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YIELD PERFORMANCE OF RICE VARIETIES UNDER NaCl INDUCED SALINITY STRESS IN BORO SEASON

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ABSTRACT

A pot experiment was conducted at the research field of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh in boro season during December 2016 to June 2017 to find out the effect of salinity on yield and yield attributes of rice varieties. Seven rice varieties (Pokkali, BRRI dhan28, BRRI dhan47, BRRI dhan61, BRRI dhan74, Binadhan-8 and Binadhan-10) and three salinity levels *viz.*, control (no salinity), moderate salinity (8 dSm^{-1}) and strong salinity (12 dSm^{-1}) were assigned in two factors completely randomized design with 3 replications. Number of tillers $hill^{-1}$, number of panicles $hill^{-1}$, panicle length, grains $panicle^{-1}$, grain weight $hill^{-1}$, 1000 grain weight and straw weight $hill^{-1}$ were significantly reduced with the increase in salinity levels in all rice varieties by different degree. In response to yield performance, Binadhan-8, Binadhan-10 and BRRI dhan74 were found as tolerant, Pokkali and BRRI dhan47 as moderate tolerant and BRRI dhan28 and BRRI dhan61 as susceptible up to a certain salinity level.

Key words: Salinity, stress, yield, salt tolerance, rice

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most cultivated crops of the world, consumed by more than two billion people as their main source of calories (Ziska *et al*. 2015). Though, rice is one of the major food crops in the world, it is extremely salt-sensitive (Islam and Hossain 2020). Salinity is one of the most serious problems that limits rice production all over the world especially in the coastal areas (Reddy *et al.* 2017). Salinization and saltwater intrusion are serious threats to rice cultivation and to agriculture in general, in coastal areas of tropical regions (Velmurugan *et al.* 2016). According to the United Nations Environment Programme (UNEP), 20% of the agricultural land and 50% of the cropland worldwide suffer from salinity (Othman *et al.* 2006). In Bangladesh, 105.6 Mha area was recorded under salt affected during 2009, out of which about 2.5 Mha of lands were coastal low laying land with salinity levels of 0.9 to 2.1 dSm^{-1} (SRDI 2010). It was reported that in Bangladesh salinity has increased about 26% in the last 35 years (Mahmuduzzaman *et al.* 2014).

Salinity adversely affects the process of germination, seedling establishment, plant growth and yield in almost all the cultivated crops by lowering the osmotic potential of water or by causing

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specific ionic toxicity, or both in the growing medium (Alom *et al.* 2016 and Kazal *et al.* 2017). High salinity causes multifarious co-operative events that adversely affect plant growth and development, and consequently yields, resulting in reduction of agricultural outputs by billions of dollars per annum (Tahjib-Ul-Arif *et al*. 2018 and Abdel Latef *et al*. 2019). Salt stress can trigger hyper-osmotic stress by reducing soil water availability and ion toxicity by accumulating excessive Na^+ in the cells, which severely impede common metabolic and physiological functions, leading to plant death in severe cases (Acosta-Motos *et al*. 2017).

Rice quality and yield are fundamental for the whole world, especially considering population rise, expected to be from 9 to 10 billion by 2050 (WPP 2019). In Bangladesh, the population was 160 million in 2015 which will reach to 186, 215.40 and 243 million in 2030, 2050 and 2071, respectively and the end of this century, population of the country is predicted to reach 249 million (Kabir *et al.* 2015). As a result, it is a big concern to increase sufficient production of rice in order to ensure food security in Bangladesh. It is bitter truth that the agricultural land of the country is decreasing day by day and it is quite impossible to expand land horizontally. Thus, to ensure food security of the country, large increase in food production is only the solution where using of marginal soils like salt affected soil of the coastal areas for the production purpose may be one of the strategies for increasing food production. Bangladesh has a coastal area of 2.85 million hectares, of which about 1.0 million hectares along the coastal belt is under intimidation of different magnitudes of salinities where salinity reduces about 50% yield of the majorcrops (Rahman *et al.* 2016). Therefore, screening and adaptation of salt tolerant rice varieties will be feasible and economical approach to increase the cropping intensities in the coastal areas as well as to increase the total food production of Bangladesh. The present investigation aimed to select comparatively salt tolerant rice variety(s) among seven rice varieties through evaluating their yield performance under NaCl induced salinity in boro season.

MATERIALS AND METHODS

Location and duration

The experiment was conducted at the research field of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during boro season of December 2016 to June 2017. The experimental site is located under the Agro-ecological zone 'Old Himalayan Piedmont Plain' (AEZ-1). The soil used in the experimental pot was non-calcareous dark gray floodplain with sandy loam texture.

Experimental design

The experiment was laid out in two factors completely randomized design with 3 replications. Factor A: Three salinity levels; Control (no salinity and irrigation with normal water), moderate salinity (8 dSm^{-1}) and strong salinity (12 dSm^{-1}) and Factor B: Seven rice varieties (Pokkali, BRRI dhan28, BRRI dhan47, BRRI dhan61, BRRI dhan74, Binadhan-8 and Binadhan-10).

Collection and preparation of experimental pots

Total 63 plastic pots (30 cm height and 25 cm diameter) were collected. The soil was collected from 0-15cm depth of the research field. The collected soil was well pulverized and dried in the sun and well decomposed cowdung was mixed with the soil. The pots were filled up with 10 kg of air dried soil and labeled properly.

Fertilizer application

Urea, triple supper phosphate, muriate of potash, gypsum and zinc sulphate were applied as the source of nitrogen, phosphorus, potassium, sulphur and zinc at the rate of 140, 100, 80, 20 and 2 kg ha^{-1}, respectively as basal dose before final preparation of the seed bed. Urea, triple supper phosphate, muriate of potash, gypsum and zinc sulphate were applied at the rate of 1.68, 0.56, 0.89, 0.63, 0.053 g, respectively for 10 kg soils in the pot. Half of urea and whole amount of triple supper phosphate, muriate of potash, gypsum and zinc sulphate were mixed with pot soil as basal dose. Rest of urea were divided in two equal splits and applied as top dressing on 20 and 40 days after transplanting.

Collection of seed

Among seven rice varieties BRRI dhan28, BRRI dhan47, BRRI dhan63, BRRI dhan71 and Pokkali were collected from Bangladesh Rice Research Institute, Gazipur, Bangladesh, whereas Binadhan-8 and Binadhan-10 were collected from Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh.

Seedbed preparation, seed sowing and transplanting

The seedbed was prepared by ploughing and cross ploughing with power-tiller followed by laddering. The land was cleaned by removing weeds, stables and crop residues before final ploughing and leveling. Previously collected seed were sun dried and soaked. Prior to germination seeds were surface sterilized. Sterilized seeds were imbibed in distilled water for 24 hours and then washed thoroughly in fresh water, and the seeds were incubated for sprouting which were sown in wet seedbed. 40 days old seedlings were uprooted carefully from the seedbed, bundled with proper care and transplanted in the respective pots. One seedling was planted in each pot in a hill. Seedling in some hills died off, and these were replaced by gap filling after one week of transplanting with the seedling from the same source.

Preparation and application of different saline solutions

Rice plants were subjected to exposure in different salinity concentration of 0 dSm^{-1} (normal water), 8 dSm^{-1} and 12 dSm^{-1}. The saline solutions were prepared by dissolving commercial salt (NaCl) at the rate of 640 mg $liter^{-1}$ distilled water for 1 dSm^{-1} salinity level. The saline treatments were started at 12 days after transplanting. Normal water and salt solution was added gradually in the respective research pot. About 3-4 cm water layer was maintained in the pot until the crop attained maturity. Water was added as per assigned salinity concentrations when and as necessary.

Intercultural operation

Recommended production technology of rice was followed and necessary intercultural operations were done whenever necessary.

Collection of data

Data were recorded on number of tillers $hill^{-1}$, number of panicles $hill^{-1}$, length of panicle, grains $panicle^{-1}$, grain weight $hill^{-1}$, 1000 grain weight and straw weight $hill^{-1}$ during final harvest of the crop.

Salt tolerance index (STI)

STI was calculated using following formula of Goudarzi and Pakniyat (2008).

STI = (Variable measured under salinity stress condition) / (Variable measured under normal condition)

Statistical analysis

The collected data were analyzed by partitioning the total variance with the help of a computer by using MSTAT-C program and the means were compared using DMRT at 5% level of probability.

RESULTS AND DISCUSSION

Number of tillers hill^{-1}

The results highlighted that the saline concentrations had considerable negative effect on tillers number hill^{-1} of rice varieties (Table 1). Under control condition, the maximum number of tillers hill^{-1} (35.00) was recorded from BRRI dhan61, while under moderate salinity stress the maximum number of tillers hill^{-1} (25.67) was obtained from BRRI dhan74 which was very close to that of BRRI dhan28. Binadhan-10 and Binadhan-8 produced statistical similar and the highest tillers number hill^{-1} (21.00 and 21.33, respectively) under strong salinity stress. BRRI dhan47 produced the minimum number of tillers hill^{-1} under both moderate and strong salinity stress, while Pokkali and BRRI dhan74 produced statistically similar and minimum number of tillers hill^{-1} under control condition. Different magnitudes of reduction were observed in number of tillers hill^{-1} of rice due to salinity stress. The degrees of reduction were 19.23 and 45.00% in Pokkali, 13.03 and 48.12% in BRRI dhan28, 15.46 and 25.00% in Binadhan-10, 27.46 and 29.67% in Binadhan-8, 6.42 and 44.88% in BRRI dhan74, 38.09 and 61.91% in BRRI dhan61 and 52.95 and 55.28% in BRRI dhan47 under moderate and strong salinity stress, respectively. The lower tiller initiation can be due to disturbed bio chemical, physiological and enzymatic activities and lower accumulation of photosynthate that hinders the vegetative growth of plants under salt induced stress. According to Munns (2002) salinity reduces the growth of plant through osmotic effects, reduces the ability of plants to take up water and this causes reduction in growth. In addition, if excessive amount of salt enters the plant, the concentration of salt eventually rises to a toxic level which hampers the photosynthesis of a plant to a level that cannot sustain growth. Our results agree with the findings of other researchers (Sultana *et al.* 2014 and Linghe and shannon 2000) who stated decreasing trend of tillers number plant^{-1} in rice with increasing salinity level.

Number of panicles hill^{-1}

Table 1 indicates that among different treatment combinations, the maximum number of panicles hill^{-1} (33.67) was recorded in BRRI dhan61 under control which was statistically similar to that of BRRI dhan47 (27.67), BRRI dhan74 (26.33) and Pokkali (26.33) at control, whereas the minimum number of panicles hill^{-1} (3.00) was recorded in BRRI dhan61 under 12 dSm^{-1} salinity which was statistically similar to that of BRRI dhan28 (6.00) and BRRI dhan47 (10.00) under same growing condition. Number of panicles hill^{-1} were decreased by different degree with the increasing of salinity level. Moderate salt stress reduced the number of panicles by 24.04% in Pokkali 68.00% in BRRI dhan28, 12.86% in Binadhan-10, 1.64% in Binadhan-8, 11.39% in BRRI dhan74, 70.30% in BRRI dhan61 and 57.63% in BRRI dhan47, whereas strong salt stress reduced the panicles number by 54.42% in Pokkali 76.00% in BRRI dhan28, 21.43% in Binadhan-10, 11.32% in Binadhan8, 5.881% in BRRI dhan74, 91.09% in BRRI dhan61 and 63.86% in BRRI dhan47 which indicate Binadhan-8 was more tolerant and BRRI dhan61 was more susceptible under both 8 dSm^{-1} and 12 dSm^{-1} salinity level in respect to number of panicles $hill^{-1}$. The lower panicle initiation can be due to disturbed bio chemical, physiological and enzymatic activities and lower accumulation of photosynthate to the reproductive parts of the plants that occur under salt induced stress. In our study, salt stress reduced the tillers number $hill^{-1}$ that caused lower number of panicles. Our results are highly consistent to results of Islam and Hossain (2020) who observed lower number of panicle in rice grown in moderately and strongly saline soil compared to normal soil. Grattan *et al*. (2002) and Hasamuzzaman *et al.* (2009) also reported that salinity stress reduces the number of panicles in rice that support our results.

Table 1. Number of tillers $hill^{-1}$ and numbers of panicles $hill^{-1}$ of different rice varieties at harvesting as influenced by salinity levels

Rice varieties	Number of tillers $hill^{-1}$			Number of panicles $hill^{-1}$		
	Control	8 dS m^{-1}	12 dS m^{-1}	Control	8 dS m^{-1}	12 dS m^{-1}
Pokkali	26.00bc	21.00c-f (-19.23)	14.30d-g (-45.00)	26.33a-c	20.00b-e (-24.04)	12.00ef (-54.42)
BRRI dhan28	35.33ab	25.00c (-13.03)	18.33de (-48.12)	25.00bc	8.00fg (-68.00)	6.00fg (-76.00)
Binadhan-10	28.00bc	23.67cd (-15.46)	21.00c-f (-25.00)	23.33bc	20.33b-e (-12.86)	18.33c-e (-21.43)
Binadhan-8	30.33bc	22.00c-e (-27.46)	21.33c-f -(29.67)	20.67b-d	20.33b-e (-1.64)	18.33c-e (-11.32)
BRRI dhan74	26.00bc	25.67c (-6.42)	14.33e-g (-44.88)	26.33a-c	23.33bc (-11.39)	12.67d-f (-51.88)
BRRI dhan61	35.00ab	21.67c-f (-38.09)	13.33fg (-61.91)	33.67a	10.00fg (-70.30)	3.00g (-91.09)
BRRI dhan47	28.33bc	13.33e-g (-52.95)	12.67fg (-55.28)	27.67ab	12.00ef (-57.63)	10.00fg (-63.86)
Level of significance		*			**	
CV (%)		9.85			8.74	

'*' and '**' indicate significant at 5% and 1% level of probability, respectively. Values followed by the different letter(s) are significantly different from each other by DMRT at 5% level of probability. Values in parenthesis indicate percent change over control.

Panicle length

Salinity stress reduced the panicle length of different rice varieties but the degree of reduction was not similar for all varieties (Table 2). Under moderate salinity stress, maximum reduction in panicle length (12.56%) was observed in Pokkali and minimum reduction (0.41%) was recorded in Binadhan-10, whereas under strong salinity stress, maximum and minimum reduction in panicle length (17.17% and 3.07%) were found in Pokkali and Binadhan-10, respectively. However, Binadhan-10 produced the longest panicle and BRRI dhan61 produced the shortest panicle in all salinity levels. Panicle length and panicle numbers are two important yield components that contribute to final grain yield. The overall control mechanism (before flowering) of sodium uptake through root properties and its subsequent distribution in different vegetative and floral parts significantly reduces the transportation of total assimilates to the growing region (Munns 2002) which may reduce the panicle length. Our results are in a line with Aslam *et al.* (2003) and Abdullah *et al.* (2001) who observed that panicle length of rice was significantly decreased due to salinity stress. Sultana *et al.* (2014) and Alam *et al*. (2001) also reported that salinity severely reduces the panicle length, seed setting percentage and panicle weight, thereby reducing the grain yield that are congruent with our findings on panicle length of rice under salt stress.

Table 2. Panicle length and number of grains panicle^{-1} of different rice varieties as influenced by salinity levels

Rice varieties	Panicle length (cm)			Number of grains panicle^{-1}		
	Control	8 dS m^{-1}	12 dS m^{-1}	Control	8 dS m^{-1}	12 dS m^{-1}
Pokkali	24.28	21.23 (-12.56)	20.11 (-17.17)	224.30a	181.00a-e (-19.30)	175.00a-e (-21.98)
BRRI dhan28	23.00	22.78 (-0.96)	22.00 (-4.35)	202.70abc	167.30b-e (-17.46)	114.30f-h (-43.61)
Binadhan-10	27.00	26.89 (-0.41)	26.17 (-3.07)	216.00ab	187.00 a-e (-13.43)	178.70a-e (-17.27)
Binadhan-8	26.83	26.11 (-2.68)	25.44 (-5.18)	225.30a	214.70ab (-4.70)	167.30b-e (-25.73)
BRRI dhan74	22.11	21.72 (-1.67)	20.50 (-7.28)	216.00ab	181.00a-e (-16.20)	135.70efg (-37.18)
BRRI dhan61	22.95	21.00 (-8.50)	19.78 d-f (-13.81)	155.00c-f	146.3def (-5.61)	84.00h (-45.81)
BRRI dhan47	25.00	24.22 (-3.12)	23.83 (-4.68)	189.30a-d	131.7efg (-30.43)	94.00gh (-50.34)
Level of significance		NS			**	
CV (%)		5.02			11.78	

‘NS’ indicates non-significant at 5% level of probability. ‘**’ indicates significant at 1% level of probability. Values followed by the different letter(s) are significantly different from each other by DMRT at 5% level of probability. Values in parenthesis indicate percent change over control.

Number of grains panicle^{-1}

The interactions among rice varieties and salinity levels portray that the highest number of grains panicle^{-1} was observed in Binadhan-8 (225.30) under control condition, while the lowest number of grains panicle^{-1} was observed in BRRI dhan61 (84.00) at salinity stress of 12 dSm^{-1} (Table 2). With the increasing in salinity levels, the number of grains panicle^{-1} decreased gradually but the degree of reduction was not similar for all varieties as well as for all salinity levels. The degrees of reduction were 19.30 and 21.98% in Pokkali, 17.46 and 43.61% in BRRI dhan28, 13.43 and 17.27% in Binadhan-10, 4.70 and 25.73% in Binadhan-8, 16.20 and 37.18% in BRRI dhan74, 5.61 and 45.81% in BRRI dhan61 and 30.43 and 50.34% in BRRI dhan47 under 8 dS m^{-1} and 12 dS m^{-1} salinity levels, respectively. The results revealed that Binadhan-8 was found as more tolerant to salinity stress up to 8 dS m^{-1} in respect to grains panicle^{-1} which was closely followed by BRRI dhan61 and Binadhan-10, whereas Binadhan-10 was found as more tolerant to salinity stress upto 12 dS m^{-1} regarding the respective traits which was nearly followed by Pokkali. BRRI dhan47 showed more susceptibility compared to other varieties under both moderate and strong salinity stress. The reduced number of grains in rice panicle might be due to failure of grain formation in rice which could be caused by lack of pollen viability resulted from salinity stress. The destructive effects of salinity include retarded plant growth due to increased Na^+ concentration (Saqib *et al.* 2008), delay in flowering and impaired fertility, with partial or complete grain loss resulting in poor panicle development in rice (Rao *et al.* 2008). Our results are parallel to the results of Hasamuzzaman *et al.* (2009) who observed filled spikelets or grains panicle^{-1} decrease significantly on increase of salinity.

1000-grain weight

Salinity stress had significant negative effect on 1000 grain weight of different rice varieties (Table 3). Differential responses to different salinity levels regarding 1000-grain weight were observed in different rice varieties. Among different treatment combinations, the highest 1000-grain weight (28.52 g) was recorded in BRRI dhan74 under control and the lowest (11.27 g) was recorded in BRRI dhan28 under 12 dS m^{-1} salinity level. Compared to other studied rice varieties, Pokkali showed more tolerance to salinity stress upto 8 dS m^{-1} with minimum reduction percentage, 3.10, whereas Binadhan-10 was found as more tolerant to salinity stress upto 12 dS m^{-1} with minimum reduction percentage, 7.40. On the other hand, BRRI dhan28 was found as more salt susceptible under both moderate and strong salinity levels with reduction percentage, 32.30 and 48.37, respectively. The magnitude of reduction in 1000 grain weight was 4.92% in Binadhan-10, 4.32% in Binadhan-8, 13.84% in BRRI dhan74, 15.92% in BRRI dhan61 and 9.17% in BRRI dhan47 under 8 dS m^{-1} salinity level. Under 12 dS m^{-1} salinity level, the degree of reduction was 19.33% in Pokkali, 11.45% in Binadhan-8, 24.72% in BRRI dhan74, 34.72% in BRRI dhan61 and 13.95% in BRRI dhan47. The reduction in 1000 grain weight might be due to reduced grain size resulted from lower accumulation of carbohydrates and other food materials into grain due to salt stress. Zubaer *et al.* (2007) observed salinity reduced the 1000-grain weight in rice and degree of reduction was different in different genotypes which supports the results of our study.

Table 3. 1000-grain weight and grain weight hill^{-1} of different rice varieties as influenced by salinity levels

Rice varieties	1000-grain weight (g)			Grain weight hill^{-1} (g)		
	Control	8 dS m^{-1}	12dS m^{-1}	Control	8 dS m^{-1}	12 dS m^{-1}
Pokkali	26.48ab	25.66 abc (-3.10)	21.36 e-g (-19.33)	34.60 de	16.83fgh (-51.36)	12.20gh (-64.74)
BRRI dhan28	21.83d-g	14.78 hi (-32.30)	11.27j (-48.37)	68.88 ab	26.90fg (-60.95)	12.60gh (-81.71)
Binadhan-10	24.61bcd	23.40 b-e (-4.92)	22.79c-f (-7.40)	54.10 bc	42.90cd (-20.70)	30.00def (-44.55)
Binadhan-8	25.93abc	24.81 bcd (-4.32)	22.96efg (-11.45)	54.64 bc	45.15cd (-17.37)	33.90def (-37.96)
BRRI dhan74	28.52a	24.57 bcd (-13.84)	21.47efg (-24.72)	65.40 ab	54.21bc (-17.11)	25.89fg (-60.40)
BRRI dhan61	19.41g	16.32 h (-15.92)	12.67ij (-34.72)	57.14 bc	34.50de (-39.62)	8.10h (-85.82)
BRRI dhan47	23.23b-f	21.10 efg (-9.17)	19.99fg (-13.95)	77.70 a	35.67de (-54.09)	19.28g (-75.19)
Level of significance		**			**	
CV (%)		6.06			8.46	

'**' indicates significant at 1% level of probability. Values followed by the different letter(s) are significantly different from each other by DMRT at 5% level of probability. Values in parenthesis indicate percent change over control.

Grain weight hill^{-1}

Table 3 reveals that among different treatment combinations, the highest grain weight hill^{-1} (77.70 g) was observed in BRRI dhan47 under control condition which was statistically at par with that of BRRI dhan74 (65.40 g) and BRRI dhan28 (68.88 g) at control, while the lowest grain weight hill^{-1} (8.10 g) was found in BRRI dhan61 under 12 dSm^{-1} salinity which was statistically similar to that of Pokkali (12.20 g) and BRRI dhan28 (12.60 g) under same growing condition. Salinity stress reduced the grain weight in all rice varieties but the degree of reduction was not similar for all varieties as well as for salinity levels. The degrees of reduction were 51.36 and 64.74% in Pokkali, 60.95 and 81.71% in BRRI dhan28, 20.70 and 44.55% in Binadhan-10, 17.37 and 37.96% in Binadhan-8, 17.11 and 60.40% in BRRI dhan74, 39.62 and 85.82% in BRRI dhan61 and 54.09 and 75.19% in BRRI dhan47 under 8 dS m^{-1} and 12 dS m^{-1} salinity levels, respectively. From the results, it is evident that BRRI dhan74 was more tolerant in respect to grain weight hill^{-1} up to 8 dS m^{-1} salinity level which was closely followed by Binadhan-8 and Binadhan-10, whereas Binadhan-8 showed more tolerance upto 12 dS m^{-1} salinity regarding the trait which was nearly followed by Binadhan-10. BRRI dhan28 and BRRI dhan61 were found as more susceptible to salt stress under 8 dS m^{-1} and 12 dS m^{-1} salinity levels, respectively. The loss of grain yield hill^{-1} may result from a combination of reduction in tillering capacity, lower panicle initiation, reduced panicle length and reduction in grain formation as well as in grain size due to salinity stress. Grain yield reduction of rice varieties due to salt stress is also reported by Linghe and shannon (2000) and Gain *et al.* (2004). Nahar *et al.* (2018) observed lower yield in foxtail millet crop under saline condition. These results are in a line with the results of our study.

Table 4. Straw weight hill^{-1} of different rice varieties as influenced by salinity levels

Rice varieties	Straw weight hill^{-1} (g)		
	Control	8 dS m^{-1}	12 dS m^{-1}
Pokkali	199.33 a	92.00 b (-53.85)	90.00 b (-54.85)
BRRI dhan28	58.00 cd	49.00 cde (-15.52)	48.00 cde (-17.24)
Binadhan-10	58.67 cd	52.00 cd (-11.37)	43.33 cde (-26.15)
Binadhan-8	55.00 cd	48.00 cde (-12.73)	46.00 cde (-16.36)
BRRI dhan74	58.67 cd	53.67 cd (-8.52)	38.67 def (-34.09)
BRRI dhan61	56.67 cd	46.67 cde (-17.65)	29.00 g (-48.83)
BRRI dhan47	60.00 c	50.00 cde (-16.67)	30.50 efg (-49.17)
Level of significance		**	
CV (%)		14.77	

'**' indicates significant at 1% level of probability. Values followed by the different letter(s) are significantly different from each other by DMRT at 5% level of probability. Values in parenthesis indicate percent change over control.

Straw weight hill^{-1}

Table 4 indicates that the rice varieties showed significant reduction in their straw yield with the increase in salinity levels. The magnitudes of reduction in straw weight hill^{-1} were 53.85% and 54.85% in Pokkali 15.52% and 17.24% in BRRI dhan28, 11.37% and 26.15% in Binadhan-10, 12.73% and 16.36% in Binadhan-8, 8.52% and 34.09% in BRRI dhan74, 17.65% and 48.83% in BRRI dhan61 and 16.67% and 49.17% in BRRI dhan47 under 8 dS m^{-1} and 12 dS m^{-1} salinity levels, respectively. The different reduction responses of different rice varieties to salinity stress paint that BRRI dhan74 was more tolerant upto 8 dS m^{-1} salinity level followed by Binadhan-10 and Binadhan-8, whereas Binadhan-8 was more tolerant upto 12 dS m^{-1} salinity level followed by BRRI dhan28. Pokkali was found as salt susceptible under both moderate and strong salinity stress. However, among different interactions, Pokkali produced the maximum straw weight hill^{-1} (199.33 g) under control and BRRI dhan61 produced the minimum straw weight hill^{-1} (29.00 g) under 12 dS m^{-1} salinity stress. The reduction in straw yield of rice under salt stress may be due to the constrained supply of carbohydrate to the developing organs during vegetative growth that reduce the tillering capacity, plant height, panicle length, leaf number as well as leaf area. In our study, salt stress significantly decreased the tillers number that subsequently reduced the total biomass resulted in lower straw yield of rice plant.

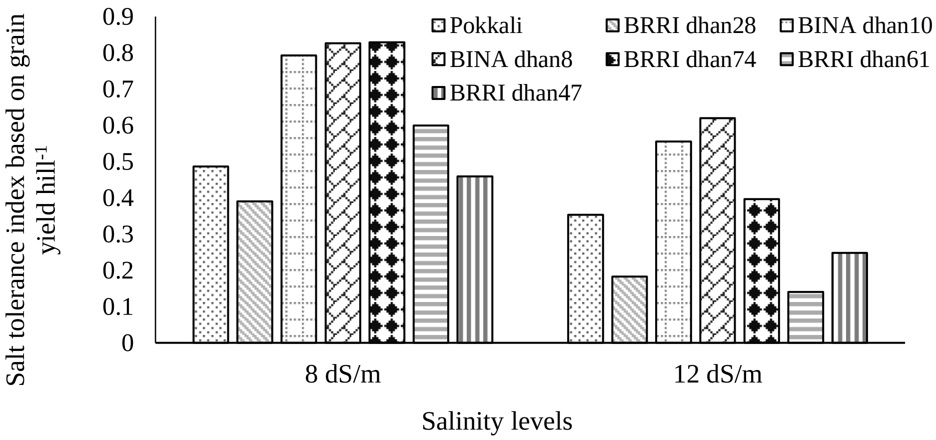

Figure 1. Salt tolerance index of different rice varieties based on grain yield hill^{-1}.

Salt tolerant index based on grain yield hill^{-1}

Figure 1 depicts the salt tolerance index of seven rice varieties based on grain yield hill^{-1}. These STI values indicate a wide difference in salt tolerance among the rice varieties. Rice varieties Binadhan-10, Binadhan-8, BRRI dhan74 and BRRI dhan61 showed greater than 0.50 STI, whereas Pokkali, BRRI dhan28 and BRRI dhan47 showed less than 0.50 STI at moderate (8 dSm^{-1}) salinity level. At moderate salinity level the order of tolerance based on grain yield hill^{-1} was BRRI dhan74 > Binadhan-8> Binadhan-10 > BRRI dhan61>Pokkali > BRRI dhan47 > BRRI dhan28. At strong salinity level (12 dSm^{-1}) rice varieties Binadhan-8 and Binadhan-10 showed STI value greater than 0.50, while BRRI dhan74, BRRI dhan63, BRRI dhan28, BRRI dhan47 and Pokkali showed less than 0.50 STI. At this salinity stress the order of salt tolerance based on grain yield hill^{-1} was Binadhan-8 > Binadhan-10 > BRRI dhan74>Pokkali > BRRI dhan47> BRRI dhan28 > BRRI dhan61. Other authors (Zeng *et al*. 2002) observed salt tolerance indexes in terms of seed yield, seed weight panicle^{-1}, spikelet number panicle^{-1} and tiller number plant^{-1} were reduced with increasing level of salinity that support our findings on salt tolerance index based on grain yield hill^{-1} of rice varieties.

CONCLUSION

Based on overall responses of rice varieties to different salinity levels it can be concluded that, Binadhan-8, Binadhan-10 and BRRI dhan74 were found as best tolerant upto 12 dS m^{-1} salinity stress. BRRI dhan61 and Pokkali were found as moderate tolerant, whereas BRRI dhan47 and BRRI dhan28 were found as susceptible upto 8 dS m^{-1} salinity stress. Under 12 dS m^{-1} salinity stress, Pokkali and BRRI dhan47 were found as moderate tolerant, while BRRI dhan28 and BRRI dhan61 were found as susceptible to salinity stress. However, further research under field condition is necessary to confirm these findings and may be tested in the saline areas of Bangladesh for evaluating their performance.

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