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SALT STRESS EFFECT ON GERMINATION AND SEEDLING GROWTH OF BRINJAL (*Solanum melongena* L.) GENOTYPES

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ABSTRACT

Salinization is one of the main natural threats affecting crop production in the coastal regions of Bangladesh. An experiment was conducted at Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh to evaluate the effects of salinity on the germination and growth of early seedlings of nineteen brinjal genotypes. A two-factor experiment was conducted laid by Completely Randomize Design (CRD) with three replications containing four salinity treatments. (T_0= Control (Tap water), T_1= 4 dSm^{-1}, T_2= 8 dSm^{-1} and T_3= 12 dSm^{-1}). The most significant negative trend of percent germination was observed at T_3 (12 dS/m NaCl), ranged from 24.46 to 66.58. Across the treatment combinations, BARI Hybrid Begun 2 (100%) recorded the highest percent of germination followed by Purple King (99%), SM 262 (98%) and BARI Begun 8 (98%). At 12dS/m salinity, the highest coefficient of velocity of germination (0.521) and the lowest (0.193) was found in BARI Hybrid 2 and BARI Begun 3, respectively. A significant reduction in the shoot length and root length was noticed among all the genotypes with increasing salinity. Root shoot ratio was highest in the genotype SM 262. Therefore considering germination and seedling parameters BARI Hybrid Begun 2 and SM 262 genotypes performed better in 12 dS/m than other genotypes.

Key words: Salinity; Brinjal; Germination; Root length; Shoot length

INTRODUCTION

Salinity is a foremost abiotic stresses that detrimentally effect on agricultural productivity (Pincay and Cantos, 2024) and threatening sustainability of the coastal areas of Bangladesh. Salt-affected soils account for 800 million hectares of the world and it is projected that by 2050, more than half of arable land worldwide will be salinized (Ge *et al.,* 2022; Wang *et al*., 2023). It intermittently has the utmost effect in decreasing the area of cultivated land. Salinity is the consequence of salt accumulation at the surface leading to hyperosmotic stress that interfere the morphological, physiological, and biological activities (Gupta *et al.,* 2020) to roots and the root microbiome. Salt stress executes substantial adverse effects on the performance and physiology of the crop plants, which ultimately leads to plant death as a consequence of growth detention and metabolic damage (Hasanuzzaman *et al*., 2012). According to Ahmed *et al.* (1990), Onkware *et al*. (1993), Begum *et al.* (1996) and Sultana *et al*. (1999), salinity damages crop establishment by lowering germination percentage and delaying seedling emergence. The particular toxic effect of ions or an imbalance of nutritional cations in the tissues of the salt-affected plant is thought to be the causes of the antagonistic effect of salt stress on plant growth (Zhu and Bernstein, 2002). Salinity stress alters the water and ionic condition of plant cells, it can have an impact on plant physiology. Excessive accumulation of Na^+ and Cl^- in the cells causes an ionic imbalance that inhibits the uptake of other mineral nutrients including K^+, Ca^{2+}, and Mn^{2+}. In Bangladesh's saline regions, the current saline intrusion brought on by climate change is severely reducing crop production efficiency (Haque *et al.,* 2014). It is imperative to increase crop productivity in the current circumstances. Growing soil salinity poses a challenge to vegetable production, which provides 40% of the world's food (FAO, 2004). Bangladesh's agriculture is already under strain due to issues with the depletion of agricultural land and water supplies as well as rising food demands. But there is an urgent need to increase its productivity and add more types that can withstand harsh environments, such as salinity stress (Abbas *et al*., 2010). It might be able to reduce salt-induced damage in brinjal plants if the mechanism behind their salt tolerance is clearly understood. In Bangladesh, after potatoes, brinjal (*Solanum melongena* L.) is ranked second important vegetable crop in terms of area and production. According to Maas (1984), brinjal is categorized as a crop that is moderately sensitive to salt, however Bresler *et al*. (1982) classified it as a salt-sensitive vegetable. Sensitivity of a plant to salinity depends on the developmental stages. Study of salt tolerance at the time of different growth stages is necessary for detecting saline limits at each developmental stage (Zapata *et al*., 2004). Therefore, the purpose of this experiment was to explore the effects of salinity on the germination and growth of early seedlings of brinjal genotypes.

MATERIALS AND METHODS

The experiment was carried out at room temperature at the Bangladesh Agricultural Research Institute (BARI), Pulse Research Centre (PRC) Lab in Gazipur. This two-factor experiment was carried out using a Completely Randomized Design (CRD), with three replications and four treatments. **Factor A:** 19 Brinjal genotypes. V_1-BARI Begun 1, V2-EG 203, V_3- BARI Begun 4, V_4-BARI Begun 5, V_5-BARI Begun 6, V_6-BARI Begun 8, V_7- BARI Begun 10, V_8-BARI Hybrid Begun 2, V_9-BARI Hybrid Begun 3, V_{10}-BARI Hybrid Begun 4, V_{11}-Singnath, V_{12}-purple king, V_{13}-F_1 12X11, V_{14}- F_1 13X12, V_{15}-F_1 14X5, V_{16}-F_1 21X11, V_{17}-SM-216, V_{18}-SM-262 and V_{19}-SM-275 collected from Bangladesh Agricultural Research Institute. **Factor B:** Four levels of salinity (dSm^{-1}) T_0= Control (Tap water), T_1= 4 dSm^{-1}, T_2= 8 dSm^{-1} and T_3= 12 dSm^{-1}. Ten seeds were placed within 76 petridishes per treatment with filter paper and then the salt solution added. On different days, ten milliliters of the suitable solution were administered to every petridishes. Evaluation of seed germination was conducted every 24 hours. Sprouting seeds were evaluated on a daily basis while the plumule and radical when emerged more than 2 mm.

Data collection:

Germination percentage was calculated using the following formula-

A. **Germination percentage** =

$$\frac{\text{Total no.of germinated seeds}}{\text{Total no.of seeds placed for germination}} \times 100$$

The rate of germination was (estimated by using a modified Times on index of germination velocity) = $\sum G/t$,

Where,

G = % seed germination at 2 days' interval, and

t = germination period.

Coefficient of velocity of germination (CVG) was evaluated according to Maguire (1962) as follows:

$$\text{CVG} = (G1 + G2 + \ldots\ldots\ldots\ldots Gn/\ 1 \times G1 + 2 \times G2 \ldots\ldots\ldots n \times Gn$$

Where, G is the number of germinated seeds per day (in this experiment 3 to 9 days), and n is the last day of germination (9th day).

Shoot length (mm): Shoot length was measured from the shoot base to the tip of the shoot. This was measured at 8^{th} day.

Reduction off shoot length (%)

$$= \frac{\text{Shoot length at nonsaline} - \text{Shoot length at saline}}{\text{Shoot length at non-saline}} \times 100$$

Root length (mm): Root length was measured from the root base to the tip of the shoot. This was measured at 8^{th} day.

Reduction of root length (%) =

$$\frac{\text{Root length at nonsaline} - \text{Root length at saline}}{\text{Root length at nonsaline}} \times 100$$

Root - shoot ratio: Ratio of root to shoot length was measured.

The software SPSS 25.0 version was used to statistically evaluate the recorded data. Using LSD at a 5% probability threshold, the treatment means were compared in accordance with Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of salinity on seed germination

Significant differences in germination percentage were found amongst the nineteen brinjal genotypes in response to salinity. Brinjal seed germination was comparatively lower at high NaCl concentrations and an increase in NaCl concentration gradually delayed germination. There was no noticeable difference in the percentage of germination in seeds treated with 4 dS/m NaCl and control in V_2, V_4, and V_5. All cultivars showed a notable decrease in germination at 12 dS/m, with a noticeable trend beginning at 4 dS/m NaCl. The highest germination percentages among the four treatments was attained at control in BARI Hybrid Begun 2 (100%) an average of 91.97% and followed by Purple King (99%) and SM 262 (98%). The lowest germination was occurred at 12 dS/m in EG 203 (76.5%) (Table 1). These findings are consistent with those of Saeed *et al*. (2014); Jeannette *et al*. (2002); Haluk and Birol (2009); Hajier *et al.* (2006) and Jamil *et al*. (2007). Loss of germination in radish, cabbage, mustard and water spinach in 8 and 16 dS/m was reported by *Sarker et al.,* (2014). According to research by Jamil and Rha (2004), the mean time to germination of almost offers a crucial hint as to how plants react to salt stress. As the concentration of salt increased, germination and its rate were significantly suppressed. This could be as a result of excessive NaCl levels upsetting the ionic equilibrium in plant cells and creating nutritional imbalances that impacted germination rates, germination percentages, and plant growth. When the water circulation into the seeds during imbibition decreases, the pace of germination and the ultimate seed germination slow down (Hadas, 1977). Miyamoto *et al*. (1985) observed a 50% reduction in germination in carrot and brinjal seeds at a root medium salinity of 12 ds/m. Increased salinity may cause less germination because of the ions' toxicity in the saline medium (Uhvits, 1946) and less access to water (Chapman, 1968).

Effect of salinity on coefficient of velocity of germination (CVG)

Table 1 revealed that increasing salinity caused significant reduction in coefficient of velocity of germination (CVG) in brinjal seeds. Under control treatment, highest velocity (1.452) was recorded in BARI Hybrid 2 and the lowest in BARI Begun 3 (0.734). CVG decreased with increasing salinity level in all the genotypes. At 12dS/m salinity, the highest coefficient of velocity of germination (0.521) and the lowest(0.193)
was found in BARI Hybrid 2 and BARI Begun 3, respectively. Similar results were found by Saeed *et al.* (2014) in brinjal and Rastegar *et al*. (2011) in soybean. The reason was germination percentage and speed decreased significantly by deterioration as compare to control Talwar *et al* (2023) and Rehman *et al*. (1999) in acacia seed.

Table 1. Mean values of germination percentage and coefficient of velocity of germination (CVG) of brinjal genotypes at different salinity levels

Genotypes	Germination (%)				CVG			
	To= Control	T_1= 4dS/m	T_2= 8dS/m	T_3= 12dS/m	To= Control	T_1= 4dS/m	T_2= 8dS/m	T_3= 12dS/m
BARI Begun 1	91.00	78.24	55.48	41.77	0.935	0.773	0.483	0.321
EG 203	76.50	63.74	47.98	36.42	0.712	0.543	0.397	0.301
BARI Begun 4	87.00	74.24	54.08	30.17	0.915	0.732	0.446	0.276
BARI Begun 5	97.00	84.24	61.48	48.33	0.954	0.845	0.522	0.374
BARI Begun 6	91.00	78.24	59.48	53.12	0.863	0.634	0.520	0.453
BARI Begun 8	98.00	85.24	67.48	40.62	0.985	0.921	0.586	0.320
BARI Begun 10	93.00	82.24	62.18	44.27	0.915	0.874	0.523	0.327
BARI Hybrid-2	100.00	89.24	73.48	66.58	1.452	0.845	0.682	0.521
BARI HyBegun3	83.00	72.24	48.18	35.93	0.734	0.712	0.328	0.265
BARI HyBegun4	92.00	81.24	62.48	42.80	0.923	0.810	0.521	0.322
Shinghnath	95.00	84.24	68.48	52.97	0.942	0.823	0.562	0.457
Purple king	99.00	90.24	71.48	49.96	0.989	0.868	0.661	0365
F1 12X11	95.00	86.24	67.48	56.71	0.943	0.836	0.543	0.476
F1 13X12	90.00	81.24	62.48	44.46	0.856	0.811	0.497	0.325
F1 14X15	88.00	79.24	60.48	48.41	0.816	0.786	0.472	0.386
F1 21X11	90.00	81.24	54.48	24.46	0.853	0.801	0.438	0.193
SM-216	87.00	74.24	54.08	31.47	0.817	0.741	0.431	0.285
SM-262	98.00	82.24	66.48	57.29	0.986	0.858	0.502	0.459
SM-275	97.00	84.24	60.61	31.10	0.993	0.841	0.481	0.279
SE±	**1.21**	**1.27**	**1.46**	**2.19**	**0.312**	**0.068**	**0.045**	**0.021**
LSD $_{(0.05)}$	**1.49**	**1.56**	**3.07**	**3.86**	**0.06**	**0.13**	**0.02**	**0.05**

Effect of different salinity levels on root length of 19 brinjal genotypes

Salinity inhibited root length, however for nineteen brinjal genotypes, there were significant differences in root length at different salinity levels. According to this finding, in brinjal genotypes, 18.11% of root length decreased with increasing salinity concentration. This result shows that in brinjal genotypes, 27.78% of root length is decreased when salt concentration is increased from 4 dS/m to 8 dS/m. Root length varied from 7.44 cm to 51.23 cm at T_3 (12 dS/m), with an average of 20.56 cm (Fig. 1). The amount of salt present may have an impact on the 32.9% decrease in root length in brinjal genotypes from 8 dS/m to 12 dS/m. Increasing salinity is also accompanied by significant reduction in root length (Parida and Das 2005; Hajier *et al*. 2006; Nag, 2005).

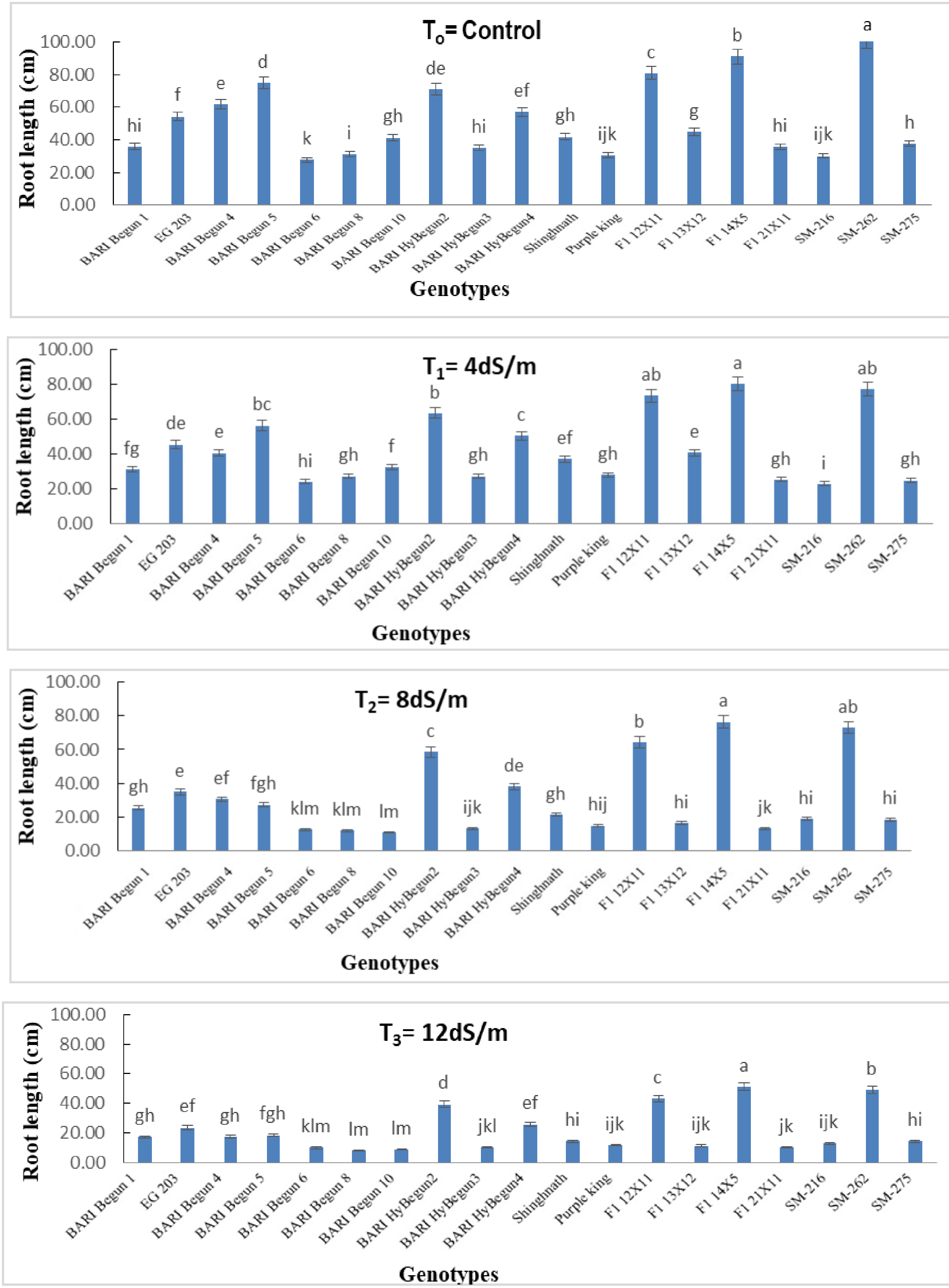

Fig. 1. Effect of different salinity levels on root length of 19 brinjal genotypes
(Here, Similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability and the vertical bars represent the standard error)

Effect of different salinity levels on shoot length of 19 brinjal genotypes

The shoot lengths of all the brinjal genotypes varied significantly at varying saline levels. This finding shows that brinjal genotypes presented 26.85% decrease in shoot length when salt concentration was increased from 4 dS/m to 8 dS/m. Between T_3 and T_0, the average shoot length decreased by 57.85%. The genotypes with the longest shoot lengths were SM-262 (108.07 cm at control, 88.26 cm at 4dS/m, 78.19 cm at 8dS/m, and 48.94 cm at 12dS/m). The findings showed that as salt levels increased, shoot length dramatically decreased (Fig. 2). This outcome is consistent with the research done by Naher and Alam (2010) in mungbean and Nag (2005), who found that increasing salt levels significantly reduced the root and shoot length of genotypes of rapeseed and mustard.

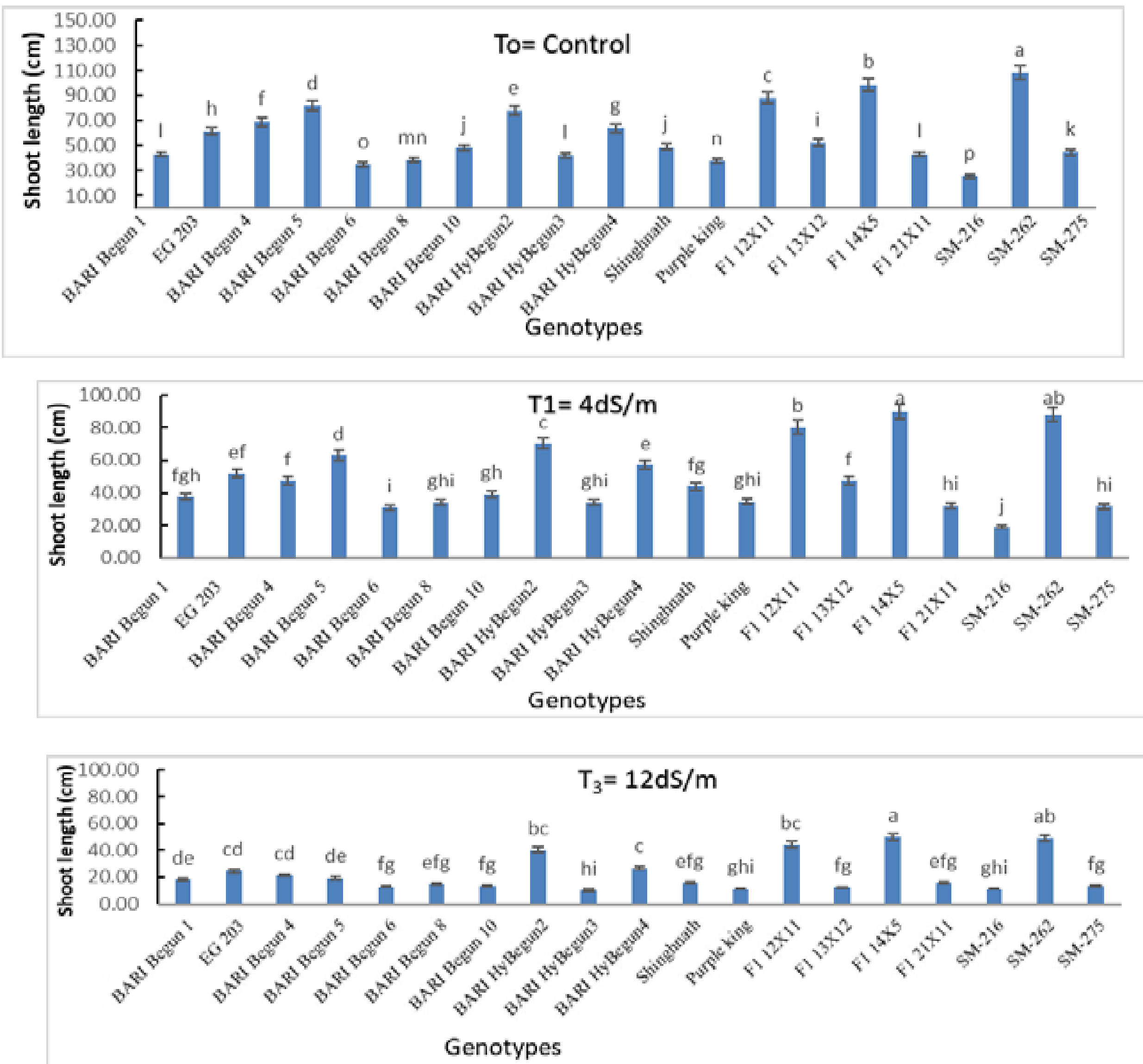

Fig. 2. Effect of different salinity levels on shoot length of 19 brinjal genotypes
(Here, Similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability and the vertical bars represent the standard error)

Effect of different salinity levels on reduction of root length (%) of 19 brinjal genotypes

Considerable diversity in the reduction in root length was noted between the cultivars. The average root length decreased at T_2 was 32.82%, with a range of 4.91 to 65.68%. Conversely, Fig. 3 showed that the ranges were 8.85 to 34.67% at T_1 and 22.90 to 42.90% at T_3. Salt stress significantly reduced the length of roots and shoots of seedlings, but it had a greater effect on the length of the roots than the shoots, especially at high salt concentrations. In all species, salt stress decreased root growth more than shoot growth. Similar outcomes were also reported by Demir and Arif (2003). Plant survival in the presence of NaCl may be largely dependent on the root system's capacity to regulate ion entrance into the shoot (Hajibagheri *et al*., 1989). Because it slows down the plant's ability to absorb water, high salinity can prevent roots and shoots from elongating (Werner and Finkelstein, 1995). This decline could have another cause. According to Neumann, salt can quickly impede the growth of roots and, as a result, their ability to absorb water and necessary minerals from soil.

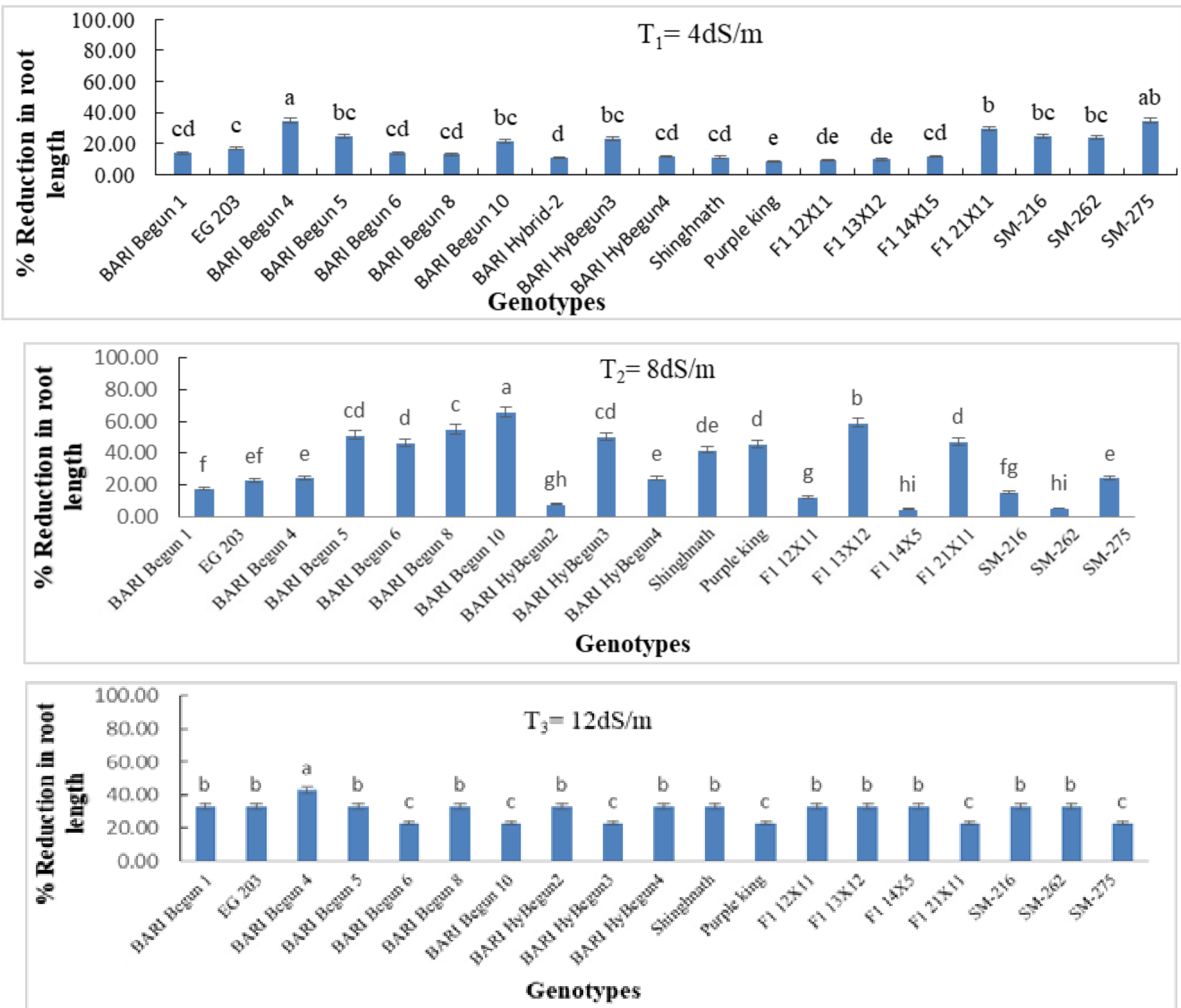

Fig. 3. Percent (%) reduction in root length of 19 brinjal genotypes at different salinity levels

(Here, Similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability and the vertical bars represent the standard error)

Effect of different salinity levels on reduction of shoot length (%) of 19 brinjal genotypes

The average reduction in root length at T_1 was 15.24%; the range of reductions at T_2 was 8.85 to 34.67%, with an average value of 29.01%; at T_3, the range of reductions was 20.73 to 50.15%, with an average value of 38.18% (Fig. 4). This number unequivocally shows that when salinity rises, roots significantly decrease. The outcome also shows that when saline levels rose, so did the decreasing rate. Reduced shoot length was noted for precocious-dwarf cashew (Carneiro *et al*., 2004) and peach palm (Fernandes *et al*., 2003) when salt increased. The imbalanced nutrient intake by the seedlings and the harmful effects of the NaCl utilized may be to responsibility for the decline in root and shoot development.

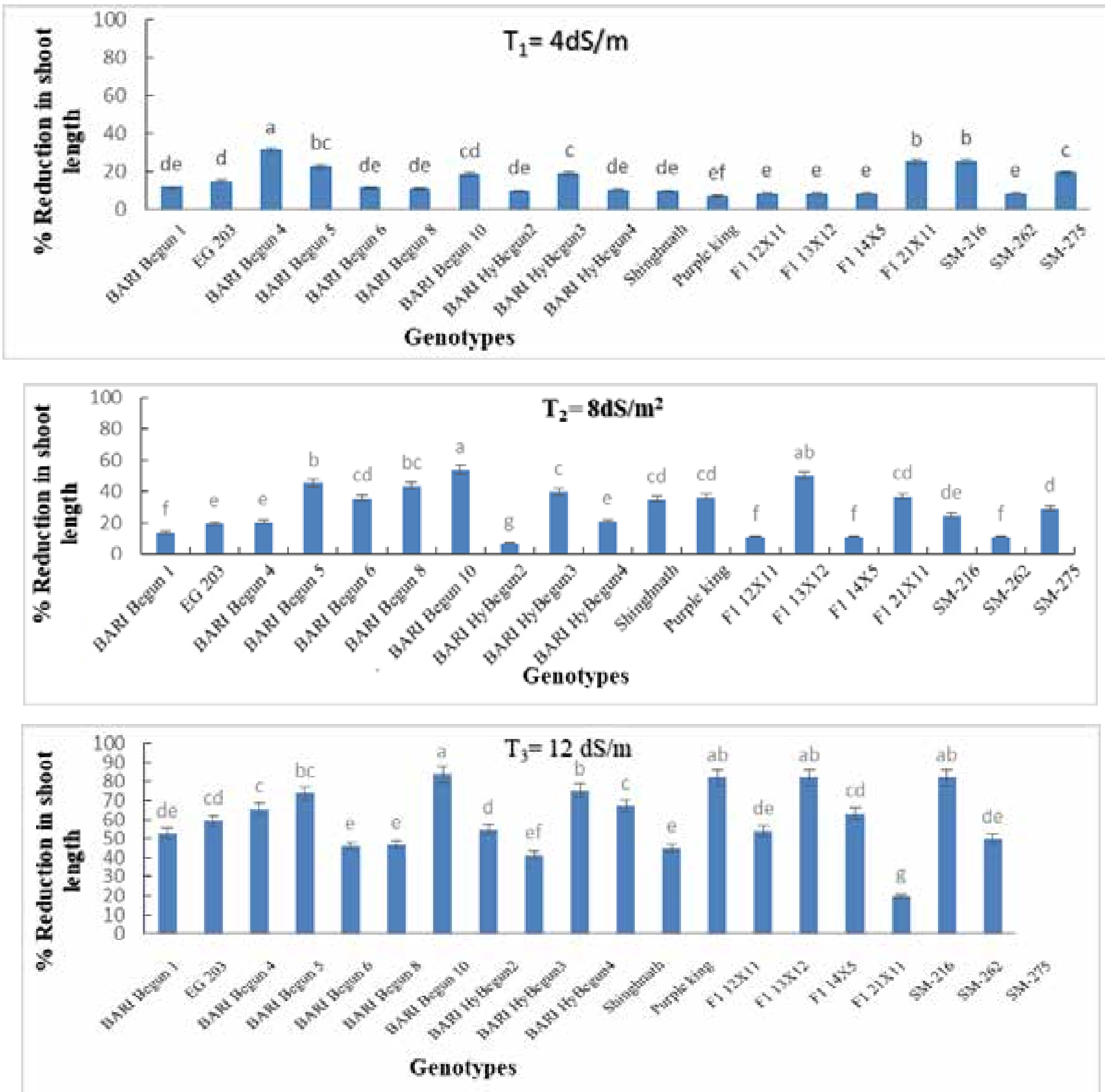

Fig. 4. Percent (%) reduction in shoot length of 19 brinjal genotypes at different salinity levels

(Here, Similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability and the vertical bars represent the standard error)

Effect of different salinity levels on root-shoot ratio of 19 brinjal genotypes

The significant differences between the genotypes were shown in Fig. 5. T_2 (1.36) had the greatest mean root shoot ratio among the types, followed by T_0 (1.20) and T_1 (1.21). The root shoot ratio's declining trend suggests that shoot growth is outpacing root growth. The two genotypes with the greatest ratios were SM 262 (0.94 at control, 0.87 at 4dS/m, 0.93 at 8dS/m, and 1.01 at 12dS/m) and SM 216 (1.20 at control, 1.21 at 4dS/m, 1.36 at 8dS/m, and 1.15 at 12dS/m). Abedin and Jafari found a similar type of observation (2002). They found that salinity and germination, as well as the length of radicle and plumule, had negative relationship

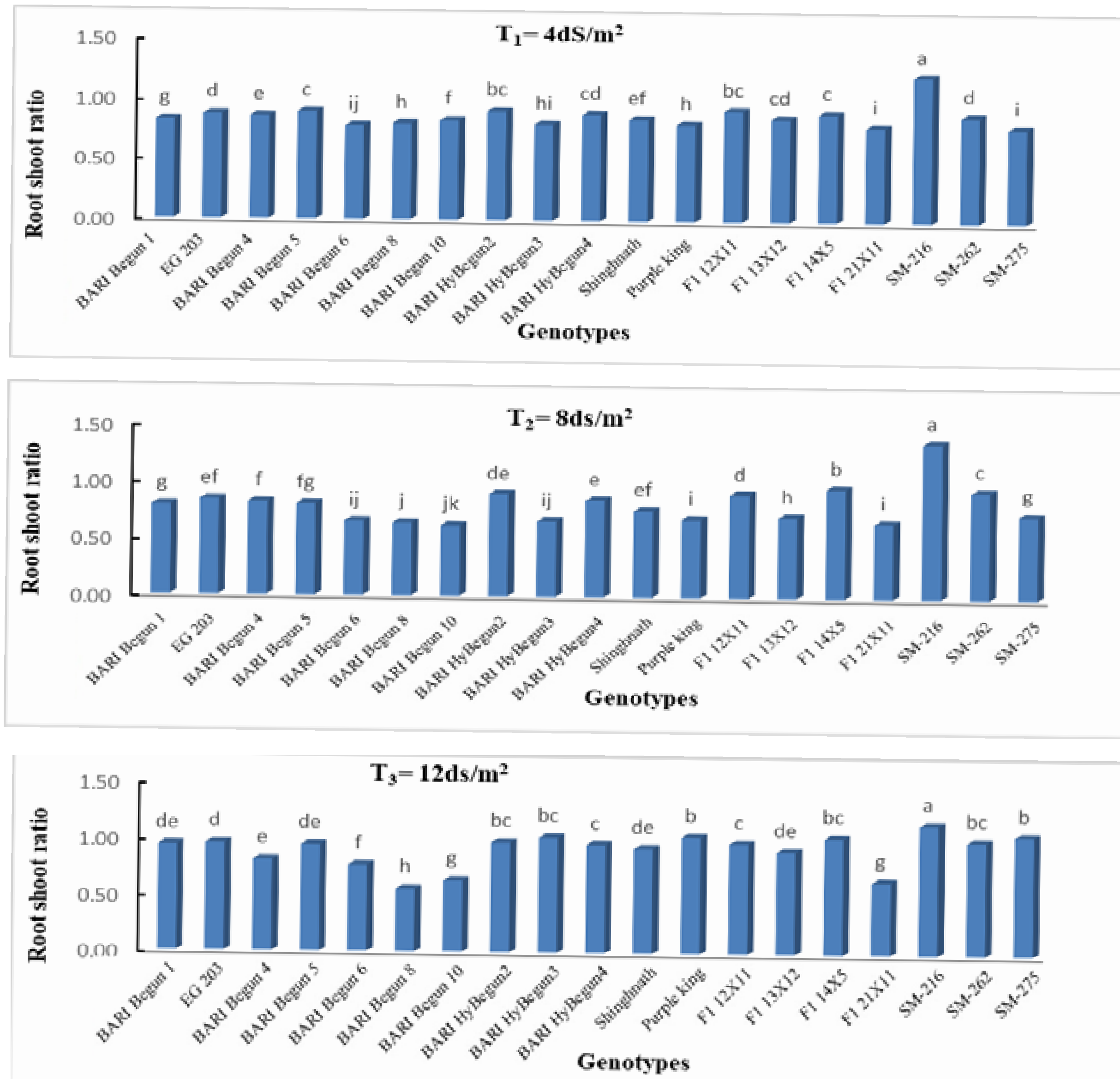

Fig. 5. Root Shoot ratio of 19 brinjal genotypes at different salinity levels
(Here, Similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability and the vertical bars represent the standard error)

CONCLUSION

Salinity became a severe problem for Agriculture all over the world. The findings revealed that increasing salt had a detrimental effect on brinjal genotypes during the germination and seedling stages. Across all the kinds, a notable significant difference in the reduction of shoot length was observed. In case of germination percentage, coefficient of velocity of germination and root and shoot length BARI Hybrid Begun 2 and SM-262 performed the best among the genotypes. This information can also be used to improve crop productivity and assess the level of salt tolerance in various genotypes for future use and could be served as consistent criterions for choosing genotypes that are more resilient to salinity stress.

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