Research Paper *Published online: 31.01.2015, Vol. 03 (01): 15-27, 2015*

Effect of NaCl Salt on Vegetative Growth and Yield of Sixteen Tomato Lines

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Abstract

An experiment was conducted at the Sher-e-Bangla Agricultural University, Bangladesh to evaluate influence of salt (NaCl) on sixteen tomato lines. Sixteen lines coded from V_1 (Line-01) to V_{16} (Line-16) were executed under different NaCl salinity conditions (S_0: Control; S_1: 12dS/m and S_2: 16 dS/m) following completely randomized design with three replications. Apart from control, V_8 provided tallest plant in 12 dS/m (43.7 cm) and in 16 dS/m (38.4 cm) salinity level at 60 days after transplanting which was statistically similar with the V_9 tomato line. V_8 line provided the maximum number of leaves per plant except control (24.2 and 21.1 in 12 dS/m and 16 dS/m respectively). V_9 line produced maximum leaf area (123.7 cm^2 and 97.6 cm^2 in 12dS/m and 16 dS/m respectively) under saline conditions which was followed by V_8 line (112.7 cm^2 and 92.6 cm^2 in 12dS/m and 16 dS/m respectively). Maximum number of bunch per plant was observed from V_9 line (10.7 and 9.3 in 12 dS/m and 16 dS/m respectively) followed by V_8 line (9.3 and 9.3 in 12 dS/m and 16 dS/m respectively) except control. Maximum yield was found from V_9 line (0.923 kg/plant) followed by V_2 line (0.493 kg/plant) in 12 dS/m salinity level and maximum yield was found fromV_9 line (0.593 kg/plant) which was closely followed by V_8 line (0.407 kg/plant) in 16 dS/m salinity level. Tomato line-09 was found the best tomato cultivar for salt affected areas in Bangladesh.

Key words: *Tomato lines, salinity, growth and yield attributes*

I. Introduction

Tomato (*Solanum lycopersicum* L.) belongs to the *Solanaceae* family is one of the important vegetable in Bangladesh and total production is low as compared to total demand. Soil salinity causes significant reductions of crop growth and development (Ashraf and Wahed, 1993) also yield (Tavakkoli *et al*., 2011; Hajiboland *et al*., 2009). Large amounts of land in southern region of Bangladesh remain uncultivable due to high level of soil salinity. The affected areas of Bangladesh are increasing rapidly (SRDI, 2010). Two recent devastating cyclonic disaster 'Aila in 2009' and 'Sidr in 2007' and excavated flood control embankment has increased the level of salinity. Due to increasing salinity affected areas normal agricultural land use practices become more restricted thus production levels decreased (Rahman and Ahsan, 2001). To overcome the salinity problem saline soils can be used to grow salt-tolerant plants (Ashraf and McNeilly, 2004). Thus development of salt tolerant crops is a key global agricultural goal (Ghanem *et al*., 2011). Tomato plant is moderately tolerant to salinity stress (Foolad, 2004; Peralta *et al.*, 2005) and can tolerate salinity up to 2.5-2.9 dS/m in the root zone without yield losses (Sonneveld and Van der Burg, 1991) but exact salinity level may depending on cultivar sensitivity (Caro *et al*., 1991; Allen *et al.*, 1998) and environmental conditions (Karlberg *et al.*, 2006). Screening can be an easier method to determine salt tolerant genotypes. Considering above points, present study was to evaluate the ability of tomato lines under different saline conditions and screen out for salinity tolerant lines.

II. Materials and Methods

Experimental site and period: The experiment was conducted at Horticultural Farm, Sher-e-Bangla Agricultural University, Bangladesh during the months of November 2012 to March 2013.

Design and treatments of experiment: Sixteen tomato lines coded from V_1 (Line-1) to V_{16} (Line-16) were executed under different salinity levels (S_0: Control; S_1: 12dS/m and S_2: 16 dS/m) using completely randomized design with three replication. In this study, 12 dS/m and 16 dS/m salinity levels were used to screen out the suitable variety for the highly saline affected areas like S3 (salinity level ranged from 8.1-12.0 dS/m) and S4 (12.1-16.0 dS/m) regions in Bangladesh (SRDI, 2010).

Genetic materials: Tomato lines were collected from local home and abroad. Seeds were sown on the regular seedbed in 5^{th} October and seedlings were transplanted into pots on 4^{th} November.

Fertilizers: Firstly 4 square meter plot was prepared with 4 inches tilling depth and entire soil of that plot was weighted. Then Cowdung (10 t/ha), Urea (300 kg/ha), Triple Super Phosphate (200 kg/ha), Muriate of Potash (220 kg/ha) (Mondal *et al*., 2011) for 8 kg soil was calculated. The entire amount of organic manure, Triple Super Phosphate and half of the Muriate of Potash were applied during final soil preparation. The remaining half of MP and entire urea applied in three equal installments, 1^{st} at 15 days after planting, 2^{nd} at flowering and the 3^{rd} at fruit maturity stages.

Application of treatments: The pot was filled with 8kg soil having no salinity. Edible salt manufactured by Advanced Chemical Industries (ACI) Limited was used to create saline water. For the control plants were not exposed to salinity; whereas for the 12 dS/m and 16 dS/m salinity level 6.6 g ACI salt/L of water and 8.8 g ACI salt/L of water (the conversion rate was 1 dS/m = 0.55 g/L) were given to each pot respectively. Saline solutions were given in the plastic bowl which was placed under the pots.

Data collection: Data were collected on plant height, number of leaves, leaf area, chlorophyll content, number of bunch/plant, days to fruiting (*visual observation*), number of flower/plant, number of fruit/plant, single fruit weight and yield/plant. Electronic precision balance was used for measuring fruit weight and yield/plant respectively.

Statistical analysis: Collected data were statistically analyzed using MSTAT-C program and mean was calculated. Differences of means between treatments were evaluated by Least Significance Difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984).

III. Results

Plant height

Plant height of tomato cultivars varied significantly at different days after transplanting also at different salinity levels. It was found that V_4 provided the tallest (61.3 cm) plant in control whereas V_8 provided the tallest plant in 12 dS/m (43.7 cm) and 16 dS/m (38.4 cm) salinity level at 60 days after transplanting which was statistically similar with the V_9 (Figure 1).

Number of leaves

Leaves number of tomato cultivars varied significantly at different days after transplanting also at different salinity levels. It was found that V_8 provided the maximum number of leaves/plant (31.3, 24.2 and 21.1 in control, 12 dS/m and 16 dS/m respectively) at 60 days after transplanting which was statistically similar with the V_9 (Figure 2).

Leaf area

Leaf area was measured at 60 days after transplanting and showed significant differences among the variety at different salinity levels. In control, maximum leaf was produced by V_8 (180.8 cm^2) followed by V_3 (157.7 cm^2) while minimum from V_{11} (97.9 cm^2) (Table 1). On the other hand, V_9 provided maximum leaf area (123.7 cm^2 and 97.6 cm^2 in 12dS/m and 16 dS/m respectively) under saline conditions which was followed by V_8 (112.7 cm^2 and 92.6 cm^2 in 12dS/m and 16 dS/m respectively) (Table 1).

Chlorophyll content

Chlorophyll content was also measured at 60 days after transplanting and showed significant differences among the variety at different salinity levels. However maximum chlorophyll content was observed in V_4 (60.8%, 51.5% and 47.4% in control, 12 dS/m and 16 dS/m respectively) while minimum in V_9 (39.7%, 30.6% and 25.6% in control, 12 dS/m and 16 dS/m salinity level respectively) which was statistically similar with V_8 (40.7%, 31.3% and 25.8% in control, 12 dS/m and 16 dS/m salinity level respectively) (Table 1).

Table 1. Leaf area and chlorophyll content of tomato lines at different salinity level[x]

Lines	Leaf area (cm^2) at 60 DAT						Chlorophyll content (%) at 60 DAT					
	Control		12 dS/m		16 dS/m		Control		12 dS/m		16 dS/m	
V_1	109.9	h	85.9	f	72.7	de	46.8	efg	38.1	e	33.2	fgh
V_2	123.9	f	83.9	g	73.1	d	45.8	fgh	38.1	e	31.8	ghi
V_3	157.7	b	94.0	d	68.9	g	43.8	i	36.0	g	31.1	i
V_4	107.5	i	73.9	j	57.1	k	60.8	a	51.5	a	47.4	a
V_5	128.0	e	89.9	e	70.0	fg	49.1	c	41.9	c	37.9	c
V_6	128.1	e	91.1	e	80.2	c	58.8	b	49.5	b	43.7	b
V_7	106.9	i	59.9	k	54.5	l	47.9	cde	40.5	cd	35.8	de
V_8	180.8	a	112.7	b	92.7	b	40.7	j	31.3	h	26.8	j
V_9	144.7	c	123.7	a	97.6	a	39.7	j	30.6	h	25.6	j
V_{10}	121.1	g	72.1	j	61.0	j	47.0	ef	38.7	de	34.5	def
V_{11}	97.9	j	79.0	i	62.1	ij	44.2	hi	35.8	g	31.2	i
V_{12}	130.1	d	81.0	h	64.9	h	47.2	def	38.9	de	34.0	ef
V_{13}	130.8	d	84.6	fg	72.2	de	48.9	cd	40.8	c	36.3	cd
V_{14}	123.9	f	83.9	g	70.9	ef	46.4	efg	37.6	efg	33.4	fg
V_{15}	131.0	d	97.8	c	71.7	def	46.0	fgh	37.9	ef	32.7	fghi
V_{16}	111.0	h	85.6	fg	62.9	i	44.9	ghi	36.1	fg	31.3	hi
LSD0.01	1.9		1.9		1.9		1.9		1.9		1.9	
CV%	0.9		1.3		1.6		2.4		2.9		3.3	

[x]In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

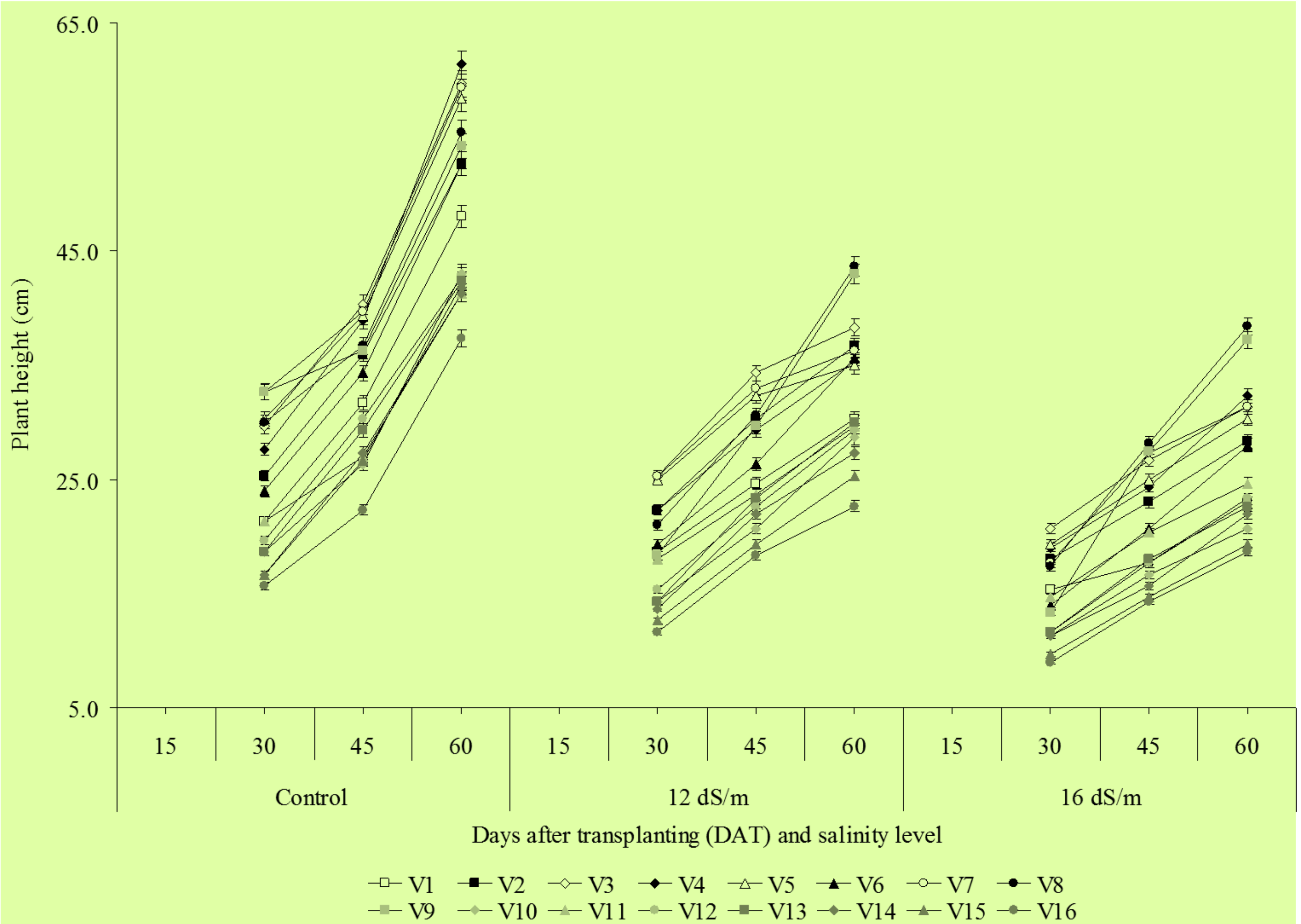

Figure 1. Response of 16 tomato varieties to plant height on 3 salinity levels at different days after transplanting

Research Paper Published online: 31.01.2015, Vol. 03 (01): 15-27, 2015

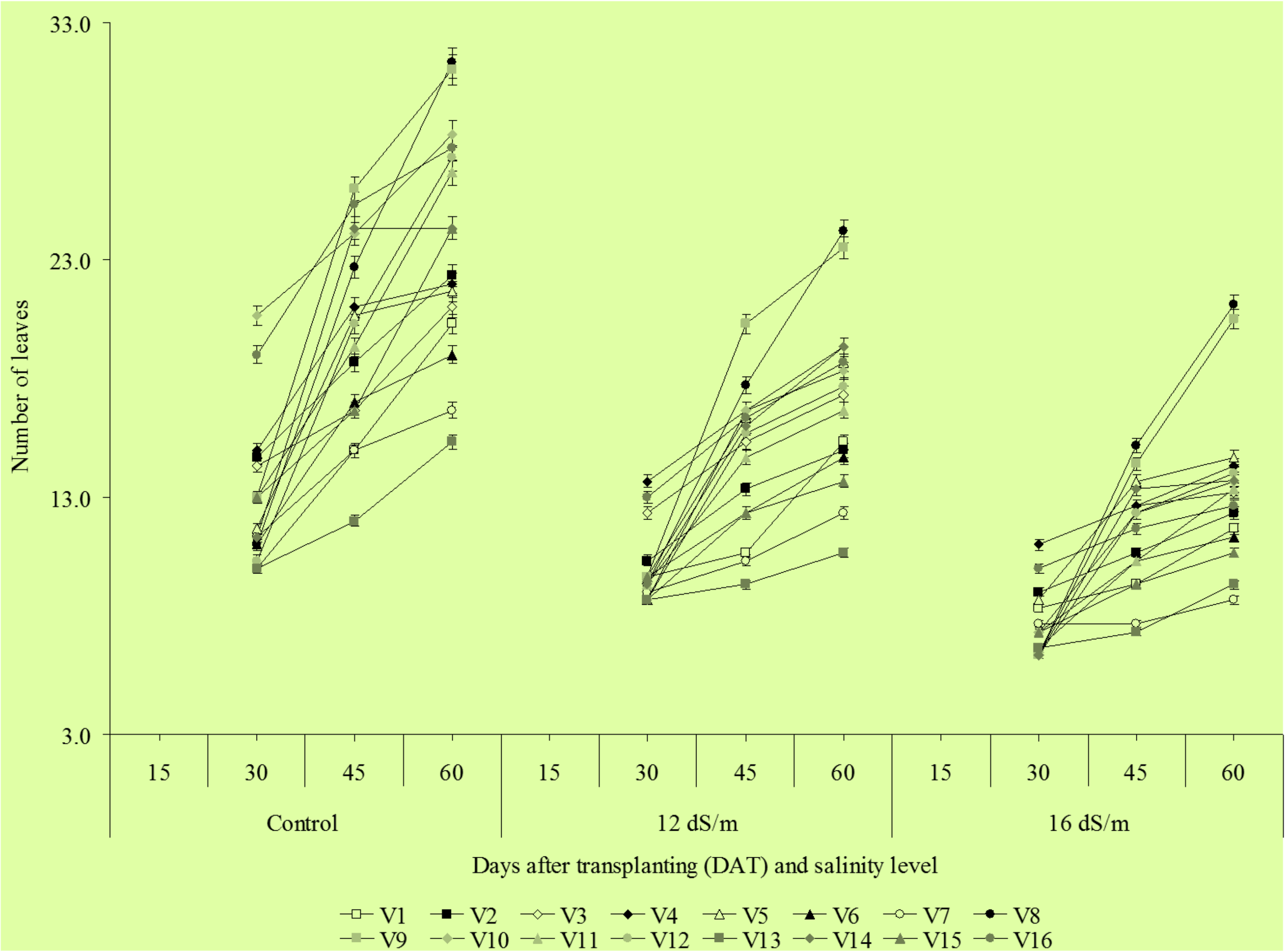

Figure 2. Response of 16 tomato lines to number of leaves on 3 salinity levels at different days after transplanting

Number of bunch per plant

Maximum number of bunch per plant was found from V_8 (15.3) followed by V_9 (13.7) whereas minimum from V_1 (7.7) in control (Table 1). On the other hand, maximum number of bunch/plant was observed from V_9 (10.7 and 9.3 in 12 dS/m and 16 dS/m respectively) followed by V_8 (9.3 and 9.3 in 12 dS/m and 16 dS/m respectively) at different salinity levels (Table 2).

Days to fruiting

V_3 was showed early fruiting (35.5, 26.7 and 22.7 days at control, 12 dS/m and 16 dS/m respectively) whereas late fruiting was found from V_{14} (50.7, 42.3 and 39.3 days at control, 12 dS/m and 16 dS/m respectively) (Table 2). From the findings of the present study it can be stated that tomato plant provided early fruiting when they were in saline stress.

Table 2. Number of bunch per plant and days to fruiting and of tomato lines at different salinity level[x]

Lines	Number of bunch per plant						Days to fruit set					
	Control		12 dS/m		16 dS/m		Control		12 dS/m		16 dS/m	
V_1	7.7	f	6.3	efg	5.3	de	41.3	gh	33.7	G	29.7	g
V_2	10.0	cd	6.3	efg	5.0	de	44.0	def	36.3	E	32.3	e
V_3	8.7	def	6.3	efg	4.7	e	35.3	i	26.7	I	22.7	j
V_4	8.3	ef	7.0	de	5.3	de	45.0	cde	36.3	E	32.3	e
V_5	9.7	cde	5.7	fg	4.3	e	43.3	defgh	33.7	G	29.7	g
V_6	9.7	cde	6.0	efg	4.3	e	42.3	fgh	35.3	F	32.3	e
V_7	10.0	cd	8.0	cd	6.3	cd	45.3	cde	36.7	E	33.7	d
V_8	15.3	a	9.3	b	8.3	ab	45.7	cd	39.3	C	34.3	c
V_9	13.7	b	10.7	a	9.3	a	47.3	bc	36.7	E	30.7	f
V_{10}	10.3	c	5.3	g	4.3	e	41.0	h	35.3	F	28.3	hi
V_{11}	9.7	cde	6.7	ef	4.3	e	42.3	fgh	32.7	H	26.7	i
V_{12}	14.0	ab	8.3	bc	6.3	cd	43.0	efgh	35.3	F	29.3	g
V_{13}	8.7	def	7.0	de	4.7	e	49.3	ab	40.7	B	33.7	d
V_{14}	10.0	cd	8.7	bc	6.3	cd	50.7	a	42.3	A	39.3	a
V_{15}	10.7	c	8.0	cd	6.3	cd	43.7	defg	38.7	D	34.7	c
V_{16}	15.0	ab	8.3	bc	7.3	bc	43.7	defg	38.3	D	36.3	b
LSD0.01	1.4		1.3		1.6		2.4		0.5		0.5	
CV%	7.9		6.3		6.7		3.3		0.8		0.9	

[x]In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Number of flower per plant and fruit per plant

Number of flower per plant and fruit per plant varied significantly among the cultivars in different salinity levels. Maximum number of flower was found from V_{10} (76.3/palnt at control, 60.7/plant at 12 dS/m and 58.0/plant at 16 dS/m) while minimum was in V_7 at control and 12 dS/m (29.7/plant and 20.3/plant respectively) and V_{14} (9.0/plant) at 16 dS/m (Table 3). Maximum number of fruit was found from V_8 (32.3/plant) followed by V_9 (22.3) in control while maximum was found from V_9 (20.3/plant and 16.3/plant in 12 dS/m and 16 dS/m respectively) which was statistically similar with the V_8 (19.3/plant and 16.3/plant in 12 dS/m and 16 dS/m respectively) (Table 3).

Table 3. Number of flower and fruit per plant of tomato lines at different salinity level[x]

Lines	No. of flower per plant						Number of fruit per plant					
	Control		12 dS/m		16 dS/m		Control		12 dS/m		16 dS/m	
V_1	46.3	g	31.3	fg	36.3	d	9.3	h	8.3	g	5.3	fg
V_2	42.0	h	28.3	fgh	25.3	f	10.3	gh	8.3	g	7.3	e
V_3	36.7	i	28.0	gh	30.0	e	9.3	h	6.3	h	4.3	g
V_4	36.3	i	30.7	fgh	20.3	g	7.3	i	5.3	h	4.3	g
V_5	42.7	h	27.3	h	12.3	h	19.3	c	12.3	bc	7.3	e
V_6	50.0	f	32.0	ef	26.7	f	16.3	d	9.3	efg	6.3	ef
V_7	29.7	j	20.3	i	15.3	h	12.3	f	8.3	g	7.3	e
V_8	37.0	i	27.3	h	20.3	g	32.3	a	19.3	a	16.3	a
V_9	43.0	h	35.7	e	30.7	e	22.3	b	20.3	a	16.3	a
V_{10}	76.3	a	60.7	a	58.0	a	20.3	c	9.3	efg	7.3	e
V_{11}	66.0	b	40.0	d	49.7	c	17.3	d	13.3	b	14.3	b
V_{12}	56.0	d	49.7	b	50.7	bc	13.3	f	10.3	de	9.3	d
V_{13}	36.7	i	29.3	fgh	53.0	b	10.0	gh	9.0	fg	9.0	d
V_{14}	53.7	e	46.7	bc	9.0	i	11.0	g	6.0	h	5.0	g
V_{15}	60.0	c	44.7	c	14.0	h	17.3	d	11.3	cd	4.3	g
V_{16}	52.3	e	47.3	bc	37.0	d	15.0	e	10.0	ef	12.0	c
LSD0.01	2.1		3.7		3.1		1.0		1.0		1.0	
CV%	2.7		6.1		6.0		4.1		6.0		7.3	

[x]In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

Table 4. Single fruit weight and yield/plant of tomato lines at different salinity level[x]

Lines	Single fruit weight (g)						Yield (kg)/plant					
	Control		12 dS/m		16 dS/m		Control		12 dS/m		16 dS/m	
V_1	65.3	f	43.3	c	30.4	c	0.627	o	0.373	e	0.183	g
V_2	76.4	c	36.9	e	26.3	e	0.793	i	0.323	f	0.213	f
V_3	130.5	a	35.9	f	16.9	h	1.193	b	0.243	i	0.137	k
V_4	90.5	b	22.9	l	22.5	f	0.663	k	0.143	o	0.157	i
V_5	42.3	n	16.9	o	15.3	i	0.833	g	0.233	j	0.143	j
V_6	42.4	n	29.0	g	9.2	l	0.647	l	0.227	k	0.050	o
V_7	71.5	d	23.6	k	8.5	m	0.893	f	0.223	l	0.127	l
V_8	64.4	g	24.2	j	21.3	g	2.093	a	0.493	b	0.407	b
V_9	46.5	m	44.5	b	35.3	a	1.053	e	0.923	a	0.593	a
V_{10}	51.5	k	40.4	d	34.7	b	1.063	d	0.413	d	0.273	d
V_{11}	35.4	o	20.4	m	14.4	j	0.633	n	0.293	h	0.233	e
V_{12}	59.3	h	27.3	h	29.5	d	0.803	h	0.303	g	0.293	c
V_{13}	54.4	j	48.5	a	14.4	j	0.573	p	0.463	c	0.163	h
V_{14}	55.4	i	25.6	i	15.4	i	0.643	m	0.183	n	0.113	n
V_{15}	66.5	e	19.5	n	3.4	n	1.163	c	0.243	i	0.043	p
V_{16}	48.4	l	20.3	m	9.9	k	0.720	j	0.200	m	0.120	m
LSD0.01	0.2		0.2		0.2		0.002		0.002		0.002	
CV%	0.2		0.3		0.5		1.560		2.650		2.840	

[x]In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.05 level of probability

From the result of the current study (Table 3), it was observed that V_{10} provided the maximum number of flower in control, 12 dS/m and 16 dS/m but maximum number of fruit was found from V_8 and V_9 in control, 12 dS/m and 16 dS/m. Though V_{10} were able to produce maximum flower but they were not able to set maximum number of fruit not only in salinity stress but also in control condition.

Single fruit weight and yield per plant

Single fruit weight and yield per plant showed significant variation among the variety at different salinity levels. Maximum single fruit weight was found from V_3 (130.5 g) in control, V_{13} (48.5 g) 12 dS/m and V_9 (35.3 g) in 16 dS/m (Table 4). However, maximum yield/plant was recorded from V_8 (2.093 kg) followed by V_3 (1.193 kg) in control (Table 4). In case of different salinity level maximum yield was found from V_9 (0.923 kg/plant in 12 dS/m and 0.593 kg/plant in 16 dS/m) followed by V_8 (0.493 kg/plant in 12 dS/m and 0.407 kg/plant in 16 dS/m) (Table 4).

Best varieties at 12 dS/m and 16 dS/m salinity level

At 12 dS/m salinity level, maximum no of fruit was found from V_9 (20.3) followed by V_8 (19.3) (Table 5). Maximum single fruit weight was found from V_{13} (48.5 g) which was followed by V_9 (44.5 g) (Table 5). On the other hand, maximum yield/plant was found from V_9 (0.923 kg) which was followed V_2 (0.493 kg) (Table 6). At 16 dS/m salinity level, maximum no of fruit was found from V_8 and V_9 (16.3) followed by V_{11} (14.3) (Table 5). Maximum single fruit weight was found from V_9 (35.3 g) which was followed by V_{10} (34.7 g) (Table 5). On the other hand, maximum yield/plant was provided by V_9 (0.593 kg) which was followed by V_8 (0.407 kg) (Table 5).

Table 5. Performance of best tomato lines under salinity in yield related attributes

At 12 dS/m					
Lines	No. of fruit/plant	Lines	Single fruit weight (g)	Lines	Yield (kg)/plant
V_9	20.3	V_{13}	48.5	V_9	0.923
V_8	19.3	V_9	44.5	V_2	0.493
At 16 dS/m					
Lines	No. of fruit/plant	Lines	Single fruit weight (g)	Lines	Yield (kg)/plant
V_9 and V_8	16.3	V_9	35.3	V_9	0.593
V_{11}	14.3	V_{10}	34.7	V_8	0.407

Reduction percentage of number of fruits, single fruit weight and yield per plant

Number of fruit was reduced 9.0 -54.1% at 12 dS/m and 10.0-75.0% at 16 dS/m over control among the tomato lines (Table 6). Maximum number of the fruit was found from V_9 (20.3) and V_8 (19.3) at 12 dS/m while V_9 (16.3), V_8 (16.3) and V_{11} (14.3) at 16 dS/m (Table 5) but number of fruit decreased 9.0% in V_9 and 40.2% in V_8 at 12 dS/m (Table 6) whereas 26.9% in V_9, 49.5% in V_8 and 17.3% in V_{11} at 16 dS/m over control (Table 6).

Single fruit weight was decreased 4.3-74.7% at 12 dS/m and 24.1-94.9% at 16 dS/m over control among tomato lines (Table 6). Maximum single fruit weight was found from V_{13} (48.5 g) and V_9 (44.5 g) at 12 dS/m whereas V_9 (35.3 g) and V_{10} (34.7 g) at 16 dS/m (Table 5) but the single fruit weight was decreased 10.8% in V_{13} and 4.3% in V_9 at 12 dS/m while 24.1% in V_9 and 32.6% in V_{10} at 16 dS/m over control (Table 6).

Yield per plant was also decreased due to the increases of salinity level. Decreases of the yield ranged from 12.3-79.6% at 12 dS/m and 43.7-96.3% at 1 dS/m over control (Table 6). Maximum yield per plant was found from V_9 (0.923 kg) and V_2 (0.493 kg) at 12 dS/m while V_9 (0.593 kg) and V_8 (0.407 kg) at 16 dS/m (Table 5) but single fruit weight was decreased 12.3% in V_9 and 59.2% in V_2 whereas 43.7% in V_9 and 80.6% in V_8 over control (Table 6).

Table 6. Reduction percentage of number of fruits, single fruit weight and yield per plant at salinity level compared to the control

Lines	Reduction (%)					
	Number of fruits		Single fruit weight		Yield (kg)/plant	
	12 dS/m	16 dS/m	12 dS/m	16 dS/m	12 dS/m	16 dS/m
V_1	10.7	42.9	33.7	53.4	40.4	70.8
V_2	19.3	29.0	51.7	65.6	59.2	73.1
V_3	32.1	53.6	72.5	87.0	79.6	88.5
V_4	27.3	40.9	74.7	75.1	78.4	76.4
V_5	36.2	62.1	60.0	63.8	72.0	82.8
V_6	42.8	61.2	31.6	78.4	64.9	92.3
V_7	32.4	40.5	67.0	88.1	75.0	85.8
V_8	40.2	49.5	62.4	66.9	76.4	80.6
V_9	9.0	26.9	4.3	24.1	12.3	43.7
V_{10}	54.1	63.9	21.6	32.6	61.1	74.3
V_{11}	23.1	17.3	42.3	59.3	53.7	63.2
V_{12}	22.5	30.0	54.0	50.3	62.2	63.5
V_{13}	10.0	10.0	10.8	73.5	19.2	71.5
V_{14}	45.5	54.5	53.8	72.2	71.5	82.4
V_{15}	34.6	75.0	70.7	94.9	79.1	96.3
V_{16}	33.3	20.0	58.1	79.5	72.2	83.3

IV. Discussion

A successful salt tolerant cultivar should exhibit salt tolerance without compromising its yield potential. Therefore some characters of tomato plant have to be taken into consideration in this study. The response of tomato cultivars to increasing salinity levels as 12 dS/m and 16 dS/m in which a significant decrease in plant height, leaves number/plant, leaf area, chlorophyll content, number of bunches, number of flowers/plant, number of fruits/plant, single fruit weight and yield was seen as the salt concentration increased (Fig. 1-2 and Table 1-4). Plant leaf number was reduced by 23.3% and average reduction of plant height was 29.03% with the salinity (Oztekin and Tuzel, 2011). Salt stress affects the plant growth and development thereby affecting the yield quantity and quality (Foolad, 2004; Maggio *et al.*, 2002; Cuartero *et al.*, 2006; Sattar *et al.*, 2010). Previous studies denotes that a reduced growth at low concentrations of salt is caused by less availability of nutrients require for its growth. As salt concentration increases besides nutrient imbalance, hyperomostic stress and ion disequilibrium plays a pivotal role in disturbing the cellular functions of plant (Foolad, 2004). In developing salt tolerant tomato cultivars, heritability of the selected trait has to be considered along with its physiological and metabolic importance. Leaf area showed the highest heritability as compared to shoot dry weight, measures of ion contents and water relations (Cuartero *et al.*, 2006). Present study showed significant decrease in leaf area of tomato leaves with application elevated salt treatment (Table 1). Salt stress reduced leaf growth rate by shortening the length of the leaf elongating zone and decreasing the growth intensity in its central and distal portions (Bernstein *et al.*, 1993). Leaf growth inhibition by salinity must be expected to occur via an effect on this region (Lazof and Bernstein, 1998). Under saline condition as soon as new cell starts its elongation process, the excess of Na^+, Cl^- and other ions modifies the metabolic activities of cell wall, which causes deposition of several materials on cell wall and limits the cell wall elasticity (Yasar *et al.*, 2006). Cell walls become rigid and turgor pressure efficiency in cell enlargement is decreased with application of elevated salt treatment. The other anticipated cause of reduction in leaf area and dry matter content could be the reduced development and differentiation of tissues, shrinkage of the cell contents, unbalanced nutrition, damage of membrane and disturbed avoidance mechanism (Akram *et al.* 2007). Plant has a reduction in its growth due to the proportional increase of Na. High salinity may inhibit root and shoot elongation due to the lower water uptake by the plant (Werner and Finkelstein, 1995). Root growth was more adversely affected as compared to shoot growth by salinity (Demir and Arif, 2003). From the current experiment it was found that significant decrease in leaf area of tomato leaves with application elevated salt treatment (Table 1).

Chlorophyll content decreases in salt susceptible plants such as tomato (Lapina and Popov, 1970). NaCl stress decreased total chlorophyll content of plant by increasing the activity of the chlorophyll degrading enzyme: cholorophyllase (Rao and Rao, 1981), inducing the destruction of the chloroplast structure and instability of pigment protein complexes (Singh and Dubey, 1995). At the highest salinity level (9.6 dS/m), the plant growth traits were smaller than those at the control level (0.5 dS/m) by approximately 13, 11, 17, 16 and 18% for plant height, stem diameter, leaf area, leaf fresh weight and dry weight, respectively. All of the plant growth traits responded similarly to salinity that is the indication of effect salt of stress on allocation and distribution of photosynthetic resources within various plant organs (Alsadon *et al*., 2013; Olympios *et al*., 2003). Early flowering and decreases the number of fruit, single fruit weight and yield caused by increasing the salinity level (Table 2-4). Average fruit weight of tomato plant reduced due to the increase of salinity level (Table 6). The successive increase in salinity level from 0.5 to 2.4, 4.8, 7.2 and 9.6 dS/m caused a reduction in average fruit weight by 7, 18, 27, and 31%, respectively, compared with the control but reductions in the number of fruit per plant were 2, 5, 8 and 10% for 2.4, 4.8, 7.2 and 9.6 dS/m, the total yield was reduced by 4, 18, 25 and 31%, respectively (Alsadon *et al*., 2013). Enhanced early growth of tomato with the intermediate salinity treatment may have been due to the addition of plant nutrients to irrigation water (Bolarin *et al*., 1993) and drastic decrease in fruit size (Vinten *et al*., 1986).

Means of different genotypes over all levels of salinity demonstrated a wide range of variability in average fruit weight, fruit number and total yield (Tables 3-4). The decrease in total yield can be ascribed to the significant decrease in fruit number than the decrease in single fruit weight because the reduction in fruit number was greater than that single fruit weight (Table 3-4). The effect of salinity on yield became more marked as the harvest period progressed, initially because of a restriction of fruit size and later because of a decrease in fruit number (Cuartero and Fernandez-Munnza, 1999). Salt stress is an abiotic stress factor that causes various deleterious effects on the overall plant growth and development (Ghanem *et al*., 2008). There exist several internal and external factors that influence the overall growth and development of plants. Plant growth hormones, which are the signaling molecules helps in transmitting signals between the cells and within the cells thus aids in development of plants in each and every stage of their life is one such internal factor. External factors include water relations, proper nutrient supplies etc. All these above factors such as water relations, carbon supply, hormonal balance involved in the control of growth of plants exposed to high salt concentrations (Albacete *et al*., 2008). Salt stress causes extensive physiological and biochemical changes in plant. Between these changes, distribution in different organs of the plant's intake of ions like K^+, Ca^{+2} and Na^+ is emphasized (Aziz *et al*., 1999). In conditions which salt concentration is high, the plant gets more Na^+ ion than it needs (Levitt, 1980). Exposure of plants to NaCl reduced the availability of water for the plants, thus causes osmotic stress. The dominance of Na+ and Cl- ions inhibits the uptake of other minerals vital for plant's growth (Ghanem *et al*., 2008; Albacete *et al*., 2008; Hamdia and Shaddad, 2010). Concentration of hormones such as auxin, cytokinin and zeatin changes in response to salinity (Ghanem *et al*., 2008, Albacete *et al*., 2008). This hormonal imbalance, osmotic stress etc is believed to play a significant role in the salinity induced changes in the shoot vigour and yield of plants (Albacete *et al*., 2008). Comparing the yield at high salinity level (12.0 and 16.0 dS/m) with those at the control level (0.0 dS/m) the results indicate that the two salt-tolerant breeding lines V_9 and V_2 had the lowest reduction for yield in 12.0 dS/m and V_9 and V_8 had the lowest reduction for yield in 16.0 dS/m (Table 5). These result indicated that V_9 (for both 12.0 and 16.0 dS/m), V_2 (for 12.0 dS/m) and V_8 (for 16.0 dS/m) lines can be classified as salt tolerant.

V. Conclusion

Salt tolerance in crops is largely determined by their ability to exclude Na^+ and Cl^- from their shoots and their ability to maintain these ions. From the results it can be concluded that different levels of salinity significantly affect the performance of different tomato lines. With the increase of salinity levels the growth and yield decrease and these effect of differs among the lines. Plant growth and yield contributing characteristics also yield were changed to different according lines. However, V_9 was best variety for the both the level of 12 dS/m and 16 dS/m saline affected area that was closely followed to the V_8 concerning yield and yield contributing characters.

VI. References

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Citation for this article (APA Style):

Shiam, I. H., Nahiyan, A. S. M., Momena, K., Mehraj, H. & Jamal Uddin, A. F. M. (2015). Effect of NaCl Salt on Vegetative Growth and Yield of Sixteen Tomato Lines. *Journal of Bioscience and Agriculture Research* 03(01), 15-27.