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Morphological Characterization of Tomato Genotypes (*Solanum lycopersicum* L.) under Drought Conditions

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ABSTRACT

A pot experiment was conducted to study the Morphological Characterization analysis of seven tomato genotypes under drought stress conditions for the traits i.e., Plant height, Number of Clusters Per Plant, Number of Flowers Per Clusters, Number of Fruits Per Plant, Average Fruits Weight and Yield Per Plant. Contrary to irrigated crops, drought-stressed plants age more slowly, produce smaller canopies, and have a smaller canopy. A surplus of reactive oxygen species (ROS) is produced during a drought, and this ROS over production causes oxidative damage that eventually results in cell death. Plant height decreased when under drought stress, which is a growth characteristic. The smallest decline in plant height was noted in Arka Rakshak (11%) while the largest was noted in Pant T-3 (18%). The number of flower clusters per plant, the number of flowers per cluster, and the number of fruits per plant are all closely related to the yield. All of the morphological features were observed to be dropping across all genotypes. However, under induced drought stress circumstances, the genotype Arka Rakshak showed very little change in these metrics.

Keywords Tomato, Drought, Stress, Growth, Yield.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is the most common and considerable crop grown worldwide, including in India. It has a diploid genome with 12 chromosome pairs and a genome size of 950 Mb (Barone *et al.* 2008). This crop is widely known for its origin in Western South America and was later domesticated throughout the world (Kimura and Sinha 2008).

The tomato is consumed in diverse forms, including raw, as an ingredient in several dishes, sauces, salads, and drinks. Tomato is usually cultivated in subtropical and mild cold climatic regions and the plant could not strive against frost and high

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humidity. Major tomato-producing countries in the world are China, the USA, Italy, Turkey, India, and Egypt. Moreover, the major tomato-growing states in India like Karnataka, Orissa, Maharashtra, Bihar, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh, and West Bengal (National Horticulture Board 2020). The global tomato production reached 41.52 million tons in 2020 whereas 20.55 million tons of tomato production were recorded in India with an estimated area of 818 thousand hectares (FAO 2020, National Horticulture Board 2020).

The most popularly grown varieties of tomato in India are Pusa-120, Pusa Sadabahar, Pusa Hybrid-4, Pusa Rohini, Pusa Hybrid-2, Pusa Hybrid-8, Arka Vardan, Arka Vikas, Arka Hisar, HS-101, Anand Tomato-3, tomato hybrid-1, CO_1, CO_2, CO_3, $COTH_1$, $COTH_2$, Co_3, Azad T-5, Azad T-6, KTH-2 (Hybrid). Tomatoes comprise ample amounts of vitamin C and provide 40% of the diurnal importance. Furthermore, tomatoes include daily requirements of the human body like vitamin-A about 15%, potassium about 8% and 10% of recommended iron value for men, and 7% of recommended iron value for women. The red pigment in tomatoes is known as lycopene which behaves as an antioxidant and neutralizes the generated free radicals which were responsible for the cell damage (Bhowmik *et al.* 2012). Tomatoes were being used at a higher rate in wealthy nations compared to developing nations and may be considered a luxury crop (Bhatia *et al.* 2004).

Production of tomatoes is known to reduce drastically due to different biotic and abiotic factors. The living agents include nematodes, fungi, bacteria, and viruses which were considered the important agents for immense destruction in tomato production. Tomato is highly sensitive to drought stress, resulting in yield losses of up to 79% which is very problematic (Aliche *et al.* 2018).

Drought severity is unpredictable since it depends on various factors such as rainfall incidence and distribution, evaporative needs, and soil moisture storing ability (Kaur and Asthir 2017). Reduced leaf development and rapid leaf senescence were common responses to water shortages and could be a plant adaptation to the situation.

Drought-stressed crops grow slower and have a smaller canopy and senescence than irrigated crops (Lahlou *et al.* 2003). Drought creates an over-abundance of reactive oxygen species (ROS), which leads to oxidative damage eventually leading to cell death (Rai *et al.* 2011).

Moreover, tomato yields were expected to drop significantly by 2055 as a result of global warming and drought. Another study predicts that as a result of biotic and abiotic pressures related to climate change, global tomato production will drop by 18–32% between 2040 and 2069 (Dahal *et al.*2019).

MATERIALS AND METHODS

The experimental trial was conducted at College of Agriculture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, India. Different varieties of tomatoes with distinct backgrounds were used in the study (Table 1). The experimental plant material for the study comprised 7 genotypes of Tomato comprising of released varieties.

Experimental design and treatment details

The experiment was conducted in Completely Randomized Design with three replications.

Drought treatment

The drought was induced by withholding all water for 7 days as the vegetative stage begins because a lack of water impairs fruit development and plant growth. Following that, the experimental material is collected, and the plants are watered and cared for till maturity.

Table 1. Tomato genotypes and their sources are as follows.

Sl. No.	Tomato genotypes	Sources
1	Arka Rakshak	IIHR, Bangalore
2	Arka Samrat	IIHR, Bangalore
3	Punjab Ratta	Punjab Agriculture University
4	Pusa Rohini	IARI, New Delhi
5	Nav Uday	SVPUAT, Meerut
6	Feb-4	SVPUAT, Meerut
7	Pant T-3	GBPUAT&T, Pant Nagar

Parameters of Study

Plant height (cm) **:** The height of the tomato plant at the flowering stage was measured in centimeters from the base of the plant to the tip of the axial shoot in the tomato plant.

Number of clusters per plant **:** The numbers of clusters were counted at the flowering stage for all three replicates and the average of them was recorded for further analysis.

Number of flowers per cluster **:** The number of flowers per cluster were counted at the flowering stage for all three replicates and the average of them was recorded for further analysis.

Total number of fruits per plant **:** The numbers of fruit per plant were counted at the fruiting stage for all three replicates and the average of them was recorded for further analysis.

Average weight of fruit (g) **:** The average fruit weight was estimated by weighing fruits in treatment, with the help of an electronic balance measuring in grams to the second decimal place and then converting to average fruit weight.

Yield per plant (g) **:** The yield of 5 randomly selected plants was recorded from each replication and averaged.

RESULTS

The studied of tomato genotypes were grown up to maturity and evaluated for various morphological characters (Fig. 1).

Plant height (cm)

The plant height under normal conditions ranging from 52.00 cm in Punjab Ratta to 68.00 cm in Arka Rakshak with general mean of 58.04 cm. Whereas in drought condition ranged from 44.66 cm in Feb-4 to 60.00 cm in Arka Rakshak with a general mean of 49.23 cm. There was a significant decrease in plant height was observed in drought stress plants when compared to control (Table 2). Minimum reduction of plant height was recorded in Arka Rakshak (11%) followed by Punjab Ratta (12%) and Feb-4 (14%). However, Pant-3 (18%) and Pusa Rohini (17%) have shown much reduction in plant height comparatively.

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Number of clusters per plant

Number of clusters per plant in normal condition ranged from lowest 8.33 in Nav-Uday to highest 13.00 in Arka Rakshak with a general mean of 9.94 whereas under drought stress conditions number of clusters per plant ranged from lowest 4.33 in Pant-3 to highest 8.33 in Arka Rakshak with a general mean of 5.75. There was a significant decrease in number of the cluster was observed in drought stress plants

Table 2. Mean performance of tomato genotypes for morphological characters under control and drought stress condition.

Sl. No.	Germplasms	Plant height (cm)			Number of clusters per plant			Number of flowers per clusters		
		Control	Treatment	Reduction in %	Control	Treatment	Reduction in %	Control	Treatment	Reduction in %
1	Arka Rakshak	68.00	60.00	11	13.00	8.33	35	4.00	3.66	9
2	Arka Samrat	59.66	50.33	15	10.66	6.33	40	3.33	2.33	30
3	Pusa Rohini	58.66	48.33	17	9.33	5.33	42	3.00	2.66	11
4	Pant T-3	62.33	50.66	18	9.66	4.33	55	3.33	2.88	13
5	Punjab Ratta	52.00	45.33	12	9.00	5.00	44	3.00	2.22	26
6	Nav-Uday	53.33	45.33	15	8.33	5.33	36	2.66	2.33	12
7	Feb-4	52.33	44.66	14	9.66	5.66	41	2.66	2.33	12
	Mean	58.04	49.23		9.94	5.75		3.14	2.63	
	CD at 5 %	3.06	2.59		0.52	0.30		0.16	0.14	
	SE (m)	1.00	0.85		0.17	0.10		0.05	0.04	
	SE (d)	1.42	1.21		0.24	0.14		0.07	0.06	
	CV%	2.44	2.45		2.41	2.43		2.22	2.28	

Fig. 1. Comparative images of control and drought stress condition in different tomato genotypes.

when compared to control (Table 2). Minimum value reduction of number of clusters was recorded in Arka Rakshak (35%) and Nav-Uday (36%). However, Pant-3 (55%) and Punjab Ratta (44%) have shown much reduction in number of clusters comparatively.

Number of flowers per cluster

Number of flowers per cluster were counted from first three flowers cluster and averaging them for all genotypes in each plant at flowering stage. The result

Table 3. Mean performance of tomato genotypes for morphological characters under control and drought stress condition.

Sl. No.	Germplasms	Number of fruits per plant			Average fruits weight (g)			Yield per plant (g)		
		Control	Treatment	Reduction in %	Control	Treatment	Reduction in %	Control	Treatment	Reduction in %
1	Arka Rakshak	18.33	15.33	16	79.00	67.66	14	1530	999	34
2	Arka Samrat	16.33	12.66	22	65.66	51.00	22	1386	753	45
3	Pusa Rohini	14.00	10.00	28	58.66	46.66	20	1073	616	42
4	Pant T-3	13.00	9.33	28	55.33	43.66	21	799	499	37
5	Punjab Ratta	12.33	8.66	29	66.66	53.33	20	759	461	39
6	Nav-Uday	9.33	6.66	28	58.33	47.00	19	704	390	44
7	Feb-4	11.33	8.00	29	57.37	44.66	22	895	533	40
	Mean	13.52	10.09		63.00	50.56		1020.85	607.28	
	CD at 5%	0.72	0.54		3.33	2.68		55.89	33.47	
	SE(m)	0.23	0.18		1.09	0.88		18.42	11.03	
	SE(d)	0.33	0.25		1.55	1.25		26.42	15.60	
	CV%	2.44	2.29		2.46	2.46		2.58	2.56	

shows that the number of flowers per cluster under normal condition ranged from lowest value 2.66 in Nav-Uday and Feb-4 to highest 4.00 in Arka Rakshak highest with a general mean of 3.14 whereas under drought stress conditions number of flowers per cluster ranged from lowest 2.22 in Punjab Ratta to highest 3.66 in Arka Rakshak with a general mean of 2.63 (Table 2). There was a significant decrease in number of flowers per cluster was observed in drought stress plants when compared to control. Minimum reduction of number of flowers per cluster was recorded in Arka Rakshak (9%), followed by Pusa Rohini (11%), Nav-Uday (12%) and Feb-4 (12%). However, Arka Samrat (30%) and Punjab Ratta (26%) have shown much reduction in the number of flowers comparatively.

Number of fruits per plant

Number of fruits per plant was counted in each harvest and adds on to get the total number of fruits per plant. The data was recorded in triplicate from each germplasm and averaging them. The results show that the number of fruits per plant under normal condition varied from a lower value 9.33 in Nav-Uday to higher 18.33 in Arka Rakshak and whereas in drought condition the number of fruits per plant varied from a lower value 6.66 in Nav-Uday to higher 15.33 in Arka Rakshak (Table 3). There was a significant decrease in number of the fruit was observed in drought stress plants when compared to control. Minimum value reduction of fruit was recorded in Arka Rakshak (16%) and Arka Samrat (22%). However, Punjab Ratta (29%), Feb-4 (29%) and Pusa Rohini (28%), Pant-3 (28%) has shown much reduction in fruit per plant comparatively.

Average of fruits weight (g)

Average fruit weight was calculated by weighting of five fruits from each genotype and averaging them. The result shows that in normal condition that the average fruit weight varied from a lower value of 55.33 g in Pant-3 to higher 79.00 gm in Arka Rakshak whereas in drought condition the average of fruits weight varied from a lower value 43.66 g in Pant-3 to higher 67.66 g in Arka Rakshak (Table 3). There was a significant decrease in number of the fruit weight was observed in drought stress plants when compared to control. Minimum value reduction of fruit weight was recorded in Arka Rakshak (14%) and Nav-Uday (19%). However, Arka Samrat (22%), Feb-4 (22%) and Pant-3 (21%) have shown much reduction in fruit weight comparatively.

Yield per plant (g)

The yield of tomato fruits per plant under normal condition varied from a lower value 704 g in Nav-Uday to higher 1530 g in Arka Rakshak with a general mean value of 1020.85 g. Whereas in drought condition the yield of tomato fruits per plant varied from a lower value 390 g in Nav Uday to higher 999 g in

Arka Rakshak with a general mean value of 607.28 g (Table 3). There was a significant decrease in number of the yield was observed in drought stress plants when compared to control. Minimum value reduction of yield was recorded in Arka Rakshak (34%) and Pant-3 (37%). However, Arka Samrat (45%), Nav Uday (44%) and Pusa Rohini (42 %) have shown much reduction in yield comparatively.

DISCUSSION

Morphological characters have been used to characterize seven varieties of tomato. Morphological characterization has been used extensively in elucidating genetic diversity among plants. Results from the study suggest that the eighteen cultivars of (*Solanum lycoperiscum* L). were distinct and robust. The distinctiveness observed among cultivars may be useful for crop improvement and breeding programs.

In the current study, observations of the seven-tomato germplasm showed significant variations under normal conditions, towards plant heights ranging from 52.00 cm to 68 cm in Punjab Ratta and Arka Rakshak germplasm, respectively, and from 44.66 cm to 54.00cm in Feb-4 and Arka Rakshak germplasm, respectively, under drought stress conditions (Table 2). Our study shows similarity with Nawaz *et al.* (2015) who revealed that the maximum height of tomato plants was 118.8 cm while the minimum tomato plant height was 70.10 cm. Naz *et al*. (2013) also stated in their study, that the maximum height of a tomato plant was 80cm while the minimum height of a tomato plant was 20cm. The traits studied have an environmental influence which causes variability in the genotypes. The variation in the genotypes would be helpful in the development of superior varieties. The present investigation revealed that the phenotypic variations contributed the maximum to the tomato genotypic variations. The phenotypic variation was high as compared to genotypic variation for all traits under the study.

Analysis of the number of clusters per plant represented variations in different germplasms. Under normal conditions, this range varies from 8.33 to 13.00 Arka Rakshak denoted the highest value, whereas Nav-Uday denoted the least value. When compared to the current study, Chernet and Zibelo (2014) findings revealed a maximum number of flower trusses per plant ranging from 8.8 to 12.3 which is quite high (Table 2).

Data analysis for number of flowers per truss showed significant variation in both normal and drought stress conditions in the tomato germplasms which ranged between 2.66 to 4.00 (Table 2).

The observations of the number of fruits per plant ranged from 9.33 to 18.33 for 7 different tomato genotypes. Under drought conditions, the range of 6.66 to 15.33. Nav-Uday represented the minimum fruit number and Arka Rakshak had the highest fruit number while Arka Rakshak signified the greatest number of fruits (Table 3). Cheema *et al.* (2013) evaluated in determinate tomato hybrids for fruit, production, and quality attributes, they found that the flower per truss value ranged from 5 to 10 and the total number of fruits per plant varied from 9 to 53. According to Domani and Maya (1997), the most significant factor directly affecting yield was the number of fruits produced per plant. The most significant and direct impact on yield was the number of fruits per plant (Rathod *et al.*1997, Patil *et al*.1998, Revanasidappa and Veena 2008). Numerous researchers (Nuruddin *et al*. 2002, Weerasinghe *et al*. 2003, Zgallai *et al.* 2005) also reported similar results.

The average fruit weight was analyzed to identify the genotypes which have the ability to produce higher yields. These genotypes produced fruit with an average weight that ranged from 53.33 gr to 79.00 gr under normal conditions. While Arka Rakshak produced the highest average weight for fruits under drought stress conditions, Pant-3 produced the lowest average weight for fruits that ranged from 43.66 gr to 67.66 gr (Table 3).

According to the study conducted by Dar and Sharma (2011), average fruit weight in tomato germplasm varied from 21.58 gr/fruit to 86.07gr/fruit yield per plant (Table 3). While in both conditions normal and drought highest yield of fruit per plant was recorded in Arka Rakshak (1530 gr). Several studies reported similar results in tomatoes (Sankari 2000, Abdel *et al.* 2013).

CONCLUSION

It was concluded that the morphological characters of tomato genotypes under control and drought stress showed significant variation in all the genotypes of the tomato. Different tomato genotypes under the drought stress showed the reduction in growth attribute i.e., plant height. The minimum reduction in plant height observed in Arka Rakshak (11%) and the maximum reduction in plant height observed in Pant T-3 (18%). The number of flower clusters per plant, number of flowers per cluster, and number of fruits per plant are directly related to the yield, they were economically important characters. All the morphological characters were found to be decreasing in all the genotypes. However, the genotypes Arka Rakshak showed very less values of reduction in these parameters under imposed drought stress conditions.

REFERENCES

Abdel-Aziz HM, Hasaneen MN, Omer AM (2013) Nano chitosan-NPK fertilizer enhances the growth and productivity of wheat plants grown in sandy soil. *Spanish J Agric Res* 14 (1) : e0902—e0907.

Aliche EB, Oortwijn, M, Theeuwen TP, Bachem CW, Visser RG, Linden CG (2018) Drought response in field grown potatoes and the interactions between canopy growth and yield. *Agric Water Manag* 206 : 20—30.

Barone A, Chiusano ML, Ercolano MR, Giuliano G, Grandillo S, Frusciante L (2008) Structural and functionalgenomics of tomato. *Internat J Pl Genomics*.

Bhatia P, Ashwath Senaratna T, Midmore D (2004) Tissue culture studies of tomato (*Lycopersicon esculentum*). *Pl Cell Tissue Organ Culture* 78 (1) : 1—21.

Bhowmik D, Sampath Kumar KP, Paswan S, Srivastava S (2012) Tomato-A natural medicine and its health benefits. *J Pharmacog Phytochem* 872 (2) : 2278—4136.

Cheema DS, Singh N, Jindal SK (2013) Evaluation of indeterminate tomato hybrids for fruit, yield and quality traits under the net house and open field conditions. *Veg Sci* 40 (1) : 45—49.

Chernet S, Zibelo H (2014) Evaluation of tomato varieties for fruit yield and yield components in western lowland of Tigray, Northern Ethiopia. *Int J Agric Res* 9 : 259—264.

Dahal K, Li XQ, Tai H, Creelman A, Bizimungu B (2019) Improving potato stress tolerance and tuber yield under a climate change scenario–a current overview. *Frontiers Pl Sci* 10 : 563.

Dar RA , Sharma JP (2011) Genetic variability studies of yield and quality traits in tomato (*Solanum lycopersicum* L.). *Int J Pl Breed Genet* 5 : 168—174.

Domani MR, Maya C (1997) Correlation and path coefficient estimate of different tomato seedlings stage. *Cultura Trop* 18 (3) : 63—65.

FAOSTAT (2020) Website (http://faostat3.fao.org/home/E).

Kaur G, Asthir B (2017) Molecular responses to drought stress in plants. *Biologia Plantarum* 61 (2) : 201—209.

Kimura S, Sinha N (2008) Tomato (*Solanum lycopersicum*) : A model fruit-bearing crop. *Cold Spring Harbor Protocols* 2008 (11) : pdb-emo105.

Lahlou O, Ouattar S, Ledent JF (2003) The effect of drought and cultivar on growth parameters, yield and yield components of potato. *Agron* 23(3) : 257—268.

Nawaz S, Chaudry Z, Bibi A, Jan SA, Bibi K (2015) Agromorphological and molecular characterization of local tomato cultivars grown in Pakhal region of Pakistan using RAPD markers. *Middle-East J Sci Res* 23 (5) : 856—860.

Naz S, Zafrullah A, Shahzadhi K, Munir N (2013) Assessment of genetic diversity within germplasm accessions in tomato using morphological and molecular markers. *The J Animal Pl Sci* 23 (4) : 1099—1106.

NHB National Horticulture Board (2020) Indian Horticulture Database. National Horticulture Board, Gurgaon.

Nuruddin MM, Madramootoo CA, Dodds GT (2002) Effects of water stress at different growth stages on greenhouse tomato yield and quality. *Hort Sci* 38 (7) : 1389—1393.

Patil GG, Oi R, Gissinger A, Moe R (1998) Plant morphology is affected by light quality selective plastic films and alternating day and night temperature. *Gartenbau-wissenschaft* 66 (2) : 53—60.

Rai GK, Jamwal D, Singh S, Parveen A, Kumar RR, Singh M, Salgotra RK (2011) Assessment of genetic variation in tomato (*Solanum lycopersicum* L.) based on quality traits and molecular markers. *SABRAO J Breed Genetics* 48 (1) : In press.

Rathod S, Singh M, Goyary D, Singh RK, Anandhan S, Sharma DK, Ahmed Z (1997) Induced ectopic expression of At-CBF1 in marker-free transgenic tomatoes confers enhanced chilling tolerance. *Pl Cell Reports* 30 (6) : 1019—1028.

Revanasiddappa HD, Veena MA (2008) Sensitive spectrophotometric methods for the determination of ascorbic acid. *E-J Chem* 5 (1) : 10—15.

Sankari HS (2000) Linseed (*Linum usitatissimum* L.) cultivars and breeding lines as stem biomass producers. *J Agron Sci* 184 (4) : 225—231.

Weerasinghe OR, De Costa WAJM, Perera A LT (2003) Evaluation of different genotypes of tomato under well-watered and water-stressed conditions on the basis of yield and some selected physiological parameters.

Zgallai H, Steppe K, Lemeur R (2005) Photosynthetic, physiological and biochemical responses of tomato plants to polyethylene glycol induced water deficit. *J Integrative Pl Biol* 47 (12) : 1470—1478.