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Screening of tomato (*Solanum lycopersicum* L.) hybrids with their parents for various growth related parameters under drought stress

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Abstract
Worldwide, tomatoes are being cultivated in tropical and temperate regions under varied amount of precipitation. Water shortage affects the growth and production to a greater extent. Yield is reduced when the drought stress is observed at early vegetative and reproductive stages. Thus, the vital aim of plant breeding program is to enhance yield under drought stress. In this study screening of three tomato hybrids and their parents with a hybrid check, for drought stress has been carried out in Factorial completely randomized design (FCRD) with three replication and two levels of water application *i.e.*, 100 and 50 percent field capacity. Observations on growth and yield parameters were recorded. Among the hybrids, EC 177824 X LE 27 recorded highest number of flowers per truss (6.89 and 5.92), individual fruit weight (46.30 g and 44.83 g), number of fruits per plant (39.65 and 26.55) and yield per plant (1.84 kg and 1.18 kg) in both treatments (100% FC and 50% FC) and also recorded early flowering (23.67 days) and maximum root length (35.87 cm) under drought stress condition.

Keywords: Tomato, drought stress, root length and yield

Introduction
Tomato (*Solanum lycopersicum* L.) originated from Peru, Ecuador region is one of the most important warm season vegetable crop grown for its multifaceted use. Owing to its importance of nutritive value and as a remunerative crop it is being cultivated worldwide. Tomato requires irrigation frequently and is mostly cultivated in tropics and semi-arid condition where water deficit is of major problem. Drought is defined most simply as a period below normal precipitation limiting the plant productivity (Kramer and Boyer, 1995) [4]. At drought condition soil water availability to plant is decreased. Drought is the decisive factor affecting 40 to 60 percent of agricultural land in the world (Mollasadeghi *et al.,* 2011) [5]. Reduction of water content, decreased growth, closure of stomata, wilting and enlargement of cells in plants are characterized under water stress condition. Drought stress affects the physiological, morphological and genetic traits of tomato. At present, stress due to drought causes 70 percent yield reduction in crops and are considered as serious threat to sustainable food production. Owing to its complex nature, drought is considered as the supremely destructive when compared to all other stress (Gosal *et al.,* 2009) [3]. Therefore breeding of tomato for drought tolerance is of prime concern that would benefit the global market. The present study was conducted to screen the tomato hybrids with their parents for various growth and yield parameters under drought stress based on two different field capacity.

Materials and methods
The present study was carried out at college orchard, Department of vegetable crops, Tamil Nadu Agricultural University, Coimbatore located geographically 11° 02' North latitude, 77°03' East longitude and at an altitude of 426.6 m above mean sea level. The experiment was laid out in a factorial completely randomized design (FCRD) with three replications and two treatment *viz.,* 100% field capacity (FC) and 50% field capacity (FC). The hybrids *viz.,* EC 169966 X LE 118, EC177824 X LE118 and Arka Ashish X LE 27, parents viz., EC177824, LE 27, EC169966, LE118 and Arka Ashish with a check hybrid COTH-3 were taken for the study. Twenty five days old seedlings were transplanted to the pots. After fifteen days of transplanting, drought was imposed to the plants where 100% field capacity was maintained for control and 50% field capacity for treated pots. The plants were given with recommended fertilizers dose and also plant protection measures were taken regularly. The observations such as plant height, days to first flowering, root length, number of truss per plant, number of branches per plant, individual fruit weight, number of fruits per plant and yield per plant were recorded under control (100% FC) and drought stress (50% FC).

Result and Discussion

The plant height directly measures the growth of the plant. The cross Arka Ashish X LE 27 grown under normal condition recorded the maximum (102.67 cm) plant height whereas the cross EC 169966 X LE 118 grown under stress condition recorded the highest plant height of 83.38 cm. The parents, Arka Ashish and LE 27 observed the maximum plant height of 99.73 cm and 81.11 cm at 100% FC and 50% FC respectively. Plant height reduction under drought stress is associated with the loss in turgor that reduces the cell enlargement and leaf senescence thereby limiting the plant growth. The inhibition of cell elongation of plant might be due to the interruption of flow of water in the surrounding elongating cells of the xylem (Nonami, 1998) [6].

Early flowering is desirable for early yield. Early flowering was noticed under drought stress. Among the parents LE 118 observed early flowering in both 100% FC (27.89 days) and 50% FC (24.67 days). Lesser mean days (26.25 days) to first flowering was recorded in the cross Arka Ashish X LE 27 at non stress condition whereas the cross EC 1777824 X LE 27 recorded early flowering (23.67 days) at stress condition. The reproduction is a pivotal phenomenon that gets affected when the plants are at any stress condition. During the flower development an increase in water stress disturbs the reproduction of plants with long term and immediate effects (Srivastava *et al.,* 2012) [12]. This might be due to fasten the phenological development and to complete the life cycle under stress conditions. Higher root length was recorded in the cross EC 177824 X LE 27 under control (30.63 cm) and treated (35.87 cm) conditions whereas in the parents, LE 118 recorded the highest root length of 28.96 cm under 100% FC and the parent LE 27 recorded the maximum root length of 35.06 cm at 50% FC. Longer root length under stress was due to continuous cell elongation that helps to extract water in moisture stress condition. Plants to adjust drought stress develop the root faster than hypocotyls. Soil water potential is higher than that of leaf water potential, as osmotic pressure is increased by accumulation of solutes and thereby urges the root in search of water. The present study corroborates with the findings of Praveen (2017) [8] and Sivakumar (2013) [10].

The parent LE 118 recorded more number of branches per plant 20.00 and 16.24 at 100% and 50% FC respectively. While the cross EC 177824 X LE 27 observed the maximum number of branches per plant both at non stress (18.53) and stress (17.36) condition. The number of branches per plant under drought stress is lesser than that of control. The differences are due to the genetic composition and varied supply of water. Similar results were reported by Chavan (2007) [1] and Sharma (2017) [9].

Number of flowers per truss is observed maximum (5.78) for the parent LE 27 at normal condition and at stress condition the parent LE 118 recorded the highest (5.32). The cross EC 177824 X LE 27 recorded the maximum number of flowers per cluster at both 100% FC (6.89) and 50% FC (5.92). Results indicated that the reduction in number of flowers per cluster was observed under 50% FC as at prolonged water shortage, the sterility of flowers increases resulting in failure of flowering and fruiting in tomato (Farooq *et al.,* 2009) [2].

Under drought condition the cross Arka Ashish X LE 27 showed the maximum (20.00) number of clusters per plant and the parent LE 118 recorded the highest (16.00) number of flowers per cluster. Under control condition the cross EC 169966 X LE 118 recorded the highest (29.00) and the parent EC 177824 recorded the maximum (24.21) number of flowers per cluster. Due to shorter canopy, the number of cluster per plant is less in drought stress compared to that of control. These results are in line with Chavan (2007) [1].

The maximum individual fruit weight for the parent was recorded in EC 177824 both under stress (37.25 g) and non-stress condition (38.54 g) and for the crosses, EC 177824 X LE 27 recorded the highest individual fruit weight of 46.30g and 44.83g at 100% FC and 50% FC respectively. Individual fruit weight are higher in control compared to that of drought condition, as the plant water content decreases under stress condition and in turn disturbs the properties of leaf gas exchange limiting both the source size and activity *i.e.* photosynthesis and sink size and activity *i.e.* fruits (Sivakumar *et al.,* 2014) [11].

Highest number of fruits per plant was observed for the cross EC 177824 X LE 27 under both non- stress (39.65) and stress (26.55) condition. The parent LE 118 recorded the maximum number of fruits per plant at both 100% FC (38.58) and 50% FC (26.33). The results showed that drought stress caused reduction in number of fruits per plant due to the low radiation load and stomatal closure that in turn affects the photosynthetic activity. Similar results were given by Sivakumar *et al*., (2014) [11].

The yield per plant was found to be highest in the parent EC 177824 at 100% FC (1.31 kg) and at 50% FC (0.72 kg). The cross EC 177824 X LE 27, showed the maximum yield per plant under both non-stress (1.84 kg) and stress (1.18 kg) condition. The decrease in number of fruit and fruit weight had a direct influence on yield reduction at drought stress. The prolonged water stress in tomato is responsible for yield loss as it reduces the photosynthetic rate by stomata closure and affects its metabolism. Similar results are obtained by Sivakumar *et al.* (2014) [11] and Prakash *et al.* (2019) [7, 12].

Table 1: *Per se* performances for plant height (cm), days to first flowering and root length (cm) of tomato hybrids and parents under non-stress and drought stress condition

Treatments	Parent & Hybrid	Plant height (cm)			Days to flowering first flowering			Root length (cm)		
		100% FC	50% FC	Mean	100% FC	50% FC	Mean	100% FC	50% FC	Mean
T_1	EC 177824	89.89	76.44	83.16	28.00	25.33	26.67	28.26	33.85	31.06
T_2	LE 27	91.11	81.11	86.11	29.33	25.00	27.17	27.36	35.06	31.21
T_3	EC 169966	87.56	77.33	82.44	31.25	27.56	29.40	24.89	28.53	26.71
T_4	LE 118	95.56	79.33	87.44	27.89	24.67	26.28	28.96	34.85	32.74
T_5	Arka Ashish	99.73	79.38	87.44	29.11	26.22	27.67	26.33	31.26	28.80
T_6	EC 169966 X LE 118	92.11	83.38	87.74	30.11	26.21	28.73	27.96	30.36	29.16
T_7	EC 177824 X LE27	96.50	78.33	87.92	27.33	23.67	25.50	30.63	35.87	32.42
T_8	Arka Ashish X LE 27	102.67	82.88	92.78	26.25	25.63	25.94	27.25	32.64	29.95
T_9	COTH 3	94.89	79.38	87.14	28.89	27.08	27.99	25.89	31.98	28.94
Mean	Parents	92.77	78.72	85.32	29.12	25.76	27.44	27.16	32.71	29.94
	Hybrids	97.09	81.53	89.31	27.90	25.17	26.53	28.61	32.96	30.79
		G	I	G X I	G	I	G X I	G	I	G X I

SE	1.57	0.74	2.22	0.49	0.23	0.69	0.55	0.26	0.78
CD	3.19*	1.50*	4.51*	1.00*	0.47*	1.41*	1.12*	0.53*	1.58*

Table 2: *Per se* performances for number of branches per plant, number of flowers per cluster and number of cluster per plant of tomato hybrids and parents under non-stress and drought stress condition

Treatments	Parents & Hybrids	Number of branches per plant			Number of flowers per truss			Number of clusters per plant		
		100% FC	50% FC	Mean	100% FC	50% FC	Mean	100% FC	50% FC	Mean
T_1	EC 177824	15.26	13.06	14.16	5.27	4.76	5.02	24.21	14.23	19.22
T_2	LE 27	18.00	15.32	16.66	5.78	5.13	5.45	20.32	13.33	16.83
T_3	EC 169966	16.70	14.00	15.35	4.56	4.13	4.34	22.23	15.00	18.62
T_4	LE 118	20.00	16.24	18.12	5.36	5.32	5.34	19.39	16.00	17.70
T_5	Arka Ashish	13.30	12.31	12.81	5.13	4.39	4.76	22.77	15.03	18.90
T_6	EC 169966 X LE 118	17.80	15.47	16.64	5.52	5.11	5.32	26.00	18.20	22.10
T_7	EC 177824 X LE27	18.55	17.36	16.64	6.89	5.92	6.40	29.00	19.10	24.05
T_8	Arka Ashish X LE 27	16.32	15.36	15.84	5.23	4.87	5.05	27.78	20.00	23.89
T_9	COTH 3	17.69	14.69	16.19	5.21	4.21	4.71	24.63	16.38	20.505
Mean	Parents	16.65	14.19	15.42	5.22	4.75	4.98	21.78	14.72	18.25
	Hybrids	17.56	16.06	16.81	5.88	5.30	5.59	27.59	19.10	23.35
		G	I	G X I	G	I	G X I	G	I	G X I
SE		0.29	0.14	0.41	0.09	0.04	0.13	0.36	0.17	0.51
CD		0.59*	0.28*	0.84*	0.19*	0.09*	0.27*	0.73*	0.34*	1.03*

Table 3: *Per se* performances for individual fruit weight (g), number of fruits per plant and yield per plant (kg) of tomato hybrids and parents under non-stress and drought stress condition

Treatments	Parents & Hybrids	Individual fruit weight (g)			Number of fruits per plant			Yield per plant (kg)		
		100% FC	50% FC	Mean	100% FC	50% FC	Mean	100% FC	50% FC	Mean
T_1	EC 177824	38.54	37.25	37.90	33.89	19.36	26.63	1.31	0.72	1.02
T_2	LE 27	13.67	12.33	13.00	27.68	20.87	24.28	0.78	0.40	0.59
T_3	EC 169966	35.33	33.42	34.38	34.33	18.96	26.65	1.21	0.63	0.92
T_4	LE 118	13.17	11.33	12.25	38.58	26.33	32.46	0.81	0.43	0.62
T_5	Arka Ashish	37.17	36.00	36.59	31.30	19.68	25.49	1.16	0.71	0.94
T_6	EC 169966 X LE 118	41.95	39.67	40.81	36.88	24.32	30.60	1.55	0.96	1.26
T_7	EC 177824 X LE27	46.30	44.83	45.57	39.65	26.55	33.10	1.84	1.18	1.51
T_8	Arka Ashish X LE 27	40.33	38.36	39.35	33.87	23.69	28.78	1.37	0.91	1.14
T_9	COTH 3	42.35	40.35	41.35	34.97	22.66	28.82	1.48	0.92	1.2
Mean	Parents	27.58	26.07	26.82	33.16	21.04	27.10	1.05	0.58	0.82
	Hybrids	42.86	40.95	41.91	36.80	24.85	30.83	1.58	1.02	1.30
		G	I	G X I	G	I	G X I	G	I	G X I
SE		0.58	0.28	0.83	0.52	0.24	0.73	0.02	0.01	0.03
CD		1.19*	0.56*	1.68	1.05*	0.50*	1.49*	0.04*	0.02*	0.05*

Conclusion

The present study revealed that there is a significant difference for all traits among the hybrids, irrigation level and their interaction. The results expressed the decreased value for all the traits under drought stress. Among the hybrids evaluated, the hybrid EC 177824 X LE 27 performed better for traits such as days to first flowering, root length, number of branches, number of flower cluster, individual fruit weight, number of fruits per plant and yield per plant whereas among the parents, LE 118 performed better for the traits such as days to first flowering, number of branches per plant, number of flowers per cluster, number of clusters per plant and number of fruits per plant. Hence the hybrid EC 177824 and the parent LE 118 are recommended for the further evaluation of drought tolerance.

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