J. Sher-e-Bangla Agric. Univ., 2(2): 85-93, July 2008 ISSN 1997-6038

# THE EFFECT OF SALINITY ON SEEDLING GROWTH OF DIFFERENT RICE GENOTYPES

M. A. Razzaque[1], N. M. Talukder[2], A. K. Bhadra[3] and M. S. Islam[4]

## ABSTRACT

The effect of salinity-stress on seedling morphology of different rice genotypes along with one standard check salt tolerant rice cultivar Pokkali were assessed in two factors [30 rice genotypes in combination with 5 levels of salinity (0, 4, 8, 12 and 16 dS $m^{-1}$)] Completely Randomized Design with three replications in pot culture. The results of this study indicated that the seedling height, root dry weight (RDW), shoot dry weight (SDW) and consequently the total dry matter (TDM) significantly decreased with increasing salinity level irrespective of genotypes. The genotypes PVSB19, Pokkali, PVSB9, PNR519, PNR381 produced higher relative-seedling height, RDW, SDW and TDM under different salinity levels. On the other hand, genotypes RD21, DM25 and NS15 showed lower performance in relative-seedling height, RDW, SDW and TDM. Based on the effect of different salinity levels on seedling morphology, the genotypes PVSB9, PVSB19, PNR519, PNR381 including the check Pokkali were designated as salt tolerant and RD21, DM25, NS15 as salt susceptible.

**Key words:** Salinity, rice, seedling morphology

## INTRODUCTION

Rice (*Oryza sativa*) is the most important crop in the world. A number of thousands rice varieties are grown across the world in an extensive range of climatic, soil and water conditions. Rice breeders have used genetic variability to produce cultivars that have high yield potential and that resist disease and insect damage and that tolerate cold, drought and salinity. But apart from some sporadic work in Sri Lanka and India, little has been done until recently to identify any breed/cultivars adaptable to adverse soil conditions such as salinity. Salinity is a major threat to crop productivity in the southern and south-western part of Bangladesh. The majority of the saline land exists in the districts of Satkhira, Khulna, Bagerhat, Barguna, Patuakhali, Pirojpur and Bhola on the western coast and a smaller portion in the districts of Chittagong, Cox's Bazar, Noakhali, Lakshmipur, Feni and Chandpur. There is a general lacking of suitable salt tolerant modern variety (MV) of rice to suit at different agroecological zones (AEZ) in the coastal areas of Bangladesh. The lack of an effective evaluation method for salt tolerance in the screening of genotypes is one of the reasons for the limited success in conventional salt tolerant breeding. Plant growth was seriously affected due to salinity, which reduced turgor in expanding tissues and osmoregulation (Steponkus, 1984).

Alam *et al.* (2001) stated that the critical EC level of salinity for seedling growth was about 5 $dSm^{-1}$. They observed that dry matter, seedling height, root length and emergence of new roots of rice decreased significantly at an electrical conductivity value of 5-6 $dSm^{-1}$ and during the early seedling stage, more higher salinity caused rolling and withering of leaves, browning of leaf tips and ultimately death of seedlings. Considerable improvements in salinity tolerance have been made in crop species in recent times through conventional selection and breeding techniques in the world (Ashraf, 2002). Most of the selection procedures have been based on differences in agronomic characters, which

[1]Associate Professor & [2]Professor, Department of Agricultural Chemistry, SAU, Dhaka and BAU, Mymensingh, respectively
[3&4]Associate Professor, Department of Agricultural Botany and Agronomy, SAU, Dhaka, respectively.

represent the combined genetic and environmental effects on plant growth. This research work was undertaken to find out the practicable strategies for selecting salt tolerant rice mutants/lines/genotypes adaptable in coastal belt of Bangladesh notably during boro season.

## MATERIALS AND METHODS

The experiment was conducted in plastic trays at the glasshouse of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh during the period from December, 2003 to June, 2004. The experiment was set in two factorial CRD (Completely Randomized Design) with three replications. Factor 1: Rice genotypes -30 and Factor 2: Salinity levels-5 (0, 4, 8, 12 and 16 $dSm^{-1}$). Among the used 30 rice genotypes for selection 8 were cultivable varieties, 1 was standard check salt tolerant rice cultivar Pokkali and the remaining 21 were advanced lines, those where collected from BINA & Bangladesh Rice Research Institute (BRRI), Gazipur. The seedlings were grown in tray and the soil was used as growth medium. Soil for this experiment was collected from the field of BINA Farm, which was non-calcarious Dark Grey Floodplain having loamy texture and belonging to the Agro-Ecological-Zone of Old Brahmaputtra Floodplain. The soil was dried under the sun followed by crushing and mixed thoroughly. Chemical fertilizers namely urea, triple supper phosphate (TSP) and muriate of potash (MOP) were used for N, P and K at the rate of 120, 100 and 75 kg/ha, respectively before final preparation of the seed bed. The fertilizers were applied one day before sowing seeds in the seed bed. Sterilized seeds were imbibed in distilled water for 24 hours and then washed thoroughly in fresh water, and the seeds were incubated for 48 hours for sprouting. After sprouting, they were placed on the thin layer of wet seed bed of soils in the trays. Saline solution was added after 1-2 leaf stage of seedling in each tray according to the treatments. To avoid osmotic shock, the required amount (at the rate of 640 mg per litre distilled water for 1 $dSm^{-1}$) of salt solution was added in three equal installments on alternate days until the expected conductivity was reached. The salinity *i.e.* electric conductivity (EC) of each tray was measured with a conductivity meter (Model-SALINITY BRIDGE CAT. NO. 5500) and the necessary adjustments of salinity were made.

**Collection of data**

The seedlings were up rooted 30 days after sowing (DAS). Ten plants of each genotype per treatment were up rooted for recording the following data.

**a) Seedling height:** Seedling height (cm) was measured from the root base to the tip of the longest leaf at the time of up rooting of seedlings.

**b) Root dry weight of seedlings:** Roots were separated from the seedlings and washed with tap water and finally with distilled water. The root samples were oven-dried to a constant weight at 70°C. The dry weight of root per seedling (mg) was recorded for each treatment.

**c) Shoot dry weight of seedlings:** After the separation of roots from up rooted seedlings, the seedling shoots were washed with tap water and finally with distilled water. Then the shoot samples were oven-dried to a constant weight at 70°C. The mean seedling dry weight of shoot (mg) was calculated for each treatment.

**d) Total dry matter of seedlings:** The total dry matter $seedling^{-1}$ (mg) was calculated from the summation of root and shoot dry weight for each treatment.

**e) Relative growth data:** The relative growth performance of seedlings of different genotypes was calculated to evaluate the salt tolerance for each genotype by the following formula proposed by Ashraf and Waheed (1990):

$$\text{Relative growth data (\%)} = \frac{\text{The growth data of salt treated seedling of a genotype}}{\text{The growth data of control treated seedling of that genotype}} \times 100$$

**Statistical analysis**

The collected data were analyzed statistically following CRD design by MSTAT-C computer package programme developed by Russel (1986). The treatment means were compared by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

# RESULTS AND DISCUSSION

This study was undertaken to evaluate the effect of salinity tolerance on seedling growth of 30 rice genotypes in respect of seedling height, root dry weight, shoot dry weight and total dry matter. The results have been expressed in terms of absolute values (Dewey, 1960) and relative values (Maas, 1986) of the growth characters. The results obtained from this experiment along with discussion have been presented following parameters under the effect of different factors and their combined effect. For easy understanding the figures, the 30 rice genotypes were grouped in 3 containing 10 genotypes in each group at all the parameters.

**Seedling height**

Seedling height of different rice genotypes significantly decreased with the increase in salinity levels (Table 1). The tallest (15.40 cm) seedling was found in control condition and the shortest (8.18 cm) was in the highest salinity level (16 $dSm^{-1}$) employed. In case of relative seedling height (% seedling height to control conditions), the same phenomena *i.e.* it gradually decreased with the increase in salinity levels and reached to the lowest at 16 $dSm^{-1}$ (Table 1).

The seedling height of different rice genotypes differed significantly due to the mean effect of different salinity levels under study (Table 2). The genotypes Pokkali (19.58 cm), Kajal Sail (16.80 cm), N. Bokra (16.31 cm) and Raja Sail (14.47 cm) were among the prominent genotypes produced higher seedling height. On the other hand, mutants Y1281 showed the lowest performance (8.21 cm) followed by NS15 (8.50 cm). These were absolute results data and Pokkali, Kajal Sail, N. Bokra and Raja Sail are genetically tallest rice cultivars. The variation in % relative seedling height of all the genotypes was found significant due to mean effect of salinity levels (Table 2), where the genotypes PVSB19, Pokkali, PVSB9, PNR519, PVSB3 produced higher % relative seedling height as compared to that of other genotypes and the genotype NS15 showed the lowest performance (56.48%) followed by DM25 (60.59%) and RD21 (60.60%).

**Table 1. The effect of different salinity levels on different morphological characters of rice seedlings (each value is a mean of 30 rice genotypes)**

| Salinity level ($dSm^{-1}$) | Seedling height (cm) | Relative seedling height (%) | Root dry wt. (mg $seedling^{-1}$) | Relative root dry wt. (%) | Shoot dry wt. (mg $seedling^{-1}$) | Relative shoot dry wt. (%) | TDM (mg $seedling^{-1}$) | Relative total dry matter (%) |
|---|---|---|---|---|---|---|---|---|
| 0 | 15.40 a | 100.0 a | 16.69 a | 100.0 a | 55.15 a | 100.0 a | 71.84 a | 100.0 a |
| 4 | 12.04 b | 78.03 b | 8.92 b | 55.09 b | 33.97 b | 61.80 b | 42.89 b | 60.22 b |
| 8 | 10.51 c | 68.46 c | 5.46 c | 34.53 c | 15.41 c | 28.83 c | 20.87 c | 30.10 c |
| 12 | 9.21 d | 60.32 d | 3.78 d | 24.14 d | 11.04 d | 20.57 d | 14.82 d | 21.35 d |
| 16 | 8.18 e | 53.93 e | 2.61 e | 16.91 e | 7.86 e | 15.10 e | 10.47 e | 15.49 e |
| $LSD_{0.05}$ | 0.17 | 1.26 | 0.18 | 0.87 | 0.58 | 0.96 | 0.72 | 0.88 |
| CV (%) | 5.31 | 5.95 | 8.20 | 6.48 | 8.09 | 7.20 | 7.65 | 6.62 |

Values having same letter(s) in a column do not differ significantly at 5% level of probability

The effect of different salinity levels on the relative seedling height was found to decrease slowly with the increase in salinity levels in genotypes PVSB19, Pokkali, PVSB9, PNR519 and PNR381 (Fig.1a) and it sharply decreased in genotype NS15, RD21 and DM25 (Fig.1c).Cristo *et al.* (2001) conducting a laboratory experiment with new rice lines 8610, 8736, 8734 and cultivars Pokkali (salt tolerant) and

Amistad-82 (salt susceptible), at different saline concentrations (0.4, 0.7 and 1.0%) found that plant height was affected by the increase of salinity levels and the rice lines 8736 and 8734 were better than Pokkali. Thirumeni *et al.* (2001) found that % germination and seedling growth decreased with increasing salt concentration in rice cultivars. Alam *et al.* (2001) stated that the critical level of salinity for seedling growth was about 5 $dSm^{-1}$, the most common salinity effect was stunting of plant growth, whereas leaf withering was less apparent and the growth parameters such as dry matter, seedling height, root length and emergence of new roots decreased significantly at electrical conductivity value of 5-6 $dSm^{-1}$. Seedling height, root length, seedling dry weight were highly correlated with the saline stress tolerance index, indicating that measuring varietal ratings for salt tolerance at the early stage of growth via these traits was likely to be effective (Gonzalez and Ramirez, 1998).

**Table 2. The effect of genotypes on germination and different morphological characters of rice seedlings [each value is a mean of 5 salinity levels (0, 4, 8, 12 & 16 $dSm^{-1}$)]**

| Genotypes | Seedling height (cm) | Relative seedling height (%) | Root dry wt. (mg seedling$^{-1}$) | Relative root dry wt. (%) | Shoot dry wt. (mg seedling$^{-1}$) | Relative shoot dry wt. (%) | TDM (mg seedling$^{-1}$) | Relative total dry matter (%) |
|---|---|---|---|---|---|---|---|---|
| Pokkali | 19.58 a | 87.81 ab | 14.93 a | 64.50 a | 60.85 a | 73.04 a | 75.77 a | 71.19 a |
| N. Bokra | 16.31 c | 72.45 g-i | 9.31 b | 47.60 d | 33.15 c | 51.66 c | 42.46 c | 50.72 de |
| Bina 6 | 10.61 g-j | 70.93 h-j | 6.05 l | 48.77 d | 19.01 n | 44.21 e-g | 25.07 m | 45.20 g-i |
| Bina 5 | 9.77 mn | 64.99 l-n | 4.43 n | 42.80 fg | 17.06 o | 42.40 g-i | 23.72 m | 42.47 j-n |
| BR41 | 13.22 e | 76.32 d-f | 6.67 i-k | 37.97 j-l | 20.49 m | 43.23 f-h | 27.15 l | 41.79 k-o |
| Kajal Sail | 16.80 b | 76.58 d-f | 6.33 kl | 39.04 jk | 31.07 d | 41.24 h-j | 37.41 d | 40.85 m-p |
| Raja Sail | 14.47 d | 66.85 k-m | 9.72 b | 38.79 jk | 36.26 b | 40.48 ij | 45.98 b | 40.12 n-p |
| PVSB 8 | 11.00 g | 74.92 e-g | 6.35 kl | 41.58 g-i | 21.24 k-m | 45.07 d-g | 27.59 kl | 44.21 h-k |
| PVSB 3 | 11.90 f | 80.15 c | 8.25 de | 44.57 ef | 29.79 d | 45.33 d-f | 38.04 d | 45.15 g-i |
| PVSB19 | 8.63 op | 89.27 a | 6.43 j-l | 63.67 a | 17.59 no | 64.79 b | 24.02 m | 64.47 b |
| PVSB 9 | 10.20 j-m | 85.87 b | 6.31 kl | 64.68 a | 20.91 k-m | 64.47 b | 27.23 l | 64.49 b |
| PVSB13 | 10.73 g-i | 78.67 cd | 6.49 j-l | 53.31 c | 24.41 fg | 47.63 d | 30.91 f-i | 48.72 ef |
| NS 22 | 8.86 o | 69.51 i-k | 6.62 i-k | 48.80 d | 24.49 fg | 46.16 de | 31.11 f-i | 46.70 fg |
| Atomita 4 | 10.57 g-k | 73.96 f-h | 8.77 c | 44.61 ef | 30.18 d | 43.88 e-g | 38.95 d | 44.03 h-l |
| Y1281 | 8.21 p | 63.86 m-o | 8.83 c | 35.82 l | 22.06 l-m | 37.15 kl | 30.89 f-i | 36.74 rs |
| TNDB100 | 8.58 op | 65.51 l-n | 7.81 ef | 39.39 i-k | 21.59 j-m | 39.83 ij | 29.40 i-k | 39.71 o-q |
| Q 31 | 8.81 o | 66.25 k-n | 7.91 ef | 40.33 h-j | 22.02 l-m | 38.64 jk | 29.93 h-j | 39.05 pq |
| RD 21 | 10.18 j-m | 60.60 p | 8.57 cd | 37.73 kl | 23.49 f-i | 34.38 m | 32.07 fg | 35.21 st |
| DM 25 | 11.01 g | 60.59 p | 8.01 ef | 33.05 m | 26.69 e | 34.41 m | 34.69 e | 34.10 t |
| Q 50 | 10.34 l-l | 75.29 d-g | 7.06 hi | 45.14 ef | 20.61 lm | 40.77 h-j | 27.67 kl | 41.80 k-o |
| THDB 21 | 8.84 o | 70.41 i-j | 7.31 gh | 43.01 e-g | 21.05 k-m | 43.29 f-h | 28.35 j-l | 43.21 i-m |
| PNR166 | 10.96 gh | 74.97 e-g | 7.57 fg | 43.07 e-g | 22.35 h-k | 41.12 h-j | 29.92 h-j | 41.58 l-o |
| PNR 519 | 10.86 gh | 80.15 c | 8.29 de | 58.33 b | 24.42 fg | 52.20 c | 32.71 f | 53.61 c |
| R3027 | 10.10 k-m | 74.63 e-g | 7.05 hi | 49.09 d | 24.83 f | 45.69 d-f | 31.88 f-h | 46.40 gh |
| PNR 381 | 10.51 h-l | 77.78 c-e | 6.37 kl | 56.30 b | 23.17 g-j | 51.39 c | 29.53 i-k | 52.35 cd |
| NS15 | 8.50 op | 56.48 q | 6.56 i-l | 36.43 l | 16.35 o | 33.31 m | 21.49 n | 34.10 t |
| NS16 | 9.86 m | 63.04 n-p | 5.19 m | 45.11 ef | 17.16 o | 35.61 lm | 21.54 n | 37.53 qr |
| NS18 | 9.39 n | 67.81 j-l | 6.40 kl | 45.40 e | 22.27 h-l | 44.10 e-g | 28.67 j-l | 44.37 g-j |
| Bina-Pok | 13.24 e | 66.27 k-n | 6.92 h-j | 42.13 gh | 23.86 f-h | 44.59 e-g | 30.78 f-i | 43.99 h-l |
| Iratom24 | 10.03 lm | 72.54 g-i | 8.19 de | 53.09 c | 22.17 l-m | 47.69 d | 30.35 g-j | 49.04 e |
| LSD $_{0.05}$ | 0.42 | 3.08 | 0.44 | 2.15 | 1.44 | 2.34 | 1.77 | 2.16 |
| CV (%) | 5.31 | 5.95 | 8.20 | 6.48 | 8.09 | 7.20 | 7.65 | 6.62 |

Values having same letter(s) in a column do not differ significantly at 5% level of probability

### Dry matter content

The yield of dry matter such as root dry weight (RDW), shoot dry weight (SDW) as well as total dry matter (TDM) along with their % relative RDW, SDW and TDM of different rice genotypes differed significantly due to the influence of different levels of salinity (Table 1). The absolute and % relative RDW, SDW and TDM were the highest at control treatment (0 $dSm^{-1}$) and their lowest results were obtained at highest level of soil salinity (16 $dSm^{-1}$).

The results in Table 2, show that the mean effect of different salinity levels significantly influence on the absolute and % relative RDW, SDW and TDM of the 30 rice genotypes under the study. Among the 30 rice genotypes, the highest absolute RDW (14.93 mg $seedling^{-1}$) was recorded in Pokkali, whereas the lowest RDW (4.43 mg $seedling^{-1}$) was in Bina 5 due to the mean effect of different salinity levels. But the higher % relative RDW values were observed in PVSB9 (64.68%), Pokkali (64.50%), PVSB19 (63.67%), PNR519 (58.33%) and PNR381 (56.30%) and the lower values were recorded in DM25 (33.05%), Y1281 (35.82%) and NS15 (36.43%). The SDW of 30 rice genotypes varied from 16.35 - 60.85 mg $seedling^{-1}$ and Pokkali performed the best and the genotypes NS15 produced lowest SDW due to mean effect of the salinity levels used (Table 2). In case of % relative SDW, the genotypes Pokkali, PVSB19, PVSB9, PNR519, Nona Bokra and PNR381 produced higher relative SDW and the genotype NS15 contained the lowest relative SDW followed by DM25 and RD21. The results in Table 2 show that the mean effect of salinity levels significantly influence on the TDM of the rice genotypes and the highest TDM was recorded in Pokkali (75.77 mg $seedling^{-1}$), on the other hand, the lowest (21.49 mg $seedling^{-1}$) TDM was found in NS15 followed by NS16 (21.54 mg $seedling^{-1}$). The mean effect of salinity levels had induced significantly the relative TDM of the rice genotypes (Table 2), where the values of % relative TDM were observed higher in Pokkali (71.19%), PVSB9 (64.49%), PVSB19 (64.47%), PNR519 (53.61%) and PNR381 (52.35%) and the lowest (34.10%) amount was found in DM25 and NS15.

The effect of different salinity levels on % relative RDW, SDW and TDM of 30 rice genotypes varied significantly. The % relative RDW slowly decreased with increasing the salinity levels in genotypes PVSB9, Pokkali, PVSB19, PNR519 and PNR381 (Fig. 2a), and it sharply decreased with increasing salinity levels in genotype DM25, NS15 and Y1281 (Fig. 2c). In case of % relative SDW was less affected in genotypes Pokkali, PVSB19, PVSB9, PNR519 and PNR381 (Fig. 3a) and it was highly affected in genotypes NS15, DM25 and RD21 (Fig. 3c) as compared to other genotypes, due to the increase in salinity levels. The Fig. 4 indicated that there were sharp differences on the effect of different salinity levels on relative TDM yield per seedling of different rice genotypes. The % relative TDM slowly decreased with increase in the salinity levels in genotypes Pokkali, PVSB19, PVSB9, PNR519 and PNR381 (Fig. 4a) and it decreased sharply with the increase in salinity levels in genotypes NS15, DM25 and RD21 (Fig. 4c). From the above results of the effect of different salinity levels on % relative seedling height, RDW, SDW and TDM decreased with the increase in salinity levels from 4 $dSm^{-1}$ to 16 $dSm^{-1}$ of 30 rice genotypes though some of the genotypes Pokkali, PVSB9, PVSB19, PNR519 and PNR381 showed better performance, indicating some-what salt tolerant and DM25, Y1281, RD21 and NS15 showed inferior performance, expressing salt susceptible as compared to other genotypes. These findings are in agreement with Shannon *et al.* (1998), who observed that salinity led to reduction in shoot and root dry weights. Zeng and Shannon (2000) in greenhouse experiment in sand and irrigated with nutrient solution amended with NaCl and $CaCl_2$ (2:1 mole ratio) at 1.9, 3.4, 4.5, 6.1,7.9, and 11.5 $dSm^{-1}$ EC with rice cultivar M-202 studied the salinity effect on seedling of rice. They observed that seedling growth was significantly reduced by salinity even at the lowest salinity treatment of 1.9 $dSm^{-1}$ as compared to control treatment. Gonzalez and Ramirez (1998) reported that seedling height,

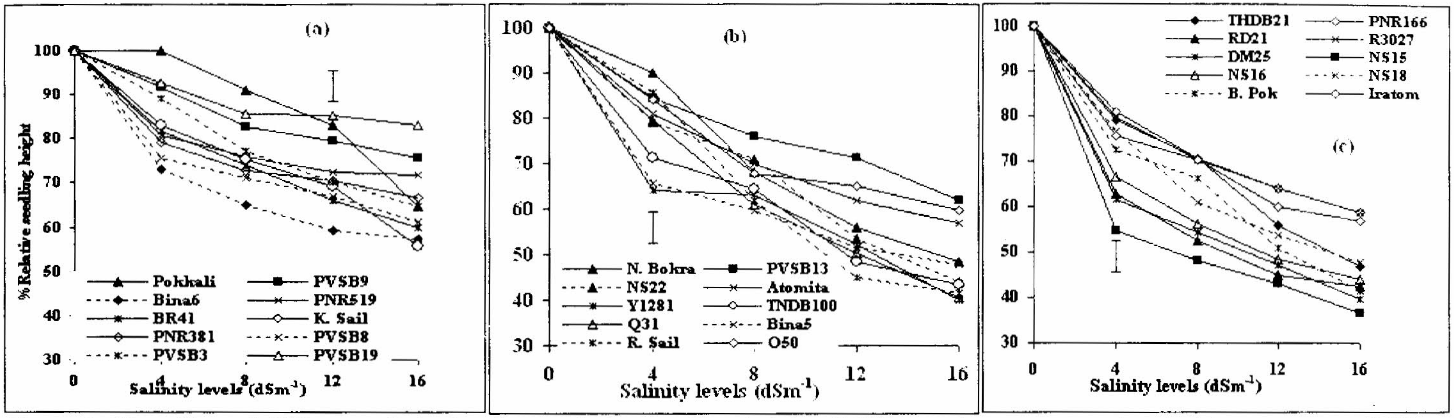


Figure 1. The effect of different salinity levels on relative seedling height of different rice genotypes (vertical bars represent LSD at 0.05 level of significance)

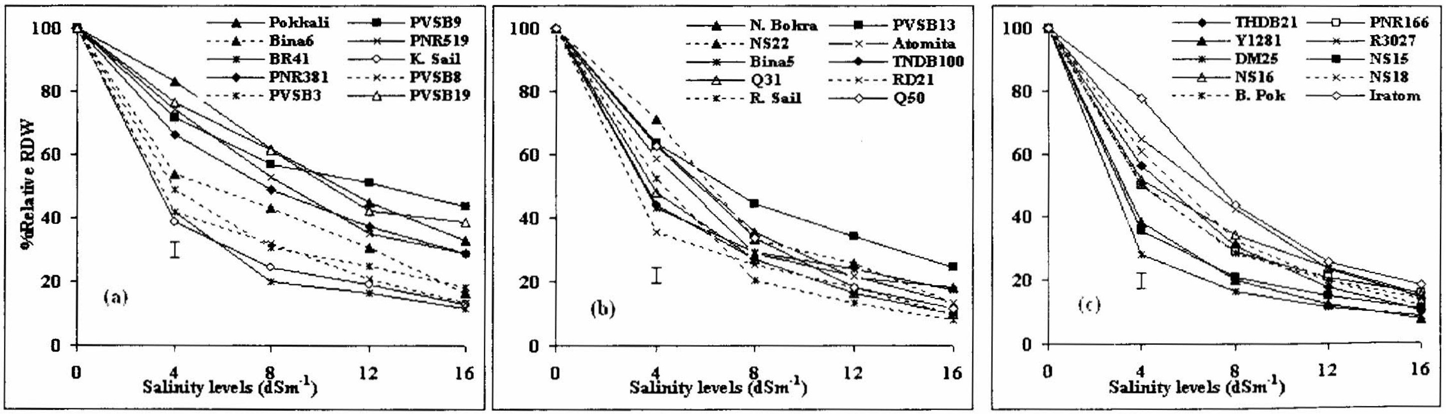


**Figure 2. The effect of different salinity levels on relative root dry weight (RDW) of different rice genotypes (vertical bars represent LSD at 0.05 level of significance)**

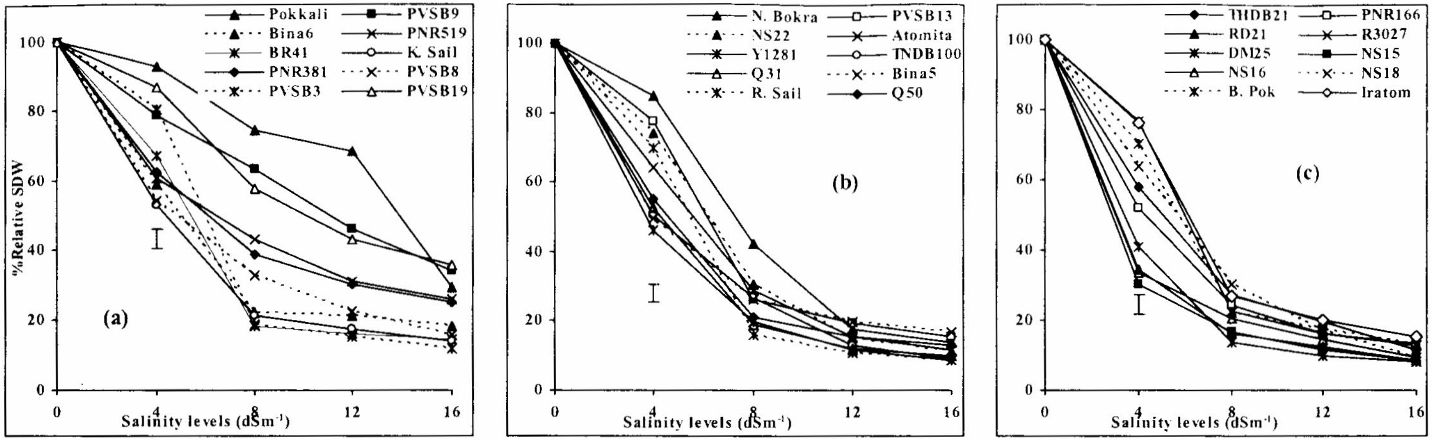


**Figure 3. The effect of different salinity levels on shoot dry weight (SDW) of different rice genotypes (vertical bars represent LSD at 0.05 level of significance**

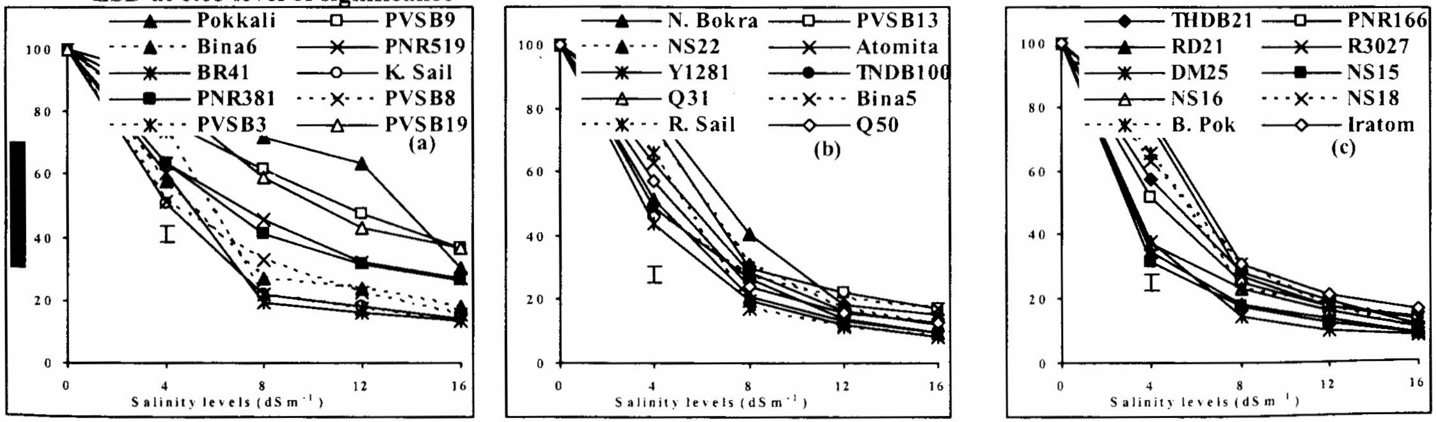


**Figure 4. The effect of different salinity levels on total dry matter (TDM) of different rice genotypes (vertical bars represent LSD at 0.05 level of significance)**

root length, seedling dry weight and relative leaf water content were highly correlated with the saline stress tolerance index. Alam *et al.* (2001) stated that the critical level of salinity for seedling growth was about EC 5 $dSm^{-1}$. They also found that growth parameters such as dry matter, seedling height, root length and emergence of new roots decreased significantly at an electrical conductivity value of 5-6 $dSm^{-1}$. Lin and Kao (2001) studied the relative importance of endogenous abscisic acid (ABA), as well as $Na^+$ and $Cl^-$ in NaCl induced responses on growth of roots of rice seedlings and observed that increasing concentrations of NaCl from 50-150 mM progressively decreased root growth. Pushpam and Rangasamy (2002) observed that salinity induced general reduction in shoot and root length in susceptible cultivars (IR-20, IR-50) compared to the tolerant cultivar (Pokkali). Pareek *et al.* (1998) found that branching of the roots of the plants was arrested in 100 mM NaCl and with further increase in NaCl concentration to 200 mM, the embryonic axis emerged from the seeds, but it did not show any further growth with respect to its elongation. Cristo *et al.* (2001) stated that at initial stage plant growth was affected by the increase of salinity level. Similar opinion was also given by Thirumeni *et al.* (2001).

The results showed that the genotypes PVSB19, Pokkali, PVSB9, PNR519, PNR381 had better expression of morphological characters under different salinity levels. On the other hand, genotypes RD21, DM25 and NS15 showed lower performance at different salinity levels. Increasing salinity sharply reduced all growth characters such as percent relative- seedling height, RDW, SDW and TDM in genotypes RD21, DM25 and NS15, but these characters were found to decrease slowly in genotypes PVSB19, Pokkali, PVSB9, PNR519 and PNR381.

## REFERENCES


Alam, S.M., Ansari, R., Mujtaba, S.M. and Shereen, A. 2001. Salinization of millions of hectares of land continues to reduce crop productivity severely worldwide. In: Saline Lands and Rice: Industry & Economy. *Pakistan Economist*, 17: 60-71.

Ashraf, M. 2002. Salt tolerance of cotton: some new advances. *Crit. Rev. Plant Sci.* 21: 1-30.

Ashraf, M. and Waheed, A. 1990. Screening of local/exotic accessions of lentil (*Lens culinaris* Medic.) for salt tolerance at two growth stages. *Plant Soilz* 128: 167- 176.

Cristo, E., Gonzalez, M.C., Cardenas, R.M. and Perez, N. 2001. Salinity tolerance evaluation at the young stage of three new rice (*Oryza sativa* L.) lines by morpho-agronomic markers. *Cultivos Trop.* 22(2): 43-45.

Dewey, D.R. 1960. Salt tolerance of 25 strains of *Agropyron*. *Agron. J.* 52: 631-635.

Gonzalez, L.M. and Ramirez, R. 1998. Correlation of some varietal characteristics with grain yield and stress tolerance index under saline conditions. *Int. Rice Res.* 23(1): 19- 20.

Lin, C.C. and Kao, C.H. 2001. Relative importance of $Na^+$, $Cl^-$, and abscisic acid in NaCl induced inhibition of root growth of rice seedlings. *Plant Soil*, 237(1): 165-171.

Maas, E.V. 1986. Salt tolerance of plants. *Appl. Agri. Res.* 1: 12-26.

Pareek, A., Singla, S.L. and Grover, A. 1998. Proteins alterations associated with salinity, desiccation, high and low temperature stresses and abscisic acid application in seedlings of Pusa 169, a high-yielding rice (*Oryza sativa* L.) cultivar. *Curr. Sci.* 75(10): 1023-1035.

Pushpam, R. and Rangasamy, S.R.S. 2002. *In vivo* response of rice cultivars to salt stress. *J. Ecobiol.* 14(3): 177-182.

Russel, D.F. 1986. *MSTAT-C Package Programme.* Dept. of Crop and Soil Science, Michigan State University, USA.

Shannon, M.C., Rhoades, J.D., Draper, J.H., Scardaci, S.C. and Spyres, M.D. 1998. Assessment of salt tolerance in rice cultivars in response to salinity problems in California. *Crop Sci.* 38(2): 394- 398.

Steponkus, P.L. 1984. Role of the plasma membrane in freezing injury and cold acclimation. *Annu. Rev. Plant Physiol.* 35: 543-584.

Thirumeni, S., Anuratha, A., Ramanadane, T. and Paramasivam, K. 2001. Effect of salinity on seed germination and seedling growth of rice varieties. *Crop Res. Hisar*, 22(3): 335-338.

Zeng, L. and Shannon, M.C. 2000. Salinity effects on seedling growth and yield components of rice. *Crop Sci.* 40(4): 996-1003.