Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(3): 3199-3201
Received: 10-03-2019
Accepted: 12-04-2019

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Screening of tomato genotypes at various levels of salinity

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Abstract
The productivity of crop is severely affected by salinity which is more harmful to seed germination, plant growth and development. The present study aimed to evaluate the effect of salinity on germination, seedling characters and to find out the genetic salt tolerance or resistance cultivars during germination and seedling growth. In this study, germination percentage, seedling length, root length, shoot length, vigour index, salt tolerant index were assayed at three different salinity levels *viz*., 25mM NaCl, 50mM NaCl and 100mM NaCl and compared with control (0mM NaCl). The germination percentage and seedling growth were significantly reduced under high saline condition. The seedling length, root length, shoot length were also significantly reduced under saline stress situation. Among the 26 genotypes, *Solanum torvum*, EC-631349, BSBS12, EC-615065, EC-620554, EC-620429 and IC-631354 were found highly tolerant to saline condition which could be used as rootstock for produce saline tolerant grafting as well as developing saline tolerant/resistant hybrids.

Keywords: Tomato, salinity, germination, vigour index, salt tolerant index

Introduction
Vegetables are playing a major role in human nutrition. Among the vegetables tomato are one of the most important vegetable crops all over the world. The cultivated area worldwide has increased at about 25% during the last 10 years. Now-a-days salinity is one of the major abiotic stresses that reduce seed germination, plant growth and crop productivity which is also affects every aspect of vegetable crop development including their morphology, physiological function and yield (Colla *et al*., 2010) [4]. It consistently has the greatest impact in reducing the area of cultivated land, often due to inappropriate irrigation techniques. To increase productivity, there is a need to produce salt-tolerant crops, which can grow successfully on salt-affected lands. The improvement of salinity tolerance or resistance of vegetables via breeding programs has been limited due to its genetic and physiological complexity (Flowers, 2004) [7]. One of the most effective ways to overcome salinity problems is the introduction of salt tolerant varieties/hybrids. Keeping these points in view, the present investigation was undertaken to investigate the response of tomato genotypes to increase salinity levels during the germination and seedling emergence.

Materials and methods
The present investigation was conducted in the Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore Tamil Nadu, during the period 2016. In this study 25 genotypes of tomato were collected from NBPGR, New Delhi and *Solanum torvum* was collected from Tamil Nadu Agricultural University, Coimbatore which are used for this study. All the genotypes were evaluated under laboratory in Completely Randomized Block design. A total number of 25 seeds in each genotype was used for germination study. The salinity level was created by using NaCl in three different concentration viz., T1: control - 0mM (only distilled water used where no NaCl added), T2: 25mM NaCl, T3: 50mM NaCl, and T4: 100mM NaCl. The seeds were soaked in distilled water and in respective concentration of sodium chloride solution for 10 minutes. Then the solution was drained and the soaked seeds were used to conduct the germination test in the laboratory under roll towel method. Each genotype with three different concentrations of NaCl and in distilled water were rolled separately and kept in germination chamber (±20^{0}C with RH 80-85 per cent). The whole set up was replicated twice. Once in three days the solution and distilled water was poured on the respective roll towel. On the 14th day of experiment, germination (%), shoot length (cm), root length (cm), seedling length (cm), vigour index and salt tolerant index (%) were measured. The recorded data were analysed with two way analysis of variance using GLIM procedure of SAS (SAS, 1985) [11].

Result and discussion
Germination and seedling characters
The germination percentage, seedling length, shoot length and root length were significantly difference in all the treatments are given in Table 1. The germination percentage of tomato was highly influenced by salt stress at higher concentration (100mM of NaCl). The mean of germination percentage ranged from 10.00 to 52.50% (100mM of NaCl) and from 79.15 to 97.50% (control). The highest germination percentage was observed in the genotype *Solanum torvum*, EC-631349, BSBS12, EC-615065, EC-620554, EC-620429 and IC-631354 under 100mM NaCl treatment. This may be during germination under saline conditions, high osmotic pressure of saline water is created due to capillary rise leading to more salt density at seed depth than at lower soil profile which reduces time and rate of germination (Munns and Tester. 2008) [10]. Salt resistant seedling high salt concentration cause increased H_2O_2 content in both roots and leaves, hence salts should be removed to ensure proper growth and development (Maas. 1990) [9].

The mean of seedling length ranged from 5.75 to 17.79cm (100mM of NaCl) and from 12.56 to 25.37cm (control). The highest seedling length was observed in the genotype *Solanum torvum*, followed by IC-631354, EC-631349, EC-620554, EC-620429 and EC-615065 under 100mM NaCl treatment. The seedling growth of salinized plant is limited predominantly by osmotic stress in species and genotypes having a low salt uptake rate. The similar results were obtained by Adams (1991) [1] in tomato.

The highest shoot and root length was observed in *Solanum torvum* followed by EC631349 under 100mM NaCl treatment. Root and shoot lengths are the important traits to be given consideration under any abiotic stress condition. In general a variety with longer root growth has ability to withstand the salinity. Both root and shoot lengths were reduced with increased NaCl concentration but roots were more damaged, with an increase in number of later roots and increases its thickness compared to shoots (Colla *et al*., 2010) [4]. Generally salinity affects plant growth by imposing both osmotic and ionic stresses (Castillo *et al*., 2007) [3]. Osmotic balance disturbed by high concentrations of NaCl which leads to physiological drought, thus decreasing plant water uptake and stomatal aperture, further leading to transpiration inhibition (Munns and Tester, 2008) [10]. In consequence, the plant is responding similarly to drought stress with regard to ionic stress, impairment is nutrient uptake and nutrient imbalance in salt stressed plants is widely reported in the literature (Flowers & Flowers, 2005) [6].

Table 1: Variation in germination and seedling characters of tomato genotypes to different levels of salinity

Germplasm	Germination %				Seedling length (cm)				Root length (cm)				Shoot length (cm)			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
SR6525	90.50	73.50	66.50	14.50	20.47	18.57	16.17	13.89	15.53	14.78	13.68	11.73	5.94	3.79	2.49	2.16
BSBS-122	96.50	85.15	77.00	50.15	21.29	18.03	15.63	13.35	14.47	13.72	12.62	10.67	6.46	4.31	3.01	2.68
BSS-144	91.50	81.50	70.50	15.50	15.90	13.00	10.60	8.32	9.53	8.78	7.68	5.73	6.37	4.22	2.92	2.59
BSS-58	89.50	60.50	50.50	14.00	15.37	12.47	10.07	7.79	9.20	8.45	7.35	5.40	6.17	4.02	2.72	2.39
KARS-425	82.50	68.50	47.75	10.00	16.10	13.20	10.80	8.52	9.95	9.20	8.10	6.15	6.15	4.00	2.70	2.37
EC620554	97.00	89.15	65.50	49.50	20.66	17.76	15.36	12.96	13.66	12.91	11.81	9.86	7.00	4.85	3.55	3.22
EC620560	93.50	87.50	61.50	14.50	19.85	16.95	14.55	12.27	13.30	12.55	11.45	9.50	6.55	4.40	3.10	2.77
EC617058	87.50	71.50	48.30	10.00	12.56	9.66	7.26	4.98	6.80	6.05	4.95	3.00	5.76	3.61	2.31	1.98
EC620570	96.50	88.50	69.50	50.75	14.50	11.60	9.20	6.92	8.16	7.41	6.31	4.36	6.34	4.19	2.89	2.56
EC620572	84.50	68.50	39.50	15.50	20.95	18.05	15.65	13.37	14.76	14.01	12.91	10.96	6.19	4.04	2.74	2.41
EC620568	88.15	71.00	42.25	10.00	19.44	16.54	14.14	11.86	13.04	12.29	11.19	9.24	6.40	4.25	2.95	2.62
EC620477	88.25	69.50	40.50	12.50	23.47	20.57	18.17	11.89	16.20	15.45	14.35	12.40	7.27	5.12	3.82	3.49
EC620464	86.15	50.50	35.50	15.00	20.54	17.64	15.24	8.79	13.42	12.67	11.57	9.62	7.12	4.97	3.67	3.34
EC615065	97.00	85.15	76.15	49.75	16.37	13.47	11.07	13.08	9.67	8.92	7.82	5.87	6.70	4.55	3.25	2.92
EC615066	79.15	50.15	35.25	10.00	15.33	12.43	10.03	7.75	9.82	9.07	7.97	6.02	5.51	3.36	2.06	1.73
EC616821	84.25	62.00	45.25	12.00	15.55	12.65	10.25	7.97	9.73	8.98	7.88	5.93	5.82	3.67	2.37	2.04
EC617072	79.15	55.15	35.00	10.00	15.28	12.38	9.98	7.70	9.63	8.88	7.78	5.83	5.65	3.50	2.20	1.87
EC631447	85.15	65.15	23.50	14.50	13.33	10.43	8.03	5.75	5.55	4.80	3.70	1.75	7.78	5.63	4.33	4
EC625656	83.75	59.75	28.50	12.50	14.82	11.92	9.52	7.24	9.43	8.68	7.58	5.63	5.39	3.24	1.94	1.61
EC621496	88.25	60.05	31.50	10.00	15.68	12.78	10.38	8.10	8.60	7.85	6.75	4.80	7.08	4.93	3.63	3.3
EC620488	87.75	73.50	43.50	14.00	16.79	13.89	11.49	9.21	10.82	10.07	8.97	7.02	5.97	3.82	2.52	2.19
EC631354	97.00	81.50	68.50	41.50	18.44	15.54	13.14	10.86	12.40	11.65	10.55	8.60	6.04	3.89	2.59	2.26
EC631349	96.00	79.50	63.00	52.15	21.62	18.72	16.32	15.89	14.26	13.51	12.41	10.46	7.36	5.21	3.91	3.58
EC625653	90.15	60.00	50.50	14.50	18.10	15.20	12.80	10.52	11.18	10.43	9.33	7.38	6.92	4.77	3.47	3.14
EC620429	95.00	85.50	69.00	43.75	21.29	18.39	15.99	13.71	14.70	13.95	12.85	10.90	6.59	4.44	3.14	2.81
S torvum	97.00	84.75	65.50	52.50	25.23	22.33	19.93	17.79	17.23	16.48	15.38	13.43	8.00	5.85	4.55	4.22
Mean	89.68	71.83	51.92	23.81	17.79	15.16	12.76	10.40	6.48	4.33	3.03	2.70	11.96	10.82	9.72	7.77
Factors	T	G	GXT		T	G	GXT		T	G	GXT		T	G	GXT	
SEd	1.35	3.43	6.86		0.30	0.78	1.56		6.09	0.23	0.47		0.22	0.56	1.12	
CD (0.05)	2.65	6.76	13.56		0.60	1.53	3.07		0.18	0.47	0.94		0.44	1.11	2.22	

Vigour index and salt tolerant index
The Vigour index and Salt tolerant index were significantly difference in all the treatments are given in Table 2. The highest vigour index was observed in *Solanum torvum* followed by EC631349 under 100mM NaCl treatment. All the genotype treated with distilled water showed improved vigour index as compared to NaCl treated seeds which were due to increased shoot length and root length of seedling than seeds treated with NaCl. They are much more vigourous than the NaCl seeds. The results are in confirmation with Hajer *et al*., 2006 [8]. The vigour index was significantly affected by salinity stress which caused a greater adverse effect. Similar findings were reported in tomato by Al-Harbi *et al*., 2008 [2]. Salt tolerant index is a more stable character and can be considered as a useful tool to screen abiotic stress tolerance genotype (Dutta and Bera, 2008) [5], among the treatments 100mM NaCl the genotype *Solanum torvum* showed significantly higher mean values followed by EC631349 The

lowest Salt tolerant index was observed in EC617058. This might be due to higher germination percentage with elevated root and shoot length leading to higher vigour index.

Table 2: Variation in Vigour index and Salt tolerant index (%) of tomato genotypes to different levels of salinity

Germplasm	Vigour index				Salt tolerant index (%)			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
SR6525	1943.04	1364.90	1075.31	201.41	100.00	70.25	55.34	10.37
BSBS-122	2019.75	1535.25	1203.51	669.50	100.00	76.01	59.59	33.15
BSS-144	1454.85	1059.50	747.30	128.96	100.00	72.83	51.37	8.86
BSS-58	2270.62	1359.44	1013.54	249.06	100.00	59.87	44.64	10.97
KARS-425	1328.25	904.20	515.70	85.20	100.00	68.07	38.83	6.41
EC620554	2004.02	1583.30	1006.08	647.46	100.00	79.01	50.20	32.31
EC620560	1855.98	1483.13	894.83	177.92	100.00	79.91	48.21	9.59
EC617058	1099.00	690.69	350.66	49.80	100.00	62.85	31.91	4.53
EC620570	1399.25	1026.60	639.40	351.19	100.00	73.37	45.70	25.10
EC620572	1770.28	1236.43	618.18	207.24	100.00	69.84	34.92	11.71
EC620568	1713.64	1174.34	597.42	118.60	100.00	68.53	34.86	6.92
EC620477	2071.23	1429.62	735.89	198.63	100.00	69.02	35.53	9.59
EC620464	1769.52	890.82	541.02	194.40	100.00	50.34	30.57	10.99
EC615065	1587.89	1146.97	842.98	437.30	100.00	72.23	53.09	27.54
EC615066	1213.37	623.36	353.56	77.50	100.00	51.37	29.14	6.39
EC616821	1310.09	784.30	463.81	95.64	100.00	59.87	35.40	7.30
EC617072	1209.41	682.76	349.30	77.00	100.00	56.45	28.88	6.37
EC631447	1135.05	679.51	188.71	83.38	100.00	59.87	16.63	7.35
EC625656	1241.18	712.22	271.32	90.50	100.00	57.38	21.86	7.29
EC621496	1383.76	767.44	326.97	81.00	100.00	55.46	23.63	5.85
EC620488	1473.32	1020.92	499.82	128.94	100.00	69.29	33.92	8.75
EC631354	1788.68	1266.51	900.09	450.69	100.00	70.81	50.32	25.20
EC631349	2075.52	1488.24	1028.16	732.19	100.00	71.70	49.54	35.28
EC625653	1631.72	912.00	646.40	152.54	100.00	55.89	39.61	9.35
EC620429	2022.55	1572.35	1103.31	599.81	100.00	77.74	54.55	29.66
S torvum	2447.31	1892.47	1305.42	926.63	100.00	77.33	53.34	37.86
Mean	1662.27	1126.43	700.71	277.4	100.00	66.74	40.44	15.17
Factors	G	T	GXT		G	T	GXT	
SEd	23.29	59.38	118.774		1.32	3.38	6.67	
CD (0.05)	45.92	117.07	234.18		2.62	6.68	13.36	

Conclusion

In this study, concluded that the *Solanum torvum* followed by IC-631354, EC-631349, EC-620554, EC-620429 and EC-615065 under 100mM NaCl treatment were found to be high saline tolerant genotype. The salt tolerant tomato genotype identified for their field appraisal. Such a tolerant genotypes can be utilize for further breeding programs for developing superior variety/hybrids or used as rootstock for produce saline tolerant grafted seedling under saline condition.

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