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Interactive effect of variety and potassium fertilizer on the yield of salt-tolerant Boro rice

Kawsar Hossen¹, Sadia Sultana¹, Md. Mahfuzar Rahman¹, Ruhul Amin Rana¹, Tahmina Ferdous², Akhinur Shila³ and Rayhan Ahmed^{1*}

¹Department of Agriculture, Noakhali Science and Technology University, Noakhali, Bangladesh

²Department of Agricultural Economics, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh

³Department of Agricultural Botany, Patuakhali Science and Technology University, Patuakhali, Bangladesh

*Corresponding author: Rayhan Ahmed, Department of Agriculture, Faculty of Science, Noakhali Science and Technology University, Noakhali-3814, Bangladesh. Phone: +8801717402875; E-mail: rayhan.rimon@gmail.com

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Abstract: Performance of salt-tolerant Boro rice was investigated under the interaction effect of variety and different doses of potassium fertilizer, which is a part of the research for developing agriculture in coastal areas of Bangladesh. A field experiment was conducted at the research field of Agriculture department, Noakhali Science and Technology University (NSTU), Noakhali-3814. The experiment was carried out in a Randomized Complete Block Design (RCBD) with three replications where two varieties viz. BINA dhan-8, BRRI dhan-28 and three doses of potassium viz. 120 kg/ha, 84 kg/ha and 36kg/ha were used as treatments. Plant height (cm), tillers/hill, grain/panicle, 1000 grain weight (g), grain yield (t/ha), straw yield (t/ha) and harvest index (%) were compared among varieties and treatments. Results revealed that only variety and only potassium fertilizer had non-significant influence but the interaction of variety and potassium fertilizer had a significant effect on the performance of salt-tolerant Boro rice. Therefore, the present study suggests that salt-tolerant BINA dhan-8 variety may be cultivated with 120 kg potassium/ha for obtaining higher yield in the southern coastal area of Bangladesh.

Keywords: Boro rice; coastal area; variety; potassium; interaction

1. Introduction

Agriculture is the most important sector of the Bangladeshi economy that contributes more than 15% to the national GDP (Gross Domestic Product) and provides employment opportunities for 43% of the total population. The Rice sector contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh (BBS, 2018). Bangladesh is one of the most important rice-growing countries of the world. Bangladesh ranks fourth in terms of rice production (FAOSTAT, 2012) and third on the basis of (FAPRI, 2009) rice consumption in the world. In Bangladesh, rice is the most important leading cereal crop. Sufficient production of rice is the main way to ensure food security in Bangladesh. In fact, 'Food security' can be called as 'Rice security' in Bangladesh as in many other rice-growing countries (Brolley, 2015). Rice security is not only an economic issue but also an important factor for determining social and political strength (Nath, 2015). According to BBS, 2016 the total cultivated area of rice per year is 15.03 million hectares and total production per year about 38.34 million metric tons in Bangladesh. Besides, 79 percent of the total cropped area is also covered by rice in Bangladesh (BBS, 2015). In Bangladesh, rice can be grown in three distinct seasons: Aus, Aman and Boro. Among these, Boro rice alone provides about 56% of total food grains and also highest in productivity (3.965 metric tons per hectare) compared to Aus rice and Aman rice (BBS, 2015). With respect to

high yield and contribution to rice production, Boro rice can be considered as one of the most important rice crops for Bangladesh (Chamely *et al.*, 2015).

As the population of our country is increasing and cultivable land area is decreasing every year, the yield per unit area needs to be increased to meet the future food demand in the country. This could be done in many ways of which, the most effective means are the cultivation of improved varieties and proper nutrient management (Salam *et al.*, 2011).

Variety is an important genetic factor that contributes a lot to produce a higher yield. However, the potential for increasing rice production strongly depends on the ability to integrate better crop management for the different varieties into existing cultivation systems (Mikkelsen *et al.*, 1995).

Potassium (K) plays an important role in the growth and development of rice (Rabbani *et al.*, 2017). Potassium is the third major nutrient element that is absorbed by plants in a larger amount than any other nutrients. Modern high-yielding rice varieties remove a much higher amount of K than Phosphorus (P) and Nitrogen (N) (Choudhury *et al.*, 1997; Liu *et al.*, 2009; Sharma *et al.*, 2013). It is also important for basic physiological functions such as the formation and translocation of the sugar, the synthesis of protein, cell division and growth (Samer *et al.*, 1990). Considering the above facts, the present study was undertaken to observe the varietal performance of Boro rice, to evaluate the effect of rate of potassium on the yield of Boro rice and for assessing the interaction effect of variety and rate of potassium.

2. Materials and Methods

2.1. Location and time

The experiment was carried out at the research field of Agriculture department, Noakhali Science and Technology University (NSTU), Noakhali-3814 from November 2018 to May 2019. The experimental field belongs to the agro-ecological region of the Young Meghna Estuarine Floodplain (AEZ-18). The experiment field was almost level having sandy loam soil and moderately alkaline (SRDI, Noakhali), with pH value 7.5 and electrical conductivity 0.91 dSm^{-1} . The pH value was measured by a pH Meter (Hach sensION+ PH1 Basic Portable pH Meter) and electrical conductivity by an EC meter (sensION+ EC7). The experimental area is under the tropical climate with an average annual temperature of $25.6 \text{ }^\circ\text{C}$ and the average annual rainfall about 3,302 mm (Weather Station, Maizdee, Noakhali).

2.2. Experimental treatments and design

Two factors included in the experiment were as follows: Factor A: Variety (2); V_1 - BINA dhan-8, V_2 - BRRI dhan-28 and Factor B: Treatments (3); T_1 - 120kg K/ha, T_2 - 84kg K/ha, T_3 - 36kg K/ha. Seeds of BINA dhan-8 were collected from Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh-2202 and BRRI dhan-28 were collected from Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The size of the unit plot was $3.0 \text{ m} \times 2.0 \text{ m}$, having an area of 6 m^2 . Thus the total number of the unit plot was 18 ($3 \times 3 \times 2$). A spacing of 1.0 m and 0.5 m was maintained between the replications and unit plot respectively.

2.3. Raising of seedlings

The collected seeds were soaked in the water for 24 hours. Then they were taken out of the water, covered with wet gunny bags and kept for sprouting. The seed started sprouting after 48 hours and almost all seeds were sprouted after 72 hours. Pre-germinated seeds of the variety BINA dhan-8 and BRRI dhan-28 were broadcasted uniformly in a well-prepared nursery bed on 16 December 2018.

2.4. Land preparation and fertilization

The land was prepared by plowing and cross-plowing by a tractor and subsequently leveled by laddering. The field was fertilized with triple superphosphate (TSP), gypsum and zinc sulfate at the rate of 120kg, 120 kg and 60kg per hectare respectively during land preparation and urea (220 kg per hectare) was applied as top dressing in three equal splits at 15, 30 and 45 days after transplanting (DAT). Muriate of potash was applied as per treatment (T_1 - 120kg K/ha, T_2 - 84kg K/ha, T_3 - 36kg K/ha).

2.5. Uprooting and transplanting of seedlings

Seedlings were uprooted carefully from the nursery bed and were transplanted in the unit plots on 25 January 2019 maintaining the spacing of $25 \text{ cm} \times 15 \text{ cm}$ (row to row and plant to plant) at the rate of 1-2 seedlings/hill. Two hand weeding was done at 20 and 35 days after transplanting (DAT). The field was irrigated from the nearest water source (pond) by irrigation devices when necessary.

2.6. Data collection and analysis

Ten hills (excluding border hills) were selected randomly from each unit plot and uprooted before harvesting for recording data. Harvesting was done when 90% of the grain became golden yellow in color. The harvested crop of each unit area was separately bundled, properly tagged and then brought to the threshing floor. The harvested crop was threshed by pedal thrasher. Grains were then sun-dried at 14% moisture level and cleaned. Straws were also sun-dried properly. Data were collected on plant height (cm), tillers/hill, grain/panicle, 1000 grain weight (g), grain yield (t/ha), straw yield (t/ha) and harvest index (%). Plant height (selected ten plants) was measured from the ground level to the tip of the longest panicle. Tillers that had at least one leaf visible were counted. Presence of any food material in the spikelet was considered as grain and the number of grain present in each panicle was counted. One thousand clean dried seed from the seed lot of each unit area were counted separately and weight by an electrical balance. The grain and straw yield per plot was recorded and finally converted to t/ha. Harvest index is the ratio of the economic yield to the total biological yield of a crop and was calculated with the following formula.

$$\text{Harvest index (\%)} = \left(\frac{\text{Grain yield}}{\text{Biological yield}} \right) \times 100$$

Where, Economic yield = Grain yield and Biological yield = Grain yield + Straw yield.

Data recorded for growth, yield and yield contributing characters were compiled and tabulated in proper form for statistical analyses. Analysis of variance was done with the help of R-Studio.

3. Results and Discussion

3.1. Effect of variety on the performance of salt-tolerant Boro rice

Variety had a non-significant effect on yield and yield contributing characters of Boro rice (Table 1).

The tallest plant height (91.02cm) was obtained in BINA dhan-8 and the smallest plant height (87.7cm) was obtained from BRR I dhan-28. Sarker *et al.* (2013) reported shorter plant height in BRR I dhan-28 among different varieties of boro rice which is similar to our result. Some researcher (Alam *et al.*, 2012; Shel *et al.*, 2015; Islam *et al.*, 2015) also reported some results which are more or less similar to our result.

BRR I dhan-28 (15.71) produced more tiller/hill than BINA dhan-8 (13.99) and the result is consistent with some other researcher (Tyeb *et al.*, 2013; Sarker *et al.*, 2013; Islam *et al.*, 2015)

BRR I dhan-28 (117.33) had less grain/panicle compare to BINA dhan-8 (121.47). Tyeb *et al.*, (2013) conducted an experiment with four varieties of rice and reported that variety BRR I dhan-52 produced more number of grains/panicle than other varieties.

Weight of thousand grain was more or less similar between BINA dhan-8 (23.63) and BRR I dhan-28 (23.16). Islam *et al.* (2015) found the higher 1000-grain weight (25.49 g) in BR-11 and the lower one (21.33 g) in BRR I dhan-49 which indicates less variation between two varieties.

Less difference also found for grain yield (t/ha.) between BINA dhan-8 (6.76) and BRR I dhan-28 (6.45). Sultana *et al.* (2012) carried out an experiment with three rice varieties viz. BR-11, BRR I Dhan-51 and BRR I dhan-52 and found that BRR I dhan-51 produced highest harvest yield compared to the other two varieties. In our experiment, BINA dhan-8 gave the highest grain yield (t/ha.) compared to BRR I dhan-28.

The highest straw yield (t/ha.) was found in BINA dhan-8 (5.51) in comparison with BRR I dhan-28 (4.84). Rajaul (2005) observed the highest straw yield (5.54 t/ha) in BRR I dhan-29 and lowest (5.43 t/ha) in BRR I dhan-28 that supports our result.

BRR I dhan-28 (56.56) showed the highest harvest index (%) than BINA dhan-8 (54.93). Arshad (2009) conducted an experiment with three rice varieties viz. BINA dhan-4, BRR I dhan-40, and BRR I dhan-41 and reported that the highest harvest index (41.9%) was obtained by BRR I dhan-40 and the lowest one (40.08%) was obtained from BRR I dhan-41.

3.2. Effect of potassium fertilizer on the performance of salt-tolerant Boro rice

Different doses of potassium fertilizer had a non-significant effect on yield and yield contributing characters of Boro rice (Table 2).

Here, more or less same plant height (cm) was obtained from T₁ (90.93) and T₂ (90.35) but T₃ showed the lowest plant height (73.04). Balliu and Ibro (2002) stated no evidence of any significant difference in plant height due to the different amounts of potassium supply.

The highest number of tiller/hill was observed from T₁ (16.5) and lowest in T₂ (14.17). T₂ and T₃ showed statistically more or less similar result. Qiangsheng *et al.* (2004) observed that the number of effective tillers/hill increased with increasing K rates which is consistent with our result.

The number of grains per panicle increased with the increase of potassium fertilizer. The highest number of grains/panicle found from T₁ (125.67) and lowest from T₃ (110.92). Talukder *et al.* (1992) found that application up to 60 kg K₂O/ha mainly increased the filled grains/panicle.

Potassium fertilizer showed little/no effect on the thousand-grain weight (g). A more or less statistically similar result (23.42, 23.0, and 23.77) was found for T₁, T₂, and T₃ respectively. Choudhury *et al.* (1993) stated that the application of K favorably influenced yield components.

A slightly increasing trend was found for grain yield (t/ha) and straw yield (t/ha) with the increase of potassium fertilizer doses. For both grain and straw yield, the highest value found in T₁ and lowest from T₃. According to BIRRI (1990), the application of only 30 kg K/ha increased the grain yield slightly over control at most of the locations. The yield of grain and straw also increased due to the application of 150 kg K₂O/ha (Choudhury *et al.*, 1993).

Potassium fertilizer had little effect on harvest index (%) and the highest value was found in T₂ (56.61) and lowest in T₃ (45.39). Amanullah *et al.* (2015) recorded the highest harvest index (39.2%) for the plots treated with the highest K level (90 kg ha⁻¹). Potassium application improved the crop harvest index and grain quality parameters of boldness, protein, and oil contents (Umar *et al.*, 1999).

3.3. Effect of interaction between variety and potassium fertilizer on the performance of salt-tolerant Boro rice

The interaction of variety and potassium fertilizer exhibited significant influence on yield and yield contributing characters of salt-tolerant Boro rice except for number of tillers/plant and number of grains/plant (Table 3).

Plant height (cm) varied significantly with the interaction of variety and potassium fertilizer. The highest plant height (101.63 cm) was found in the treatment combination of V₁T₂ (BINA dhan-8 and 84 kg K/ha) and the lowest plant height (82.37 cm) was observed in V₂T₃ (BIRRI dhan-28 and 36 kg K/ha).

Interaction between variety and fertilizer doses of potassium had a non-significant effect on number of tillers/plant and number of grains/panicle. The highest number of tiller/hill (14.13) was found in the treatment combination V₁T₁ (BINA dhan-8 and 120 kg K/ha) and lowest number of tiller/hill (10.67) was observed in V₂T₂ (BIRRI dhan-28 and 84 kg K/ha). On the other hand, maximum grain/panicle (136.23) was identified in the treatment combination of V₁T₃ (BINA dhan-8 and 36 kg K/ha) and minimum grain/panicle (106.53) was found in V₂T₁ (BIRRI dhan-28 and 120 kg K/ha).

1000 grain weight (g) was influenced significantly by the interaction effect of variety and potassium fertilizer. The maximum weight of 1000 grain (39.17 g) was found in the treatment combination V₂T₃ (BIRRI dhan-28 and 36 kg K/ha). On the other hand, minimum weight of 1000 grain (21.67 g) was observed in V₁T₂ (BINA dhan-8 and 84 kg K/ha).

Interaction of variety and potassium fertilizer significantly influenced grain yield and straw yield. The highest grain yield (8.43 t/ha) was found in the treatment combination of V₁T₁ (BINA dhan-8 and 120 kg K/ha) and lowest grain yield (5.03 t/ha) was observed in V₂T₃ (BIRRI dhan-28 and 36 kg K/ha). Similarly, the highest straw yield (8.90 t/ha) was found in the treatment combination of V₁T₁ (BINA dhan-8 and 120 kg K/ha). On the other hand, lowest straw yield (5.93 t/ha) was observed in V₂T₁ (BIRRI dhan-8 and 120 kg K/ha).

Harvest index (%) also affected significantly by the interaction effect of variety and potassium fertilizer. The highest harvest index (52.14 %) was found in the treatment combination of V₂T₁ (BIRRI dhan-28 and 120 kg K/ha). On the other hand, lowest harvest index (42.52 %) was observed in V₂T₃ (BIRRI dhan-28 and 36 kg K/ha).

Table 1. Effect of variety on the performance of salt-tolerant Boro rice.

Variety	Plant height (cm)	Tiller/hill	Grain/panicle	1000 grain weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)
BINA dhan-8	91.02	13.99	121.47	23.63	6.76	5.51	54.93
BIRRI dhan-28	87.7	15.71	117.33	23.16	6.45	4.84	56.56
Mean	89.36	14.85	119.4	23.4	6.6	5.18	55.75
std	2.35	1.22	2.93	0.33	0.22	0.47	1.15
Cv (%)	2.63	8.22	2.45	1.41	3.33	9.07	2.06
Level of significance	NS	NS	NS	NS	NS	NS	NS

Table 2. Effect of different doses of potassium fertilizer on the performance of salt-tolerant Boro rice.

Treatment	Plant height (cm)	Tiller/hill	Grain/panicle	1000 grain weight (g)	Grain yield (t/h)	Straw yield (t/h)	Harvest index (%)
T ₁ (120kg K/ha)	90.93	16.5	125.67	23.42	6.91	5.22	54.39
T ₂ (84kg K/ha)	90.35	14.17	121.62	23.0	6.72	5.16	56.61
T ₃ (36kg K/ha)	73.04	14.23	110.92	23.77	6.2	5.14	45.39
Mean	84.77	14.97	119.40	23.39	6.61	5.17	52.13
std	10.17	1.33	7.62	0.39	0.37	0.04	5.94
cv	11.99	8.88	6.38	1.65	5.56	0.82	168.71
Level of significance	NS	NS	NS	NS	NS	NS	NS

Table 3. Effect of interaction between variety and fertilizer doses of potassium on the performance of salt-tolerant Boro rice.

Treatment	Plant height (cm)	Tiller/hill	Grain/panicle	1000 grain weight (g)	Grain yield (t/ha)	Straw Yield (t/ha)	Harvest index (%)
V ₁ T ₁	95.23	14.13	126.77	23.77	8.43	8.90	48.65
V ₁ T ₂	101.63	13.40	130.30	21.67	7.30	7.73	48.52
V ₁ T ₃	89.23	12.03	136.23	22.83	6.0	6.17	49.31
V ₂ T ₁	90.77	11.10	106.53	26.17	6.47	5.93	52.14
V ₂ T ₂	83.57	10.67	106.70	28.93	6.67	6.30	51.40
V ₂ T ₃	82.37	10.40	110.47	39.17	5.03	6.80	42.52
Mean	90.47	11.96	119.50	27.09	6.65	6.97	48.76
std	7.24	1.52	13.14	6.46	1.16	1.14	3.40
Cv (%)	8.00	12.75	10.99	23.85	17.37	16.36	6.97
Level of significance	**	NS	NS	***	***	***	***

NS = Non Significant

*** = Significant at 0.1% level of probability

** = Significant at 1% level of probability

* = Significant at 5% level of probability

4. Conclusions

The only variety and potassium fertilizer doses had a non-significant effect but the interaction of variety and potassium fertilizer doses had a significant influence on yield and yield contributing characters of Boro rice. After considering all results as references, we can conclude that the highest yield obtained from the combination of BINA dhan-8 variety and treatment 120 kg potassium/ha (V₁T₁). However, to attain a final decision more research work on Boro rice with the same treatment should be done in different Agro-ecological Zones (AEZs) of Bangladesh.

Conflict of interest

None to declare.

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