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Morphological Characterization of Tomato Genotypes (*Solanum lycopersicum* L.) under Moisture Stress conditions

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ABSTRACT: Abiotic stressors like drought, salt, or temperature have a significant impact on plant development. One of the most significant global constraints on agricultural crop output, and vegetable production in particular, is drought. In most cases, yield is decreased by drought stress during vegetative or early reproductive development by lowering the quantity, size, and quality of seeds. There were one treatment i.e. water hold capacity for 7 days. A pot experiment was carried out to examine the traits of Plant height, Number of Clusters per plant, Number of flowers per clusters, Number of fruits per plant, Average fruits weight, and Yield per plant for seven tomato genotypes under drought stress conditions. Drought-stressed plants age more slowly, produce smaller canopies, and have a smaller canopy than irrigated crops. During a drought, an excess of reactive oxygen species (ROS) is created, and this ROS overproduction results in oxidative damage and, ultimately, cell death. A growth characteristic of plants under drought stress was a reduction in height. Action-666 saw the least reduction in plant height (50.6cm) whereas Cherry Tomato experienced the biggest (76cm). The yield is directly correlated with the number of flower clusters per plant, the number of flowers per cluster, and the number of fruits per plant. All morphological characteristics were shown to be deteriorating across all genotypes. However, the genotype Action-666 exhibited very little change in these parameters under conditions of induced drought stress.

Keywords: Tomato, Drought, Stress, Growth, Yield and Characterization.

INTRODUCTION

Tomato **(***Lycopersicum esculentum* Mill.) syn. (*Solanum lycopersicum* L.), belongs to the Solanaceae family. The cultivated tomato belongs to the species *Solanum lycopersicum*, while *Solanum pimpinellifolium* is the closest wild relative with a divergence of only 0.6% nucleotide base pairs (The Tomato Genome *et al.,* 2012). Tomato is one of the most significant vegetable plants in the world. They are assumed to have originated in western South America and were domesticated in Central America**.** Tomato is the most widely grown vegetable in the world, and they are a good source of micronutrients in the human diet**.**

Tomato is a rich source of vitamins such as vitamin A and C, as well as fibres and also good source of the antioxidant lycopene. Tomato contains about 20–50 mg of lycopene per 100g of fruit weight. Lycopene is the most potent antioxidant in the carotenoid family, protecting people from free radicals that destroy numerous body parts. Lycopene is also known to protect humans from cancer. Tomatoes are being used at a higher rate in wealthy countries than in underdeveloped countries, and hence may be considered a luxury crop (Bhatia *et al.,* 2004).

A widely used vegetable with several applications (fresh, dried, sauce, tomato paste, meal, etc.). The tomato accounts for around 14% of the world's vegetable output (Bauchet and Causse 2012; Athinodorou *et al*., 2021; El-Mansy *et al*., 2021). After China and India, Turkey is one of the major tomato-producing countries in the world. Additionally, Turkey produces around 7% of the tomatoes consumed worldwide (Okumus and Dagidir 2021). It has significant nutritional value, particularly in terms of the antioxidants and vitamins A and C. It is particularly significant as a source of lycopene, an antioxidant that shields cells from oxidative damage. The Solanaceae family includes the self-pollinating tomato plant (2n=2x=24) (Delices *et al.*, 2021).

According to the National Horticulture Board's second estimate for the 2021 annual report, the estimated area and output of tomato in India are 852 thousands hectares and 21 million metric tonnes, respectively. In India, the average tomato yield per hectare is only 24 tonnes. Karnataka, Orissa, Maharashtra, Bihar, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh, and West Bengal are the major tomato-growing states in India (National Horticulture Board, 2020). In 2020, India produced 20.55 million tonnes of tomato, which grew to 21 million tonnes in 2021 (FAOSTAT, 2022).

Plants may be stressed by a variety of unfavourable environmental situations. Stress has an impact on plant growth, development, and metabolism, and can even result in plant mortality. Mechanical damage, herbicides, UV radiation, salt, low/high temperatures, soil dryness, and flooding are all significant stressors that affect crop growth. Drought is one of the most significant abiotic stressors limiting agricultural crop productivity (Boguszewska *et al*., 2010).

Drought is defined as a period of below-average precipitation, fewer rain events, or higher-than-normal evaporation, which results in a decline in crop yield and growth. Drought severity is unpredictable since it is dependent on a variety of factors such as rainfall incidence and distribution, evaporative needs, and soil moisture storing ability (Kaur and Asthir 2017). Tomato (*Lycopersicon esculentum* Mill.) is highly sensitive to soil drought. If water requirements are not met, yield losses of up to 79 percent can occur (Aliche *et al.,* 2018). Tomato yields are 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 with climate change, global tomato production will drop by 18–32 percent between 2040 and 2069 (Dahal *et al*., 2019).

This new millennium, marked by increased globalisation, growing environmental concern, increased importance of food safety, and rising importance of intellectual property rights (IPR), presents tomatoes with enormous challenges, not only in connecting millions of poor small/ marginal farmers to the international market, but also in providing safety nets for poor households struggling to avoid poverty and hunger.

MATERIAL AND METHODS

A replicated experiment consisting of 7 genotypes of Tomato was conducted at field laboratory of Department of Biotechnology, S.V.B.P.UA&T, Meerut (North West Plains Zone, India, 28.990N and 77.700E). The experimental plant material for the study comprised 7 genotypes of Tomato comprising of released varieties. Tomato genotypes and their sources are as follows-

Experimental Design and Treatment Details. A replicated experiment consisting of seven genotypes of tomato was conducted in Randomized Block Design (RBD) with three replications in which 3.4 cm seedlings were transplanted in pots from the nursery tray.

Drought Treatment. The drought will be implemented by withholding all water for 7 days as the flowering stage begins, because a lack of water impairs fruit development and plant growth. Following that, the experimental material will be collected, and the plants will be watered and cared for till maturity.

Criteria of Study. Plant height at flowering stage (cm). Plant height was measured just before last harvesting in centimeters from the ground level to the top of the primary branch.

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

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

Total number of fruits selting per plant. The numbers of Fruit selting per plant were counted at flowering stage for all three replicates and average of them was recorded for further analysis.

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

Yield per plant. The total yield for treatment was calculated by weighing the fruit picked in each replication.

RESULTS AND DISCUSSION

Tomato varieties was evaluated for various morphological characters *viz.*, plant height, number of trusses per plant, number of flower per trusses, number of fruit per plant, average fruit weight (single tomato) . Morphological data will be recorded at maturity when the plants starts flowering-

Plant height. Plant height is an important parameter with respect to strong life span, seed mass, and time to maturity. Presently, the plants in each replicate were taken from each variety in both control and water stress condition and the data were recorded. Plant height was measured (in cm) from base of the plant to the tip of the auxiliary shoot and presented in Table 1. In control, result shows that the plant height varied from a lower value of 56.33cm in S-22 variety to a higher value of 83cm in Cherry Tomato variety. However the varieties S-22 and Action-666 shows lesser plant height value whereas Cherry Tomato and Plum Yellow shows significantly higher plant height. In water stress condition, plant height varied from a lower value of 50.6 cm in Action-666 to a higher value of 76 cm in Cherry Tomato. However the varieties Action-666 and F-1H Tomato Cherry Tomato and Plum Yellow show lesser plant height value whereas Cherry Tomato and Plum Yellow shows significantly higher plant height. However Kaushik *et al*. (2011) reported 23.2cm average plant height which is significantly less as compared to the present study.

Number of flower per truss. Numbers of flower trusses per plant was counted in each tomato varieties. The data was recorded from each variety in both control and water stress condition and shown in Table 1. The result in control shows that the number of trusses per plant was varied from lower value that was observed 2.33 in Action-666 and highest number of trusses per plant is 6 and was observed in Cherry Tomato. However the varieties Action-666 and F-1H Tomato less number of flower trusses per plant whereas the varieties plum yellow and cherry tomato significantly higher number of flower trusses per plant. In water stress condition, result shows that the number of flower trusses per plant varied from a lower value of 4 in Action-666 and highest number of flower trusses per plant is 7.6 was observed in Cherry Tomato. However the varieties Action-666 and Suhana has less number of flower trusses per plant whereas the varieties Plum Yellow and Cherry Tomato significantly higher number of flower trusses per plant. Earlier reports of Ilakiya *et al*. (2019) were also in conformity to present results where observations on number of flower truss-1 were in the range of 4.56-6.89 in 100% FC and 4.13-5.92 in 50% FC. Findings of Parveen *et al.* (2019) also showed that number of flower truss-1 varied from 4.33-7.33 under control conditions while under drought stress condition, it varied from 2.00-4.33.

Number of trusses per plant. Number of trusses per plant were counted from first three flower cluster and averaging them for all varieties in each control and water stress condition and shown in Table 1. In control result shows that the minimum number of trusses per plant were observed is 5 in the variety Action-666 and maximum number of trusses per plant was 12.6 were observed in Cherry Tomato. However the varieties Action-666 and S-22 shows less number of trusses per plant whereas the varieties Cherry Tomato and F-1H Tomato shows significantly higher number of trusses per plant. In water stress condition, result shows that number of trusses per plant varied from a lower value of 4.3 were observed in Action-666 variety and highest number of number of trusses per plant 12.3 was observed in cherry tomato. However the Action-666 and Suhana has less number of trusses per plant whereas the varieties Cherry Tomato and Plum Yellow significantly higher number of trusses per plant.

Number of fruits per plant: Numbers of fruits per plant was counted in each harvest and add on to get the total no of fruits per plant. The data was recorded from three replicates of each variety in control and water stress condition separately and presented in Table 2. In control result shows that the numbers of fruits per plant were observed lowest is 11.6 in the variety Action-666 and highest number of fruits per plant 31.6 was observed in Cherry Tomato. However the varieties S-22 and Action-666 shows less number of fruits per plant whereas the varieties Plum Yellow and Cherry Tomato shows significantly higher number of fruits per plant in tomato germplasm. In water stress condition, result shows that the number of fruits varied from a lower value of 7.6 were observed in Action-666 variety and higher value of 19 was observed in Cherry Tomato. However, Action-666 and Suhana has less number of fruits whereas the varieties Plum Yellow and Cherry Tomato significantly higher number of fruits. Similarly findings of Parveen *et al.* (2019) also observed that fruit setting percentage varied from 7.01%-48.14% under control conditions while under drought stress conditions it varied from 2.86%-43.85%.

Average Fruit weight: Average fruit weight was calculated by weighing of five fruits from each variety in control and water stress condition and averaging them. The data was presented in Table 2. In control result shows that the average fruit weight varied from a lower value of 46.6 gram in Suhana to a higher value of 71.6 gram in Plum Yellow variety. However the varieties F-1H Tomato and Suhana shows less average weight of fruit whereas the varieties Plum Yellow and Cherry Tomato shows significantly higher average weight of fruit in tomato germplasm. In water stress condition, result shows that the average fruit weight varied from a lower value of 28.3 gram in variety Action-666 to a higher value of 48.3 gram in Cherry Tomato variety. However, Action-666 and Suhana has less average weight of fruits where as the varieties Plum Yellow and Cherry Tomato significantly higher average weight of fruits. Similar effects of drought stress on tomato fruit growth were reported by Sladjana *et al.* (2008). They mentioned that potential size of tomato fruit also depends on the rate of water accumulation since water may account for 95% of the total fresh weight.

Table 1: Mean Performance of Tomato Genotypes for Morphological Characters under Control and Drought Stress condition.

	Varieties	Plant Height(cm)		Number of flower per truss		Number of trusses per plant	
Sr. No.		Control	Treatment	Control	Treatment	Control	Treatment
1.	Plum Yellow	82	73	5.667	7.667	9.333	10.667
2.	Cherry Tomato	83	76	6	7.667	12.667	12.333
3.	TS-15	77.333	67.667	5	7	10	10
4.	Suhana	64	51	3.667	4	8	5
5.	F-1H Tomato	58	52	3.667	5	14	5.667
6.	S-22	56.333	51.333	3.667	4.333	6.333	5.333
7.	Action-666	58	50.667	2.333	4	5	4.333
	C.D.	7.812	9.549	1.956	2.162	4.683	2.955
	SE(m)	2.508	3.065	0.628	0.694	1.503	0.948
	SE(d)	3.546	4.335	0.888	0.981	2.126	1.341
	C.V.	6.352	8.813	25.34	21.209	27.894	21.56

Table 2: Mean Performance of Tomato Genotypes for Morphological Characters under Control and Drought Stress condition.

Sr. No.	Varieties	Number of fruit per plant		Average Fruit weight (grams)	
		Control	Treatment	Control	Treatment
1.	Plum Yellow	28.333	18	71.667	48.333
2.	Cherry Tomato	31.667	19	56.667	48.333
3.	TS-15	28.333	14	48.333	45
4.	Suhana	21.667	8.333	46.667	31.667
5.	F-1H Tomato	20	12	46.667	41.667
6.	S-22	15	10.667	51.667	33.333
7.	Action-666	11.667	7.667	55	28.333
	C.D.	5.942	3.338	14.86	13.644
	SE(m)	1.907	1.072	4.77	4.379
	SE(d)	2.697	1.515	6.746	6.194
	C.V.	14.76	14.489	15.353	19.192

Contrasting Images of Control and Drought Stress condition in different Tomato Genotypes

S-22 (Control and Treatment)

Cherry Tomato(Control and Treatment)

Plum Yellow (Control and Treatment)

TS-15 (Control and Treatment)

Action-666 (Control and Treatment)

F-1H Tomato (Control and Treatment)

Suhana (Control and Treatment)

CONCLUSION

The morphological characteristics of tomato genotypes under control and drought stress revealed substantial variance in all tomato genotypes. Different tomato genotypes demonstrated a reduction in growth characteristic, *i.e*. plant height, when subjected to drought stress. The least plant height decrease detected in Action-666 (50.6cm) and the largest plant height reduction observed in Cherry Tomato (76cm). The amount of flower clusters per plant, flowers per cluster, and fruits per plant are all strongly connected to output, making them economically significant characteristics. In all genotypes, all morphological features were found to be declining. However, under forced drought stress circumstances, the genotypes Action-666 demonstrated extremely low levels of decrease in these metrics.

FUTURE SCOPE

The tomato genome will need to be modified in the future using transgenic technologies and genome editing techniques to meet the demand for tomato fruit. It is widely known that modifying one or more tomato genes increased the plant's ability to withstand drought and stress. Additionally, in order to maintain sustainable tomato production, targeting the genes connected to the drought stress would not be sufficient since other abiotic stressors, such as salt, heat, and cold, also share water shortage owing to various physiological processes. In order to sustain tomato survival in unfavourable environmental circumstances and provide potential yield, numerous abiotic stressors should be tackled. A greater knowledge of the many molecular, biochemical, and metabolite(s) identities involved in various abiotic stressors is also required. In order to promote abiotic stress tolerance in tomatoes, a greater knowledge of the mechanisms behind tomato stress tolerance using metabolomics is necessary. The bulk of a pathway's proteins interact with the proteins of other pathways, making it difficult to manipulate metabolic pathways. Therefore, manipulating several genes of a single route or other interconnected pathways will be the only approach to manipulate metabolic pathways. While transgenic crops have been grown for more than two decades in the United States and for ten years in India without any adverse effects on people or the environment being noted, the journey of new genetically modified tomatoes to a farmer's field is not straightforward. The transgenic tomatoes have the ability to survive and produce under drought stress, but due to social, ethical, and political concerns, their adoption throughout the world is in doubt. Therefore, a thorough grasp of science, the mechanism behind transgenic activity, and all relevant research pertaining to the safety and harmlessness of transgenes are required. Therefore, there is an urgent need to increase knowledge of the advantages of transgenic crops among farmers and communities.

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