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Evaluation of Rice (*Oryza sativa* L.) Genotypes at Germination and Early Seedling Stage for Their Tolerance to Salinity

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Abstract

An experiment was conducted at the Laboratory of Agronomy Department, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur from July-June, 2009-2010 to evaluate the rice (*Oryza sativa* L.) genotypes for their tolerance to salinity. One hundred rice genotypes and two check cultivars (Pokkali as tolerant and IR29 as susceptible) were exposed to solution of Electrical Conductivity (EC) of 10, 15, and 20 dSm^{-1} (5:1 molar concentration of NaCl and $CaCl_2$ solution) at germination and early seedling stage. Based on visual salt injury symptoms at 15 dSm^{-1}, 13 genotypes were found fairly tolerant to salinity. However, among the 13 genotypes, only Patnai23 showed higher germination index and seedling relative dry weight than the check salt tolerant Pokkali at 15 dSm^{-1}. Beside these, performance of Awned-1, Nonasail and Soloi was also well at this level. The genotypes Patnai23, Awned-1, Nonasail and Soloi showed the best performance under saline condition.

Keywords: Rice genotypes, germination, salinity, tolerance

1. Introduction

Salinity results in poor plant stand due to decrease in the rate of seed germination and seedling survival for most of the agricultural crops (Karim *et al*., 1992). Rice is generally sensitive to salinity (Yeo *et al.*, 1991) though rice varieties differ greatly in salt tolerance (Akbar *et al*., 1997; Amin *et al*., 1996; Yeo *et al.*, 1991). Salinity may affect seed germination in two ways: (a) osmotically, by decreasing the ease with which seeds may take up water; and (b) ionically, by facilitating the uptake of ions in excess amount to be toxic for the embryonic activity (Ayers, 1953). For many plants, salt stress is more inhibitor during seed germination than at any other stage of growth (Bewley and Black, 1982). Seed germination is affected by the increase in salinity (Pushpam and Rangasamy, 2002). According to Yoshida (1981) rice is more sensitive to salinity during early seedling growth and flowering than other growth stages. Under saline conditions germination ability of seeds differs from one crop to another and even amongst the cultivars of the same crop (Asana and Kale, 1965; Maliwal and Paliwal, 1967; Kumar and Bhardwaj, 1981). Rice cultivars are also reported to show a great variation in germination due to salinity (Afroze, 1996).

In Bangladesh, modern rice cultivars tolerant to saline soils are few in number. Works on salt tolerance of rice cultivars are generally scanty in Bangladesh (BRRI, 1995; Banik *et al*., 1994; Quayyum *et al.*, 1991). Although several studies have been conducted for analyzing salt tolerance of rice at early growth stages (Islam *et al*., 2007; Akbar and Yabuno, 1975; Mondal *et al*., 1988; Reddy and Vaidyanath, 1982; Afroze, 1996) the information on comparative performance of different types of rice is quite low. The aim of the present investigation was to analyze genotypic variations in salt tolerance of rice at germination and early seedling stage of growth.

2. Materials and Methods

A laboratory experiment was conducted at the Department of Agronomy, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh during July, 2009 to June, 2010. One hundred genotypes/landraces of rice (*Oryza sativa* L.) and two check cultivars Pokkali as tolerant and IR29 as susceptible were used in the experiment. Most of the genotypes were collected from Genetic Resources Unit of BSMRAU that includes land races and some HYV from Bangladesh, India and Thailand and rest of the genotypes were collect from the Bangladesh Rice Research Institute (BRRI).

Three levels of NaCl and $CaCl_2$ (5:1 molar concentration) solution namely 10, 15, 20 dSm^{-1} and distilled water as the control made up a total of four salinity treatments. Fifty seeds from each genotype in each treatment were placed for germination on filter paper in 10 cm diameter Petri dish. The Petri dishes were kept under laboratory conditions. After 3 days, when seedlings were well established, the distilled water was replaced with salinized solution. The number of germinated seeds were recorded at 24 hours interval for 9 days. Seeds were considered germinated when both plumule and radicle extended to more than 2 mm from the seeds. The experiment was laid out in a complete randomized design (CRD) with four replications. The modified standard evaluating scores were used for screening of the rice genotypes (Table 1). This scoring discriminates the susceptible from the tolerant and the moderately tolerant genotypes.

Table 1. Modified standard evaluation score (SES) of visual salt injury at seedling stage. (Gregorio *et al*. 1997)

Observation	Tolerance	Score
Normal growth, no leaf symptoms	Highly tolerant	1
Nearly normal growth, but leaf tips or few leaves whitish and rolled	Tolerant	3
Growth severely retarded; most leaves rolled; only a few are elongating	Moderately tolerant	5
Complete cessation of growth; most leaves dry; some plants dying	Susceptible	7
Almost all plants dead or dying.	Highly susceptible	9

2.1. Germination Index

The germination index was calculated after final germination following Karim *et al.* (1992) as:

$$\left[\mathrm{GI} = \frac{\text{Germination percentage in each treatment}}{\text{Germination percentage in the control}} x100 \right]$$

2.2. Seedling height and dry weight

Seedling height was recorded on the 9th day after the seeds were placed for germination. After harvest on the 9th day, the seedlings were oven dried at 70^0C until they reached a constant weight. Data on germination and seedling characteristics for each treatment were compared with control for determining the salt tolerant rice genotypes.

2.3. Seedling height reduction

The seedling height reduction (SHR) was calculated using the following equation:

$$\left[\mathrm{SHR}\ (\%) = \frac{\text{Plant height at control - Plant height at saline condition}}{\text{Plant height at saline condition}} x100 \right]$$

2.3. Relative dry weight

The relative dry weight (RDW) was calculated using the following equation

$$\left[\mathrm{RDW}\ (\%) = \frac{\text{Total dry weight under saline condition}}{\text{Total dry weight under control condition}} x100 \right]$$

The data were analyzed statistically following CRD design by MSTAT-C computer package developed by Russel (1986). The mean separation was done by Duncan's Multiple Range Test (DMRT).

3. Results and Discussion

3.1 Visual scoring of salt injury at seedling stage

The modified standard evaluating score of salt injury method was used for screening the 100 rice genotypes and compared with the two check cultivars at seedling stage. It was found that 13 genotypes were tolerant and two genotypes were moderately tolerant at 15 dSm^{-1} (Table2). However, all the selected genotypes were found moderately tolerant to 20 dSm^{-1} except the two i.e. Tilkapur and Chinikamini2. For this reason, only genotypes tolerant to 15 dSm^{-1} were considered for further discussion.

3.2. Percent germination and germination index (GI)

Effect of different salinity level had significant effect on percent seed germination of different rice varieties. The maximum percentage of germination was found in control condition and the minimum was in 20 dSm^{-1} (Table 3). The results revealed that germination percent decreased with the increasing salinity levels. At 15 dSm^{-1} salinity lever, the highest seed germination was found in Patnai23 (89.3%). Salt concentration above 20 dSm^{-1} drastically reduced germination and all the selected genotypes had germination less than 80%. At this level Patnai23 showed the highest germination percentage (Table 3). Salinity decreased germination of seeds which is directly related to the amount of absorbed water by the seeds.

However, the GI of Patnai23, Awned-1, Gunshi, Soloi was found similar to that of the check Pokkali (Table 4). The results further indicated that these materials showed superiority over the rest selected genotypes in relation to germination at 15 dSm^{-1}. Hossain (2004) and Khan *et al.* (1997) also found that germination percentage and germination index of different rice genotypes were decreased with the increase in salinity levels. Similar results were also reported by Koyro and Eisa (2008) and Pushpam and Rangasamy (2002).

Table 2. Visual score at seedling stage of different rice genotypes under varied salinity levels

Genotypes	Visual score			
	Control	10	15	20
		dSm^{-1}		
Awned-1	1	1	3	5
Kalguchi	1	1	3	5
Black	1	1	3	5
Chini atab	1	1	3	5
Til kapur	1	3	5	7
Chini kamini-2	1	3	5	7
Rajbhog-2	1	1	3	5
Khorina	1	1	3	5
Soloi	1	3	3	5
Nonasail	1	1	3	5
Patnai 23	1	3	3	5
Sada mota	1	1	3	5
Gunshi	1	1	3	5
Koijuri	1	1	3	5
Chapali	1	1	3	5
IR-29 (check)	1	5	7	9
Pokkali (check)	1	1	1	3

Table3. Germination percentage of different rice genotypes under varied salinity levels

Genotypes	Germination (%)			
	Control	10	15	20
		dSm^{-1}		
Awned-1	92.7	86.7 bc	83.3 bc	75.0 a
Hati sail (G-20)	94.0	82.0 def	77.3 def	69.7 bc
Black	90.7	81.7 ef	77.0 ef	70.0 bc
Chini atab	95.0	85.3 cdf	76.7 f	72.5 abc
Til kapur	90.7	79.3 f	73.3 cdf	64.3 d
Chini kamini-2	96.7	84.3 cdf	78.3 bcde	68.3 cd
Rajbhog-2	91.2	85.0 cdf	80.0 bcd	69.7 bc
Khorina	95.6	86.6 bc	81. 8 bc	73.3 ab
Soloi	92.5	84.3 cdf	82.1 bc	75.7 a
Nonasail	97.3	89.7 ab	81.0 bc	75.7 a
Patnai 23	96.3	92.7 a	89.3 a	75.8 a
Sada mota	93.1	86.0 bcd	82.0 bc	75.7 a
Gunshi	88.3	82.0 def	79.0 cde	72.7 abc
Koijuri	90.2	83.0 cdef	78.7 cde	73.7 ab
Chapali	93.7	87.0 bc	82.3 bc	74.0 ab
IR-29 (check)	95.6	81.3 ef	77.3 def	69.2 bc
Pokkali (check)	93.4	88.2 b	83.7 b	74.5 a
S x	0.97	0.93	1.0	1.1

Figure having common letter(s) in a column do not differ significantly at 5% level of significance.

Table 4. Germination index of different rice genotypes under varied salinity levels

Genotypes	Germination Index			
	Control	10	15	20
		dSm^{-1}		
Awned-1	-	93.5	89.9	80.9
Hati sail (G-20)	-	87.2	82.2	74.1
Black	-	90.1	84.9	77.2
Chini atab	-	89.8	80.7	76.3
Til kapur	-	87.4	80.8	70.9
Chini kamini-2	-	87.2	81.0	70.6
Rajbhog-2	-	93.2	87.7	76.4
Khorina	-	90.6	85.6	76.7
Soloi	-	91.1	88.8	81.8
Nonasail	-	92.2	83.2	77.8
Patnai 23	-	96.3	92.7	78.7
Sada mota	-	92.4	88.1	81.3
Gunshi	-	92.9	89.5	82.3
Koijuri	-	92.0	87.3	81.7
Chapali	-	92.8	87.8	79.0
IR-29 (check)	-	85.0	80.9	72.4
Pokkali (check)	-	94.4	89.6	79.8

3.3. Seedling height and its dry weight

As in the case of germination percentage, seedling height also decreased with the increase in salinity level (Table 5). The highest reduction of seedling height was recorded at 20 dSm^{-1} (Fig. 1). However, the difference in reduction percentage at 10 and 15 dSm^{-1} was minimum; and for this reason salinity level of 15 dSm^{-1} may be considered as the optimum for screening of rice genotypes. In contrary, the seedling height reduction percentage at 15 dSm^{-1} was far less in Patnai23, Nonasail, Chapali, Awned-1 and Sadamota than the check tolerant Pokkali variety. The decrease of seedling height was due to the application of salinity which was also reported by early investigators (Zeng and Shannon, 2000).

The seedling dry weight and relative dry weight of different rice genotypes were influenced by salinity stress. In all genotype the seedling dry weight and percent relative dry weight were decreased due to increasing the salinity level (Tables 6 and 7). At 15 dSm^{-1} salinity lever, the highest relative dry weight was found in Patnai23 (90.88%) and the lowest (70.1%) in IR29 (Table 7). Awned-1 (84.52%), Nonasail (90.78%), Soloi (83.28%), also perform better compared to others variety (Table 7). The result indicated that as the salinity level increased, seedling dry weight and percent relative dry weight decreased. Islam *et al.* (2007) found that total chlorophyll content was reduced with increased levels of salinity. So, seedling dry weight decreased due to reduction of chlorophyll content under saline condition. Hossain (2004), Roy *et al.* (2002) and Khan *et al.* (1997) also found that seedling height and dry weight of different rice genotypes showed a declining trend with the increase of salinity level.

Table 5. Seedling height of different rice genotypes under varied salinity levels

Genotypes	Seedling height (cm)			
	Control	10	15	20
		dSm^{-1}		
Awned-1	13.93	13.24	12.26	11.3
Hati sail (G-20)	14.22	12.7	12.24	10.8
Black	16.35	14.68	13.84	11.5
Chini atab	14.04	12.11	12.1	10.1
Til kapur	11.53	10.05	9.81	9.0
Chini kamini-2	15.04	13.56	12.86	10
Rajbhog-2	13.01	11.26	11.26	9.5
Khorina	16.34	15	13.7	10.5
Soloi	14.53	12.96	13.32	10.88
Nonasail	21.68	20.3	19.53	17.90
Patnai 23	22.29	20.46	20.15	17.90
Sada mota	23.53	22.59	20.61	17.89
Gunshi	25.57	22.07	20.63	18.27
Koijuri	19.2	17.57	16.38	13.23
Chapali	17.1	15.74	15.34	13.54
IR-29 (check)	16.9	12.47	10.37	9.45
Pokkali (check)	19.6	17.62	16.66	15.35

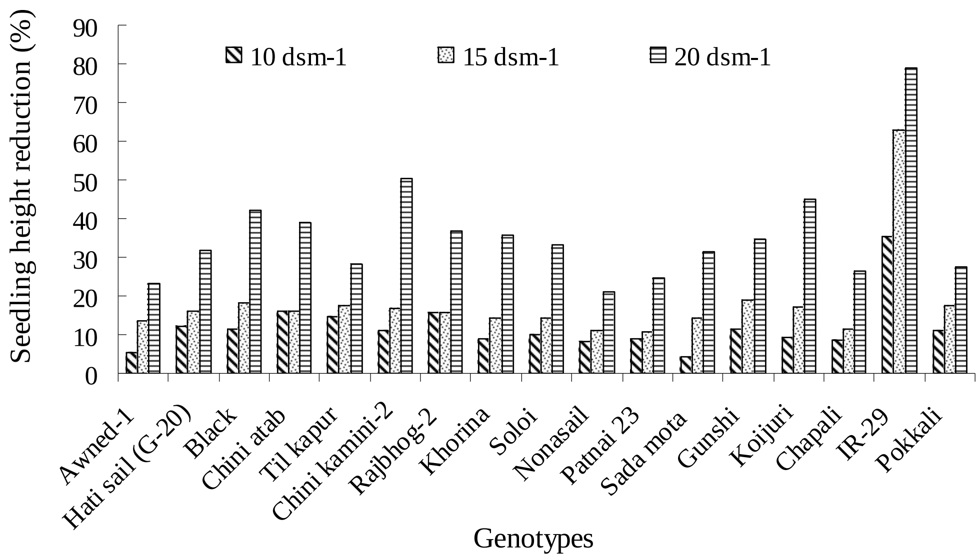

Fig. 1. Seedling height reduction (%) of different rice genotypes under varied salinity level.

Table 6. Seedling dry weight of different rice genotypes under varied salinity levels

Genotypes	Seedling dry weight (mg)			
	Control	10	15	20
		dSm^{-1}		
Awned-1	8.40	7.52	7.10	5.90
Hati sail (G-20)	8.1	6.7	6.3	5.7
Black	5.5	4.6	4.04	3.1
Chini atab	5.00	4.00	3.75	3.00
Til kapur	4.6	3.8	3.5	3.05
Chini kamini-2	7.10	5.95	5.20	4.50
Rajbhog-2	8.9	7.83	7	6.1
Khorina	8.35	8	7	6.4
Soloi	8.97	7.76	7.47	5.4
Nonasail	10.3	9.97	9.35	8.4
Patnai 23	11.30	10.94	10.27	9.32
Sada mota	17.7	11.46	10.83	9.53
Gunshi	10.1	9.27	8.56	8.1
Koijuri	9	8.99	8.33	7.15
Chapali	10.1	9.11	8.55	7.12
IR-29 (check)	9.7	7.8	6.8	5.6
Pokkali (check)	10.4	9.58	9.16	8.1

Table 7. Relative dry weight (%) of different rice genotypes under varied salinity levels

Genotypes	Relative Dry Weight (%)			
	Control	10	15	20
		dSm^{-1}		
Awned-1	-	89.52	84.52	70.24
Hati sail (G-20)	-	82.72	77.78	70.37
Black	-	83.64	73.45	56.36
Chini atab	-	80.00	75.00	60.00
Til kapur	-	82.61	76.09	66.3
Chini kamini-2	-	83.80	73.23	63.38
Rajbhog-2	-	87.98	78.65	68.45
Khorina	-	95.81	83.83	76.65
Soloi	-	86.51	83.28	60.2
Nonasail	-	96.8	90.78	81.55

Patnai 23	-	96.81	90.88	82.48
Sada mota	-	90.24	85.28	75.04
Gunshi	-	91.78	84.75	80.2
Koijuri	-	90.81	84.14	72.22
Chapali	-	90.2	84.65	70.5
IR-29 (check)	-	80.41	70.1	57.73
Pokkali (check)	-	92.12	88.08	77.88

4. Conclusions

Based on visual salt injury symptoms, 13 genotypes were found tolerant at 15 dSm^{-1} salinity level. However, among the 13 genotypes, only Patnai23 showed higher germination index and seedling relative dry weight than the check salt tolerant Pokkali at 15 dSm^{-1}. Beside these, performance of Awned-1, Nonasail and Soloi were also well at 15 dSm^{-1} salinity level. So, the results of the experiments clearly indicated that most of the rice genotypes could not perform better under salinity level of 15 dSm^{-1} at germination and early seedling stage.

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