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EVALUATION OF TOMATO PROMISING HYBRIDS PRODUCTIVITY UNDER DIFFERENT ENVIRONMENTAL CONDITIONS

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The impact of successive climate changes has become a phenomenon that requires continuous evaluation and selection of suitable genotypes in terms of quality and productivity for most crops around the world, and this is one of the objectives of plant breeding and conservation program of Desert Research Center. Therefore, this study aimed to evaluate 60 tomato (*Solanum lycopersicum*) hybrids under six environments (three locations during two agricultural seasons; 2022 and 2023). The results indicated that, the variance of genotypes (G), environments (E), genotype x environment and G x E (linear) components were significant for mean yield weight per plant. According to Eberhart and Russell model, the data indicated the selection of some distinctive hybrids according to the high average yield, the regression coefficient close to one, and the non-significant deviation from the regression, and they were the most stable across different environments. In general, and according to the results, G16, G18, G28 and G29 were distinguished in terms of stability and yield across different environments. Stability of the performance of tested tomato genotypes is a major goal of breeding programs that keep pace with changing environmental conditions.

Keywords: *Solanum lycopersicum*, stability, variance, breeding, regression

INTRODUCTION

Due to the diversity of geographical location, growing season and current agricultural practices, plants show a wide range of diverse responses to their environments (Napier et al., 2019 and Onogi et al., 2021). While focusing on the quantity of food production, its quality must also be improved, to support continued population growth (Jiang et al., 2022). Climate change has a negative impact on food productivity, as heat waves and water shortages intensify the depletion of water resources (Hein et al., 2021). These difficult conditions are concentrated in arid and semi-arid regions such as the Mediterranean Basin, which is one of the most densely populated regions and a well-known agricultural center in the world. The ability of plants to grow despite being unstable and thus unable to determine their optimal environment is of interest. One important way in which plants respond to environmental changes is to monitor the phenotypic plasticity of tested plants, which refers to the ability of a single genotype to produce multiple phenotypes (Schlichting, 1986). The impact of climate change and the increasing world population make crops that are able to tolerate abiotic stresses and have nutritional value a major target in agriculture. Tomato (*Solanum lycopersicum*) is one of the most important horticultural species in terms of production and nutritional quality. Egea et al. (2022) focused on the responses to different stresses and their effect on plant adaptation to avoid poor productivity and improve fruit quality under abiotic stress. As well as identifying genes whose simple variation determines a significant change in vegetative and fruit development.

Depending on the physiological changes, different responses arise which are caused by each type of stress. In tomato, the effect on plant growth when exposed to both salinity and heat together is less than the effect caused by salinity alone. This is because higher temperatures can result in a higher transpiration rate that protects the photosynthetic system; therefore, the rates of CO_2 assimilation and plant growth are higher for a limited period (Lopez-Delacalle et al., 2020). There is no doubt that environmental changes are a phenomenon that deserves continuous focus to evaluate the diverse genotypes in different crops for productivity and quality around the world, especially in the Middle East (Badran, 2022 and Naiem et al., 2022). Phenotypic variation results from the interaction of two variables: the genetic variable and the environmental variable. Therefore, the interaction between the genotype and the environment results in important differences in the performance of these genotypes when evaluated in different locations (Zhe et al., 2010). In experiments of varieties and strains, a series of specific genotypes are planted in a wide range of environments. If the response of each genotype is similar in performance in those environments, then this performance will have the same confidence in other environments.

The target of this study was productivity evaluation of 60 tomato hybrids under six environments (three locations during two agricultural seasons) as a basis for a breeding program aiming to produce genotypes that are distinguished in yield and stability.

MATERIALS AND METHODS

1. Experimental Conditions

The trial was set up during the period from 2021 to 2023 and divided into two parts. The first: Half diallel crosses were done among fifteen lines (Table 1) of tomato to produce enough F_1 seeds of 105 hybrids. Crossing were made manually by hand emasculation and pollination carried out at greenhouse program of Desert Research Center (DRC) in Saint Catherine of South Sinai during summer season 2021. The second: 60 hybrids had been chosen only. They were evaluation during the two seasons growing 2021/2022 and 2022/2023 in three locations with Egyptian desert conditions, namely Toshka Station, DRC in Aswan Governorate (L1: N 24.0982, E 32.8823), Balouza Station, DRC in North Sinai Governorate (L2: N 31.1309, E 33.792) and Alsaalihia zone, El-Sharkia Governorate (L3: N 30.7278, E 31.6865). Thirty days old seedlings were transplanted in the field on 15th October 2021 and 2022 in three study locations. Sixty tomato hybrids were evaluated in a randomized complete blocks design with three replications in 100 cm × 50 cm spacing keeping 15 plants in each plot. Drip irrigation system was used. Normal agricultural treatments were applied.

Table (1). Fifteen tomato genotypes (inbred lines) obtained from plant breeding and conservation program of Desert Research Center.

No.	Lines	Growth habit	Fruit size	Maturity
1	STel7/1/3	Determinate	Medium	Medium
2	SA1-7/1/3	Determinate	Medium	Early
3	SA2-7/2/3	Determinate	Small	Early
4	SB1-7/1/3	Semi-determinate	Small	Early
5	SB2-7/2/3	Semi-determinate	Small	Early
6	SC1-0-5/2/3	Determinate	Small	Early
7	SD1-6/1/3	Determinate	Medium	Medium/late
8	SD2-6/2/3	Determinate	Medium	Medium/late
9	SK2-5/2/3	Determinate	Medium	Medium
10	SY1,1-7/1/3	Semi-determinate	Medium	Medium
11	SY2,2,1-7/2/3	Semi-determinate	Small	Medium
12	SR1-7/1/3	Determinate	Medium	Early
13	SR2-7/2/3	Determinate	Medium	Early
14	SS5-1-7/1/3	Determinate	Medium	Medium
15	Edkawy	Semi-determinate	Large	Medium

With regard to metrology data of three locations in two agricultural seasons were done as shown in Table (2). Some measurements were recorded which are: temperature at 2 meters (C), dew/frost point at 2 meters (C), temperature at 2 meters maximum (C), temperature at 2 meters minimum (C), precipitation corrected (mm/day), relative humidity at 2 meters (%) and wind speed at 2 meters (m/s) as a monthly average of four months (October, November, December and January).

Table (2). Metrology data of three locations Aswan (L1), North Sinai (L2) and Sharkia (L3) during four months in two agricultural seasons.

Loc.	Month	Temp.		T. Dew		T. Max		T. Min		Prect.		R. H.		W. S.	
		2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
L1	Oct.	27.8	30.2	6.6	7.9	36.1	38.8	20.3	22.6	0.0	0.1	28.7	27.5	3.5	3.3
	Nov.	21.2	24.9	4.6	7.8	29.4	32.6	14.3	18.1	0.0	0.0	36.2	36.7	2.7	2.7
	Dec.	17.8	19.1	3.5	5.7	26.7	27.9	10.7	11.9	0.0	0.0	43.2	46.4	2.7	2.5
	Jan.	15.8	17.9	1.2	3.9	25.0	25.3	8.2	9.0	0.0	0.0	43.0	44.0	2.4	2.4
L2	Oct.	24.1	25.0	17.1	17.7	28.3	29.3	21.2	21.9	0.4	0.1	67.3	66.5	2.7	2.6
	Nov.	20.	21.2	13.0	14.5	24.2	25.6	16.7	18.1	0.7	0.4	66.5	68.2	2.8	2.8
	Dec.	16.7	17.2	10.7	11.0	21.3	22.0	13.4	13.6	1.5	0.4	70.3	69.8	2.5	2.7
	Jan.	14.5	15.9	8.5	9.2	19.4	20.0	10.7	11.4	1.2	0.4	69.8	68.8	2.7	2.9
L3	Oct.	24.6	25.9	14.2	15.7	31.9	33.3	18.7	20.0	0.2	0.2	57.6	59.1	2.4	2.3
	Nov.	19.8	21.4	10.6	12.3	26.8	28.6	14.5	16.1	0.0	0.1	60.6	61.3	2.1	2.3
	Dec.	16.7	17.0	9.3	10.9	24.0	23.8	11.7	12.1	0.7	0.8	66.7	70.8	2.0	2.3
	Jan.	14.0	14.2	7.7	9.6	21.4	21.6	8.9	10.2	1.3	1.0	69.5	72.2	2.1	2.4

Temp.: temperature (c); T. Dew: dew/frost point (°C); T. Max: temperature maximum (°C); T. Min: temperature minimum (°C); Prect.: precipitation corrected (mm/day); R.H.: relative humidity (%); W.S.: wind speed (m/s).

2. Stability Parameters Analysis for Yield

Tomato yield data for the tested genotypes obtained from each environment were statistically analyzed for the studied traits according to Steel and Torrie (1997). Total yield/plant (kg) was recorded from five randomly selected plants of each genotype in a plot during two growing seasons (2022 and 2023) to evaluate 60 hybrids using the interaction between environment and genotype, G × E, to evaluate phenotypic stability by obtaining the parameters bi and S2 di as described by Eberhart and Russell model.

The stability parameters of tomato yield for 60 hybrids were calculated in 6 different environments (three locations x two seasons) as suggested by Eberhart and Russell (1966) and the following model was used to study the stability of genotypes according to this mathematical model: $Y_{ij} = \mu + B_i I_j + \delta_{ij}$. Two stability coefficients were calculated as follow: 1) the regression coefficient (b_i); 2) the mean squared deviation (S^2d_i) from the linear regression of each construct in different environments. Where, $\sum Ij = 0$, $\sum bi/n = 1$. Where, Ij is the environmental index, n is the number of evaluated genotypes.

RESULTS

Means Performance and Stability Parameters

The data in Table (3) indicate that there were significant differences between each of the tested genotypes and the six environments under study as well as the interaction between them (G x E). The data in Table (3) indicate that when looking at the general mean only, there were 25 hybrids above the overall mean of the tested hybrids in the six environments, and there were 35 hybrids below the overall mean for plant yield (kg). These data can only be relied upon to determine the initial selection of the crop without considering the stability of the selected genotypes in the six environments tested. Also, the data in Table (3) indicate a decrease in the mean yield per plant for all hybrids tested in the second location (North Sinai) during the two agricultural seasons compared to the other two sites.

Table (3). Mean tomato genotypes, environments, and general mean of yield per plant.

Genotype	Mean	Genotype	Mean	Genotype	Mean
G1	2.850	G21	2.794	G41	1.683
G2	2.722	G22	3.006	G42	2.194
G3	2.828	G23	1.456	G43	1.811
G4	2.861	G24	3.072	G44	1.706
G5	2.822	G25	1.556	G45	1.644
G6	3.333	G26	1.611	G46	1.861
G7	2.550	G27	2.033	G47	1.644
G8	3.217	G28	2.928	G48	1.711
G9	2.706	G29	2.822	G49	2.039
G10	2.733	G30	2.133	G50	1.683
G11	2.050	G31	1.878	G51	1.778
G12	2.183	G32	1.561	G52	2.222
G13	2.861	G33	1.589	G53	2.156
G14	2.883	G34	1.444	G54	1.711
G15	2.900	G35	1.767	G55	1.378
G16	3.056	G36	1.717	G56	1.506
G17	2.333	G37	2.261	G57	1.511
G18	3.028	G38	1.750	G58	1.722
G19	2.594	G39	1.661	G59	1.972
G20	2.767	G40	1.517	G60	1.994
Mean (E1) = 2.251		Mean (E2) = 1.503		Mean (E3) = 2.252	
Mean (E4) = 2.676		Mean (E5) = 1.854		Mean (E6) = 2.641	
General mean = 2.196					

The data in Table (4) indicate that, the yield of 60 tomato hybrids responded differently to different environmental conditions, indicating the importance of evaluating these hybrids under different environments (three locations during two seasons) in order to determine the best genotypes for the yield per plant (kg). Using the determination of the deviation of the tested genotypes to calculate their stability across diverse environments, the analysis of variance can be further extended by dividing the total sum of squares into different sections as shown in Table (5).

The sum of squares (S.S.) due to genotypes x environments in Table (5) is further partitioned into two sections: I) S.S. due to genotype x environment (linear) which is in fact the sum of square due to regression; II) S.S. due to pooled deviation (i.e., S.S due to deviation linearity of response).

Breeding programs are concerned with producing new genotypes that keep pace with changing environmental conditions, so the stability of the performance of tomato tested hybrids across environments can be a crucial factor in this program. The stability parameters, regression coefficient and deviation from regression for the trait yield per plant (kg) were estimated for 60 genotypes across six environments, which represent three locations during two growing seasons, as shown in Tables (3 and 4 a, b). The significances of the standard error of the regression coefficient, the population mean and the standard error of the mean are also shown in Table (5 a, b).

According to sum of squared deviation, the data presented in Table (4-b) showed that the genotypes of tomato hybrids G23, G44, G21, G42, G35, G32, G16, G29 and G33 can be considered the most stable genotypes for plant yield across different environments, as they recorded the lowest values in the sum of squared deviation (0.052, 0.063, 0.073, 0.076 and 0.079, respectively), while the genotypes of G28, G45 and G1 were the least stable across the same environments, as they recorded the highest squared deviation (1.880, 1.734 and 1.702, respectively).

Table (4). Analysis of variance for the pooled data of tomato hybrids yield during the two growing seasons.

Source of variance	d.f.	M.S.	F calculated
Genotypes (G)	59	5.917 *	103.433
Environments (E)	5	37.130 *	649.113
Replicates in Environments	12	1.562	
G * E	295	0.559 *.	9.764
Error	709	0.057	

*: significant at 5% probability level.

Table (5-a). Analysis of variance for 60 tomato hybrids under six different environmental conditions for yield.

Source of variance	d.f.	S.S.	M.S.	F calculated
Total	359	233.164		
Genotypes (G)	59	116.359	1.972*	16.628
Env. + (genotypes x Env.)	300	116.806	0.389	
Env. (linear)	1	61.884	61.884	
Genotype x Env. (linear)	59	26.457	0.448*	3.781
Pooled deviation	240	28.465	0.119	
Pooled error	721	19.767	0.027	

Table (5-b). Pooled deviation of 60 tomato hybrids.

Genotype	d.f.	S.S	M.S	Genotype	d.f.	S.S	M.S	Genotype	d.f.	S.S	M.S
G1	4	1.702	0.426	G21	4	0.076	0.019	G41	4	0.550	0.138
G2	4	0.353	0.088	G22	4	0.429	0.107	G42	4	0.082	0.020
G3	4	0.310	0.078	G23	4	0.052	0.013	G43	4	0.232	0.058
G4	4	0.966	0.241	G24	4	1.095	0.274	G44	4	0.063	0.016
G5	4	0.163	0.041	G25	4	0.169	0.042	G45	4	1.734	0.433
G6	4	0.365	0.091	G26	4	0.111	0.028	G46	4	0.350	0.087
G7	4	0.656	0.164	G27	4	0.328	0.082	G47	4	0.206	0.052
G8	4	0.279	0.070	G28	4	1.880	0.470	G48	4	0.171	0.043
G9	4	0.581	0.145	G29	4	0.080	0.020	G49	4	0.340	0.085
G10	4	0.948	0.237	G30	4	0.503	0.126	G50	4	0.149	0.037
G11	4	0.440	0.110	G31	4	0.543	0.136	G51	4	0.203	0.051
G12	4	0.225	0.056	G32	4	0.073	0.018	G52	4	0.177	0.044
G13	4	1.132	0.283	G33	4	0.093	0.023	G53	4	1.428	0.357
G14	4	0.567	0.142	G34	4	0.121	0.030	G54	4	0.386	0.097
G15	4	0.926	0.231	G35	4	0.079	0.020	G55	4	0.186	0.046
G16	4	0.085	0.021	G36	4	0.250	0.063	G56	4	0.454	0.114
G17	4	0.161	0.040	G37	4	1.050	0.263	G57	4	0.797	0.199
G18	4	0.323	0.081	G38	4	0.966	0.242	G58	4	0.454	0.114
G19	4	1.012	0.253	G39	4	0.286	0.071	G59	4	0.099	0.025
G20	4	0.197	0.049	G40	4	0.718	0.180	G60	4	0.107	0.027

*: significant at 5% probability level respectively.

According to means, regression coefficient (b_i) and deviation mean squares (S^2d_i), the results in Table (5) show that the genotypes G16, G18, G13, G24, G21, G17, G42 , G52 and G29 recorded high yield means and a regression coefficient close to unity (non-significant) and a non-significant deviation from the regression, which indicates their stability across the six different environments (i.e. the genotypes that are weakly affected by the environment) and thus can be used in generalizing them for cultivation in diverse environments.

Although the genotypes G6, G8, G22 G4, G1 and G3 had high means for yield per plant and a non-significant deviation from the regression, a regression coefficient was significantly and exceeded one, indicating their instability across diverse environments with expected performance and thus being candidates for cultivation in specific environments.

The genotypes G36, G45, G46 and G40 were found stable with non-significant regression coefficients approaching one (1.10, 0.96, 1.14 and 0.98, respectively) having lower mean values, which can be classified within the commercially acceptable range (Table 6).

Conversely and considering the overall mean of the genotypes (2.196 kg) there were genotypes, G55, G57, G26 and G50 that recorded very small average yield per plant, and their regression coefficient was significant, indicating the benefit of excluding the parents of these hybrids from the tomato breeding program.

In general, considering the minimum deviation mean square recorded for some of the tested genotypes (Table 5) and according to the Eberhart and Russell model in Table (6), the data indicate that the high mean yield, regression coefficient close to one and non-significant deviation from the regression were represented by the genotypes G16, G18, G28 and G29 followed by G21, G13, G24, G17 and G52 for yield per plant (i.e. highest stability) while the genotypes G57, G54, G55, G50, G58, G26, G1, G6, G8, G22, G4 G3 and G39 had the lowest yield stability per plant (i.e. least stability) under different environments. From the data in Table (4 and 5), the distribution of the tested genotypes can be summarized based on the study parameters (mean performance, regression coefficient and deviation mean squares yield/ plant as indicated in Fig. (1).

Table (6). Mean performance values of yield/ plant (kg), regression coefficient (bi) and deviation mean squares (S^2di) for 60 tomato hybrids (Genotypes) over environments.

Geno.	Mean	bi	S^2di	Geno.	Mean	bi	S^2di	Geno.	Mean	bi	S^2di
G1	2.850	2.54*	0.001	G21	2.794	1.37	-0.026	G41	1.683	0.52	-0.018
G2	2.722	1.86*	-0.022	G22	3.006	1.71*	-0.020	G42	2.194	1.15	-0.026
G3	2.828	1.80*	-0.022	G23	1.456	0.46	-0.027	G43	1.811	0.53	-0.024
G4	2.861	1.97*	-0.011	G24	3.072	1.19	-0.009	G44	1.706	1.05	-0.026
G5	2.822	1.70	-0.025	G25	1.556	0.32	-0.025	G45	1.644	0.96	0.001
G6	3.333	2.09*	-0.021	G26	1.611	0.25*	-0.026	G46	1.861	1.14	-0.022
G7	2.550	2.20*	-0.016	G27	2.033	0.73	-0.022	G47	1.644	0.51	-0.024
G8	3.217	1.84*	-0.023	G28	2.928	1.07	0.004	G48	1.711	0.48	-0.025
G9	2.706	2.18*	-0.018	G29	2.822	1.59	-0.026	G49	2.039	0.66	-0.022
G10	2.733	1.90*	-0.012	G30	2.133	1.27	-0.019	G50	1.683	0.11*	-0.025
G11	2.050	0.76	-0.020	G31	1.878	0.35	-0.018	G51	1.778	0.68	-0.024
G12	2.183	0.58	-0.024	G32	1.561	0.36	-0.026	G52	2.222	0.69	-0.024
G13	2.861	1.16	-0.009	G33	1.589	0.37	-0.026	G53	2.156	1.19	-0.004
G14	2.883	1.59	-0.018	G34	1.444	0.54	-0.025	G54	1.711	-0.18*	-0.021
G15	2.900	1.80*	-0.012	G35	1.767	0.74	-0.026	G55	1.378	0.18*	-0.024
G16	3.056	1.10	-0.026	G36	1.717	1.10	-0.023	G56	1.506	0.44	-0.020
G17	2.333	0.75	-0.025	G37	2.261	1.14	-0.010	G57	1.511	-0.02*	-0.014
G18	3.028	1.36	-0.022	G38	1.750	0.88	-0.011	G58	1.722	-0.15*	-0.020
G19	2.594	1.84*	-0.011	G39	1.661	0.09*	-0.023	G59	1.972	0.48	-0.026
G20	2.767	1.63	-0.024	G40	1.517	0.98	-0.015	G60	1.994	0.40	-0.026
Mean	Mean (Geno.) = 2.196, Mean bi= 1.00										
L.S.D. $_{(0.5)}$	L.S.D. (Mean) = 0.135										
S.E. (bi)	0.339										
μ (m)	13.176										
S.E. (m)	0.104										

S.E. (bi) = standard error of regression coefficient. μ (m)= population mean. S.E. (m) = standard error of mean. bj *: Regression coefficient significantly different from unity at *P*= 0.05. S*: Deviation from regression significantly different from zero at *P*= 0.05

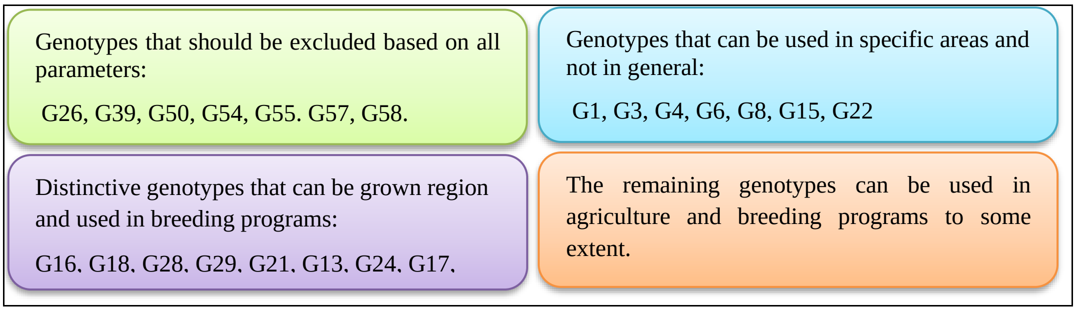

Fig. (1). The distribution of the tested tomato genotypes using the study parameters.

DISCUSSION

The Interaction Between Genotypes and Different Environments

Phenotypic stability is effective in selecting crop genotypes during breeding programs. The phenotypic performance of a genotype is not necessarily the same under different successive environmental conditions (Ali et al., 2003; Badran et al., 2013 and Badran, 2015). The study of the interaction between genotype and different environments (G x E) plays a significant and effective role in selecting the best genotypes that combine high yield and stability. The environmental differences of this interaction are attributed to the effect of location and the effect of season (Singh et al., 2006). In general, Eberhart and Russell (1966) confirmed that a genotype with unit regression coefficient equal one or close to one (b = 1) and the deviation not significantly different from zero (Sd2 = 0) is considered stable or the most stable across different environments.

The interaction (G x E) showed a significant effect on the performance of genes, as it led to the differentiation of genes across different environments (Tables 4 and 5), which many studies have relied on in selecting genotypes across diverse environments for the yield and its components in many crops such as tomato (Aravindakumar et al., 2003), garlic (Badran, 2015), and faba beans (Badran et al., 2013). Therefore, this study relied on the Eberhart and Russell model to verify reliability, as the genotype with a unitary regression coefficient (b = 1) and the smallest value of Sd2 that does not differ significantly from zero ($Sd^2 = 0$) is considered the most stable model. In the same manner Djidonou et al. (2020) reported that, average fruit weight, number of fruit per plant and total marketable yield were significantly influenced by environment (E), genotype (G), and G × E interaction. Environmental component explained 71–86% to the total variation, while genotype contributed 1.5–10.8%, and the contribution of G × E was 4.3 to 6.7%.

The stability of yield of tested genotypes across environments according to Eberhart and Russell model is referred to as sensitivity (high stability or low sensitivity). This model provides an opportunity to target positive interaction effects that lead to better performance across unfavorable sites or seasons, increasing the safety range for the breeder and the farmer in the expected yield that target the desired environments, making this model particularly useful for seed production institutions responsible for breeding programs and issuing variety certifications to private breeders. Also, identifying genotypes compatible with different environments with an emphasis on high yields is more effective compared to other models that minimize the interaction effect (G x E) leading to crop response to renewable agricultural conditions (Cleveland, 2001; Annicchiarico, 2002 and Badran, 2022).

Based on the different responses caused by each type of stress on tomatoes, and because the effect resulting from exposure to salinity and heat, for example, is less than the effect resulting from salinity alone, and due to the increase in the transpiration rate with increasing temperature (Lopez-Delacalle et al., 2020), the stability of these tomato genotypes was studied under various environmental conditions.

Generally, stability assessment is an important tool in agriculture as we aim to grow genotypes that are relatively stable in their yield and also resilient to climate change. One parameter used to estimate yield stability is the linear regression coefficient which describes the behavior of a genotype across different environments. It also shows the deviation from the estimated regression which can be reliably used to compare the yield consistency of different genotypes. This is consistent with what was reported by Fisher and Zamir (2021) who mapped candidate genomic regions associated with yield stability in tomato.

CONCLUSION

Tomato growing environments in Egypt are characterized by great diversity including agricultural seasons, many hybrids and different locations. In such environments, the effect of the interaction between the genotype and the environment is relatively large. Therefore, the effect of these important interactions on the selection of genotypes based on their general average across these environments cannot be ignored. Accordingly, the breeder relies on the available results according to the average tomato yield for each genotype in its environment, the environmental variation and the interaction between them.

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REFERENCES

Ali, N., F. Javidfar and Y. Mirza (2003). Selection of stable rapeseed (*Brassica napus* L.) genotypes through regression analysis. Pakistan Journal of Botany, 35 (2): 175-180.

Annicchiarico, P. (2002). Genotype × environments interactions-challenges and opportunities for plant breeding and cultivar recommendation. FAO Plant Production and Protection Paper No. 174. Food and Agriculture Organization, Rome.

Aravindakumar, J.S., M. Ravindra and B.R. Patil (2003). Stability of yield and its component characters in tomato (*Lycopersicon esculentum* Mill.). Indian Journal of Genetics and Plant Breeding, 63 (1): 63-66.

Badran, E.A. (2022). Assessment of variation and stability parameters of five quinoa genotypes under drought stress conditions. Egyptian Journal of Botany, 62 (1): 21-30.

Badran A.E. (2015). Comparative analysis of some garlic varieties under drought stress conditions. Journal of Agricultural Science, 7 (10): 271-280.

Badran, A.E, A.M Abd El-Gawad and S.A. Omar (2013). Evaluation of some selected faba bean genotypes grown under drought conditions using some biofertilization treatments. Egyptian Journal of Plant Breeding, 17 (5): 175-182.

Cleveland, D.A. (2001). Is plant breeding science objective truth or social construction? The case of yield stability. Agriculture and Human Values, 18: 251-270.

Djidonou, D., D.I. Leskovar, M. Joshi, J. Jifon, C.A. Avila et al. (2020). Stability of yield and its components in grafted tomato tested across multiple environments in Texas. Scientific Reports, 10: 13535.

Eberhart S.A. and W.A. Russell (1966). Stability parameters for comparing the varieties. Crop Science, 6: 36-40.

Egea, I., Y. Estrada, F.B. Flores and M.C. Bolarín (2022). Improving production and fruit quality of tomato under abiotic stress: Genes for the future of tomato breeding for a sustainable agriculture. Environmental and Experimental Botany, 204: 105086.

Hein, N.T., I.A. Ciampitti and S.V.K. Jagadish (2021). Bottlenecks and opportunities in field-based high-throughput phenotyping for heat and drought stress. Journal of Experimental Botany, 72 (14): 5102–5116.

Jiang, X., W. Zhang, A.R. Fernie and W. Wen (2022). Combining novel technologies with interdisciplinary basic research to enhance horticultural crops. The Plant Journal, 109 (1): 35–46.

Fisher, J. and D. Zamir (2021). Genes for yield stability in tomatoes. Advanced Genetics, 2 (4): 2100049.

Lopez-Delacalle, M., D.M. Camejo, M. Garcia-Marti, P.A. Nortes, M. Nieves-Cordones et al. (2020). Using tomato recombinant lines to improve plant tolerance to stress combination through a more efficient nitrogen metabolism. Frontiers in Plant Science, 10: 1702.

Naiem, S.Y., A.E. Badran, M.S. Boghdady, S.S. Alotaibi, A.M. El-Shehawi et al. (2022). Stability and anatomical parameters of irradiated potato cultivars under drought stress. Saudi Journal of Biological Sciences, 29 (4): 2819-2827.

Napier, J.D., G. de Lafontaine, K.D. Heath and F.S. Hu (2019). Rethinking long-term vegetation dynamics: multiple glacial refugia and local expansion of a species complex. Ecography, 42: 1056–1067.

Onogi, A., D. Sekine, A. Kaga, S. Nakano, T. Yamada et al. (2021). A method for identifying environmental stimuli and genes responsible for genotype-by-environment interactions from a large-scale multi-environment data set. Front Genet, 12: 803636.

Schlichting, C.D. (1986). The evolution of phenotypic plasticity in plants. Annual Review of Ecology, Evolution, and Systematics, 17: 667–693.

Singh, M., S. Grando and S. Ceccarelli (2006). Measures of repeatability of genotype by location interactions using data from barley trials in northern Syria. Experimental Agriculture, 42: 189-198.

Steel, R.C. and S.H. Torrie (1997). In: "Principles and Procedures of Statistics". McGrauc Hill Book Company, Inc., New York, London.

Zhe, Y., J.G. Lauer, R. Borges and N. de Leon (2010). Effect of genotype x environment interaction on agronomic traits in sorghum. Crop Science, 50: 696-702.

تقييم إنتاجية هجن الطماطم الواعدة تحت ظروف بيئية مختلفة

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لقد أصبح تأثير التغيرات المناخية المتعاقبة ظاهرة تتطلب التقييم المستمر وإختيار التراكيب الوراثية المناسبة من حيث الجودة والإنتاجية لمعظم المحاصيل حول العالم، وهذا هو أحد أهداف برنامج تربية وصون النباتات بمركز بحوث الصحراء. لذلك إستهدفت هذه الدراسة تقييم ٦٠ هجينًا من الطماطم تحت ستة بيئات (ثلاثة مواقع خلال موسمين زراعيين ٢٠٢٢ و ٢٠٢٣). وقد أشارت النتائج إلى أن تباين التراكيب الوراثية (G) والبيئات (E) والتركيب الوراثي x البيئة ومكونات G x E (الخطية) كانت معنوية لمتوسط وزن المحصول للنبات. ووفقًا لنموذج Eberhart and Russell، أشارت البيانات إلى إختيار بعض الهجن المميزة وفقًا لمتوسط المحصول العالي ومعامل الانحدار القريب من الواحد والإنحراف غير المعنوي عن الانحدار، وهي الأكثر ثباتا عبر البيئات المختلفة. وبشكل عام، ووفقًا للنتائج، تميز G16، G18، G28، G29 من حيث الثبات والمحصول عبر البيئات المختلفة. يعد استقرار أداء التراكيب الوراثية للطماطم المختبرة هدفًا رئيسيًا لبرامج التربية التي تواكب الظروف البيئية المتغيرة.