



EFFECTS OF DIFFERENT LEVELS OF FLOODING AND ADDITIONAL APPLICATION OF TWO NUTRIENTS ON BORO RICE (Binadhan-8) IN SALINE SOIL

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ABSTRACT

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A field experiment was conducted at Kalikapur village of Kaliganj upazila under Satkhira district in order to observe the effects of flooding duration and additional application of K and S on transplanted boro rice cv. Binadhan-8 during January - May 2013. The experiment was laid out in a split-plot design where the main plots comprised of five flooding levels viz. continuous flooding (W_1), flooding for 10 days (W_2), flooding for 20 days (W_3), flooding for 30 days (W_4), flooding for 40 days (W_5), and the sub-plots of four additional (over the recommended dose) nutrients rates viz. $S_{43} + K_{25}$ (T_1), K_{38} (T_2), $S_{32} + K_{38}$ (T_3), and K_{50} (T_4), with three replications. The duration of flooding showed significant positive effect on the yield and yield components of boro rice cv. Binadhan-8. The highest values for plant height (106.8 cm), panicle length (28.4 cm), number of plants hill⁻¹ (15.3), grain yield (4.8 t ha⁻¹) and straw yield (6.5 t ha⁻¹) were recorded in continuous flooding (W_1) while these values were decreased with the decrease in the duration of flooding from 40 days to 10 days. Additional application of K and S also significantly influenced all of the parameters. Results revealed that the highest values for plant height (102.8 cm), panicle length (26.6 cm), plants hill⁻¹ (15.4), 1000-grain weight (23.9 g), grain yield (4.8 t ha⁻¹) and straw yield (6.1 t ha⁻¹) were obtained from T_3 where S and K were applied @ 32 and 38 Kg ha⁻¹ in addition to the recommended fertilizer rate. The interaction of flooding and nutrients significantly manipulated the yield and yield attributes. Due to interaction of flooding and nutrients, the highest growth and yield was observed in continuous flooding with $S_{32} + K_{38}$ (W_1T_3). The results indicated that the flooding with fresh water and use of additional nutrients (K and S) had a remarkable effect in growing boro rice cv. Binadhan-8 in saline soils of Bangladesh.

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INTRODUCTION

Rice (*Oryza sativa* L.) is the principal source of food for more than one third of the world's population. It is rated as one of the major food crops in the world, but is also considered extremely salt-sensitive (Maas and Hoffman, 1977). The total area and production of rice in Bangladesh are about 11.7 million hectares and 31.98 million metric tons, respectively (BBS, 2011). Soil salinity is a worldwide problem. Bangladesh is no exception to it. Coastal area in Bangladesh constitutes 20% of the country of which about 53% are affected by different degrees of salinity (Islam, 2005). Various agricultural regions have significantly lost their productivity due to soil salinity in last several decades. The worst salinity conditions are reported from the Khulna, Bagerhat, Satkhira and Patuakhali districts (SRDI, 2010). Salinity from flood irrigation can occur over time wherever irrigation occurs; since almost all water (even natural rainfall) contains some dissolved salts. When the plants use the water, the salts are left behind in the soil and eventually begin to accumulate. Since soil salinity makes it more difficult for plants to absorb soil moisture, these salts must be leached out of the plant root zone by applying additional water. Salinization from irrigation water is also greatly increased by poor drainage and use of saline water for irrigating agricultural crops (ILRI, 1989). Nelson (1978) reported that potassium has a positive role in plant growth under saline conditions, because this element plays an essential role in photosynthesis, osmoregulatory adaptations of plant to water stress. On the other hand, Sharma (2001) stated that the application of gypsum could alleviate the adverse effects of salinity and increase tolerance to salinity in rice plants. The aim of the present study was to explore the impact of flooding (with fresh water irrigation) duration and additional application of K and S (as gypsum) on transplanted boro rice cv. Binadhan-8 in a saline area of Bangladesh.

MATERIALS AND METHODS

The study was conducted in a farmer's field at Kalikapur village in Kaliganj upazila under Satkhira district during the boro season (January to May 2013). The experimental site belongs to the Agro-ecological Zone of the Ganges Tidal Floodplain. The general soil type was the Calcareous Dark Grey Floodplain Soils. The soil was clay in texture, having pH 7.4, total nitrogen 0.1%, available phosphorus 4.37mg kg⁻¹, and available potassium 0.082 cmol_c kg⁻¹. The salinity of water in the experimental site was gradually increased from January to May 2013 (except February) having EC values of 3.70, 2.90, 4.50, 5.31, 8.8 dS m⁻¹, respectively. The variety used for the experiment was Binadhan-8. It was developed by the Bangladesh Institute of Nuclear Agriculture. It was released in 2010 as salt tolerant boro rice variety.

The experiment was laid out in a split-plot design with three replications. The size of the individual plot was: 3m x 4m. The block to block and plot to plot distances were maintained as 1m and 40cm, respectively. Total 1000 m² area was used for this study. The main plots were used for five flooding levels viz. continuous flooding (W₁), flooding for 10 days (W₂), flooding for 20 days (W₃), flooding for 30 days (W₄), flooding for 40 days (W₅), and the sub-plots were used for four treatments of additional (over the recommended dose) nutrients rates viz. S₄₃ + K₂₅ (T₁), K₃₈ (T₂), S₃₂ + K₃₈ (T₃), and K₅₀ (T₄), with three replications. In cases of W₂ to W₅, the flooding was done with fresh water at 15 days after transplanting. The subscript in the nutrients treatments means the amount of particular nutrient @ kg ha⁻¹. A basal dose of 120 kg N, 14 Kg P, 36 Kg K, and 8 kg S from urea, TSP, MoP and gypsum, respectively, were applied in all plots as per the recommended dose of the soil of that AEZ (BARC, 2005). The full amount of TSP, MoP and gypsum were added as broadcast during final land preparation. Urea was applied in three equal splits viz. three days of transplanting, 28 days after transplanting (tillering stage) and 50 days of transplanting (panicle initiation stage).

RESULTS

Effects of flooding levels on Binadhan-8

Results revealed that different levels of flooding significantly affected the yield components of boro rice cv. Binadhan-8. The maximum values of plant height (106.80 cm), panicle length (28.41 cm), plants hill⁻¹ (15.32) were recorded in continuous flooding (W₁), then decreased with the duration of flooding (40, 30, 20 and 10 days) and the minimum values of these parameters were observed in flooding for 10 days (W₂). However, the flooding treatments had no significant impact on the 1000-grain weight (Table 1).

The similar trend was also observed for the yield of Binadhan-8. The highest grain yield (4.84 t ha⁻¹) and straw yield (6.47 t ha⁻¹) were recorded in continuous flooding (W₁) and the lowest (3.94 and 5.16 t ha⁻¹, respectively) in W₂ (Table 1). The grain yield was significantly decreased with the reduction in flooding duration, although straw yield for 30 and 40 days flooding were statistically similar.

Effect of additional application of nutrients on Binadhan-8

Application of additional nutrients (K and S) significantly influenced all parameters of rice (Table 2). The highest values for plant height (102.80 cm), panicle length (26.60 cm), plants hill⁻¹ (15.44), the 1000-grain weight (23.88 g) were obtained from T₃, where S and K were applied at the rate of 32 and 38 kg ha⁻¹, respectively. Except 1000-grain weight, the next highest values were observed in T₁, where 43 Kg S and 25 Kg K were applied. The application of K alone (T₂ and T₄) showed inferior result compared to both additional nutrients application (T₁ and T₃).

Similarly, the highest grain yield (4.84 t ha⁻¹) and straw yield (6.05 t ha⁻¹) were also obtained from (S₃₂ + K₃₈) (T₃), followed by S₄₃ + K₂₅ (T₁), whereas the lowest values were obtained from T₂, where K alone was applied at the rate of 38 kg K ha⁻¹.

Interaction effect of flooding level and additional application of nutrients on Binadhan-8

It is evident from Table 3 that the interaction between different levels of flooding and additional application of nutrients had significant effect in respect of all parameters. The highest plant height (108.7 cm), panicle length (28.99 cm), number of plants hill⁻¹ (21.53), number of 1000-grain weight (25.43 g), grain yield (5.14 t ha⁻¹), straw yield (6.82 t ha⁻¹) were obtained from continuous flooding, S₃₂ + K₃₈ (W₁T₃) while the lowest value obtained from flooding for 10 days, K₃₈ (W₂T₂) except number of plants hill⁻¹. The highest grain yield obtained from W₁T₃ was also statistically comparable with those obtained from W₄T₃ and W₅T₃ treatment combinations.

Table 1. Effect of flooding levels on yield contributing characters and yield of Boro rice (cv. Binadhan-8)

Level of flooding	Plant height (cm)	Panicle length (cm)	Plants hill ⁻¹	1000 grain weight (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
Continuous flooding (W ₁)	106.8 a	28.41 a	15.32 a	23.40	4.841 a	6.466 a
Flooding for 10 days (W ₂)	98.3 d	25.30 d	12.35 c	23.77	3.935 e	5.155 c
Flooding for 20 days (W ₃)	99.6 c	25.31 d	12.88 bc	22.87	4.282 d	5.174 c
Flooding for 30 days (W ₄)	100.1 bc	26.09 c	13.00 bc	23.57	4.439 c	5.790 b
Flooding for 40 days (W ₅)	101.0 b	26.31 b	13.85 b	23.90	4.597 b	5.918 b
LSD _{0.05}	0.96	0.174	1.03	0.764	0.148	0.234

Figures in a column having common letters do not differ significantly at 5% level of significance

Table 2. Effect of additional application of nutrients on yield and yield contributing characters of rice (cv. Binadhan 8)

Nutrients	Plant height (cm)	Panicle length (cm)	Plants hill ⁻¹	1000 grain weight (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
S ₄₃ + K ₂₅ (T ₁)	101.30 b	26.37 b	13.45 b	23.88 a	4.54 b	5.82 b
K ₃₈ (T ₂)	99.56 c	26.01 c	12.23 c	23.00 b	4.02 d	5.31 d
S ₃₂ + K ₃₈ (T ₃)	102.80 a	26.60 a	15.44 a	23.88 a	4.84 a	6.05 a
K ₅₀ (T ₄)	100.90 b	26.16 c	12.80 c	23.26 b	4.27 c	5.63 c
LSD _{0.05}	0.847	0.145	0.629	0.568	0.115	0.153

In a column having common letters do not differ significantly at 5% level of significance.

Table 3. Interaction effect of flooding levels and additional application of nutrients on yield and yield contributing characters of rice (cv. Binadhan-8)

Flooding × nutrient	Plant height (cm)	Panicle length (cm)	Plants hill ⁻¹	1000 grain weight (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
W ₁ T ₁	107.20a	28.39 b	14.73 bc	22.27 fgh	5.06 ab	6.43 b
W ₁ T ₂	103.6 b	27.97 c	12.00 g	22.50 efgh	4.32 ghi	6.27 bcd
W ₁ T ₃	108.7 a	28.99 a	21.53 a	25.43 a	5.14 a	6.82 a
W ₁ T ₄	107.8 a	28.31 b	13.00 defg	23.40 cdefg	4.84 bcde	6.34 bc
W ₂ T ₁	98.37 fgh	25.27 h	12.33 fg	24.65 abcd	4.08 ijk	5.17 ijk
W ₂ T ₂	96.89 h	25.07 h	12.00 g	21.89 h	3.48 l	4.73 l
W ₂ T ₃	100.4 cdef	25.77 f	13.00 defg	24.87 abc	4.58 efg	5.70 fgh
W ₂ T ₄	97.47 gh	25.10 h	12.07 g	23.68 bcdef	3.60 l	5.02 jkl
W ₃ T ₁	98.87 fgh	25.39 gh	13.20 cdefg	23.18 defgh	4.320ghi	5.36 hij
W ₃ T ₂	99.07 efg	25.21 h	12.27 fg	22.10 gh	3.93 k	4.89 kl
W ₃ T ₃	101.3 cd	25.40 gh	13.60 bcdefg	22.65 efgh	4.66 def	5.43 hi
W ₃ T ₄	99.13 efg	25.22 h	12.47 efg	23.57 cdefg	4.22 hij	5.02 jkl
W ₄ T ₁	101.0 cde	26.41d	12.80 defg	24.67 abc	4.71 cdef	6.01 cdef
W ₄ T ₂	97.87 gh	25.63 fg	12.47 efg	23.48 cdefg	3.96 jk	5.05 jkl
W ₄ T ₃	102.3 bc	26.41 d	14.07 bcde	22.67 efgh	4.87 abcd	6.20 bcde
W ₄ T ₄	99.27 defg	25.92 ef	12.67 defg	23.48 cdefg	4.22 hij	5.90 defg
W ₅ T ₁	101.1 cde	26.37 d	14.20 bcd	24.62 abcd	4.51 fgh	6.12 bcde
W ₅ T ₂	100.4 cdef	26.19 de	12.40 fg	25.05ab	4.42 fgh	5.61 gh
W ₅ T ₃	101.4 cd	26.43 d	15.00 b	23.77bcde	4.97 abc	6.08 bcde
W ₅ T ₄	101.1 cde	26.23 de	13.80 bcdef	22.17 gh	4.49 fgh	5.86 efg
LSD _{0.05}	1.89	0.325	1.41	1.27	0.258	0.342

In a column having common letters do not differ significantly at 5% level of significance.

DISCUSSION

Rice is one of the most widely grown crops in coastal areas (Akbar and Yabuno, 1972). Binadhan-8, a salt tolerant boro rice variety was tested in saline area to see the impacts of prolonged flooding with fresh water (in the form of irrigation) and additional application of two nutrients K and S on its yield performance. It was observed that the different levels of flooding had significant effect on the yield and yield components. The most yield and yield components were increased with increasing flooding duration, on the other hand, it decreased due to short duration flooding. Rice yield usually decreases at salt stress, but in this study it was increased due to application of fresh water in different duration. Certain depth of irrigation water is kept in the field for growing successful rice crop. This practice simultaneously helps in leaching of soluble salt consequently reducing soil salinity (SRDI, 2010). If sufficient irrigation water of good quality is available, introduction of rice crop is possible in saline area resulting in the additional production of grain yield.

Binadhan-8 was responded significantly due to application of different nutrients (K and S) over the normal recommended rate. Combined application of these two nutrients gave the better results than using K alone. Potassium application alleviated the stress condition and significantly improved dry matter yield and yield components in rice (Ebrahimi *et al.*, 2012). The number of tillers increased significantly ($P < 0.01$) by the application of potassium over control (Mohiti *et al.*, 2011). Similar result found by Fatema and Khan (2013) who conducted a field experiment to evaluate the potentiality and effectiveness of gypsum in saline soils collected from coastal areas of Bangladesh. Growth and yield parameters of rice, such as, plant height, number of tillers, etc. were found to be significantly ($p \leq 0.05$) induced by the application of gypsum. Hanay *et al.* (2004)

examined that use of gypsum, calcite, calcium chloride, and other chemical agents that provide Ca, which tends to replace exchangeable Na, is effective for saline soil amelioration.

Nutrients play essential roles in plant metabolism. In addition to osmotic adjustment, genotypic differences in inorganic ions uptake under salinity have implications for maintaining adequate nutrition and for optimizing nutrients/elements related salinity tolerance mechanisms. Binadhan-8 is a saline tolerant high yielding paddy variety. It can tolerate the salinity level of 8 to 10 dS m⁻¹ which was released by the Seed Certification Agency in 2010. The range of existing water salinity levels in this experiment site was 3.7-8.8 dS m⁻¹. It was successfully cultivated in this saline level and gave a good yield with the application of fresh water irrigation for a prolonged duration and additional K and S application over the recommended fertilizer rates.

CONCLUSION

The result of the experiment provides clear understanding that Binadhan-8 can be grown successfully in a saline area under the continuous flooding and application of additional S₃₂ + K₃₈ nutrients per hectare.

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