indicated average stability. When this was associated with high mean yield, genotypes had a general adaptability, while their associations with low mean yield, genotypes were poorly adapted to all environments. Moreover, “b” values above 1.0 describe the genotypes that adapted to high yielding environments and “b” values below 1.0 describe genotypes better adapted to low yielding environments. The genotypes mean value above the grand mean (mean of all eight genotypes) and bi > 1.0 were considered unstable and only adapted to favorable environments. Genotypes with a mean value below the grand mean and bi>1.0 were considered unstable with low mean value. Genotypes with a mean magnitude below the grand mean in specific trait and bi > 1.0 were considered unstable with low mean value. However, a genotype was considered desirable when it had a mean value above the grand mean, bi < 1.0 and its deviation from regression as small as possible (S2d near zero). Ortiz and Izquierdo (1994) reported that a high-yielding and stable tomato cultivar had a mean yield higher than the general mean, b= 1 and S2d= 0. Alsadon and Wahballah(2006) studied phenotypic stability for tomato , a stable genotype was defined as one with an individual mean greater than the grand mean , b ≤ 1 and S2d = 0 .

Based on the principle of structural relationship analysis, the genotype-environment interaction effect of a genotype is partitioned into two components as discussed by Tai (1971). They are the linear response to environmental effects (α) and the deviation from the linear response (λ).

A perfectly stable genotype has (α , λ)= (-1, 1)or (α< 0) and(λ = 1) and a genotype with average stability has (α , λ)= (0 , 1) or (α > 0) and (λ = 1) (Tai, 1971).

1. Plant height:

Data presented in Tables 1 and 2 indicated that differences among all genotypes and environmental effect and interaction between genotypes and environments were highly significant. These results confirm those previously reported by Kalloo and Pandey (1979), Patil (1994), Kalloo *et al.* (1998), Pandey *et al.* (2000), Mulge and Aravindakumar (2003) and Mane *et al.* (2010) who found that significant genotype x environment effects were observed in tomato for plant height. Upadhay *et al.* (2001), Mane (2009) and Thapliyal and Singh (2009) found that pooled analysis of variance exhibited significant mean of squares due to the genotypes. The significant variations due to the environments were observed. Significant mean squares due to genotype environment interaction were observed.

The genotypes L-2, L-5 and L-6 gave higher plant height than the grand mean, while the genotypes L-1 and L-7 gave a plant height nearly equal the grand mean. The different means and the estimated stability parameters are presented in Table 3.

Regression coefficient (bi) and the deviations from regression (S2d) showed that L-2 genotype was phenotypically stable (bi < 1 and S2d near zero).Castle Rock, L-2, L-1, L-3 and L-4 genotypes were stable genetically.

In general, the estimation of various stability parameters of the studied genotypes for plant height indicated that L-2 genotype was stable.

2. Number of branches per plant

Results illustrated in Tables 1 and 2 showed that the differences among all genotypes, environmental effect and the interactions between genotypes and environments were highly significant; stability analysis was useful in this case. These results confirm those previously reported by Kalloo and Pandey (1979), Patil (1994), Pandey *et al.* (2000) reported significant genotype x environment effects were observed in tomato for number of primary branches.

The genotypes L-2, L-5, L-7 and L-6 gave higher number of branches per plant than the grand mean, while

Castle Rock and L-1 gave a number of branches per plant nearly equal the grand mean. The different means and the estimated stability parameters are presented in Table 3.

Regression coefficient (bi) and the deviations from regression (S2d), Castle Rock, L-1, L-3 and L-4 genotypes phenotypically stable. Castle Rock, L-1, L-3 and L-4 genotypes were stable genetically.

In general, the estimation of various stability parameters of the studied genotypes for number of branches per plant indicated that Castle Rock cultivar was stable with the mean nearly equal the grand mean, while L-1, L-4 and L-3 genotypes were stable with the mean below the grand mean.

3. Fruit length:

The differences among the tested genotypes, environmental effect and the interactions between genotypes and environments were highly significant as shown in Table1. These results confirmed with those previously reached by Kalloo *et al.*, (1998), Pandey *et al.*, (2000), Aravindakumar et.al. (2003), Mane (2009) and Mane *et al.* (2010) who found that significant genotype x environment effects were observed in tomato for fruit length.

The genotypes L-2, L-5 and L-4 gave fruit length higher than the grand mean; while L-1, L-3, L-6, Castle Rock and L-7 gave fruit length nearly equal the grand mean. The different means and the estimated stability parameters are presented in Table 3.

Regression coefficient (bi) and the deviations from regression (S2d) showed that L-2, L-4, L-6 and L-7 genotypes were phenotypically stable. L-1, L-2, L-4, L-6 and L-7 genotypes were stable genetically.

In general, the estimation of various stability parameters of the studied genotypes for fruit length indicated that L-2 and L-4 were stable with higher mean compared to grand mean; while L-6 and L-7 were stable with mean nearly equal the grand mean.

4. Fruit diameter:

The differences among the tested genotypes, environmental effect and the interaction between genotypes and environments were highly significant as shown in Table1. These results confirmed with those previously reached by Aravindakumar *et. al.* (2003) found that variance due to genotypes, environments, genotype x environment and G x E (linear) components were highly significant for average fruit polar diameter, fruit equatorial diameter.

The genotypes L-1, L-3, L-4, L-5 and L-6 gave fruit diameter higher than the grand mean; while L-7 and Castle Rock genotypes gave fruit diameter nearly equal the grand mean. The different means and the estimated stability parameters are presented in Table 3.

Regression coefficient (bi) and the deviations from regression (S2d) showed that L-1, L-3 L-4, L-5, L-6, L-7and Castlerock genotypes were phenotypically stable. L-4, L-5, L-7, L-6 and Castle Rock genotypes were stable genetically.

In general, the estimation of various stability parameters of the studied genotypes for fruit diameter indicated that L-6, L-5and L-4 were stable with higher mean compared to grand mean, while the genotype L-7 was stable with mean nearly equal the grand mean.

5. Fruit flesh thickness:

Results illustrated in Table 4 showed that the differences among all genotypes, the environmental effect and the interaction between genotypes and environments were highly significant. These results confirmed with those previously reached by Aravindakumar *et al.* (2001), Mane (2009) and Mane *et al.* (2010) who found that the mean squares for G x E and G x E (linear) were significant for flesh thickness in tomato genotypes.

The genotypes L-2, L-7, L-5 and L-6 gave fruit flesh thickness higher than the grand mean, while L-3, L-1, L-4 and Castle Rock gave fruit flesh thickness nearly equal the grand mean. The different means and the estimated stability parameters are presented in Table 3.

Regression coefficient (bi) and the deviations from regression (S2d) showed that L-1, L-2, L-3, L-4, L-5, L-6 and Castle Rock genotypes were phenotypically stable. L-3 and L-5 genotypes were stable genetically.

In general, the estimation of various stability parameters of the studied genotypes for fruit flesh thickness indicated that the genotype L-5 was stable with higher mean compared to grand mean, while the genotype L-3 was stable with mean nearly equal the grand mean.

Table1. Pooled analysis of variance for plant height, number of branches per plant, fruit length and fruit diameter in tomato genotypes evaluated.

Source of variance	d.f.	M.S.			
		Plant height	number of branches \plant	Fruit length	Fruit diameter
Environments (E)	3	641.9583* *	34.5524**	1.5508**	0.8615**
Replication / E	12	14.2344	0.5134	0.2869	0.2598
Genotypes (G)	7	133.4732**	5.4842**	0.7106**	0.8674**
G x E	21	115.0149**	0.9110**	0.4270**	0.2911**
Error	84	19.5647	0.2239	0.1496	0.1266

** = highly significant at P < 0.01.

Table2. Mean square from stability analysis of variance for plant height, number of branches/plant, fruit length, and fruit diameter of eight tomato genotypes

Source of variance	d.f.	M.S.			
		Plant height	number of branches \plant	Fruit length	Fruit diameter
Genotypes (G)	7	33.3571**	1.3710**	0.1906*	0.2168**
E + (G x E)	24	45.2274**	1.2790**	0.1419n.s	0.0468**
E (linear)	1				
G x E (Linear)	7	70.6440**	0.5376**	0.1463*	0.0465*
Pooled deviation	16	6.8361	0.0637	0.0902	0.0140
(1) L-1	2	3.3519ns	0.0071ns	0.0374ns	0.0027 ns
(2) L-2	2	5.3076ns	0.0206ns	0.0934ns	0.0031 ns
(3) L-3	2	2.6889ns	0.0208ns	0.2435**	0.0026 ns
(4) L-4	2	8.4427ns	0.0988ns	0.0258ns	0.0110 ns
(5) L-5	2	6.2111n.s	0.0254ns	0.2046**	0.0019 ns
(6) L-6	2	12.6830ns	0.1421ns	0.0591ns	0.0249 ns
(7) L-7	2	9.1288ns	0.0468ns	0.0310ns	0.0385 ns
(8)Castle Rock	2	6.8751ns	0.1483ns	0.0272ns	0.0272 ns
C.V	2				
Pooled error	96	4.7246	0.0650	0.0417	0.0358

ns, * and **= not significant, significant and highly significant at $P < 0.05$ and 0.01, respectively.

6. Vitamin C (V.C):

The data presented in Table 4 indicated that differences among all genotypes were highly significant. Meanwhile, the environmental effect and the interaction between genotypes and environments were significant.

The genotypes L-6, L-3, L-1 and L-2 gave V.C value higher than the grand mean; while L-5, L-7 and Castle Rock gave V.C value nearly equal the grand mean. The different means and the estimated stability parameters are presented in Table 6.

Regression coefficient (bi) and the deviations from regression (S2d) showed that L-1, L-2, L-3, L-7, L-5, L-6 and Castle Rock genotypes were phenotypically stable. L-1, L-7, Castle Rock and L-6 genotypes were stable genetically.

In general, the estimation of various stability parameters of the studied genotypes for V.C indicated that L-6 and L-1 genotypes were stable with higher mean compared to grand mean. Meanwhile, L-7 and Castle Rock genotypes were stable with mean nearly equal the grand mean. Xian *et al.* (2007) found that Lines having unstable contents of vitamin C has higher content. This showed the hereditary mechanism of the nutritive quality traits of fruit is complex.

7. Total soluble solids (T.S.S)

The data presented in Table 4 indicated that differences among all genotypes the environmental effect and the interaction between genotypes and environments were significant. These results confirmed with those previously reached by Aravindakumar *et al.* (2001) who found that the mean squares for G x E and G x E (linear) were significant for total soluble solids in tomato genotypes.

The genotypes L-6, L-3 and L-7 gave T.S.S value higher than the grand mean, while L-2 genotype gave T.S.S value equal the grand mean. The different means and the estimated stability parameters are presented in Table 6.

Regression coefficient (bi) and the deviations from regression (S2d) showed that L-1, L-4, L-5, L-7 and L-3 genotypes were phenotypically stable. L-1, L-7 and L-5 genotypes were stable genetically.

In general, the estimation of various stability parameters of the studied genotypes for T.S.S indicated that L-7 genotype were stable with higher mean compared to grand mean. Meanwhile, the genotypes L-5 and L-1 were stable with mean below the grand mean. Xian *et al.* (2007) found that lines having unstable contents of T.S.S were relatively higher.

8. Dry weight of fruit:

Data in Table 4 indicated that the differences among the tested genotypes and the environmental effect were highly significant, while the interaction between the genotypes and environments was significant. These results confirmed with those previously reached by Aravindakumar *et al.* (2001) who found that the mean squares for G x E and G x E (linear) were significant for total soluble solids in tomato genotypes.

The genotypes L-7, L-2, L-1 and L-5 gave mean higher than the grand mean, while L-6 and L-4 genotypes gave mean value nearly equal the grand mean. The different means and the estimated stability parameters are presented in Table 6.

Regression coefficient (bi) and the deviations from regression (S2d) showed that L-6, L-2, L-5 and Castle Rock genotypes were phenotypically stable. L-2, Castle Rock and L-6 genotypes were stable genetically.

In general, the estimation of various stability parameters of the studied genotypes for dry weight of fruit indicated that L-2 genotype were stable with higher mean compared to grand mean, while the genotype L-6 was stable with mean nearly equal the grand mean.

9. Weight of fruit:

Data in Table 7 and 8 indicated that the differences among the tested genotypes, the environmental effect and the interaction between the genotypes and environments were highly significant. Aravindakumar *et. al.* (2003) found that variance due to genotypes, environments, genotype x environment and G x E (linear) components were highly significant for average fruit weight.

The genotypes L-6, L-7, L-2 and L-5 gave mean higher than the grand mean. The different means and the estimated stability parameters are presented in Table 9.

Regression coefficient (bi) and the deviations from regression (S2d) showed that L-7, L-3 and L-4 genotypes were phenotypically stable. L-7, L-3 and L-2 genotypes were stable genetically.

In general, the estimation of various stability parameters of the studied genotypes for weight of fruit indicated that L-7 genotype was stable with higher mean compared to grand mean, while the genotype L-3 was stable with mean nearly equal the grand mean

Table4. Pooled analysis of variance for fruit flesh thickness, Vitamin C, Total soluble solids (T.S.S) and dry weight of fruit in tomato genotypes evaluated.

Source of variance	d.f.	M.S.			
		fruit flesh thickness	V.C	T.S.S	Dry weight of fruit
Environments (E)	3	0.0152**	9.5964*	2.6217*	1.2565**
Replication / E	12	0.0009	3.0804	0.6922	0.2522
Genotypes (G)	7	0.0235**	11.4459**	0.1589*	1.0370**
G x E	21	0.0041**	2.8330*	0.1608*	0.3901*
Error	84	0.0016	1.4629	0.0902	0.1990

*and ** = significant and highly significant at P < 0.05 and 0.01, respectively.

Table 5. Mean square from stability analysis of variance for fruit flesh thickness, Vitamin C, Total soluble solids (T.S.S) and dry weight of fruit of eight tomato genotypes evaluated.

Source of variance	d.f.	M.S.			
		fruit flesh thickness	V.C	T.S.S	Dry weight of fruit
Genotypes (G)	7	0.0059**	2.8613**	0.0757*	0.2592*
E + (G x E)	24	0.0014*	0.9196*	0.1084**	0.1246**
E (linear)	1				
G x E (Linear)	7	0.0070**	0.4206**	0.0628*	0.2413*
Pooled deviation	16	0.0010	0.0746	0.0253	0.1100
(1) L-1	2	0.0024**	0.2391ns	0.0230ns	0.2256*
(2) L-2	2	0.0004ns	0.9060ns	0.0019ns	0.0079ns
(3) L-3	2	0.0004ns	0.0619ns	0.0283ns	0.1725*
(4) L-4	2	0.0003ns	2.7795**	0.0001ns	0.0128ns
(5) L-5	2	0.0003ns	0.0677ns	0.0712*	0.0100ns
(6) L-6	2	0.0020**	0.4406ns	0.0972*	0.3435**
(7) L-7	2	0.0006ns	1.2965*	0.0003ns	0.0021ns
(8)Castle Rock C.V	2	0.0020**	0.3140ns	0.0205ns	0.1053ns
Pooled error	96	0.0004	0.4163	0.0414	0.0514

ns, * and **= not significant, significant and highly significant at P < 0.05 and 0.01, respectively.

10. Number of fruit \ plant:

The results of this character in Table 7 indicated that the differences among genotypes and environmental effect were highly significant, while the interaction between genotypes and environments was significant. These results confirmed with those previously reached by Aravindakumar *et. al.* (2003), Mane (2009) and Mane *et al.* (2010) who found that variance due to genotypes, environments, genotype x environment and G x E (linear) components were highly significant for number of fruits per plant.

The genotypes L-6, L-7 and L-5 gave mean higher than the grand mean. Meanwhile, L-2 and Castle Rock genotypes gave mean value nearly equal the grand mean. The different means and the estimated stability parameters are presented in Table 9.

Regression coefficient (bi) and the deviations from regression (S2d) showed that L-7, L-5, L-6, L-3 and Castle Rock genotypes were phenotypically stable. L-7, L-6 and Castle Rock genotypes were stable genetically.

In general, the estimation of various stability parameters of the studied genotypes for weight of fruit indicated that L-6 and L-7 genotypes were stable with higher mean compared to grand mean; while Castle Rock cultivar was stable with mean nearly equal the grand mean.

11. Early yield:

The data in Tables 7 and 8 indicated that the differences among the tested genotypes were highly significant, while the environmental effect and the interaction between the genotypes and environments were significant. These results confirmed with those previously reached by Aravindakumar *et. al.* (2003), Mane (2009) and Mane *et al.* (2010) found that variance due to genotypes, environments, genotype x environment and G x E (linear) components were highly significant for early yield per plot.

The genotypes L-6, L-7, L-2 and Castle Rock gave mean higher than the grand mean. The different means and the estimated stability parameters are presented in Table 9.

Regression coefficient (bi) and the deviations from regression (S2d) showed that L-7, L-6, L-2 and Castle Rock genotypes were phenotypically stable. L-7, L-2 and L-6 genotypes were stable genetically.

In general, the estimation of various stability parameters of the studied genotypes for early yield indicated that L-6, L-2 and L-7 genotypes were stable with higher mean compared to grand mean.

12. Total yield:

The data in Tables 7 and 8 indicated that the differences among the tested genotypes and the environmental effect were highly significant, while the interaction between the genotypes and environments was significant. These results confirmed with those previously reached by Kalloo and Pandey (1979), Mandal *et al.* (2000) found highly significant differences among genotypes, environment and G x E interaction. Aravindakumar *et. al.* (2003) found that variance due to genotypes, environments, genotype x environment and G x E (linear) components were highly significant for total yield per plot. Kalloo and Pandey (1979), Patil (1994), Kalloo *et al.* (1998), Pandey *et al.* (2000), Mulge and Aravindakumar (2003) and Mane *et al.* (2010) who found that significant genotype x environment effects were observed in tomato for yield. Meanwhile, Upadhay *et al.* (2001), Mane (2009) and Thapliyal and Singh (2009) found that pooled analysis of variance exhibited significant mean of squares due to the genotypes. The significant variations due to the environments were observed. Significant mean squares due to genotype environment interaction were observed.

The genotypes L-6, L-7, L-2 and Castle Rock gave mean higher than the grand mean, while L-5 genotype gave mean value nearly equal the grand mean. The different means and the estimated stability parameters are presented in Table 9.

Regression coefficient (bi) and the deviations from regression (S2d) showed that L-7, L-6 and L-2 genotypes were phenotypically stable. L-7, L-2, L-5 and L-6 genotypes were stable genetically.

In general, the estimation of various stability parameters of the studied genotypes for total yield indicated that L-6, L-7 and L-2 genotypes were stable with higher mean compared to grand mean.

Jinks and Pooni (1982) indicated that Genotype x environment interaction force the breeder to choose between developing widely adaptable cultivars or cultivars adapted to unfavorable environment.

Conclusion:

The results of this study indicated that highly significant differences were observed due to effect of genotypes(G), environmental effect (E) and interaction between environments and genotypes (G x E) . The genotypes L-7, L-6 and L-2 were stable with higher mean compared to grand mean. These new lines are recommended for cultivation in the different locations studied.

Table7. Pooled analysis of variance for weight of fruit, number of fruit per plant, early yield and total yield in tomato genotypes evaluated.

Source of variance	d.f.	M.S.			
		weight of fruit	number of fruit per plant	Early yield	Total yield
Environments (E)	3	635.7500**	372.1419**	1.7233*	54.6224**
Replication \ E	12	49.6042	3.2458	0.5184	6.21097
Genotypes (G)	7	2103.3215**	23.7924**	5.2774**	77.3242**
G x E	21	67.2976**	4.7219*	1.3139*	7.1920*
Error	84	24.7292	2.7178	0.6989	4.1522

* and **= significant and highly significant at P < 0.05 and 0.01, respectively.

Table 8. Mean square from stability analysis of variance for weight of fruit, number of fruit per plant, early yield and total yield of eight tomato genotypes evaluated.

Source of variance	d.f.	M.S.			
		weight of fruit	number of fruit\plant	Early yield	Total yield
Genotypes (G)	7	525.8482**	5.9492**	1.3194**	19.3311**
E + (G x E)	24	34.5885**	12.6624**	0.2198*	3.2365**
E (linear)	1				
G x E (Linear)	7	32.6849**	2.0686**	0.3571*	3.8245**
Pooled deviation	16	7.7756	0.6438	0.1151	0.6209
(1) L-1	2	14.3782^{ns}	0.0918^{ns}	0.1925^{ns}	3.6659*
(2) L-2	2	1.3243^{ns}	1.6553^{ns}	0.0002^{ns}	0.0479^{ns}
(3) L-3	2	7.7295^{ns}	1.0275^{ns}	0.0882^{ns}	0.2105^{ns}
(4) L-4	2	18.460^{ns}	0.1880^{ns}	0.0078^{ns}	0.3275^{ns}
(5) L-5	2	6.1538^{ns}	0.1999^{ns}	0.0811^{ns}	0.1628^{ns}
(6) L-6	2	2.6052^{ns}	0.9307^{ns}	0.0811^{ns}	0.5296^{ns}
(7) L-7	2	5.0290^{ns}	0.0575^{ns}	0.0793^{ns}	0.5457^{ns}
(8)Castle Rock C.V	2	6.5246^{ns}	1.0001^{ns}	0.5506*	0.0774^{ns}
Pooled error	96	28.8346^{ns}	0.6960	0.1691	1.1154

ns, * and ** = not significant, significant and highly significant at P < 0.05 and 0.01, respectively.

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الثبات الوراثى والظاهرى لسلالات جديدة من الطماطم

أحمد جمعة محمد ، عبد الجواد محمد أحمد، رأفت محمد جلال
قسم بحوث الخضر – معهد بحوث البساتين – مركز البحوث الزراعية – الجيزة – مصر

تم تقييم ثمانية تراكيب وراثية من الطماطم وهى سبعة سلالات تمت مقارنتها مع الصنف كاسل روك لدراسة صفات النمو والمحصول وتم قياس الثبات الوراثى والظاهرى لهذه التراكيب الوراثية . زرعت التجارب الحقلية فى موقعين فى الموسم النيلى فى عـامي2011 و 2012م . تمت دراسة الصفات التالية : طول النبات – عدد الفروع / النبات – طول الثمرة – قطر الثمـرة – سمك الثمرة – فيتامين سى – المواد الصلبة الكلية – الوزن الجاف للثمرة – وزن الثمـرة – عدد الثمار / النبات – المحصول المبكر للفدان – المحصول الكلى للفدان. اظهرت النتائج وجود معنوية عالية بين التراكيب الوراثية وبين البيئات وايضا التفاعل بين التراكيب الوراثية والبيئات لكل الصفات المدروسة . السلالات أرقام 7 و 6 و 2 كانت ثابتة وراثيـا وظاهريـا وأعطـت متوسط أعلى من المتوسط العام .