



Performance of Salt Tolerant Tomato (*Solanum lycopersicum* L.) Genotypes at Coastal Belt in Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. Authors NZ and MSRB planned the experiment and lead the research. Authors BB, MEH and NZ designed and carried out the research. Author MEH performed the statistical analysis. Authors BB, RA and AKMYH carried out the research on the field. Authors BB, MEH and RA collected the data. Authors MEH and AKMYH wrote the manuscript. Authors BB, RA and AKMYH managed the literature searches. All authors provided critical feedback and helped shape the research, analysis and manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted at Golgolia village, Debhata upazila under Satkhira District of Bangladesh during the period from November 2015 to March 2016. This study was conducted to identify salt tolerant genotypes by analyzing the agromorphogenic traits to identify the best salt

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tolerant genotypes in coastal belt of Bangladesh. During stressed condition, the plants became stunted, leaves showed chlorosis, fruits became smaller and gradually died. Large amounts of land in southern region of Bangladesh remain uncultivable due to high level of soil salinity. The salinity affected areas of Bangladesh are increasing rapidly. To overcome the salinity problem saline soils can be used to grow salt-tolerant plants. Thus development of salt tolerant crops is a key to agricultural goal. Thirty tomato genotypes were laid out and evaluated under field condition in Randomized Complete Block Design (RCBD) with three replications. Collected data were statistically analyzed using MSTAT-C computer package program. Yield contributing characters like number of cluster per plant was obtained maximum from genotype G8 (27.67/plant), maximum fruits per cluster from G25 (9.00/cluster), fruits per plant from G8 (195.67/plant). Yield per plant and yield per plot was found highest in genotype G27 (3.28 kg/plant & 29.56 kg/plot respectively). G27 genotypes could also be served as parent material for future hybridization or genetic transformation program in Bangladesh.

Keywords: Agromorphogenic; Bangladesh; salinity; tomato and yield.

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is a model species for genetics and genomic studies. It is a short-lived perennial plant, grown as an annual plant. The fruit is edible, colored (usually red) berry, 1-2 cm diameter in wild plants, commonly much larger in cultivated forms. It is botanically a berry, a subset of fruit and nutritionally categorized as a vegetable [1]. Though tomato genotypes have a dominant influence on the quality determinant properties, the environment in which tomato grows also has a significant impact on quality characters [1]. Nutritional importance of tomato is very amusing because of higher contents of vitamins A, B and C including calcium and carotene [2]. World production of fresh tomato for 2010 was about 141 million tons planted on 4.5 million hectares in 144 countries [3]. From 1996 to 2008 global consumption of tomatoes increased ~ 4.5% each year [4]. In 2009-10, tomato growing area was 58,854 acres and production was 190 thousand metric tons in Bangladesh [5]. The average tomato production in Bangladesh in 50-90 tons/ha [6]. At the present time, tomatoes are grown round the year and all over the country but yield of tomato is not enough satisfactory in comparison to the other tomato growing countries of the world. The causes of low yield of tomato in Bangladesh mainly improper irrigation facilities as well as production in abiotic stress conditions [7].

Bangladesh is one of the most climate vulnerable country in the world. Climate change accelerated the frequency and intensity of occurrences of salinity, storms, drought, irregular rainfall, high temperature, flash floods etc that resulted from global warming [7]. The coastal area covers about 20% of Bangladesh and over 30% of the

net cultivable area. The cultivable areas in coastal districts are affected with varying degrees of soil salinity. The coastal area of the Ganges delta in Bangladesh is characterized by tides and salinity from the Bay of Bengal. Salinity intrusion due to a reduction of fresh water flow from upstream, salinization of groundwater and fluctuation of soil salinity are the major concern of the coastal area of the country [8]. The higher salinity levels have adverse impacts on agriculture of coastal belt as well as southern part of Bangladesh [8]. The farming of tomato requires accurate quantity of water and this requirement can meet by applying irrigation. For high yield and good quality, the tomato needs a controlled supply of water throughout the growing period [9]. The effects of water stress on the growth and yield of tomato vary with the stage of crop growth during which stress occurs [10]. Combined effect of drought and salinity decreasing agricultural production by unavailability of fresh water or water stress [11]. Estimates of the effect of abiotic stress on global agriculture suggest that up to 70% of crop production is affected by environmental constraints [12,13].

Salinity is an increasingly important environmental constraint to crop production worldwide [14]. The deleterious effects of salinity on plant growth are associated with low osmotic potential of soil solution (water stress), nutritional imbalance, specific ion effect (salt stress) or a combination of these factors [15]. All of this cause adverse pleiotropic effects on plant growth and development at physiological and biochemical levels [16] and at the molecular level [17,18]. Tomato and other crops are sensitive to salt stress [19]. However, tomato production has been gradually extended into more marginal

lands, thus, exposing the crop to a greater risk of salt stress [19]. The quest for better tomato yielding varieties for the marginal areas continues to receive global attention with limited break-through in producing salt tolerant tomato cultivars [20]. Byari and Al-Maghrabi (1991) [21] found that tomato cultivars varied greatly in response to different salinity levels. Increasing NaCl concentration in nutrient solution adversely affected tomato shoot and roots, plant height, K^+ concentration, and K/Na ratio [22]. K^+ has been also considered often to play a role in osmotic stress and salt toxicity remediation, and some studies show inhibition of K^+ influx by NaCl in the cytosol. K^+ is an essential activator for some enzymes and Na^+ can rarely substitute for these biochemical functions [23,24]. Na^+ can compete directly with the K^+ on the binding sites and on the enzymes, suggesting that the cytosolic K^+ / Na^+ have a rapport which is critical for tolerance on rather than the absolute Na^+ concentration [25]. This study was conducted to identify salt tolerant genotypes in tomato by analyzing the agromorphogenic traits to identify the best salt tolerant genotypes at coastal belt in Bangladesh.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was accomplished in Golgolia village, Mouja-Golgolia, Ward-3, Debhata union of Debhataupazila under Satkhira district in the division of Khulna, Bangladesh during the period from November 2015 to March 2016. Location of the site in between 22°31' and 22°40' north latitudes and in between 88°55' and 89°07' east longitudes (Banglapedia: National Encyclopedia of Bangladesh) [26] with an elevation of 6 meter from sea level in Agro-ecological zone of "Ganges Tidal Floodplain" (AEZ-13) [27].

2.2 Experimental Frame Work

A total number of thirty genotypes of tomato were used in this experiment (Table 1a). The experiment was conducted to evaluate the performance of thirty tomato genotypes under real salinity condition. The experiment was laid out and evaluated under field condition during Rabi 2015-16 in Randomized Complete Block Design (RCBD) with three replications. The spacing was 40 cm × 60 cm. The number of plots was 90. Each plot was 2 × 1.5 m² in size. The number of seedling plot was nine and total numbers of seedlings were 810. The seedlings were transplanted on November 22 in 2015. Salinity status is presented in Table 1b.

2.3 Seed Bed Preparation and Raising of Seedlings

The sowing was carried out on October 22, 2015 in the seedbed. Before sowing, seeds were treated with Bavistin for 5 minutes. Seedlings of all genotypes were raised in seedbeds in the BADC farm, Sadarupazila of Satkhira district. 10 days old seedlings transferred to second seed bed for hardening. Seedlings were planted in rows spaced at 4 cm apart, beds were watered regularly. Seedlings were raised using regular nursery practices. Recommended cultural practices were taken up before and after sowing the seeds. When the seedlings become 30 days old, those were transplanted in the main field.

2.4 Land Preparation and Transplanting of Seedlings

The experimental plots were ploughed and brought into a fine tilth and raised the bed. Farm yard manures (FYM) and fertilizers were applied according to the recommendation dose (Table 2). Weeds and other stubbles were removed carefully from the experimental plot and leveled properly. The final land preparation was done on November 21, 2015. The seedlings were raised in the second seedbed in usual way and 30 days old seedlings were transplanted in the main field on November 22, 2015. The transplanted seedlings were watered regularly to make a firm relation with roots and soil to stand along.

2.5 Manure and Fertilizers Application

Total cow dung and Triple Super Phosphate (TSP) were applied in the field during final land preparation. Half Urea and half Muriate of Potash (MOP) were applied in the plot after three weeks of transplanting. Remaining Urea and Muriate of Potash (MOP) were applied after five weeks of transplanting. Doses of manure and fertilizers used in the study are presented in Table 2.

2.6 Data Recording

Five plants in each entry were selected randomly and were tagged. These tagged plants were used for recording observations for the following characters- days to first flowering, days to maturity, plant height (cm), number of cluster/plant, number of fruits per cluster, number of fruits per plant, average fruit weight/plant (g), shoot and root ratio, fruit yield per plant (kg), fruit yield per plot (kg) and fruit yield per hectare (Ton).

Table 1a. Name and source of collection of thirty tomato genotypes used in the study

Sl. No.	Genotypes no.	Materials used	Source of collection
1	G1	SL-001	Chairman, Advisory Committee, Dept. Of GEPB, SAU
2	G2	SL-002	
3	G3	SL-003	
4	G4	SL-004	
5	G5	SL-005	
6	G6	SL-006	
7	G7	SL-007	
8	G8	SL-008	
9	G9	SL-009	
10	G10	SL-010	
11	G11	SL-011	
12	G12	SL-012	
13	G13	SL-013	
14	G14	SL-014	
15	G15	SL-015	
16	G16	SL-016	
17	G17	SL-017	
18	G18	SL-018	
19	G19	SL-019	
20	G20	SL-020	
21	G21	SL-021	
22	G22	SL-022	
23	G23	BARI Tomato-15	PGRC
24	G24	BARI Tomato-14	
25	G25	BARI Tomato-11	
26	G26	BARI Tomato-9	
27	G27	BARI Tomato-8	
28	G28	BARI Tomato-7	
29	G29	BARI Tomato-3	
30	G30	BARI Tomato-2	

PGRC=Plant Genetic Resource Centre, BARI=Bangladesh Agricultural Research Institute

Table 1b. Recorded data of EC of the experimental field during October 2015 –March 2016

SL No.	Date of measuring	EC (dS/m)	Remarks
1.	20.10.2015	1.1	Before planting
2.	22.11.2015	3.34	Date of planting
3.	19.01.2016	4.32	Vegetative growth and flowering
4.	07.02.2016	4.69	Fruiting
5.	22.02.2016	4.70	Harvesting
6.	07.03.2016	6.20	Harvesting
7.	22.03.2016	8.83	Harvesting and uprooting

Table 2. Doses of manures and fertilizers used in the experimental field

Sl. No.	Fertilizers/ manures	Dose		Quantity /ha
		Applied in the one plot (2*1.5m ²)	Applied in 90 plots (2*1.5m ²)*90	
1.	Urea	0.165 kg	14.85 kg	550 kg
2.	TSP	0.135 kg	12.15 kg	450 kg
3.	MOP	0.075 kg	6.75 kg	250 kg
4.	Cow dung	3 kg	270 kg	10 ton

Source: Soil Resources Development Institute (SRDI) [28]

2.7 Statistical Analysis

Collected data were statistically analyzed using MSTAT-C computer package program. Mean for every treatments were calculated and analysis of variance for each character was performed by F-test (Variance Ratio). Difference between treatments was assessed by Least Significant Difference (LSD) test [29].

3. RESULTS AND DISCUSSION

3.1 Days to First Flowering

From the result of the experiment it was observed that statistically significant variation was found among the tomato genotypes in respect of days to first flowering from days after transplantation of tomato seedlings (Table 3). The longest period required (65.00 days) for flowering in G30 which was statistically identical with the genotypes G3 and G16 (64.33 days), G12, G26 and G28 (66.67 days) while shortest period in G18 (58.67 days) which was statistically identical with G19 and G22 (59.00 days) (Table 4).

3.2 Days to Maturity

From the result of the experiment it was observed that days to first fruit harvest from date of transplanting showed statistically significant variation among different tomato genotypes (Table 3). The longest period (91.33 days) was required for harvesting in G17 genotype which was statistically identical with G5, G15 (90.00 days) and G10 (89.67 days) whereas the shortest period (72.67 days) was required for G8 genotype (Table 4). Maturity time affects by salinity condition and other ions in the root zone of tomato plant [30,31].

3.3 Plant Height

It was observed from the result of the experiment that plant height showed statistically significant variation among thirty tomato genotypes (Table 3). The tallest plant was obtained from G19 (229.33 cm) which was statistically identical with genotypes G6 (223.50 cm), G18 (221.67 cm) and G19 (229.33 cm) whereas the shortest from G15 (84.33 cm) which was statistically identical with the genotype G14 (90.00 cm) (Table 4). Accumulation of Na⁺ and Cl⁻ and reduction in the uptake of macronutrients especially Na⁺ and Ca⁺ causing retardation in plant growth [32].

3.4 Number of Clusters per Plant

It was observed from the result of the experiment that number of clusters per plant showed statistically significant variation among thirty tomato genotypes (Table 3). The maximum number of clusters per plant (27.67/plant) was counted in G8 whereas the minimum number of clusters per plant (4.33/plant) was counted in G24 (Table 4). Higher levels of salinity decreased the number of cluster per plant in tomato [33,34].

3.5 Number of Fruits per Cluster

Number of fruits per cluster was significantly varied statistically among different tomato genotypes (Table 3). The maximum number of fruits per cluster (9.00/cluster) were obtained from G25 which was statistically identical with G18 and G23 (8.00/cluster) whereas the minimum fruits per cluster (2.67/cluster) was found in G10 which was statistically identical with G3 and G4 (3.00/cluster) (Table 5). Salinity reduces the fruit setting on trusses [35].

Table 3. Analysis of variance of thirteen agromorphogenic traits in tomato

SV	df	MS							
		DFF	DM	PH	NCP	NFC	NFP	YP	YPL
Replication	2	24.97	21.26	0.397	1.654	5.44	0.20	0.698	0.698
Genotype	29	742.76**	429.44**	12.243**	88.15**	98.93**	33.38**	10.935**	10.935**
Error	58	49.95	20.45	0.189	2.98	9.95	2.18	1.917	1.917
SV	df	MS							
		YTH	FL	FD	RL	SRR			
Replication	2	2.544	2.169	1.633	0.102	3.466			
Genotype	29	18.236**	20.922**	13.795**	0.855**	38.192**			
Error	58	2.078	3.24	4.465	0.143	7.047			

*Significant at 0.01 level of probability; SV= Source of variation; MS= Mean Square of; df= Degrees of freedom; DFF= Days to first flowering; PH= Plant height (cm); NCP= No. of cluster/plant; DM= Days to maturity; NFC= No. of fruits/cluster; NFP= No. of fruits/plant; YPL= Yield/plot (gm); YP= Yield/plant (kg); YTH= Yield ton/hectare; FL=Fruit length; FD=Fruit diameter; RL= Root length; SRR=Shoot length :Root length

Table 4. Mean performances of tomato genotypes on days to first flowering, plant height, days to maturity, no. of cluster per plant

Genotype	Days to first flowering	Days to maturity	Plant height	Cluster/ plant
G1	62.66	86.33	154.67	8.33
G2	63.00	85.00	146.67	13.00
G3	64.33	88.33	161.83	13.67
G4	62.67	82.00	196.17	11.67
G5	59.33	90.00	188.00	12.00
G6	63.33	85.66	223.50	9.33
G7	61.00	82.00	130.83	18.33
G8	63.33	72.66	202.33	27.67
G9	62.67	86.33	98.17	12.00
G10	61.00	89.66	188.33	10.00
G11	63.00	74.66	136.67	8.67
G12	64.67	83.00	113.17	18.67
G13	59.33	85.67	119.83	13.00
G14	63.00	82.67	90.00	11.33
G15	61.33	90.00	84.83	14.33
G16	64.33	86.00	162.17	14.67
G17	61.33	91.33	160.67	8.67
G18	58.67	73.67	221.67	8.67
G19	59.00	79.33	229.33	13.00
G20	59.33	76.67	216.67	7.33
G21	59.33	78.67	112.50	7.33
G22	59.00	79.00	91.33	6.00
G23	62.33	86.00	122.83	5.00
G24	63.00	85.67	104.17	4.33
G25	60.67	73.00	133.17	15.33
G26	64.67	86.00	168.83	6.33
G27	61.67	79.00	103.50	4.67
G28	64.67	86.00	121.50	6.00
G29	63.33	86.33	91.33	7.00
G30	65.00	85.67	99.00	7.00
CV %	9.38	8.35	12.3	10.30
LSD (0.05)	2.41	1.83	16.14	2.69

3.6 Number of Fruits per Plant

Number of fruits per plant was significantly varied statistically among different tomato genotypes (Table 3). The maximum number of fruits (195.67 /plant) was obtained from G8 genotype whereas the minimum number of fruits (21.67/plant) was found in G28 genotype (Table 5). The number of fruits per plant was restricted when the level of salinity in the root zone was 8 dS/m or higher [36].

3.7 Yield per Plant

Yield per plant was significantly varied statistically among different tomato genotypes (Table 3). The highest yield per plant (3.28 kg /plant) was obtained from G27 genotype which was statistically similar with genotype G28 (3.21 kg /plant), G21 (3.08 kg /plant), G26 (2.88 kg /plant) and G24 (2.83 kg /plant) whereas the

lowest yield per plant (0.42 kg/plant) was found in G3 genotype (Table 5). Growth and plant yield affected by salinity can be the reason of variation in photosynthetic products translocation toward root, decrease of plant top especially leaves, partial or total enclosed of stomata, direct effect of salt on photosynthesis system and ion imbalance [37].

3.8 Yield per Plot

Yield per plot was significantly varied statistically among different tomato genotypes (Table 3). The highest yield per plot (29.56 kg /plot) was obtained from G27 genotype which was statistically similar with genotype G28 (28.89 kg /plot), G21 (27.73 kg /plot), G26 (25.98 kg /plot) and G24 (25.50 kg /plot) whereas the lowest yield per plot (3.84 kg/plot) was found in G3 genotype (Table 5).

Table 5. Mean performances of tomato genotypes on no. of fruits per cluster, no. of fruits per plant, yield per plant, yield per plot and yield per hectare

Genotype	Fruits/cluster	Fruits/plant	Yield/plant	Yield/plot	Yield/hec.
G1	4.67	39.00	1.72	15.48	51.62
G2	3.33	43.67	1.52	13.64	45.49
G3	3.00	41.00	0.42	3.84	12.79
G4	3.00	35.00	1.134	10.26	34.19
G5	3.33	40.33	1.67	15.06	50.19
G6	5.67	53.33	1.31	11.78	39.25
G7	3.67	67.00	1.16	10.43	34.75
G8	7.00	195.67	2.04	18.34	61.15
G9	4.33	52.00	1.66	14.95	49.85
G10	2.67	27.00	1.44	12.92	43.07
G11	7.67	66.00	1.74	15.69	52.33
G12	3.67	67.67	1.71	15.39	51.29
G13	3.67	48.33	1.33	12.02	40.06
G14	3.67	41.67	1.73	15.59	51.96
G15	4.67	66.67	1.41	12.69	42.30
G16	4.00	59.00	1.38	12.38	41.27
G17	3.67	31.67	2.12	19.06	63.53
G18	8.00	69.00	1.65	14.86	49.53
G19	3.33	44.33	1.18	10.63	35.45
G20	5.67	41.33	1.87	16.82	56.08
G21	4.33	31.67	3.08	27.73	92.42
G22	5.00	29.33	1.46	13.13	43.78
G23	8.00	40.00	2.69	24.29	80.98
G24	7.00	30.33	2.83	25.50	85.01
G25	9.00	137.67	1.26	11.42	38.07
G26	6.33	40.00	2.88	25.98	86.59
G27	6.33	29.67	3.28	29.56	98.52
G28	3.67	21.67	3.21	28.89	96.29
G29	4.33	31.00	2.67	24.04	80.12
G30	4.33	30.00	2.63	23.63	78.76
CV %	11.54	8.9	10.8	10.82	10.82
LSD (0.05)	0.84	15.01	0.64	3.74	15.14

3.9 Yield per Hectare

Yield per hectare was significantly varied statistically among different tomato genotypes (Table 3). The highest yield per hectare (98.52 ton /ha) was obtained from G27 genotype which was statistically similar with genotype G28 (96.29 ton /ha), G21 (92.42 ton /ha), G26 (86.59 ton /ha) and G24 (85.01 ton /ha) whereas lowest yield per hectare (12.79 ton /ha) was found in G3 genotype (Table 5).

3.10 Average Fruit Length

It was observed from the result of the experiment that statistically significant variation was found for average fruit length among tomato genotypes (Table 3). The longest fruit (51.35 mm) was found from G27 tomato genotype which was statistically identical with G24 (50.39 mm) while

the shortest one found from G25 tomato genotype (24.65 mm) (Table 6).

3.11 Average Fruit Diameter

Statistically significant variation was recorded for fruit diameter among tomato genotypes (Table 3). The maximum diameter (53.53 mm) was obtained from G28 and the minimum (21.94 mm) was measured from G25 (Table 6).

3.12 Root Length

Statistically significant variation was recorded for root length amongtomato genotypes (Table 3). G20 tomato genotype provide the maximum root length (44.66 cm) which was identical with genotypes G28 (38.67 cm) and G10 (38.50 cm) while the minimum (24.17 cm) was obtained from G24 tomato genotype (Table 6).

Table 6. Mean performances of tomato genotypes on average length of fruit, average diameter of fruit, root length and shoot & root length ratio

Genotype	Length of fruit	Diameter of fruit	Root length	Shoot length : root length
G1	35.96	42.02	33.33	4.65
G2	43.14	43.84	34.16	4.33
G3	36.54	35.37	31.33	5.13
G4	42.39	44.89	31.17	6.21
G5	41.87	45.03	32.33	5.78
G6	39.84	43.93	35.33	6.34
G7	39.48	38.53	28.33	4.83
G8	35.56	36.47	31.33	6.55
G9	42.94	38.77	25.67	3.88
G10	41.95	45.70	38.50	4.93
G11	45.61	45.23	35.17	3.92
G12	46.68	42.83	32.50	3.49
G13	46.25	44.83	31.83	3.82
G14	46.18	46.13	31.33	2.92
G15	35.52	35.27	30.33	2.86
G16	35.98	41.32	30.83	5.30
G17	46.00	46.03	30.00	5.33
G18	38.07	44.35	34.00	6.49
G19	38.66	44.30	34.83	6.87
G20	36.02	40.60	44.66	4.97
G21	44.18	47.11	35.03	3.26
G22	36.15	45.57	33.17	2.79
G23	45.33	45.30	25.50	4.89
G24	50.39	49.58	24.17	4.39
G25	24.65	21.94	25.50	5.35
G26	42.01	43.53	37.17	4.56
G27	51.35	48.53	32.67	3.19
G28	45.38	53.53	38.67	3.35
G29	42.56	46.00	31.17	3.06
G30	44.93	49.90	30.17	3.29
CV %	10.78	15.33	15.36	9.77
LSD (0.05)	2.23	3.78	3.18	1.62

3.13 Shoot and Root Ratio

Statistically significant variation was recorded for shoot and root length ratio among tomato genotypes (Table 3). G19 tomato genotype provided the maximum shoot and root length ratio (6.87) while the minimum (2.79) was obtained from G22 tomato genotype which was statistically similar with G14 (2.92) and G15 (2.86) (Table 6).

4. CONCLUSION

Thirty tomato genotypes were used for the experiment. Randomized Complete Block Design (RCBD) with three replications were outlined for the experiment under Debhata Upazila. G27 genotype provided highest yield per plant as well as highest yield per hectare. For coastal region of Bangladesh, genotype G27 could be

recommended for cultivation. G27 genotypes could be served as parent material for future hybridization or genetic transformation program.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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