



EFFECT OF SALINITY ON GERMINATION AND SEEDLING GROWTH OF BORO RICE (*Oryza sativa* L.) VARIETIES

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Abstract: Germination parameters and seedling growth of three varieties of boro rice (V_1 = BRRI dhan28, V_2 = Sylhet Boro and V_3 = Bere Ratna) were studied in three concentrations of NaCl (S_0 = control (distilled water), S_1 = 75 mM NaCl and S_2 = 150 mM NaCl). Germination test was performed following Petri dish method with Completely Randomized Design (CRD) in three replications. Data were collected on germination (%) and shoot and root lengths. There was a wide variation in germination parameters and shoot and root growth among the rice varieties. In all the germination parameters Bere Ratna was found superior, followed by Sylhet Boro. Generally shoot length of the rice varieties gradually decreased with increasing salinity. The highest shoot length (5.53 cm) was found in Sylhet Boro in control. The lowest shoot length (1.30 cm) was found in BRRI dhan28 at 75 mM NaCl. However, root growth was not influenced by salinity. Root and shoot length were negatively related to salt levels.

Keywords: Boro rice, germination, salinity, BRRI dhan28, Bere Ratna, Sylhet Boro

Introduction

Salinity is one of the major obstacles to increase production in rice growing areas worldwide (Scardaci *et al.*, 1996). Increased Na content in rice plants may cause salinity injury, which may lead to germination loss. The critical concentration of salt (NaCl) at which toxicity symptoms appear, however, differs widely between varieties. Rice varieties that show the greatest tolerance for salt within plant tissues are not necessarily will show the greatest overall phenotypic resistance to salinity.

Rice is rated as an especially salt-sensitive crop (Shannon *et al.*, 1998; Maas and Hoffman, 1977). The response of rice to salinity varies with growth stage. Many reports of rice showed effects of salinity at early stage (Dobermann and Fairhurst, 2000). In most of the common rice cultivars, young seedlings are very sensitive to salinity (Lutts *et al.*, 1995; Heenan *et al.*, 1988; Flowers and Yeo, 1981; Kaddah, 1963; Pearson and Bernstein, 1959). Yield components, e.g. panicle length, spikelet number per panicle, and grain yield are also significantly reduced in presence of salt (Cui *et al.*, 1995; Khatun *et al.*, 1995; Heenan *et al.*, 1988; Sajjad, 1984). Salinity also delays the emergence of panicle and flowering (Khatun *et al.*, 1995) and decreases seed set through reduced pollen viability (Khatun and Flowers, 1995; Khatun *et al.*, 1995). In contrast, rice is more salt tolerant at germination (Khan *et al.*, 1997; Heenan *et al.*, 1988; Narale *et al.*, 1969). Seed germination is not significantly affected up to 16.3 dS m⁻¹ salinity though is severely inhibited when salinity increases to 22 dS m⁻¹ (Heenan *et al.*, 1988). The suppression of germination at high salt levels might be due to osmotic stress (Heenan *et al.*, 1988; Narale *et al.*, 1969). Rice is generally sensitive to salinity (Yeo *et al.*, 1991; Sajjad, 1990), and accumulation of

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salt in the plough zone may affect germination and result in poor stand establishment (Afroze, 1996). Salinity may cause reduced root and shoot growth at the seedling stage (Amin *et al.*, 1996; Banik *et al.*, 1994) though rice varieties differ greatly in salinity tolerance (Yeo *et al.*, 1991; Akber *et al.*, 1972). Variability in seedling growth is, therefore, would affect the tolerance of rice seedlings. Verma and Yadava (1986) found that germination and seedling stages have a bearing on plant development at later stages of growth and ultimately crop yield.

In Bangladesh, about 1.0 million hectare of arable land in the coast is affected by varying degrees of salinity (Karim *et al.*, 1990). Salinity is a major constraint on rice production in the coastal areas in Bangladesh (Amin *et al.*, 1996). Identification of easily visible growth parameters which are related to salt tolerance is, therefore, important for the development of selection criteria for screening salt tolerant cultivars and thus for the increasing of yield in salt affected areas.

Although a number of reports on the effect of salinity on rice are available (Banik *et al.*, 1994; Quayyum *et al.*, 1991; Akber *et al.*, 1972), a few of them dealt with the relationship between germination, stand establishment, yield and yield attributes of rice under saline condition. This study was initiated to analyze germination behaviour and early seedling growth of two local and one high yielding popular rice varieties of Bangladesh.

Materials and Methods

The experiment was conducted in the Agronomy Laboratory of Agrotechnology Discipline, Khulna University. Factor A consisted of three boro rice varieties *viz.* BRRI dhan28, Sylhet Boro and Bere Ratna while, factor B consisted of three salt levels *viz.* 0 mM, 75 mM and 150 mM.

Preparation of salt solution: To make 75 mM salt solution, 4.3875 g NaCl was taken in a 1000 ml volumetric flask and filled up to the mark with distilled water. Then 150 mM salt solution was prepared in the same way by taking 8.775 g NaCl.

Germination test: In a 9 cm Petri dish, two pieces of germination papers were layed as substrate. Fourty seeds were placed in each Petri dish. The seeds were tested for germination before setting the experiment. Measured volume of salt solutions (75 mM and 150 mM) was used for germination of seeds and distilled water was used as control. The Petri dishes were observed every day and only distilled water was applied whenever required (equal to the volume as applied earlier).

Data Collection

Germination percentage: The number of germinated seeds was recorded daily. After one day of seed setting in Petri dishes seeds began to germinate. Within 10 days after seed sowing in Petri dishes germination of seeds was completed. A seed was considered to be germinated as seed coat ruptured, plumule and radicle came out and were >2 mm long. The germination percentage was calculated using the following formula-

$$\text{Germination (\%)} = (\text{Number of seeds germinated} / \text{Total number of seeds set for test}) \times 100$$

The speed of germination was calculated using the following formula (Krisnasamy and Seshu, 1990).

$$\text{Speed of germination (\%)} = (\text{Number of seeds germinated at 72 h} / \text{Number of seeds germinated at 168 h}) \times 100$$

$$\text{Germination energy} = \text{Percentage of seeds germinated at 72 h (Bam et al., 2006).}$$

$$\text{Germination capacity} = \text{Percentage of seeds germinated at 168 h (Bam et al., 2006).}$$

Root and shoot length measurements: Root and shoot lengths were measured after 17 days of seed setting in Petri dishes. Randomly selected five seedlings were taken from each Petri dish to measure root and shoot lengths. A meter scale was used to measure the lengths of the root and shoot.

Analysis of data: Analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) were used.

Results

Germination parameters: All the studied parameters *viz.* germination percentage, germination energy, germination capacity and germination speed in the tested varieties differed widely across the variety (Fig. 1).

In all the germination parameters studied, variety Bere Ratna was found superior followed by Sylhet Boro. The improved variety BBRI dhan28 was the inferior regarding germination parameters. The results indicate that Bere Ratna is more tolerant to salinity compared to that of Sylhet Boro and BBRI dhan28

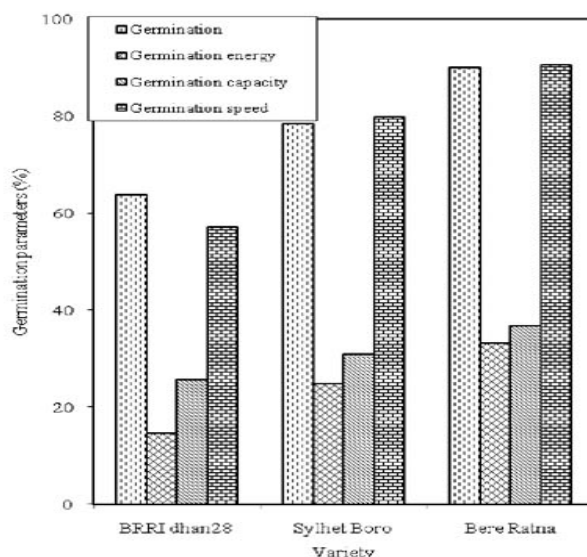


Fig. 1. Differences in germination parameters (%) among three boro rice varieties

There was no effect of salinity on seed germination of different rice varieties. Salt levels showed variable effect on seed germination and germination capacity although germination energy and germination speed reduced slightly due to increased salinity (Fig. 2).

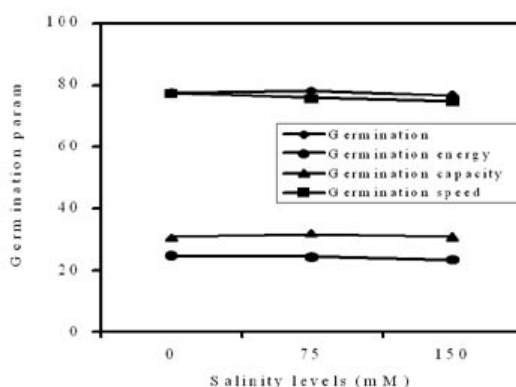


Fig. 2. Effect of salinity levels (mM) on germination parameters (%) of three boro rice varieties

Seed germination percentage differed due to interaction of different rice varieties and different levels of salinity (Table 1). However, there was no significant difference among different varieties in response to different salinity level on germination energy, germination capacity and germination speed. Germination percentage ranged from 57.33 to 95.00 (Table 1). The highest germination was found in Bere Ratna (95.00%) with distilled water, which was statistically similar to Bere Ratna (90.00%) at 75 mM NaCl. The lowest germination percentage was recorded in BRRI dhan28 (57.33%) in control. Like seed germination, treatment combination Bere Ratna with distilled water was found superior regarding germination energy, germination capacity and germination speed while, BRRI dhan28 with distilled water was found inferior.

Table 1. Interaction effect of varieties and salinity levels on germination among three boro rice varieties

Treatment	Germination (%)	Germination energy (%)	Germination capacity (%)	Germination speed (%)
V ₁ S ₀	57.33e	14.00	23.00	60.50
V ₁ S ₁	66.50d	15.00	26.67	56.99
V ₁ S ₂	67.50d	14.67	27.00	54.05
V ₂ S ₀	80.00c	24.67	31.00	79.42
V ₂ S ₁	77.50c	25.33	31.33	80.65
V ₂ S ₂	77.50c	24.00	30.33	79.27
V ₃ S ₀	95.00a	35.00	38.00	92.10
V ₃ S ₁	90.00ab	33.00	37.00	89.18
V ₃ S ₂	85.00bc	31.67	35.00	90.49
Level of significance	*	NS	NS	NS

* $p < 0.05$, NS: $p > 0.05$; V₁= BRRI dhan28; V₂ = Sylhet Boro; V₃ = Bere Ratna
S₀ = Control (distilled water); S₁ = 75 mM NaCl solution; S₂ = 150 mM NaCl solution

Root length and shoot length: Rice varieties showed significant difference in shoot and root length. Shoot length varied from 2.16 to 3.02 cm and root length varied from 2.23 to 3.20 cm (Fig. 3). The highest shoot length was found in Sylhet Boro (3.02 cm) which was statistically similar to BRRI dhan28 (2.28 cm). The lowest shoot length was recorded in Bere Ratna (2.16 cm). The highest root length was observed in Sylhet Boro (3.20 cm) which was statistically similar to Bere Ratna (2.56 cm). The lowest root length was noticed in BRRI dhan28 (2.23 cm).

Unlike germination, shoot length varied greatly across salinity levels. Shoot length varied from 4.01 to 1.64 cm (Fig. 4). As the salt concentration increased, shoot length was reduced. Average over cultivars, salinity caused a decrease in shoot length to 45 and 40 percent at 75 mM and 150 mM, respectively (Fig. 4).

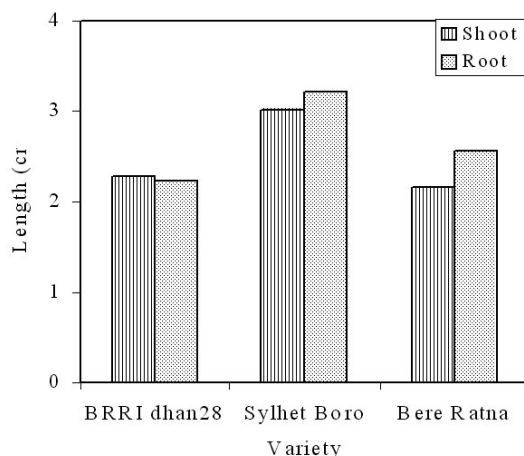


Fig. 3. Differences in shoot and root lengths (cm) among three boro rice varieties

The maximum shoot length (4.01 cm) was recorded in the control while, the lowest (1.64 cm) was recorded at 150 mM of NaCl which was statistically similar to shoot length (1.82) at 75 mM of NaCl. Similarly, the maximum root length was obtained in the control (fresh water) and the minimum was recorded when seeds were subjected to 75 mM solution of NaCl. However, the results did not vary significantly.

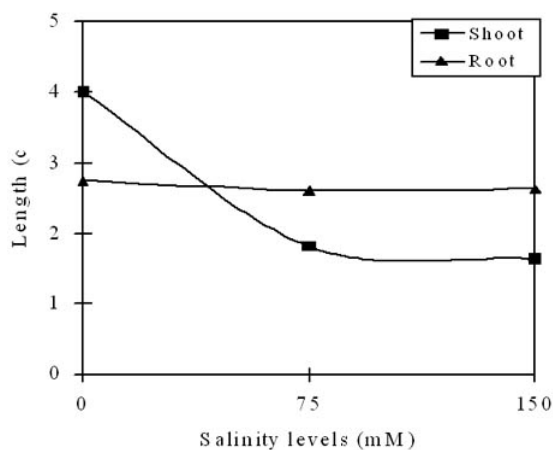


Fig. 4. Effect of salinity levels (mM) on the shoot and root lengths (cm) of three boro rice varieties

Shoot length of different rice varieties at different levels of salinity were found significant but there was no significant difference in root length of different rice varieties at different salinities. Shoot length varied from 1.30 to 5.53 cm (Table 2). The highest shoot length was found in Sylhet Boro (5.53 cm) at control. The lowest shoot length was found in BRRRI dhan28 (1.30 cm) at 75 mM of NaCl which was statistically similar to the shoot length of Sylhet Boro (1.67 cm) at 75 mM of NaCl, Sylhet Boro (1.87 cm) at 150 mM of NaCl, Bere Ratna (1.74 cm) at 150 mM of NaCl, Bere Ratna (1.86 cm) at 75 mM of NaCl and BRRRI dhan28 (1.95 cm) at 75 mM of NaCl.

Discussion

Rice is generally sensitive to salinity (Yeo *et al.*, 1991; Sajjad, 1990) though rice varieties differ greatly in salinity tolerance (Yeo *et al.*, 1991; Akber *et al.*, 1972). In this study significant variation was observed in germinability among boro rice varieties (Fig. 1). The variation in germinability across variety might be due to different level of tolerance of the varieties. Afroze (1996) and Fatema (2008) also reported variation in germinability across cultivars in rice and sesame, respectively. In the present investigation we used moderate level of saline water (up to 150 mM). Afroze (1996) reported that at low salt concentration (100 mM) germination of 104 rice cultivars was reduced only slightly but as salt concentration increased to 200 mM germination was reduced dramatically in most of the varieties. Narale *et al.* (1969) also demonstrated that electrical conductivity (EC) of medium up to 4.5 mmho cm⁻¹ did not affect germination (100%) at all. At and beyond 8.9 mmho cm⁻¹ it was greatly retarded (70% and less), and finally, at 59.5 mmho cm⁻¹ complete inhibition took place (about 25% germination).

Table 2. Interaction effect of varieties and salinity levels on shoot length and root length of three boro rice varieties

Treatment	Shoot length (cm)	Root length (cm)
V ₁ S ₀	3.61b	2.54
V ₁ S ₁	1.95cd	2.40
V ₁ S ₂	1.30d	1.77
V ₂ S ₀	5.53a	2.97
V ₂ S ₁	1.67cd	3.10
V ₂ S ₂	1.87cd	3.53
V ₃ S ₀	2.89bc	2.75
V ₃ S ₁	1.86cd	2.34
V ₃ S ₂	1.74cd	2.58
Level of significance	**	NS

**p<0.01, NS: p>0.05; V₁= BRRI dhan28; V₂ = Sylhet Boro; V₃ = Bere Ratna
S₀ = Control (distilled water); S₁ = 75 mM NaCl solution; S₂ = 150 mM NaCl solution

Germination of BRRI dhan28 was more affected at control than that of 75 mM and 150 mM. Perhaps seeds of BRRI dhan28 need lower level of salinity for osmotic adjustment. Khan and Hossain (2006) reported that yield contributing characters *viz.* panicle length, grains per panicle, harvest index as well as final yield of three local and a high yielding rice variety showed the maximum value at salinity levels of 4 dS m⁻¹; the control treatment had the lowest value.

The results of the present investigation revealed that seedling growth (shoot and root length) was markedly influenced by varieties (Fig. 3). Varietal difference in shoot and root length was reported by Amin *et al.* (1996).

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Increasing salinity caused a remarkable reduction in shoot length in the rice varieties tested (Fig. 4). This is in agreement with those of Amin *et al.* (1990) and Gupta (1993) who also reported that shoot length generally decreased with increasing salinity. However, it is worth noting that root growth was not affected by saline conditions (Fig. 4). This differs with those of Gupta (1993) who observed increased root length at moderate salinity levels (7.8 dS m⁻¹) and Amin *et al.* (1996) who observed a significant reduction in root length due to salinity among rice varieties. It is possible that the difference recorded in shoot and root length at different salt content for the different cultivars may simply reflected differences in individual seedling vigor (Al-Khatib *et al.*, 1994).

Conclusion

There was significant variation in germination parameters and shoot and root length among the boro rice varieties namely Bere Ratna, Sylhet boro and BRRI dhan28. From the present study it might be concluded that

- i) The variety Bere Ratna is superior to others considering germinability.
- ii) The variety Sylhet Boro is superior to others considering shoot and root length.
- iii) Shoot growth of different Boro rice varieties were affected more by salinity than that of germination and root growth.

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