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Research Article

Agronomic Performance of Modern Rice Varieties in South-west Bangladesh

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Abstract

An experiment was carried out in Boro season during November 2018 to April 2019 at two farmer's fields of Batiaghata and Dumuria sub-district under Khulna district of Bangladesh with the objective of testing agronomic status and adaptability of four modern rice varieties in comparison with the popular mega variety BRRI dhan28. The varieties were BRRI dhan67, BRRI dhan81, BRRI dhan84 and BRRI dhan86. BRRI dhan28 was chosen as a control due to its wide acceptability among the farmers. The soil of the studied area was moderately alkaline and medium to moderately saline. In Batiaghata and Dumuria field, initial soil EC was 3.19 and 3.29 dS/m, respectively and it was 4.7 and 4.8 dS/m, accordingly at maturity stage. It was observed that germination rate, plant height, effective tiller number were significantly higher in BRRI dhan67 than the other varieties but insignificant with BRRI dhan28 ($p \leq 0.05$) for both fields. All the yield components spikelets per panicle, filled grain and 1000-grain weight were also significantly higher in BRRI dhan67 in compared to the other varieties but insignificant with BRRI dhan28 ($p \leq 0.05$) for both fields as well. The highest grain yield was observed in BRRI dhan67 in both plots (7.89 and 7.29 t/ha) and showed significant differences among all other varieties ($p \leq 0.05$). Harvest Index of BRRI dhan67 (51.02±4.2, 57.84±8.6)% indicated that this variety is the best yielder among the varieties. Considering overall performances and facts, BRRI dhan67 showed better agronomic performance and adaptation than the other modern varieties in compare with popular mega BRRI dhan28.

Keywords: Boro (dry season) rice; soil salinity; germination; grain yield; harvest Index.

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Introduction

Rice is the main source of food for people of Bangladesh and staple food almost half of the world's population. The dominant food crop of Bangladesh is rice covering about 75% of agricultural land and contributing 28% of GDP (1). Bangladesh is very vulnerable about the impact of climate change. Due to climatic change effects, salinity is increasing day by day, decreasing pest controlling capability, and increasing new pest invasion in the south-western part of Bangladesh. Out of 2.86 million hectares of coastal and offshore

Table 2. Seed germination rate and plant height of rice varieties at different stages

Rice Variety	Seed germination (%)		Plant height (cm)					
			Seedling		Maximum tillering stage		Maturity stage	
	F1	F2	F1	F2	F1	F2	F1	F2
BRRI dhan 28	85 b	90 a	21.2±1.6 a	20.2±1.3 a	55.3±4.8 a	73.7±6.2 a	108.7±10.2ab	93.9±6.3 b
BRRI dhan 67	90 a	90 a	27.3±1.3 a	29.6±1.2 a	50.6±5.5ab	76.6±4.3 a	116.6±6.8 a	109.9±5.9 a
BRRI dhan 81	85 b	90 a	23.4±1.5 a	22.4±1.9 a	46.6±3.7 b	70.3±5.3 a	94.3±9.5 c	103.1±9.6ab
BRRI dhan 84	80 c	80 b	23.7±1.7 a	27.8±2.9 a	42.8±4.1 b	60.4±6.8ab	90.5±7.2bc	122.9±11.3 a
BRRI dhan 86	85 b	70 c	21.6±2.2 a	25.9±1.6 a	43.2±5.2 b	76.4±6.1ab	86.8±8.8 c	92.4±9.5 b

F1=Dumuria Field and **F2**= Batiaghata Field

Table 3. Growth contributing characters of rice varieties

Rice Variety	Number of tillers				Spikelets per panicle				1000-grain weight (gm)	
	Effective		Total		Filled		Total			
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
BRRI dhan 28	18±2 a	10±2 b	19±2 a	11±2 b	111±11 a	119±9 a	120±12 a	131±14 a	23.47±2.13 a	22.3±3.3 a
BRRI dhan67	20±2 a	14±3 a	23±2 a	16±2 a	110±9 a	123±8 a	115±9 a	128±11 a	22.47±3.1 a	22.2±2.6 a
BRRI dhan81	14±3 b	11±2 b	18±3 b	15±3 a	76±6 b	108±9ab	85±7 b	113±12ab	21.2±1.4 b	22.4±3.26 c
BRRI dhan84	12±1ab	14±1 a	16±1 b	16±1 a	87±8 b	82±6 b	109±8 b	112±8ab	23.13±0.9 c	22.4±2.56 b
BRRI dhan86	16±3 b	13±1 a	19±3 a	16±1 a	102±7 a	86±7 b	117±8 a	103±9 b	22.54±1.21 c	22.0±4.12 a

F1=Dumuria Field and **F2**= Batiaghata Field

lands, about 1.056 million hectares are affected by varying degrees of salinity that usually covers 30% of cultivable land (2). Batiaghata Upazila is a sub-district that is situated in the southwestern part of the country. The areas are covered by Kazibacha river that is seasonally flooded by this river. This causes various degrees of salinity in the soil. Mostly low-yielding, traditional rice varieties are grown during the wet season (2). Rice (*Oryza sativa* L.) is considered a salt-sensitive crop. Among the various factors limiting rice yield, salinity is one of the oldest and most serious environmental problems in the world (3). Rice yield components like grain yield are severely exaggerated by root-zone salinity. Primary branches per panicle, panicle length, spikelets per panicle, number of filled spikelets, and seed weight per panicle are significantly hampered by salinity (4). Negative impacts of salinity on seed germination and seedling growth as well as some physiological activities of cultivated plant species have been extensively investigated previously by various scientists (5, 6). BRRI dhan28 is the most locally accepted rice varieties for its growth and yield response, but over the year this variety is losing its strength because of its susceptibility to neck blast disease and increasing of soil salinity in the south-west Bangladesh. That's why; new varieties have been tested to investigate the adaptability of the new varieties to replace BRRI dhan28 in the local environment. One of the important purposes of the present research is to generate information on the agronomic status (germination, growth and yield) and adaptability of newly released modern Boro rice varieties compared to the mega variety BRRI dhan28. This research will accelerate the vibrant information and varietal selection for rice cultivation and its performance in future of the investigated environment.

Materials and Methods

The experiment was conducted at two farmer's fields of Batiaghata and Dumuria Sub-district. Geographically, the experimental areas located at Rajbad, Batiaghata (22°46' N latitude and 89°31'E longitude at the elevation of above 5m of sea level) and Koiya Bazar, Dumuria (22°47' N latitude and 89°29'E longitude at the elevation of above 7.7m of sea level). In November to March, the weather is usually dry and the average temperature is 10 to 12°C with no to minimum precipitation rate. The soil of the experimental field was silty-loam having moderate saline to saline soil properties. Soil salinity was measured by Jeneway EC meter (1:2) at different stages of the rice plant as presented in Table 1. Different time EC was measured for observing whether there have any impacts of salinity on plant growth, yield and yield components. Salinity was increased as the field irrigated with more or less saline water over the time (Table 1). The experiment was carried out in two separate plots with a Randomized Complete Block Design (RCBD) where unit plot size was 4 m × 5 m. Each experiment was replicated in a thrice and the differences between the block was 1 m at all sites. A basal dose of triple super phosphate (TSP), muriate of potash (MP), gypsum and Zinc sulfate were used as the source of phosphorus, potassium, sulphur and Zinc applied at 22,75, 20 and 4 kg P, K, S Zn ha^{-1}, respectively. Urea was top

Table 4. Yield contributing characters of rice varieties

Rice Variety	Grain yield (t/ha)		Straw Yield (t/ha)		Harvest Index (HI) (%)	
	F1	F2	F1	F2	F1	F2
BRRI dhan28	7.05±1.6b	7.14±1.9 b	2.82±0.3ab	2.35±0.29ab	51.42±5.6 a	55.24±7.2 a
BRRI dhan67	7.29±1.1 a	7.89±1.23 a	2.98±0.2 a	2.51±0.32 a	51.02±4.2 a	57.84±8.6a
BRRI dhan81	3.45±0.4 c	6.11±1.3ab	3.17±0.4 a	1.83±0.26 c	52.08±2.3 b	56.92±9.2 a
BRRI dhan84	3.74±0.8 c	7.16±2.3 b	1.92±0.12 c	2.57±0.65 a	56.10±4.6ab	53.58±5.4 b
BRRI dhan86	5.26±1.2 bc	4.60±1.23 c	2.0±0.36 bc	2.34±0.8 ab	52.50±6.3 a	56.32±6.3 c

F1=Dumuria Field and **F2**= Batiaghata Field

dressed as a source of nitrogen at 120 kg N ha^{-1} in 3 equal splits (7). The Boro (dry season) crop is totally irrigated and the plots were irrigated as and when necessary. Five rice varieties BRRI dhan28 as a control, BRRI dhan67, BRRI dhan81, BRRI dhan84, BRRI dhan86 developed by the Bangladesh Rice Research Institute (BRRI) were used in the experiment. Seeds were sown in seedbed at farmer's field for the field trials and also some seeds were allowed for germination in petri dishes at room temperature. Forty-day old seedling was transplanted in puddled field at a designed block. Intercultural operations as well as irrigation were done as required. Uniform management practices were followed for all the varieties. Different growth data were taken at from germination to maturity stages. Grain yield and yield components data were determined at maturity. Grain yield was recorded from each plot and then converted to tons per hectare at 14% moisture. Data were analyzed following the Analysis of Variance (ANOVA) technique and mean differences were adjusted by the multiple comparison test (8) using the statistical computer based programme SPSS-16.

Table 1: Soil and water salinity at different stages of rice plant

Stages	Soil Salinity (dS/m)		Irrigation water Salinity (dS/m)	
	F1	F2	F1	F2
Initial sampling before fertilizer application	3.29±0.7	3.19±0.5	2.42±0.9	2.33±0.2
Tillering	3.5±0.9	3.42±0.2	2.6±0.9	2.95±1.1
Panicle initiation	3.7±0.6	3.9±0.8	3.8±0.8	3.7±0.6
Milking	4.7±0.8	4.8±0.6	4.2±0.7	4.4±0.4

F1=Dumuria Field and **F2**= Batiaghata Field

Results and Discussion

Germination rate of different varieties is presented in Table 2. BRRI dhan67 showed the best result and significantly differed from others for Dumuria field whereas BRRI dhan67 and BRRI dhan81 were insignificant with BRRI dhan28 but significant with other varieties in Batiaghata field. The lowest germination rate was observed at BRRI dhan86 for Batiaghata field. This may due to seed germination rate was reduced by initial soil salinity due to the enzyme inhibition (9). High ion content in plant cells can persuade changes in protein hydration and their precipitation resulting in inhibition of enzyme activity (10). According to the Bangladesh Rice Research Institute (7), BRRI dhan67 can tolerate soil salinity up to 10 dS/m in its germination stages and other new verities are sensitive to salinity. The result supports the findings of the Bangladesh Rice Research Institute.

Genotype and interaction of genotype and environment had significant effect on plant height (Table 2). At initial tillering stage, all varieties showed insignificant differences among them but in the maximum tillering stage, BRRI dhan67 showed the significant difference among varieties but insignificant with BRRI dhan28. In maturity stage, BRRI dhan67 asserted the best result that was significant with BRRI dhan28 and other varieties in Dumuria and Batiaghata field. This may due to increasing soil salinity at matured stage. There are observations on the differences in plant height of rice varieties at different level of salinity (11). This result also supports another where high mortality rate of seedlings was found under saline field conditions (12). If an excessive amount of salt enters the plant, the concentration of salt eventually rises to a toxic level in older transpiring leaves causing premature senescence and reduces the photosynthetic leaf area of a plant to a level that cannot sustain growth (13). According to Bangladesh Rice Research Institute (7), BRRI dhan67 can tolerate up to 8 dS/m in its matured stage and 12-14 dS/m in its seedling stage up to 3 weeks whereas other new verities don't tolerate excessive soil salinity (<3 dS/m). The result supports the findings of Bangladesh Rice Research Institute.

Rice grain yields are highly reliant on the number of panicle-bearing tillers produced per plant. Different varieties showed the different tiller number according to Table 3. In terms of effective tiller and total tiller number, BRRI dhan67 showed the significant difference among other varieties except BRRI dhan28 for Dumuria field but in Batiaghata field, BRRI dhan67 showed the significant difference with BRRI dhan28 and BRRI dhan81 but insignificant with other varieties. According to Bangladesh Rice Research Institute (7), BRRI dhan67 showed a tolerance to salinity stress. This result supports the study of Bangladesh

Rice Research Institute (7). Reports are also there on variable tiller number due to varietal differences (14).

Table 3 also illustrates the grains per panicle and total spikelets per panicle that significantly varied among the varieties. BRRI dhan67 showed the best response in accordance with BRRI dhan28 that showed insignificant differences with each other. BRRI dhan84 responded comparatively poorer than that of other varieties. Salinity was found to be sharply decreased the filled grain per panicle (15). In an earlier study it was observed that filled grains per panicle correlated significantly with grain yield that supports the study (16).

Thousand grain weight was significantly affected the interaction of varieties and environments (Table 3). The highest 1000-grain weight was recorded in BRRI dhan28 (23.47±2.13gm and 22.3±3.3gm) that was insignificant with BRRI dhan67 but significant with other varieties. BRRI dhan67 had the finer grain than BRRI dhan28. The lowest value was found in BRRI dhan84 for Dumuria and BRRI dhan81 for Batiaghata. The highest 1000-grain weight of BRRI dhan28 was may be due to long and fine grain. Many scientists have found different 1000-grain weight for different varieties that support the study. Studies are also on 12 different rice varieties for observing the difference in thousand weights of grains due to morphological and varietal variation and found the differences that supports the study (17).

Interaction of variety and environments had significant effect on grain yield of the tested varieties (Table 4). Among five varieties, BRRI dhan67 yielded (7.04 t/ha) significantly higher than others. BRRI dhan28 was the second best yielder but it's statistically insignificant with BRRI dhan67. BRRI dhan81 was the poorest yielder for Dumuria field and BRRI Dhan86 was the poorest for Batiaghata field. More number of grains per panicle, less number of non-effective tillers and maximum tolerance of salinity stress of BRRI Dhan-67 resulted in higher yield. Poor tillering, less number of grains per panicle, lodging tendency, more straw yield and poor performance in salinity stress may be the reasons for such lower yield in BRRI dhan81 and BRRI dhan86. BRRI dhan81 and BRRI dhan84 showed poor results in Dumuria plot rather than Batiaghata plot due to susceptibility of more blast attack at matured stage and these two varieties highly affected by salinity. Differences in grain yield were also reported (18). The genotypes, which produced higher number of effective tillers per hill and higher number of grains per panicle also showed higher grain yield in rice (19). At matured stage, soil salinity increased thus reduced the yield growth for other varieties. Reduction in grain yield among varieties was reported due to salt stress (20, 21).

Straw yield also significantly affected by variety, environments and their interaction (Table 4). The highest straw weight was recorded in Dumuria for BRRI dhan81 (3.17t/ha) followed by BRRI dhan67 (2.98 t/ha). The lowest straw weight was observed in BRRI dhan84 (1.92 t/ha) followed by BRRI dhan86 (2 t/ha) and BRRI dhan28 (2.82 t/ha). In Batiaghata, the highest straw yield was found in BRRI dhan84 (2.57 t/ha) followed by BRRI dhan67 (2.51 t/ha) but they were statistically insignificant. Medium plant height, short duration and high yield can be the reason of low straw weight (22). Studies revealed that straw yield might be assigned to plant height and straw weight differed significantly due to varieties (14).

Harvest index (HI) is an important character that has physiological importance. It reflects translocation on alternatively dry matter partitioning of a given genotype to the economic parts. HI (%) of different varieties is presented in Table 4. BRRI dhan67 showed the highest HI (57.84±8.6)% in Batiaghata filed. Though BRRI dhan28 HI (51.42±5.6) % was the highest performer in Dumuria field but it showed the insignificant difference with BRRI dhan67 but was significant with other varieties. BRRI dhan81 and BRRI dhan86 were the poorest HI consecutively Dumuria and Batiaghata field. There are reports on the contribution of high harvest index to yield (24). High yield is determined by the physiological process leading to a high net accumulation of photosynthates and their partitioning (25). Studies also revealed that variety has a significant influence on harvest index (25, 26).

Conclusion

Based on overall performances, BRRI dhan67 showed the highest potentiality among the tested varieties. BRRI dhan67 produced significantly highest grain yield followed by the highest value of the yield components compared to the check and other varieties. In compare with BRRI dhan28, maximum grain yield was obtained from BRRI dhan67 significantly ($p \leq 0.05$). Considering all other parameters like effective and total tiller number along with germination rate, filled and total spikelets per panicle, plant height at different stages, 1000-grain weight, straw yield and harvest index, it can be asserted that BRRI dhan67 would be the best modern rice varieties and could be the best choice as a new cultivars for environmental adaptation of rice in southwest Bangladesh.

Competing Interest

The authors declare that they have no competing interest.

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Authors' contribution

TBS visited and supervised the experimental plots; wrote the manuscript. BK designed, executed the field trials, edited and improved the manuscript. TH worked as co-investigator and took care of the experiment throughout season and also data collection. MHR, ZM, MH helped in field and laboratory work.

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