Egyptian J. Desert Res., **70**, No. 1, 1-10 (2020)

PERFORMANCE OF SOME TOMATO GENOTYPES UNDER GREENHOUSE CONDITIONS

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Evaluation of genotypes under greenhouse conditions comes in the first order for Tomato Breeding Program of Desert Research Center (DRC). A major objective of the program has been to develop breeding lines that possess characteristics needed in high-performing hybrid varieties at greenhouse conditions. The twelve genotypes indeterminate were transplanted in a greenhouse at Baloza Station, DRC, North Sinai, during 2016/2017 and 2017/2018 seasons. The experimental design was randomized complete block design with three replicates. The results indicated that tomato genotypes mean squares were highly significant for all traits (growth, yield and quality). Based on the results obtained in the two growing seasons, the most productive tomato genotypes and those best adapted to the climatic conditions of the area are identified. The best results of plant height, stem diameter and yield /plant were obtained from S922, S923 and S24. The genotypes S802, S811 and S812 recorded the highest mean for fruit set percentage. The genotypes S700, S710, S720 and S740 had high total soluble solids percentage. Total soluble solids percentage showed negative correlation with all characters.

Keywords: Tomato genotypes indeterminate, *Solanum lycopersicum*, greenhouse, North Sinai

Today, tomato is a premier vegetable and is one of the most popular and globally grown crop all over the year. It belongs to the family Solanaceae. It is originated from Peru-Ecuador Bolivia region of the Andes in South America. It is recognized as an important commercial and dietary vegetable crop and occupies a prominent position among vegetables, due to its export value (Singh et al., 2014). One of the most important factors in the intensification of greenhouse tomato production is the introduction of new high-yielding varieties and hybrids, which have high resistance against diseases and pests adapted to new technologies and unfavorable climatic conditions (Balashov, 2006 and Gavrish, 2015). The development of high yielding varieties requires detailed knowledge of the genetic variability present in the germplasm of the crop, the association among yield components, input requirements and culture practices (Dutta et al., 2013).

The development of new tomato cultivars has intended to improve productivity, quality and adaptation to different production conditions. Sometimes, this is difficult to achieve due to reduced availability of genetic resources (Warnock, 1991). Plant breeding applied on tomato has produced high-yielding varieties, though little attention has been paid to the fruit quality (Foolad, 2007). Rajasekar et al. (2013) also reported the fact that growth, development, productivity and quality of any crop are heavily depending on the interaction between the plant genetics and the environmental conditions of plants growth.

Kumar et al. (2015) evaluated tomato lines for quantitative traits such as plant height, fruit yield, fruit weight, total soluble solids, fruit weight loss and fruit shelf-life in greenhouse as well as plants which were grown in field conditions. They found that in greenhouse conditions, the plant height was between 93.3 to 165 cm. The total fruit yield per plant was between 615 to 1730 g, fruit weight was between 34.4 to 82.0 g. Number of locules per fruit was between 2.0 to 5.0.

The aim of protected cultivation is to achieve independence of climate and weather also, to allow crop production in areas, where the natural environment limits or prohibits plant growth. Under protected environment, the natural environment is modified to the suitable conditions for optimum plant growth, which ultimately helps in the production of tomatoes with suitable quality for exports and domestic consumption. It has been observed that net house grown tomatoes have potential for better performance and produce higher fruit yield than that grown in open field conditions. Tomato can be grown successfully in the off-season in net house for obtaining higher fruit yield. Occurrence of frost coupled with low temperature during the months of December and January cause death of tomato plants when grown in open field conditions, but under protected environment, the yield loss can be minimized (Cheema et al., 2013). However, as economic matters currently stand, greenhouse facilities for vegetables production can be profitable for obtaining high stable yields with simultaneous cost reduction, which is very high, mainly due to significant energy costs (Rodica et al., 2015). In Egypt, for economic production of tomato under greenhouse conditions, all greenhouses inputs must be provided locally including good hybrid seeds, especially, after project work began with one million and a half greenhouses.

The objective of this study was the evaluation of twelve tomato genotypes indeterminate for the production of tomato under greenhouse conditions to select good genotypes for hybrids production in the future.

This research is a step in a breeding program to produce indeterminate tomato hybrids.

MATERIALS AND METHODS

The trial was executed at Baloza station, Desert Research Center (DRC), North Sinai, during 2016/2017 and 2017/2018 seasons. The material used in this study consists of twelve tomato indeterminate inbred lines; S421, S422, S700, S710, S720, S740, S802, S811, S812, S922, S923 and S924 that were obtained from Tomato Breeding Program of DRC.

Each experimental plot was 22.5 m^2 (15 m long and 1.5 m wide). A randomized complete block design with three replicates was used. Each replicate contained 12 experimental units. Thirty days old seedlings were transplanted in a greenhouse on 10^{th} October in the two seasons and the distance between plants was 50 cm in the row. Drip irrigation system was used; fertigation was carried out according to the recommendations of Baloza Research Station. Routine cultural practices were done as needed similar to those used in tomato production at North Sinai governorate. The data recorded for five plants from each experimental unit were plant height (cm), stem diameter (cm), fruit set percentage (%), yield /plant (g), average fruit weight (g), number of locules/fruit and total soluble solids percentage (TSS%), determined by using Hand Refractometer and expressed as percentage of the juice.

Statistical Analysis

Statistical analysis was performed using analysis of variance technique by means of “MSTAT” computer software package. The treatment means were compared using Duncan’s multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Analyses of variance for genotypes in the two growing seasons are presented in table (1). Tomato genotypes mean squares were highly significant for all traits at the two seasons, indicating that the genotypes behaved differently from year to another. Differences among genotypes are necessary to continue to study the genetic behavior of these traits to improve them. These results are in the same line with those obtained by Metwally et al. (1996), Phookan et al. (1998), Abdel-Ati et al. (2000) and Kumar et al. (2015).

Table (1). Analysis of variance (ANOVA) for plant height, stem diameter, fruit set %, yield, fruit weight, number of locules/fruit and T.S.S % of twelve tomato genotypes under greenhouse conditions in two growing seasons.

SOV	df	Plant height (cm)	Stem diameter (cm)	Fruit set (%)	Yield/plant (kg)	Average fruit weight (g)	No. of locules/ fruit	T.S.S (%)
2016 Season								
Rep.	2	24.53	0.0011	4.12	0.0038	1.46	0.0108	0.1011
Genotype	11	792.99**	0.0469**	144.34**	0.4122**	676.48**	0.6595**	0.3708**
Error	22	11.59	0.0032	8.01	0.0022	0.73	0.0096	0.1102
2017 Season								
Rep.	2	9.63	0.0058	1.93	0.0064	0.39	0.0136	0.1158
Genotype	11	815.48**	0.1067**	149.72**	0.1679**	460.59**	0.7220**	0.4213*
Error	22	20.37	0.0064	1.11	0.0027	2.25	0.0082	0.1401

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

The results presented in table (2) indicate clearly that, significant differences were recorded among the different tomato genotypes in plant height trait at the two seasons. In the first season, average trait was 180.97 cm, while, in the second season it was 179.53 cm. S924 genotype gave the highest value of plant height (208.17 cm) in the first season, while, S802 genotype gave the lowest value of plant height (157.83 cm) in the second season. The average stem diameter was 1.66 and 1.88 cm in the first and second seasons, respectively. S922, S923 and S924 genotypes gave the highest values of stem diameter of 1.80, 1.83 and 1.83 in the first season, respectively and 2.17 cm in the second season. While, S811 and S710 genotypes gave the lowest values of stem diameter of 1.47 and 1.67 cm in the first and second seasons, respectively. Generally, S922, S923 and S924 genotypes recorded the highest values of plant height and stem diameter at the two growing seasons. Kumar et al. (2015) found that in greenhouse conditions, the plant height was between 93.3 and 165 cm.

The average fruits set percentage were 85.62 and 88.69% in the first and second seasons, respectively. The highest value of fruit set percentage was recorded for S812 (95.30% in first season) and S922 (95.83% in the second season) genotypes. While, S710 genotype gave the lowest values of fruit set percentage of 75.43 and 76.50% in the first and second seasons, respectively. Generally, S422, S802 and S812 genotypes were recorded the best of fruit set percentage in the two seasons.

Table (2). Average performance for plant height, stem diameter, fruit set %, yield /plant, fruit weight, number of locules/fruit and T.S.S % of twelve tomato genotypes under greenhouse conditions in two growing seasons.

Genotype	Plant height (cm)		Stem diameter (cm)		Fruit set (%)		Yield /plant (kg)	
	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18	2016/17	2017/18
S421	189.50b	186.83b	1.77a	1.93b	83.83ef	89.50b	2.14e	2.63c
S422	178.17c	176.17c	1.67b	1.87bc	93.83ab	94.50a	2.42ab	2.53d
S700	168.83d	167.50de	1.60bc	1.73cd	77.83g	79.50d	1.50g	2.27e
S710	164.17d	160.10ef	1.53cd	1.67d	75.43g	76.50e	1.46g	2.08f
S720	169.83d	171.03cd	1.60bc	1.73cd	76.77g	78.10de	1.73f	2.20e
S740	167.83d	167.83de	1.60bc	1.80bcd	84.70def	86.43c	1.74f	2.18e
S802	158.17e	157.83f	1.63bc	1.77cd	93.10ab	94.03a	2.43a	2.66bc
S811	178.17c	170.30cd	1.47d	1.73cd	89.43bcd	94.83a	2.34bc	2.62cd
S812	192.83b	191.17b	1.53cd	1.77cd	95.30a	95.30a	2.15e	2.57cd
S922	205.50a	203.50a	1.80a	2.17a	86.43cde	95.83a	2.31cd	2.76a
S923	190.50b	200.50a	1.83a	2.17a	80.37fg	89.37b	2.23d	2.74ab
S924	208.17a	201.63a	1.83a	2.17a	90.37abc	90.37b	2.48a	2.60cd
Average	180.97	179.53	1.66	1.88	85.62	88.69	2.08	2.49

Table (2). Cont.

Genotype	Average fruit weight (g)		No. of locules /fruit		T.S.S (%)	
	2016/2017	2017/2018	2016/2017	2017/2018	2016/2017	2017/2018
S421	83.75c	81.75d	3.07b	3.07c	4.83ab	4.50a-d
S422	79.75d	78.53e	3.90a	3.90b	4.50abc	4.17bcd
S700	54.90f	60.69fg	3.07b	3.07c	4.83ab	4.50a-d
S710	53.19g	57.96h	3.03b	3.03c	4.83ab	4.67abc
S720	52.12g	58.80gh	3.03b	3.03c	5.00a	4.83ab
S740	60.32e	61.95f	3.03b	3.07c	5.00a	5.17a
S802	89.70a	90.46a	3.90a	3.90b	4.50abc	4.33bcd
S811	87.66b	87.62b	3.03b	3.07c	4.00c	3.90d
S812	83.72c	83.99cd	3.90a	4.03ab	4.50abc	4.33bcd
S922	90.20a	86.58bc	4.07a	4.10a	4.50abc	4.33bcd
S923	82.69c	84.32cd	3.07b	3.10c	4.00c	3.90d
S924	79.51d	78.73e	4.00a	4.10a	4.23bc	4.07cd
Average	74.79	75.95	3.43	3.46	4.56	4.39

The average of yield per plant was 2.08 and 2.49 kg in the first and second seasons, respectively. S924, S802 and S422 genotypes gave the highest values of yield per plant of 2.48, 2.43 and 2.42 kg in the first season, respectively. S922 and S923 genotypes gave the highest values of yield per plant of 2.76 and 2.74 kg in the second season, respectively. While, S710 genotype gave the lowest values of yield per plant of 1.46 and 2.08 kg in the first and second seasons, respectively. Kumar et al. (2015) found that in greenhouse conditions, the total fruit yield per plant from 615 to 1730 g.

Phookan et al. (1998) found that heritability values were high for fruit set percentage and total yield/plant, they reported that selection of fruit set percentage and total yield/plant in tomato population would be successful.

In the first season, mean average fruit weight was 74.79 g, while in the second season it was 75.95g. S922 and S802 genotypes gave the highest values of average fruit weight was 90.20 g for S922 in the first season, while 89.70 and 90.46 g for S802 in the first and second seasons, respectively. Moreover, S720 and S710 genotypes gave the lowest values of average fruit weight of 52.12 g for S720 in the first season and 57.96 g in the second seasons. Kumar et al. (2015) found that in greenhouse conditions, the average fruit weight was between 34.4 to 82.0 g. Concerning average fruit weight, heritability estimation in broad sense for this trait was high, while heritability estimation in narrow-sense for average fruit weight was low (Metwally et al., 1996 and Abdel-Ati et al., 2000).

The average number of locules per fruit was 3.43 and 3.46 in the first and second seasons, respectively. S922 and S924 genotypes gave the highest values of number of locules per fruit of 4.07 and 4.00 in the first season, respectively and 4.10 in the second season. While, S710 and S720 genotypes gave the lowest values of number of locules per fruit in the first and second seasons. Kumar et al. (2015) found that in greenhouse conditions, the number of locules per fruit was 2.0 to 5.0.

The average of T.S.S. percentage was 4.56 and 4.39% in the first and second seasons, respectively. S421, S700, S710, S720 and S740 genotypes gave the highest values of T.S.S. percentage of 4.83% for S421, S700 and S710 and 5.00% for S720 and S740 in the first season, while in the second season it reached 4.50% for S421 and S700, 4.67% for S710, 4.83% for S720 and 5.17% for S740 genotype. On the other hand, S811 and S923 genotypes gave the lowest values of T.S.S. percentage of 4.0 and 3.9% in the first and second seasons, respectively.

The knowledge of degree and direction of correlation among different traits of tomato are of great importance for selection of programs in the future. The results presented in table (3) reveal the combination between seven important traits of tomato genotypes under greenhouse conditions at the two growing seasons. In that context, plant height had highly significant positive correlation with each of stem diameter, fruit set percentage, yield per plant, fruit weight and number of locules per fruit. In the contrary, negative correlation was found between plant height and T.S.S. percentage. Highly significant positive correlation was observed between fruit set percentage and each of yield per plant, fruit weight and number of locules fruit. On the other hand, fruit set percentage showed a significant negative correlation with T.S.S. percentage. Yield per plant had highly significant positive correlation with fruit weight and number of locules per fruit. Highly significant negative correlation was also found between yield per plant and T.S.S. percentage. Fruit weight had highly significant positive correlation with number of locules per fruit. Highly significant negative correlation was also found between fruit weight and T.S.S. percentage. Ghosh et al. (1995) found that total yield had positive correlation with fruit weight. On the other hand, Khalaf-Allah et al. (1996) found that negative correlation was detected between total yield and T.S.S.

Table (3). Simple correlation coefficients among the traits at the two growing seasons.

Traits	Season	1	2	3	4	5	6	7
1. Plant height	2016/17	1.000	0.621^{**}	0.279^{**}	0.520^{**}	0.518^{**}	0.464^{**}	-0.396^{*}
	2017/18	1.000	0.801^{**}	0.432^{**}	0.637^{**}	0.448^{**}	0.424^{*}	-0.320
2. Stem diameter	2016/17		1.000	-0.012	0.394^{*}	0.339^{*}	0.319	-0.142
	2017/18		1.000	0.393^{*}	0.638^{**}	0.446^{**}	0.398^{*}	-0.273
3. Fruit set (%)	2016/17			1.000	0.777^{**}	0.697^{**}	0.703^{**}	-0.309
	2017/18			1.000	0.831^{**}	0.899^{**}	0.661^{**}	-0.446^{**}
4. Yield plant	2016/17				1.000	0.903^{**}	0.659^{**}	-0.541^{**}
	2017/18				1.000	0.935^{**}	0.523^{**}	-0.522^{**}
5. Fruit weight	2016/17					1.000	0.577^{**}	-0.546^{**}
	2017/18					1.000	0.546^{**}	-0.540^{**}
6. No. of locules/ fruit	2016/17						1.000	-0.184
	2017/18						1.000	-0.273
7. T.S.S. (%)	2016/17							1.000
	2017/18							1.000

CONCLUSION

This study is an important step of the Tomato Breeding Program of DRC to identify the best genotypes for hybrids production in the future and suitable for agriculture under greenhouse conditions. S924 genotype was the best for plant height, stem diameter, fruit set percentage and yield per plant. It was moderate for average fruit weight and T.S.S. percentage. Total soluble solids percentage showed a high significant negative correlation with all traits. Generally, differences among genotypes are necessary. Therefore, when starting the breeding program, a large number of genotypes with good traits should be selected. However, further studies should be carried out on hybrids in the future under greenhouse conditions in all research stations of DRC to insure better results.

REFERENCES

Abdel-Ati, K.E.A., A.A. Hassan, S.E.S. Moustafa and A.A. Mohammed (2000). Genetics of some tomato fruit quality characters. I. Physical Characters. Egypt. J. Hort., 27 (2): 249-264.

Balashov, E.S. (2006). Features of growth and development of new tomato hybrids under cultivation in the extended cycle of winter glazed greenhouse. PhD Thesis, All-Russian Research Institute of Vegetable Growing, Moscow.

Cheema, D.S., N. Singh and S.K. Jindal (2013). Evaluation of indeterminate tomato hybrids for fruit, yield and quality traits under net house and open field conditions. Vegetable Science, 40 (1): 45-49.

Duncan, B.D. (1955). Multiple ranges and multiple F-tests. Biometrics, 11: 1-42.

Dutta, P., P.N. Dutta and P.K. Borua (2013). Morphological traits as selection indices in rice: A statistical view. Univers. J. Agric. Res., 1: 85-96.

Foolad, M.R. (2007). Genome mapping and molecular breeding of tomato. Int. J. Plant. Genomics. DOI:10.1155/2007/64358.

Gavrish, S.F. (2015). Modern hybrids tomato and cucumber. Gavrish, 4: 2-5.

Ghosh, P.K., M.M. Syamal, N. Rai and A.K. Joshi (1995). Improvement of hybrid tomatoes. Advances in Plant Sciences, 8 (1): 207-213.

Khalaf-Allah, A.M., M. Horeya Hassan and M.A. Wahb-Allah (1996). Estimates of genotypic and phenotypic correlation for some growth yield and fruit characters in tomato. Zagazig J. Agric. Res., 23 (1): 125-130.

Kumar, S., P.H.R. Gowda and N.M. Mallikarjuna (2015). Evaluation of selected f6 tomato lines for extended shelf life. SABRAO J. Breed. Genet., 47 (4): 326-334.

Metwally, E.I., A. El-Zawily, N. Hassan and O. Zanata (1996). Inheritance of fruit set and yield of tomato under high temperature conditions in Egypt. 1^{st} Egypt-Hung. Hort. Conf., I: 112-122.

Phookan, D.B., P. Talukdar, A. Shadeque and B.K. Chakravarty (1998). Genetic variability and heritability in tomato (*Lycopersicon esculentum*) genotypes during summer season under plastic-house condition. Indian Journal of Agricultural Science, 68 (6): 304-306.

Rajasekar, M., T. Arumugam and S. Ramesh Kumar (2013). Influence of weather and growing environment on vegetable growth and yield. J. Horticulture Forestry, 5: 160-167.

Rodica, S., S.A. Apahidean, M. Apahidean, D. Maniuţiu and L. Paulette (2015). Yield, physical and chemical characteristics of greenhouse tomato grown on soil and organic substratum. Proceedings of the 3rd International Symposium on Agriculture (ISA' 15), p. 439-443.

Singh, T., N. Singh, A. Bahuguna, M. Nautiyal and V.K. Sharma (2014). Performance of tomato (*Solanum lycopersicum* L.) hybrids for growth, yield and quality inside polyhouse under mid hill condition of Uttarakhand. Am. J. Drug Discovery Dev., 4: 202-209.

Warnock, S.J. (1991). Natural habitats of *Lycopersicon* species. HortScience, 26: 466-471.

أداء بعض التراكيب الوراثية من الطماطم تحت ظروف البيوت المحمية

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تقييم أداء التراكيب الوراثية من الطماطم تحت ظروف البيوت المحمية يأتي في المرتبة الأولى لبرنامج تربية الطماطم بمركز بحوث الصحراء. الهدف الرئيسي للبرنامج هو الحصول على هجن من الطماطم تناسب ظروف البيوت المحمية بتطوير سلالات التربية ذات الخصائص المطلوبة. تم زراعة أثني عشر تركيب وراثي من الطماطم غير محدود النمو بالبيوت المحمية بمحطة بحوث بالوظة، مركز بحوث الصحراء بشمال سيناء خلال موسمي النمو ٢٠١٧/٢٠١٦ و٢٠١٨/٢٠١٧. التصميم الإحصائي المستخدم هو القطاعات الكاملة العشوائية مع استخدام ثلاث مكررات. وكانت النتائج تشير إلى وجود اختلافات معنوية بين التراكيب الوراثية لجميع الصفات الخاصة بالنمو والإنتاج والجودة، واستنادًا إلى النتائج المتحصل عليها فى الموسمين، تم تحديد أكثر تراكيب الطماطم انتاجيةً وتكيفًا مع ظروف المنطقة. كانت التراكيب S924, S923, S922 الأفضل لصفات إرتفاع النبات وسمك الساق ومحصول النبات. سجلت التراكيب S811, S812, S802 أعلى متوسط لنسبة عقد الثمار. سجلت التراكيب S740, S720, S710, S700 أعلى متوسط لنسبة المواد الصلبة الذائبة الكلية. وجد ارتباط سالب بين نسبة المواد الصلبة الذائبة الكلية وجميع الصفات.