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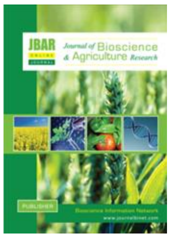

Screening of brinjal lines to high salinity levels

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ABSTRACT

A pot experiment was conducted at the Sher-e-Bangla Agricultural University, Bangladesh during the months of November 2012 to April 2013 for screening the salt tolerant brinjal lines. Ten lines coded from V_1 (Line-1) to V_{10} (Line-10) were executed under different salinity conditions (S_0: Control; S_1: 12dS/m and S_2: 16 dS/m) following completely randomized design (CRD) *with three replication. Maximum yield was provided by V_1 and V_6 (2.4 kg/plant) in 12 dS/m salinity level and V_6 provided the maximum yield (1.3 kg/plant) which was closely followed by V_1 (1.2 kg/plant) in 16 dS/m salinity level whereas 4.1 kg/plant and 3.8 kg/plant from V_6 and V_1 respectively in control. From the current study it can be stated that V_6 and V_1 lines were the best lines to grow in the highly saline affected areas in Bangladesh but varietal development form promising line and further field trials in different areas is recommended.*

Key Words: *Solanum melongena, Brinjal lines, Salinity levels, Growth and Yield*

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I. Introduction

Salinity affected area is increasing day by day and spreading all over the country (Mondal *et al*., 2011). Salinity is affecting potential yield of some crops in salinity affected coastal areas of Bangladesh. Due to evident lower yield, in some areas lands remain as fallow during some parts of a year. Salinity problems can be severe in arid and semi-arid regions since precipitation is not sufficient and water supplies are also scarce as compared to water needs for crop production (Lamsal *et al.*, 1999). Salinity can reduce evapo-transpiration by making soil water less available for plant and reduces potential energy of soil water solution (Allen *et al.*, 1998). Brinjal (*Solanum melongena* L.) belongs to *Solanaceae* family is considered one of the most popular vegetable in Bangladesh. Its demand is increasing day by day throughout the year while production is far from the requirements and or varies year to year. Brinjal was classified as a moderately (Maas, 1984) to highly (Bresler *et al.*, 1982) sensitive crop but it has great potentiality to grow in saline soil. Keeping the above point in view the current study was conducted to search salt tolerant brinjal lines at different salinity level and to bring the uncultivable land of the highly saline affected area under cultivation.

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II. Materials and Methods

A pot experiment was conducted at Horticultural Farm of the Sher-e-Bangla Agricultural University, Bangladesh during the months of November 2012 to April 2013 following completely randomized design with three replication for screening the salt tolerant brinjal lines. The pot size was 14 inch which was filled with 8 kg soil. Seeds were sown on the seedbed in 10th October and seedlings were transplanted into the pot on 12th November. Ten lines coded from V_1 (Line-1) to V_{10} (Line-10) were executed under different salinity conditions (S_0: Control; S_1: 12dS/m and S_2: 16 dS/m). Lines were collected from abroad. Control plants were not exposed to salinity whereas for the 12 dS/m and 16 dS/m salinity level 6.6g ACI salt/L of water and 8.8g ACI salt/L of water were given to each pot respectively. Saline solutions were placed in the plastic bowl placed under the pots. Manures and fertilizers were used as recommended by Bangladesh Agricultural Research Institute (Mondal *et al.*, 2011). The entire amount of organic manure, TSP, Gypsum, Borax and half of the MP were applied during final pot soil preparation. The remaining half of MP and entire urea applied in three equal installments, 1st at 15 days after planting, 2nd at flowering and the 3rd at fruit maturity stages. Data were collected on plant height, leaf area, chlorophyll content, days to fruiting (visual observation), number of flower bud/plant, number of flower/plant, number of fruit/plant, fruit length, fruit diameter, fruit weight and yield/plant. Digital caliper (DC-515) and electronic precision balance were used for measuring fruit diameter and fruit weight, yield/plant respectively. Collected data were statistically analyzed using MSTAT-C program, mean was calculated and analysis of variance for each of treatment was represented by F-test. Differences 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 brinjal lines varied significantly at different days after transplanting also at different salinity levels. It was found that V_2 provided the tallest (70.5 cm, 50.5 cm and 50.5 cm at control 12 dS/m and 16 dS/m respectively) plant at 95 days after transplanting (Figure 01).

Leaf area: Leaf area was measured at 40 days after transplanting and showed significant differences among the lines at different salinity levels. In control, maximum leaf area was provided by V_7 (113.8 cm^2) followed by V_6 (106.5 cm^2) while minimum from V_2 (37.5 cm^2) (Table 01). On the other hand, V_5 provided maximum leaf area (58.6 cm^2 and 43.6 cm^2 for the 12dS/m and 16 dS/m respectively) under saline conditions (Table 01).

Chlorophyll content: Chlorophyll content was also measured at 40 days after transplanting and showed significant differences among the lines at different salinity levels. However, maximum chlorophyll content was observed in V_6 (59.2%, 53.5% and 44.3% in control, 12 dS/m and 16 dS/m respectively) while minimum in V_8 (46.4% and 43.5% for control and 12 dS/m salinity level) and V_{10} (37.5% for 16 dS/m salinity level) (Table 01).

Days to fruiting: Line -1 (V_1) was provided early fruiting (49.4, 54.4 and 62.4 days at control, 12 dS/m and 16 dS/m respectively) whereas late fruiting was found from V3 (94.4, 98.4 and 100.4 days at control, 12 dS/m and 16 dS/m respectively) (Table 02). From the findings of the present study, it can be stated that brinjal plant provided early fruiting when they were in saline stress.

Number of flower bud/plant, flower/plant and fruit/plant: Maximum number of flower bud was provided by V_9 (80.4/plant) at control, V_7 (70.4/plant) at 12 dS/m and V_9 (53.4/plant) at 16 dS/m while minimum was in V_1 (61.4/plant) at control, V_1 & V_3 (58.4/plant) at 12 dS/m and V_1 (45.4/plant) at 16 dS/m (Table 02). Maximum number of flower was provided by V_9 (74.4/palnt) at control, V_7 (65.4/plant) at 12 dS/m and V_9 (48.4/plant) at 16 dS/m while minimum was in V_1 (56.4/plant) at control, V_2 (52.4/plant) at 12 dS/m and V_1 (39.4/plant) at 16 dS/m (Table 03). Maximum number of fruit was provided by V_1 (47.4/plant) (followed by V_6 & V_8) at control, V_1 (34.4/plant) (followed by V_4 & V_2) at 12 dS/m and V_4 (23.4/plant) (followed by V_2 & V_6) at 16 dS/m while minimum was in V_4 (39.4/plant at control) and V_{10} (26.4/plant and 17.4/plant at 12 dS/m and 16 dS/m respectively) (Table 03).

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From the result of the current study as stated in Table 02 and 03, it was observed that V_9 provided the maximum number of flower bud and flower but maximum number of fruit was provided by V_1 at control condition. On the other hand, V_7 provided the maximum number of flower bud and flower followed by V_9 but maximum number of fruit was provided by V_1 at 12 dS/m salinity level while V_9 provided the maximum number of flower bud and flower but maximum number of fruit was provided by V_4 at 16 dS/m salinity level. Though V_9 and V_7 provided maximum flower bud and flower but they were not able to set maximum number of fruit not only in salinity stress but also in control condition.

Fruit length and diameter: Longest fruit was obtained from V_1 (12.9 cm, 11.4 cm and 9.2 cm in control, 12 dS/m and 16 dS/m respectively) whereas shortest from V_8 (5.2 cm, 4.3 cm and 3.4 cm in control, 12 dS/m and 16 dS/m respectively) (Table 04). On the other hand, V_6 provided maximum fruit diameter (57.7 mm, 54.1 mm and 42.5 mm in control, 12 dS/m and 16 dS/m respectively) while minimum from V_{10} (29.5 mm, 26.7 mm and 20.7 mm in control, 12 dS/m and 16 dS/m respectively) (Table 04).

Fruit weight and yield/plant: Fruit weight and yield/plant showed significant variation among the variety at different salinity levels. Maximum fruit weight was found from V_6 (88.7 g, 74.8 and 51.7 g in control, 12 dS/m and 16 dS/m respectively) followed by V_1 (76.8 g, 64.6 g and 50.6 g in control, 12 dS/m and 16 dS/m respectively) while minimum from V_4 (43.5 g, 31.5 g and 18.3 g in control, 12 dS/m and 16 dS/m respectively) (Table 05). On the other hand, maximum yield/plant was recorded from V_6 (4.1 kg) followed by V_1 (3.87 kg) in control, from V_6 & V_1 (2.4 kg) in 12 dS/m also from V_6 (1.3 kg) followed by V_1 (1.2 kg) in 16 dS/m (Table 05).

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_1 (34.4) followed by V_4 and V_6 (30.4) lines (Table 06). Maximum single fruit weight was found from V_6 (74.8 g) line which was followed by V_1 (64.6 g) line (Table 06). On the other hand, maximum yield/plant was fond from V_6 and V_1 (2.4 kg) lines which was followed V_2 (1.5 kg) line (Table 06). At 16 dS/m salinity level, maximum no of fruit was found from V_4 (23.4) line followed by V_2 and V_6 (22.4) lines (Table 06). Maximum single fruit weight was found from V_6 (51.7 g) line which was followed by V_1 (50.6 g) line (Table 06). On the other hand, maximum yield/plant was found from V_6 (1.3 kg) line which was followed by V_1 (1.2 kg) line (Table 06).

IV. Discussion

From the Figure 01, it was observed that brinjal plants under the saline conditions reduced the plant height. It is well known that one of the first plant responses to salinity stress is a reduction in plant growth rate with associated reductions in leaf area available for photosynthesis. Subsequently, excessive accumulation of salts can lead to death of tissues, organs and whole plants (Munns and Termaat, 1986). From the current study, it was observed that leaf area of brinjal plant was dramatically reduced with the increases of saline stress. At higher EC levels (6.1 and 8.1 dS/m) the leaf area was restricted (Savvas and Lenz, 1994b). Plant height and leaf elongation decrease with increasing NaCl in the nutrient solution in tomato (Al-Karaki, 2000; Montesano and van Iersel, 2007). Growth and leaf area development of cotton, bean and tomato were strongly inhibited by salinity (Brugnoli and Lauteri, 1991; Romero-Aranda *et al.*, 2001). Excessive amounts of salt in plants can become toxic in older leaves, causing premature senescence and a reduction in total photosynthetic leaf area (Munns, 2002). Such reductions in leaf area are likely to decrease whole plant photosynthesis and thus growth. Chlorophyll content also reduced when brinjal plants were in salt stress. Plants growing under saline conditions accumulate more Na resulting ionic imbalance. Increasing Na^+ uptake had been reported to interfere with uptake of K^+ (Al-Karaki, 2000; Montesano and van Iersel, 2007; Serrano and Rodriquez-Navarro, 2001). Decreased K^+ and Ca^{2+} uptake apparently depresses growth at higher Na^+ concentrations (Cuartero and Fernandez-Munoz, 1999; Sairam *et al.*, 2002). The K^+ deficiency of plants was inversely correlated to the increased accumulation of Na^+ indicating the existence of competition between Na^+ and K^+ ions which most likely share the same transport system at the root surface (Rus *et al.*, 2001). The Ca^{2+} deficiency in salt stress had been associated to a decreased transpiration rate rather than competition effects with Na^+, additionally Ca^{2+} may ameliorate plant response to salinity (Maggio *et al.*, 2006). Na^+ becomes highly toxic at different physiological levels when absorbed and accumulated at large amount in plant. Physiological impairments caused by Na^+ toxicity include disruption of K^+ and Ca^{2+} nutrition, development of water stress and induction of oxidative cell damage (Aktas *et al.*, 2006). Reduction of K^+ and Ca^{2+} ions in plant tissues at high level of NaCl salt treatments is a very known fact for eggplant, tomato and melon (Savvas and Lenz, 2000), spinach (Wilson *et al.*, 2000), pepper (Aktas *et al.*, 2006), squash plant (Yildirim *et al.*, 2006). Increase in concentrations of Ca^{2+} and K^+ in plant under salt stress could improve the harmful effects of salinity on growth and yield (Grattan and Grieve, 1999; Sivritepe *et al.*, 2003; Kaya *et al.*; 2003). Table 03 indicated that number of fruits/plant were decreased while brinjal plant was exposed to the salinity level 12 dS/m and 16 dS/m while Table 04 indicated that fruit length and diameter were reduced in each variety with the increases of the salinity level. Reduction of fruit length and diameter caused the smaller fruit size. It was also found that fresh fruit weight of individual fruit were decreased in both 12 dS/m and 16 dS/m salinity compared to the control (Table 05). At higher EC levels the fruit fresh weight was more severely depressed (Savvas and Lenz, 1994b). The more detrimental effects of salinity on the yield than on the vegetative organs of eggplant should be attributed to a restriction of water accumulation in the fruit. Water flow into the fruit under saline conditions is restricted by a lower water potential in the plant (Johnson *et al.*, 1992). Response of water flow into the fruit is osmotic origin and therefore, independent of the salts raising the EC of the nutrient solution in the root environment. A lower water accumulation in the fruit was observed also in tomatoes when they were exposed to increased EC, irrespective of the salinity source (Ehret and Ho, 1986; Adams, 1991; Willumsen *et al.*, 1996). As the plants provided lower number, smaller fruits and lower individual fruit weight at the salinity stress thus ultimately reduced the yield/plant. But this reduction was varied among the germplasms due to their genetic factors. Salt tolerant cultivars are capable of maintaining higher K^+/Na^+ ratios in tissues (Mansour, 2003; Zeng *et al.*, 2003). Plant growth under 12 dS/m saline conditions accumulated more of Na^+, decreased Ca^{2+} uptake, reducing Ca^{2+}/Na^+ ratios in root, shoot and leaf. Conversely, some cultivars were more reluctant to lesser Ca^{2+}/Na^+ ratios thus were less affected by high salt concentrations (Turhan *et al.*, 2009) in tomato. From the current experiment, it was found that some of the brinjal lines were comparatively less affected by both 12 dS/m and 16 dS/m salinity which confirmed the most salt tolerant cultivar. In spite of the negative effect of salt on plant growth and yield in brinjal some varieties appeared to be less affected by salinity treatment. This argument is also similar to the results obtained by Cruz and Cuartero (1990). Salinity stress results in a clear stunting of plant growth, which results in a considerable decrease in growth and yield of brinjal but some of the cultivars were comparatively less affected in salinity stress.

V. Conclusion

Plant growth and yield contributing characteristics of Brinjal lines were influenced according to genetical factors of the responsible with lines and salinity levels. Line-6 (V_6) 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 Line-1 (V_1) concerning yield and yield contributing characters.

VI. References

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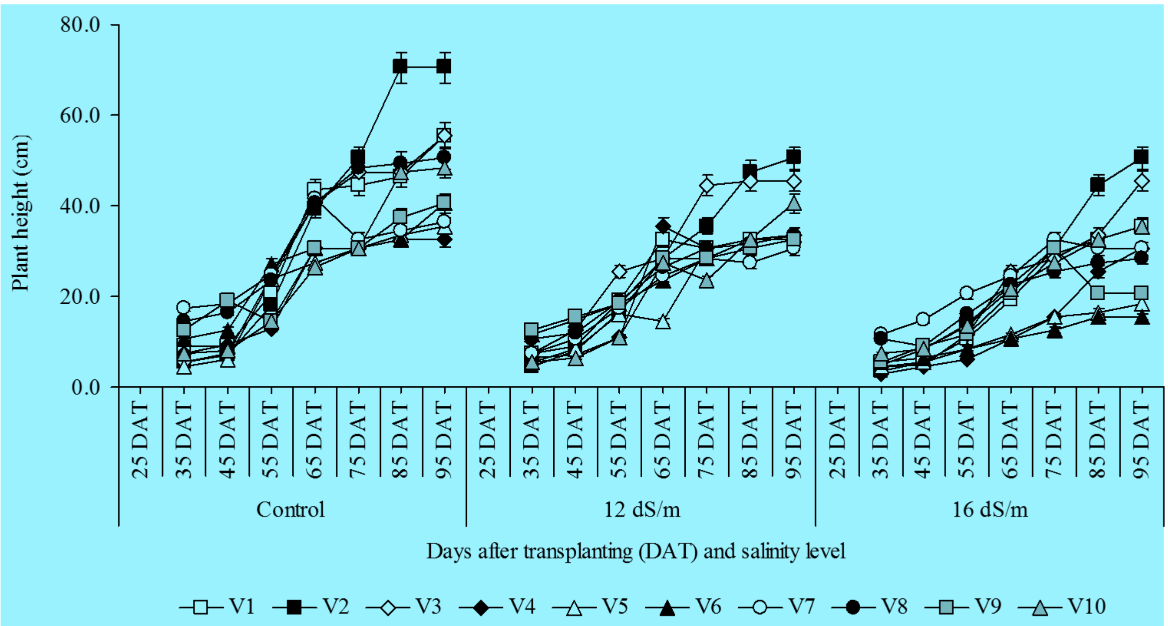

Figure 01. Response of 10 brinjal lines to plant height on three salinity levels at different days after transplanting.

Table 01. Leaf area and chlorophyll content of brinjal lines at different salinity level[x]

Line	Leaf area (cm^2) at 40 DAT			Chlorophyll content (%) at 40 DAT		
	Control	12 dS/m	16 dS/m	Control	12 dS/m	16 dS/m
V_1	91.4 d	54.5 c	40.5 b	54.5 c	51.6 b	44.2 b
V_2	37.5 j	24.5 j	15.8 i	54.3 d	49.5 c	42.2 c
V_3	67.3 h	47.7 f	22.7 h	55.0 b	49.5 c	41.6 e
V_4	44.1 i	28.0 i	7.7 j	48.9 i	46.0 g	39.4 h
V_5	97.5 c	58.6 a	43.6 a	53.6 e	49.1 d	39.9 g
V_6	106.5 b	45.9 g	30.6 f	59.2 a	53.5 a	44.3 a
V_7	113.8 a	32.8 h	25.7 g	52.7 f	48.1 f	41.7 d
V_8	73.9 f	53.4 d	36.6 c	46.4 j	43.5 i	40.3 f
V_9	72.0 g	56.7 b	33.2 d	51.1 h	45.0 h	38.5 i
V_{10}	78.2 e	50.7 e	32.4 e	51.7 g	48.3 e	37.5 j
LSD0.01	*0.5*	*1.0*	*0.3*	*0.1*	*0.1*	*0.02*
CV%	*11.1*	*9.23*	*8.56*	*13.2*	*11.6*	*10.8*

[x] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.01 level of probability

Table 02. Days to fruiting and no. of flower bud/plant of brinjal lines at different salinity level[x]

Line	Days to fruiting			No. of flower bud/plant		
	Control	12 dS/m	16 dS/m	Control	12 dS/m	16 dS/m
V_1	49.4 i	54.4 i	62.4 j	61.4 i	58.4 h	45.4 g
V_2	75.4 c	79.4 d	80.4 e	64.4 h	59.4 g	50.4 d
V_3	94.4 a	98.4 a	100.4 a	64.4 h	58.4 h	50.4 d
V_4	59.4 f	63.4 g	69.4 h	65.4 g	60.4 f	47.4 f
V_5	82.4 b	86.4 b	90.4 b	68.4 e	62.4 e	51.4 c
V_6	52.4 h	57.4 h	68.4 i	66.4 f	60.4 f	49.4 e
V_7	62.4 e	67.4 f	75.4 f	78.4 b	70.4 a	52.4 b
V_8	75.4 c	80.4 c	84.4 d	73.4 d	64.4 d	51.4 c
V_9	58.4 g	63.4 g	73.4 g	80.4 a	69.4 b	53.4 a
V_{10}	66.4 d	72.4 e	86.4 c	75.4 c	66.4 c	52.4 b
LSD0.01	*1.1*	*0.9*	*1.3*	*0.8*	*0.6*	*0.5*
CV%	*6.8*	*5.4*	*3.7*	*2.7*	*2.1*	*1.7*

[x] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.01 level of probability

Table 03. Number of flower/plant and fruit/plant of brinjal lines at different salinity level[x]

Line	No. of flower/plant			No. of fruit/plant		
	Control	12 dS/m	16 dS/m	Control	12 dS/m	16 dS/m
V_1	56.4 i	54.4 f	39.4 f	47.4 a	34.4 a	20.4 d
V_2	57.4 h	52.4 h	44.4 d	40.4 d	29.4 c	22.4 b
V_3	59.4 f	53.4 g	45.4 c	41.4 c	28.4 d	21.4 c
V_4	58.4 g	55.4 e	41.4 e	39.4 e	30.4 b	23.4 a
V_5	63.4 e	57.4 d	45.4 c	40.4 d	29.4 c	21.4 c
V_6	59.4 f	53.4 g	44.4 d	44.4 b	30.4 b	22.4 b
V_7	73.4 b	65.4 a	47.4 b	40.4 d	27.4 e	19.4 e
V_8	66.4 d	57.4 d	44.4 d	44.4 b	29.4 c	20.4 d
V_9	74.4 a	62.4 b	48.4 a	41.4 c	28.4 d	18.4 f
V_{10}	69.4 c	60.4 c	45.4 c	40.4 d	26.4 f	17.4 g
LSD0.01	*0.7*	*0..5*	*0.5*	*0.9*	*0.5*	*0.5*
CV%	*4.3*	*2.8*	*2.3*	*3.3*	*3.1*	*3.1*

[x] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.01 level of probability

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Table 04. Fruit length and diameter of brinjal cultivars at different salinity level[x]

Line	Fruit length (cm)						Fruit diameter (mm)					
	Control		12 dS/m		16 dS/m		Control		12 dS/m		16 dS/m	
V_1	12.9	a	11.4	a	9.2	a	50.6	c	43.6	c	39.6	b
V_2	9.2	d	7.9	e	6.6	e	36.7	g	33.7	h	29.8	f
V_3	11.4	b	10.3	b	8.2	c	42.1	d	37.2	d	31.6	d
V_4	9.2	d	8.1	d	7.0	d	36.7	g	35.2	g	29.0	g
V_5	6.3	f	5.2	g	4.3	g	40.8	e	36.7	e	30.3	e
V_6	8.1	e	6.9	f	6.2	f	57.7	a	54.1	a	42.5	a
V_7	5.9	g	5.2	g	4.3	g	52.6	b	46.8	b	37.5	c
V_8	5.2	i	4.3	i	3.4	i	36.3	h	30.6	i	22.3	i
V_9	10.4	c	9.3	c	8.4	b	40.6	f	36.3	f	26.3	h
V_{10}	5.4	h	4.7	h	4.1	h	29.5	i	26.7	j	20.7	j
LSD0.01	*0.1*		*0.1*		*0.1*		*0.1*		*0.3*		*0.4*	
CV%	*1.2*		*0.9*		*0.9*		*8.6*		*5.7*		*3.2*	

[x] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.01 level of probability

Table 05. Fruit weight and yield/plant of brinjal line at different salinity level[x]

Line	Fruit weight (g)						Yield (kg)/plant					
	Control		12 dS/m		16 dS/m		Control		12 dS/m		16 dS/m	
V_1	76.8	b	64.6	b	50.6	b	3.8	b	2.4	a	1.2	b
V_2	58.7	f	47.7	e	34.2	d	2.5	e	1.5	b	0.9	c
V_3	52.6	h	40.6	g	28.8	g	2.3	f	1.3	c	0.7	e
V_4	39.6	j	30.3	j	18.1	j	1.7	h	1.1	d	0.5	g
V_5	43.5	i	31.5	i	18.3	i	1.9	g	1.1	d	0.5	g
V_6	88.7	a	74.8	a	51.7	a	4.1	a	2.4	a	1.3	a
V_7	62.8	d	51.1	c	32.1	e	2.7	d	1.5	b	0.8	d
V_8	57.1	g	40.2	h	23.6	h	2.7	d	1.3	c	0.6	f
V_9	64.6	c	49.0	d	35.2	c	2.8	c	1.5	b	0.8	d
V_{10}	62.1	e	43.9	f	30.6	f	2.7	d	1.3	c	0.7	e
LSD0.01	*0.6*		*0.3*		*0.1*		*0.02*		*0.02*		*0.02*	
CV%	*7.9*		*7.1*		*6.8*		*0.5*		*0.3*		*0.3*	

[x] In a column means having similar letter (s) are statistically identical and those having dissimilar letter (s) differ significantly as per 0.01 level of probability

Table 06. Performance of best Brinjal lines under salinity in yield related attributes

At 12 dS/m					
Varieties	No. of fruit/plant	Varieties	Single fruit weight (g)	Varieties	Yield (kg)/plant
V_1	34.4	V_6	74.8	V_6 and V_1	2.4
V_4 and V_6	30.4	V_1	64.6	V_2	1.5
At 16 dS/m					
Varieties	No. of fruit/plant	Varieties	Single fruit weight (g)	Varieties	Yield (kg)/plant
V_4	23.4	V_6	51.7	V_6	1.3
V_2 and V_6	22.4	V_1	50.6	V_1	1.2

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