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PERFORMANCE OF TOMATO (*Lysopersicon esculentum*) GERMPLASMS GROWN IN BANGLADESH FOR SALINITY TOLERANCE

Md. Alamqir Siddiky[1)], Md. Shahabuddin[2)], Md. Mostafizur[1)] and Md. Khabir Uddin[1*)]

[1)] Department of Environmental Science, Jahangirnagar University, Dhaka 1342, Bangladesh
[2)] Soil Science Division, Bangladesh Agricultural Research Institute, Gazipur1701, Bangladesh
[*)] Corresponding author: E-mail: khabir88@yahoo.com

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ABSTRACT

A solution culture experiment was conducted to screen out a number of Bangladeshi tomato germplasms for salinity tolerance by giving up to 120 mM NaCl (salt stress). Salinity tolerance of tomato germplasms was evaluated with respect to severity of leaf symptoms, shoot and root dry matter production, shoot Na^+, K^+, Ca^{2+} accumulation and their respective ratio. The salinity tolerance scale ranges from 1.00 (most tolerant) to 3.50 (most sensitive). Based on the severity of leaf symptoms caused by the NaCl treatment "BT14 (BARI Tomato 14)" and "BHT5 (BARI Hybrid Tomato 5)" were found the most tolerant germplasms to salinity with score 1.0. Reduction of dry weight was found to be 19% (shoot) and 15% (root) in BT14 and BHT5, 30-76% (shoot) and 27-83% (root) in other germplasms when salinity was added. Higher correlation was found between salinity tolerance scale classes and the reduction of shoot/root dry weight, Na^+ concentration, K^+/Na^+, and Ca^{2+}/Na^+ ratios. Thus, "BT14" and "BHT5" can be regarded as a breeding material for development of new tomato varieties for tolerance to salinity.

Keywords: dry matter, ion concentration, NaCl, salt tolerance, tomato germplasms

INTRODUCTION

Vegetable is important for food security in Bangladesh. However, the availability of vegetable is only about 20 percent of the recommended requirement of 200 g/person/day. Tomato is one of the most important horticultural crops in the world including Bangladesh. Average tomato production in the world is 26.29 t/ ha, while it is 6.46 t/ha in Bangladesh (FAO, 2011).

Salinity is a significant problem affecting agriculture worldwide, including Bangladesh, resulting in substantial loss in crop yield. In Bangladesh, coastal areas are about 2.86 million ha covered by 30 % of the total crop land of the country. Of this, nearly 1.056 million ha cultivable lands are affected by varying degrees of salinity and 75% cultivated land (very low to moderate salinity) have scope for successful crop production (SRDI, 2010). Increasing evidence suggests that plant species and varieties vary greatly in their resistance to salinity (Ashraf and Foolad, 2007). The tomato plant is moderately tolerant to salinity stress (Ayers and Westcot, 1989) although this sensitivity is dependent on the cultivar (Cramer *et al*., 1994).

Plant breeding methods are time consuming, slow processing, laborious, costly, and rely on existing genetic variability. The use of physiological selection criteria can improve the probability of success by making empirical selection more efficient (Noble and Rogers, 1992). In this context, screening at earlier stage is an easier method to determine salt tolerant genotypes. The present study was undertaken to screen out the salt tolerant tomato germplasms.

MATERIALS AND METHODS

This experiment was carried out in a Solution culture at the Hydroponic Culture House of Horticulture Research Centre, BARI, Gazipur, Bangladesh in winter season of 2010. Sixteen tomato germplasms were used as plant material (Table 1). Seeds were germinated and seedlings were grown in water for 7 days and tomato seedlings at the second true leaf stage

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were transferred to other plastic containers containing half-Hoagland solution (sixteen plants, one for each germplasm per container) for 19 days. Nutrient solution was renewed at weekly interval throughout the growing period. When the plants were at the fifth-true leaf stage, salt treatment was initiated by adding NaCl to the culture solution. The experiment was carried out in a completely randomized design with 3 replications. Three plants were used per genotype in each replication. The concentration of NaCl was gradually elevated at 20 mM increment every other day and on day 30; finally NaCl concentration had been reached to 120 mM NaCl. The plants were grown for 10 days under 120 mM salt stress condition. A set of control plants was simultaneously grown in non-salinized solution. Fifty-five-day old plants were classified for their salt tolerance by the visual appearance. Plants were rated for severity of salt susceptibility by 0-4 scale (Figure 1). The scale was (0) normal green plants with fully expanded leaves; (1) green leaves with slight inward curly and dry leaves; (2) dry leaves from moderate to severe damage; (3) most leaves with drying damage; (4) all leaves of the plant with drying damage (Dasgan *et al.,* 2002). After scale scoring, the plants were harvested and separated into shoots and roots dried at 65 °C for 48 h and weighed. Dried plant samples were digested with wet oxidation method using nitric and perchloric acids. Na, K and Ca were measured with the flame photometer (Sherwood, M410, Scientific Limited). Data were analyzed using MSTAT-C (version 2.1, Michigan State University, 1991). Duncan's Multiple Range Test (DMRT) was performed to identify any significant difference among treatment means.

RESULTS AND DISCUSSION

Symptom score

The tomato germplasms tested displayed a large variation in salt tolerance to treatments based on the visual appearance (Figure1). Among the sixteen germplasm screened, five (30.77%) were slightly affected and fell between scale classes 1.00 to 1.50, including BT14, BHTT5, BT7,BT2 and BHT4 (Table1). For the most tolerant germplasms BT14 and BHT5 (scale1), the plants were able to effectively tolerate the 120 mM NaC1 treatment, remained unaffected and appeared as healthy as the control plants. The remaining three germplasms were only slightly to mildly affected (score 1.25-1.50). Plants with scores between 1.50 to 2.75 showed mild tolerances to 120mM NaCl concentration.

Table 1. Leaf chlorosis and necrosis symptom score (0-4) of 16 tomato germplasms grown at 120 mM NaCl salinity

Germplasm	Status	Score
BT14 (BARI Tomato 14)	Approved variety	1.00 a
BHT5 (BARI Hybrid Tomato 5)	Approved Hybrid variety	1.00 a
BT7 (BARI Tomato 7)	Approved variety	1.25 ab
BT2 (BARI Tomato 2)	Approved variety	1.25 ab
BHT4 (BARI Hybrid Tomato 4)	Approved Hybrid variety	1.50 a-c
BT9 (BARI Tomato 9)	Approved variety	2.00 bc
BT8 (BARI Tomato 8)	Approved variety	2.00 bc
BT11 (BARI Tomato 11)	Approved variety	2.25 cd
BHT3 (BARI Hybrid Tomato 3)	Approved Hybrid variety	2.25 cd
BT3 (BARI Tomato 3)	Approved variety	2.50 de
WP7	Line	2.25 cd
C71	Line	2.50 de
C51	Line	2.50 de
WP2	Line	2.50 de
WP8	Line	2.75 d-f
BT4 (BARI Tomato 4)	Approved variety	3.50 g

Remarks: Means followed by the same letters are statistically not significant (Duncan's multiple range test, P=0.05)

Figure 1. The salinity scale classes used in the experiment. (0) normal plant; (1) slight; (2) mild (3) severe; (4) very severe (Dasgan *et al.,* 2002)

The most sensitive germplasm BT4 (score 3.50) suffered from severe wilting of leaves. The similar response was reported by Chookhampaeng *et al*. (2007). Oztekin and Tuzel, (2011) observed that screening of genotypes based on severity of symptoms at early stage of development and their dry matter production could be used as a tool to indicate genotypic variation to salt stress.

Dry matter production

Tomato germplasms showed insignificant control treatment in terms of shoot and root dry weight (Table 2). However, in 120 mM NaCl stress condition, shoot and root dry matter production was statistically significant ($p \leq 0.05$). Shoot and root DW of the tested germplasms BT14 and BHT5 showed reduction as much as 17.97%, 18.96% and 13.47%, 14.68%, respectively, followed by BT7, BT2 and BHT4 germplasms. In contrast, the most sensitive germplasm, BT4 (scale class 3.50) suffered from 75.65% and 82.86% reduction in shoot and root DW, respectively. However, significant relations were found between shoot-root dry weights and the salinity scale classes. Highly significant correlations were found between the percentage of reduction in shoot DW (with the scale classes r^2=0.945**, Figure 2a) and root DW (with the scale classes r^2=0.903**, Figure 2b). The relationship between salt tolerance, as indicated by scale classes and the percentage of reduction of plant biomass production were found to have significantly positive correlation, indicating that growth of tomato plants were highly dependent on salt tolerance. This correlation was contradictory to Dasgan *et al.* (2002) which may be due to large differences in growth potential of different geno-types.

Table 2. Shoot and root dry weight of tomato germplasms grown under saline condition.

Genotypes	Shoot DW (g/plant)			Root DW (g/plant)		
	Control	120 mM NaCl	% reduction in shoot DW	Control	120 mM NaCl	% reduction in root DW
BT14	3.84	3.15 a	17.97	2.45	2.12 a	13.47
BHT5	3.85	3.12 a	18.96	2.52	2.15 a	14.68
BT7	3.7	2.58 b	30.27	2.22	1.62 b	27.03
BT2	3.63	2.49 b	31.40	2.35	1.68 b	28.51
BHT4	3.69	2.45 b	33.60	2.15	1.46 b	32.09
BT9	3.62	1.74 c	51.93	2.00	1.10 c	45.00
BT8	3.73	1.79 c	52.01	2.10	1.09 c	48.10
BT11	3.59	1.64 cd	54.32	1.60	0.89 cd	44.38
BHT3	3.44	1.55 c-e	54.94	1.97	0.88 cd	55.33
BT3	3.57	1.54 c-e	56.86	1.55	0.86 d	44.52
WP7	3.72	1.49 c-e	59.95	1.75	0.78 de	55.43
C71	3.65	1.45 c-e	60.27	1.95	0.75 de	61.54
C51	3.68	1.33 c-f	63.86	1.91	0.67 d-f	64.92
WP2	3.55	1.27 c-f	64.23	1.08	0.48 ef	55.56
WP8	3.58	1.25 d-f	65.08	1.09	0.45 ef	58.72
BT4	3.08	0.75 g	75.65	1.05	0.18 g	82.86

Remarks: Means followed by the same letters are statistically not significant (Duncan's multiple range test, P=0.05)

Table 3. Different ion concentration in the shoot of the tomato germplasms

Germplasm	NaCl concentration									
	Control					120 mM				
	Na^+	K^+	Ca^{2+}	K^+/Na^+	Ca^{2+}/Na^+	Na^+	K^+	Ca^{2+}	K^+/Na^+	Ca^{2+}/Na^+
BT14	0.43	3.59c	3.30b	8.35 a	7.67a	1.11h	1.99a	1.28a	1.79a	1.15a
BHT5	0.53	4.37ab	4.00a	8.25 a	7.55a	1.05h	1.89a	1.23a	1.70a	1.11a
BT7	0.61	4.76a	3.89a	7.80 b	6.38b	1.25g	1.78b	1.19ab	1.42b	0.82b
BT2	0.65	5.03a	4.04a	7.75 b	6.21b	1.30g	1.76b	1.18ab	1.35b	0.78b
BHT4	0.68	5.00a	4.00a	7.35bc	5.88bc	1.45f	1.60c	0.90c	1.10bc	0.62bc
BT9	0.70	4.47ab	3.51b	6.38d	4.87c	1.48f	1.55c	0.89c	1.05c	0.60bc
BT8	0.63	3.98c	2.93c	6.32d	4.65cd	1.50f	1.43d	0.81cd	0.95c	0.54cd
BT11	0.57	3.60c	2.50d	6.31d	4.38cd	1.65e	1.40d	0.84c	0.85cd	0.5cd
BHT3	0.58	3.51c	2.41d	6.05de	4.15de	1.66e	1.20e	0.75d	0.72d	0.45d
BT3	0.47	2.81cd	1.93de	5.98 e	4.11de	1.69e	1.13e	0.71d	0.60d	0.42d
WP7	0.50	2.88cd	1.91de	5.75ef	3.85e	1.71e	0.94f	0.70d	0.50e	0.41d
C71	0.49	2.70d	1.85de	5.50ef	3.78e	1.85cd	0.89f	0.65e	0.48e	0.35e
C51	0.53	2.87cd	1.95de	5.41f	3.68e	1.86cd	0.73g	0.63e	0.39f	0.34e
WP2	0.46	2.42e	1.67e	5.27f	3.62ef	1.95c	0.56h	0.60e	0.30f	0.31e
WP8	0.48	2.51de	1.72e	5.22f	5.59ef	2.10b	0.61h	0.61e	0.29fg	0.29e
BT4	0.45	1.96f	1.58e	4.37g	3.52f	2.52a	0.63h	0.43f	0.25g	0.17f

Remarks: Means followed by the same letters are not statistically significant (Duncan's multiple range test, P=0.05

Ion concentration

When NaCl was not supplied the sensitive and tolerant germplasms had very similar Na$^+$ concentrations in shoot (Table 3). In comparison with the control plants, the tissues of salt-treated plants accumulated more Na$^+$ but less K$^+$ and Ca^{2+}, resulting in lowered K$^+$/Na$^+$ and Ca^{2+}/Na$^+$ ratio. Under salinity stress, the Na$^+$ concentration produced by all germplasms, was positively significant co-related (r=0.883*) with symptom scale classes (Figure 2e). On average, the K$^+$/Na$^+$ and Ca^{2+}/Na$^+$ ratio were very similar between sensitive and tolerant germplasms when NaCl was not supplied. The highest potassium contents at 120 mM salinity level had resulted in higher K$^+$/ Na$^+$ ratio in BT14 and BHT5, followed by BT7, BT2 and BHT4 germplasms, while the most sensitive germplasm BT4, these changes were always smaller. Similar trend of result was also found in Calcium content. The most tolerant and sensitive germplasms BT14, BHT5 and BT4 had Ca/Na ratio of 1.15, 1.11 and 0.17, respectively. However, the K^+/Na^+ and Ca^{2+}/Na^+ ratio showed very significantly negative correlation ($r=0.820^*$, Figure 2c and $r=0.898^*$, Figure 2c) with the salinity scale classes.

Characteristics like dry matter production, Na^+ accumulation, K^+/Na^+ ratio and Ca^{2+}/Na^+ ratio have been considered a useful guide to assess salt tolerance and selection of genotypes in saline soils (Santa-Maria and Epstein, 2001).

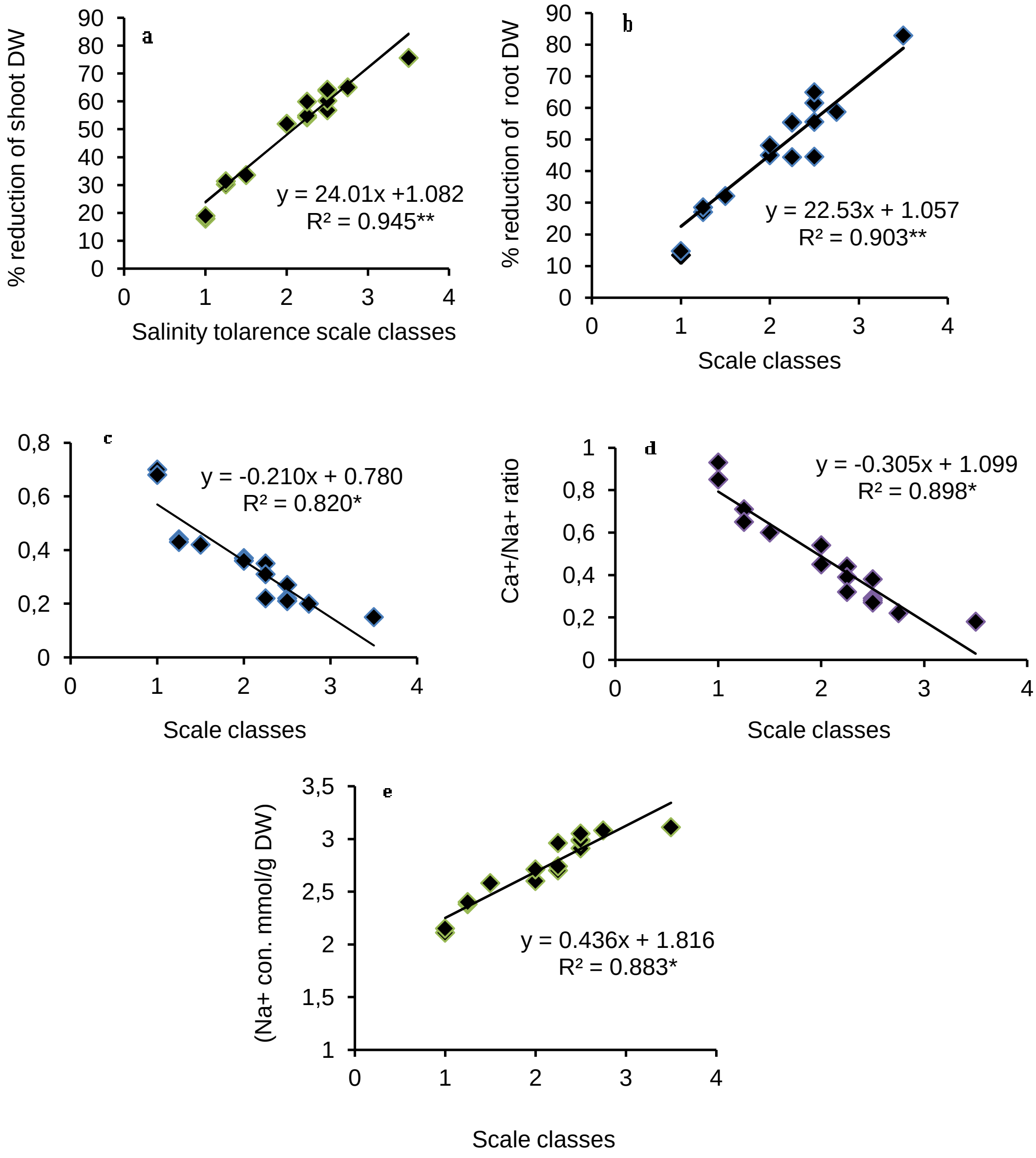

Figure 2. Relation between the salinity scale classes and (a) % reduction of shoot DW, (b) % reduction of root DW (c) K^+/Na^+ ratios, (d) Ca^{2+}/Na^+ ratio and (e) Na^+ concentration of the tomato germplasms grown under saline condition. n=16, *p=0.05 and *p=0.01. Increasing scale classes from 1-4 indicate increases in salt damages.

In high salinity, K^+/Na^+ and Ca^{2+}/Na^+ ratio were decreased from control but less decreased in BT14 and BHT5 germplasms (Table 3). Houshmand *et al*. (2005) conducted a study under salt stressed greenhouse condition test of eight wheat genotypes and it was found that the tolerant genotypes had higher shoot K^+/Na^+ than the sensitive ones. Strong correlation was found between shoot K^+/Na^+ and dry matter in plants treated with 150 mM NaCl (). When absorbed and accumulated at large amount in plants, Na^+ becomes highly toxic at different physiological levels. Physiological impairments caused by Na^+ toxicity include disruption of K^+ and Ca^{2+} nutrition, development of water stress and induction of oxidative cell damage. Therefore, maintenance of low Na^+ concentration by preventing Na^+ uptake or regulating Na^+ homeostasis in the cells by higher K^+/Na^+ ratio or sequestering Na ions in vacuole is the major strategies of plants against Na^+ stress (Zhu, 2001; Rengel, 1992).

CONCLUSION AND SUGGESTIONS

By screening 16 tomato, 2 germplasms; BHT5 (BARI Hybrid Tomato 5) and BT14 (BARI Tomato 14) reflected good performance under saline condition, and these germplasms can be used popularly in the saline zones of Bangladesh to have better production.

REFERENCES

Ashraf, M. and M.R. Foolad. 2007. Improving plant abiotic-stress resistance by exogenous application of osmo-protectants glycine betaine and proline. Environ. Exp. Bot. 59: 206–216.

Ayers, R.S. and D.W. Westcot.1989. Water Quality for Agriculture. FAO Irrigation and Drainage Paper 29, Rome.

Chookhampaeng, S., W. Pattanagul and P. Theerakulpisut. 2007. Screening some tomato commercial cultivars from Thiland for salinity tolerance. Asian J. Plant Sci. 6(5): 788-794.

Cramer, G.R., G.J. Alberico and C. Schmidt. 1994. Leaf expansion limits dry matter accumulation of salt stressed maize. Aust. J. Plant Physiol. 21: 663-674.

Dasgan, H. Y., H. Aktas, K. Abak and I. Cakmak. 2002. Determination of screening techniques to salt tolerance in tomatoes and investigation of genotype responses. Plant Science 163: 695-703.

F.A.O. 2011. Global network on integrated soil management for sustainable use of salt affected soils. Rome, Italy: FAO Land and Plant Nutr. Manag. Service. http://www.fao.org/ag/agl/agll/spush

Houshmand, S., A. Arzanib, S.A.M. Maibodyb and M. Feizi. 2005. Evaluation of salt-tolerant genotypes of durum wheat derived from *in vitro* and field experiments. Field Crop Res. 91: 345-354.

Noble, C.L. and M.E. Rogers. 1992. Arguments for the use of physiological criteria for improving the salt tolerance in crops. Plant Soil, 146: 99-107.

Oztekin, G.B. and Y. Tuzel. 2011. Comparative salinity responses among tomato Genotypes and rootstocks. Pak. J. Bot., 43(6): 2665-2672.

Rengel, Z. 1992. The role of calcium in salt toxicity. Plant and Cell Environ. 15: 625-632.

Santa-Maria, G.E. and E. Epstein. 2001. Potasium/sodium selectivityu in wheat and the amphiploid cross wheat × Lophophyrum elongatum. Plant Sci. 160: 523-534.

SRDI. 2010. Salinity of Bangladesh. Soil Resources and Development Institute. MoA, Government of People Republic of Bangladesh. December, 2010.

Zhu, J.K. 2001. Plant salt tolerance. Trends Plant Sci. 6: 66-71.