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Screening of tomato genotypes for various morphological and yield parameters under controlled deficit irrigations in northern dry zone of Karnataka

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Abstract
Tomato is one of the most popular and widely grown vegetable crop in the world which ranks next to potato. Although tomato is generally grown under irrigated conditions, its cultivation as a rainfed crop has gained importance particularly in semi-arid regions. It has been established that, stress due to water deficit is a very important limiting factor at the initial phase of plant growth and establishment. Studies related to identification of suitable drought tolerant genotypes of tomato with the physiological understanding are limiting, hence, the present investigation was carried out to screen the tomato genotypes for various morphological parameters viz plant height, plant spread north to south and plant spread east to west, days to first flowering, days to 50% flowering, stem girth and yield potential by adopting simple field screenings with regulated levels of irrigation at two different stages of plant growth to know the effect of drought on tomato genotypes. The experiment was laid out in a factorial randomized block design with thirteen genotypes and two replications. Water stress was imposed two weeks after the transplanting to all the genotypes in two stress conditions viz the IW/CPE ratio of 0.40, 1.20 and farmers practice as control. Furrow irrigation was given when the pan evaporation reading reached 41.66 mm (1.20 IW/CPE ratio) and 125 mm (0.40 IW/CPE ratio) using V notch. Under moisture stress condition of 1.2 IW/CPE ratio the genotype, Arka Meghali had significantly higher yield (1.65 kg $plant^{-1}$ and 49.95 t ha^{-1}) and under the sever moisture stress of 0.4 IW/CPE ratio higher yield was noticed in the genotype EC 631962 (1.37 kg $plant^{-1}$ and 39.48 t ha^{-1}) and least yield was noticed in the susceptible genotype EC 608269 (0.66 kg $plant^{-1}$) at 0.4 IW/CPE ratio. Irrespective of the irrigation levels, EC 638519 had maximum number of fruits per plant. Genotypes EC 608362, EC 610652, EC 634394, EC 638519, EC 610661, EC 631962, Kashi Anupam and Pusa 120 performed better under drought conditions.

Keywords: tomato stress, deficit irrigation, morphological traits, yield, IW/CPE ratio

Introduction
Although tomato is generally grown under irrigated conditions, its cultivation as a rainfed crop has gained importance particularly in semi-arid regions. Drought affects both elongation and expansion growth, water deficit in the early stages of tomato showed a greater effect on reduction in plant height. There are several physiological, genetical and biochemical traits contributing to the drought tolerance in various agricultural/ horticultural crops. Plants which tolerate moderate stress at low tissue water potential may do so by virtue of several dehydration tolerance mechanisms like maintenance of membrane integrity, osmotic adjustment and chloroplast integrity. The present investigation was carried out to screen the tomato genotypes for various morphological parameters and yield potential by adopting simple field technique of two levels of irrigation water to cumulative pan evaporation ratio (IW/CPE ratio) along with control.

Materials and Methods
The experiment was conducted at the Biotechnology and Crop Improvement unit of Kittur Rani Channamma College of Horticulture, Arabhavi, is situated in northern dry zone of Karnataka at 16°15' north latitude, 75°45' east longitude and at an altitude of 612.03 meters above mean sea level. The experiments were laid out in a factorial randomized block design

with thirteen genotypes viz, 1) Arka Meghali, 2) EC 608362, 3) EC 610652, 4) EC 634394, 5) EC 638519, 6) EC 610661, 7) EC 631962, 8) EC 686550, 9) Kashi Anupam, 10) EC 686543, 11) EC 608269, 12) EC 686553, 13) PUSA 120, and two replications and with the spacing of 60cm x 60 cm by following all the recommended production practices. Water stress was imposed after two weeks of transplanting to all the genotypes in both the IW/CPE ratio of 0.40, 1.20 and farmers practice as control. Furrow irrigation was given when the pan evaporation reading reached 41.66 mm (1.20 IW/CPE ratio) and 125 mm (0.40 IW/CPE ratio) using V notch.

Results and Discussion

Plant height and stem girth are important characters of growth and development of the crop canopy. The tomato genotypes differed significantly for plant height and stem girth (Table 1) at all the growth phases under different irrigation levels, 0.4, 1.2 IW/CPE ratios and control. Both parameters decreased in 0.4 IW/CPE ratio compared to control, indicating the effect of moisture stress on the tomato genotypes. However, among the genotypes EC 638519 (58.66 cm), EC 610667, (82.23 cm) showed significantly maximum height at 45 and 90 DAT respectively, whereas, genotype Kashi Anupam (5.56 mm) and EC 608362 (8.01 mm) showed significantly maximum stem girth at 45 and 90 DAT, respectively. Among the genotypes, Kashi Anupam recorded significantly maximum stem girth at 0.4 IW/CPE ratio, on par with EC 610661 and minimum stem girth was recorded in the genotype EC 608269 at 45 DAT. During 90 DAT, significantly maximum stem girth was recorded in the genotype EC 608362, on par with the EC 610652, and minimum was recorded in the genotype EC 686543. The results indicate that EC 686543, EC 608269 show higher drought susceptibility. Thus, main stem had active role in translocating plant assimilates and help in increasing the sink capacity under drought (Mukesh, 2010) in tomato. The decrease in plant height and stem girth at 0.4 IW/CPE ratio was due to the development of water deficit in leaves during drought resulting in decline in leaf water potential, as well as reduction in both cell volume and cell turgor and was attributed to maintenance of higher cell volume. These results are in confirmity with finding of earlier workers who also reported that, the cell elongation of plants can be inhibited by interruption of water flow from the xylem to the surrounding elongating cells (Nonami, 1998) [7]. Drought caused impaired mitosis, cell elongation and expansion resulted in reduced growth and yield traits (Hussain *et al*., 2008) [4] in sunflower. Bhatt and Rao (2005) [1] reported that, the reduction in plant height was associated with a decline in the cell enlargement and more leaf senescence in *A. esculentus* under water stress. Water deficit in the early stages of tomato showed a greater effect on reduction in plant height as observed by Gladden *et al*. (2012) [3] in tomato.

Plant spread: highest north south plant spread was noticed in EC 610661 (64.52 cm^2) under severe stress of 0.4 IW/CPE ratio while minimu was exhibited by the genotype EC608269. There was 26.91 percent decrease in plant spread at 0.4 IW/CPE ratio over control. Arka meghali exhibited significantly higher East –west plant spread at 0.4 IW/CPE ratio over control. Number of branches is another important morphological character contributing for spread of canopy. Reduced canopy level under the water deficit is one of the important character which can be used for screening of any genotypes. Present investigation is in conformity with Mukesh (2007) [6]. Pubescence is another important character which can reduce the radiant heat load of leaves by increasing the reflection of the leaf surface. Increased pubescence was observed under stress in some species and cultivars. In the present investigation also, there was significant difference for the density of pubescence among genotypes and irrigation levels at both adaxial and abaxial surface (Table.2). Pubescence increase significantly at 0.4 IW/CPE ratio both on abaxial and adaxial surface indicating adaptive mechanism in tomato to water stress conditions. On abaxial surface of the leaf, maximum number of pubescence was noticed in the genotype EC 634 394 (237.06) at 0.4 IW/CPE ratio. Maximum per cent increase in number of pubescence in 0.4 IW/CPE ratio over the control was noticed in the Arka Meghali (78.40 %). but in case of selected as susceptible genotypes the per cent increase in number of pubescence was minimum in the genotype EC 686543 (21.18%), EC 686553 (24.28 %) and EC 686550 (38.45%). On adaxial surface of the leaf, genotype EC 634394 recorded significantly maximum number of pubescence (592.64), followed by EC 610652 (577.88). While, higher per cent increase at 0.4 IW/CPE ratio over control on adaxial leaf surface was noticed in the Arka Meghali followed by Pusa 120, EC 634394 and minimum per cent increase was seen in EC 686543, EC 68553. Pubescence count was more than eight times greater on the abaxial than adaxial leaf surface under the drought condition as reported by Ratnayak and Kincaid (2005) [9] in *Tinnevelly senna* and *Cassia agnustifolia*. The drought tolerance is attributed to reduced water loss through cuticular and stomatal transpiration, because hairs on the stems and leaves protect the stomata and cuticle to the direct contact of wind. These preclude water loss through transpiration.

Number of days taken for first flowering and 50 per cent flowering reduced significantly among genotypes as a stress level increased and early flowering was noticed at 0.4 IW/CPE ratio compared to control (Table 3). The genotype EC 638519 took maximum days for first flowering (29.93 days) followed by EC 610652 (28.97 days) and EC 610661 (28.87 days) and minimum days was noticed in the genotype EC 686553 (20.87 days) at 0.4 IW/CPE ratio. In case of control, the genotype EC 610661 took maximum number of days to first flowering (32.07 days) and minimum days were taken in the genotype EC 686543 (30.33 days). Among the genotypes, EC 638591 had taken significantly maximum days for 50 per cent flowering (38 days) followed by EC 610661 (37.33 days), EC 634394 (36.33 days) and minimum days to flowering was noticed in the genotype EC 608261 (28.67 days) at 0.4 IW/CPE ratio. In case of control the genotype EC 610661 took maximum number of days to first flowering (42.33 days) and minimum days were taken in the genotype EC 608269 (39.67 days). Present study is in conformity with the work conducted by Inga *et al.* who reported that, early flowering in arabidopsis, a common drought strategy that ensure plant survival under sever water deficit was associated strongly inferred plant fitness.

Significant difference for yield per plant and yield per hectare were noticed among the irrigation levels, genotypes and their interaction during both experimentation Significant yield reduction was noticed as irrigation frequency reduced and reduction was to the extent of 21.92 and 22.95 per cent, respectively (Table …). Data on yield per plant of selected genotypes for experimental trail during second phase at 0.4 IW/CPE ratio showed significantly maximum yield in the genotype EC 631962 (1.37 kg/plant) followed by Arka meghali and EC 634394 (1.33 kg/plant), EC 608362 (1.28 kg/plant) and minimum was recorded in the genotype EC 608269 (0.66 kg/plant).

Table 1: Plant height (cm) and stem girth (cm) as influenced by irrigation levels in tomato genotypes.

Sl. No.	Genotypes	Plant height at 45 DAT				Plant height at 90 DAT				Girth 45 DAT				Girth 90 DAT			
		IW/CPE ratio				IW/CPE ratio				IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean	Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	61.33	58.47	52.61	57.47	81.99	74.28	61.92	72.73	4.50	5.34	5.86	5.21	7.19	7.43	8.88	7.83
2	EC 608362	61.07	58.07	49.30	56.14	77.05	68.70	62.77	69.51	4.49	5.57	5.93	5.33	7.10	7.25	9.67	8.01
3	EC 610652	60.93	58.40	48.33	55.89	73.72	71.51	64.15	69.79	4.29	5.43	5.76	5.16	6.60	7.36	9.13	7.70
4	EC 634394	60.40	57.67	50.47	56.18	78.14	70.05	62.11	70.10	4.56	5.15	5.60	5.10	6.66	7.40	8.93	7.66
5	EC 638519	61.51	57.87	56.60	58.66	87.52	74.61	69.51	77.21	4.26	5.38	5.45	5.03	7.12	7.50	8.83	7.81
6	EC 610661	61.63	51.77	53.83	55.75	94.67	79.18	72.85	82.23	4.60	5.74	6.12	5.49	6.95	7.43	8.90	7.76
7	EC 631962	60.60	53.03	43.97	52.53	73.38	70.99	62.40	68.92	4.15	5.67	5.64	5.16	6.95	7.43	9.05	7.81
8	EC 686550	59.70	41.33	36.70	45.91	66.50	55.05	37.70	53.08	4.50	4.35	3.81	4.22	7.50	6.38	5.80	6.56
9	Kashi Anupam	61.80	56.23	47.23	55.09	79.20	72.69	63.58	71.82	4.83	5.68	6.16	5.56	7.06	7.00	8.12	7.39
10	EC 686543	60.07	39.90	36.07	45.34	71.37	53.46	36.10	53.64	4.52	4.08	3.74	4.17	7.36	6.53	5.10	6.33
11	EC 608269	58.83	40.30	32.17	43.77	69.99	52.91	34.61	52.50	4.21	3.99	3.63	3.95	7.06	6.37	5.34	6.26
12	EC 686553	58.57	40.70	32.53	43.93	71.19	48.44	35.99	51.87	4.35	4.12	3.64	4.04	6.62	6.28	5.30	6.07
13	PUSA 120	60.13	55.47	47.00	54.20	72.90	67.65	61.29	67.28	4.02	5.46	6.07	5.18	6.86	7.87	8.77	7.83
Mean		60.51	51.48	45.14	52.37	76.74	66.12	55.77	66.21	4.41	5.07	5.19	4.89	7.00	7.09	7.83	7.31
Range		61.80	58.47	56.60	58.66	94.67	79.18	72.85	82.23	4.83	5.74	6.16	5.56	7.50	7.87	9.67	8.01
		58.57	39.90	32.17	43.77	66.50	48.44	34.61	51.87	4.02	3.99	3.63	3.95	6.60	6.28	5.1	6.07
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes (G)		1.04		2.94		0.67		1.89		0.17		0.48		0.21		0.59	
Irrigation (I)		0.50		1.41		0.32		0.91		0.08		0.23		0.10		0.28	
G X I		1.81		5.09		1.16		3.28		0.29		0.83		0.36		1.02	

DAT = Days after transplanting **Control =** Farmers practice

Table 2: Plant spread (cm^2) and number of pubescence as influenced by irrigation levels in tomato genotypes.

Sl. No.	Genotypes	Plant Spread								Pubescence							
		North – South				East – West				Abaxial				Adaxial			
		IW/CPE ratio				IW/CPE ratio				IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean	Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	69.66	63.33	60.03	64.34	71.55	66.65	62.25	66.82	44.79	119.01	205.64	123.15	111.97	297.53	514.10	307.87
2	EC 608362	69.60	62.31	57.98	63.29	74.71	65.04	58.98	66.25	76.83	103.20	166.59	115.54	192.07	258.01	416.47	288.85
3	EC 610652	69.60	62.98	56.99	63.19	70.73	63.83	55.39	63.32	54.94	106.57	231.15	130.89	137.36	266.43	577.88	327.22
4	EC 634394	71.33	63.68	59.80	64.94	73.19	66.78	61.91	67.29	56.16	156.29	237.06	149.84	140.40	390.73	592.64	374.59
5	EC 638519	74.24	63.00	60.38	65.87	67.40	60.13	53.98	60.50	79.40	132.92	166.46	126.26	198.50	332.30	416.16	315.65
6	EC 610661	79.75	69.33	64.52	71.20	70.03	63.52	60.66	64.74	70.03	97.50	169.05	112.19	175.08	243.76	422.63	280.49
7	EC 631962	68.90	62.92	59.87	63.90	69.34	60.94	58.97	63.08	58.56	86.31	159.10	101.32	146.39	215.77	397.76	253.31
8	EC 686550	66.22	42.13	34.25	47.53	68.35	49.64	31.45	49.82	23.00	21.70	37.37	27.36	57.50	54.25	93.43	68.39
9	Kashi Anupam	70.29	63.87	59.12	64.43	73.47	66.08	61.08	66.88	72.58	84.91	148.05	101.85	181.46	212.28	370.13	254.62
10	EC 686543	72.05	41.99	33.92	49.32	67.94	49.84	35.78	51.19	27.81	32.19	35.28	31.76	69.53	80.48	88.21	79.40
11	EC 608269	64.09	39.46	30.43	44.66	69.00	48.31	33.33	50.21	20.51	32.35	47.90	33.58	51.28	80.87	119.74	83.96
12	EC 686553	69.85	39.19	34.66	47.90	69.45	44.40	31.27	48.37	46.14	52.80	60.94	53.29	115.35	132.00	152.34	133.23
13	PUSA 120	70.98	62.86	57.95	63.93	73.01	63.12	59.95	65.36	35.31	130.07	152.06	105.81	88.27	325.18	380.14	264.53
Mean		70.50	56.70	51.53	59.58	70.63	59.10	51.15	60.29	51.23	88.91	139.74	93.30	128.09	222.27	349.36	233.24
Range		79.75	69.33	64.52	71.20	74.71	66.78	62.25	67.29	79.40	156.29	237.06	149.84	198.50	390.73	592.64	374.59
		64.09	39.19	30.43	44.66	67.40	44.40	31.27	48.37	20.51	21.70	35.28	27.36	128.09	222.27	349.36	233.24
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes (G)		0.47		1.31		0.56		1.57		4.18		11.78		10.45		29.44	
Irrigation (I)		0.22		0.63		0.27		0.76		2.01		5.66		5.02		14.10	
G X I		0.81		2.27		0.97		2.72		7.24		20.40		18.11		51.00	

DAT = Days after transplanting **Control =** Farmers practice

Table 3: Days to first flowering., days to 50 per cent flowering and yield per plant and yield per hectare as influenced by irrigation levels in tomato genotypes.

Sl. No.	Genotypes	Days to first flowering				Days to 50% flowering				Yield/plant				Yield/ hectare			
		IW/CPE ratio				IW/CPE ratio				IW/CPE ratio				IW/CPE ratio			
		Control	1.2	0.4	Mean	Control	1.2	0.4	Mean	Control	1.2	0.4	Mean	Control	1.2	0.4	Mean
1	Arka Meghali	31.91	30.00	25.40	29.10	40.67	38.00	36.00	38.22	1.89	1.65	1.33	1.62	58.83	49.95	38.14	48.97
2	EC 608362	31.93	28.73	27.20	29.29	41.67	39.33	34.67	38.56	1.77	1.50	1.28	1.52	54.48	44.33	36.21	45.01
3	EC 610652	31.33	29.80	28.97	30.03	41.67	39.33	35.33	38.78	1.65	1.44	1.22	1.44	49.98	42.19	34.19	42.12
4	EC 634394	31.80	30.07	26.13	29.33	40.67	38.67	36.33	38.56	1.79	1.52	1.33	1.55	55.10	45.25	38.33	46.22
5	EC 638519	31.67	30.53	29.93	30.71	40.67	39.00	38.00	39.22	1.67	1.46	1.27	1.47	50.83	42.94	36.03	43.27
6	EC 610661	32.07	30.53	28.87	30.49	42.33	38.00	37.33	39.22	1.59	1.31	1.21	1.37	47.61	37.55	33.76	39.64
7	EC 631962	31.47	30.90	26.67	29.68	39.67	38.67	35.00	37.78	1.95	1.62	1.37	1.65	61.29	48.73	39.48	49.83
8	EC 686550	31.13	28.56	22.90	27.53	41.67	38.33	29.67	36.56	1.79	1.24	0.95	1.33	55.25	34.72	24.07	38.01
9	Kashi Anupam	31.80	29.53	25.93	29.09	42.00	38.00	35.00	38.33	1.66	1.39	1.24	1.43	50.48	40.55	34.98	42.01

10	EC 686543	30.33	27.91	21.17	26.47	39.67	36.67	30.00	35.44	1.69	1.21	0.82	1.24	51.33	33.74	19.25	34.77
11	EC 608269	30.60	27.03	21.63	26.42	39.67	37.00	28.67	35.11	1.62	1.22	0.66	1.17	48.75	33.99	13.41	32.05
12	EC 686553	30.73	27.87	20.87	26.49	40.00	36.00	29.67	35.22	1.64	1.20	0.70	1.18	49.49	33.32	14.70	32.50
13	PUSA 120	32.07	30.27	26.20	29.51	39.67	37.67	34.67	37.33	1.77	1.39	1.27	1.48	54.36	40.36	35.85	43.52
Mean		31.45	29.36	25.53	28.78	40.77	38.05	33.87	37.56	1.73	1.40	1.13	1.42	52.91	40.59	30.65	41.38
Range		32.07	30.90	29.93	30.71	42.33	39.33	38.00	39.22	1.95	1.65	1.37	1.65	61.3	49.95	39.48	49.83
		30.33	27.03	20.87	26.42	39.67	36.00	28.67	35.11	1.59	1.20	0.66	1.17	47.61	33.32	13.41	32.05
		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%		S.Em ±		CD @ 5%	
Genotypes (G)		0.25		0.70		0.70		1.96		0.04		0.1		1.29		3.64	
Irrigation (I)		0.52		1.46		0.33		0.94		0.02		0.05		0.62		1.75	
G X I		0.90		2.52		1.21		3.40		0.06		0.17		2.24		6.30	

DAT = Days after transplanting **Control =** Farmers practice

Conclusion

Under moisture stress condition of 1.2 IW/CPE ratio the genotype, Arka Meghali had significantly higher yield and under the sever moisture stress of 0.4 IW/CPE ratio higher yield was noticed in the genotype EC 631962 and least yield was noticed in the susceptible genotype EC 608269 at 0.4 IW/CPE ratio. Irrespective of the irrigation levels, EC 638519 had maximum number of fruits per plant. Genotypes EC 608362, EC 610652, EC 634394, EC 638519, EC 610661, EC 631962, Kashi Anupam and Pusa 120 performed better under drought conditions. These genotypes are confirmed once again and can be used in the hybridization programme as parents to incorporate the drought tolerant characters.

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