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Research Article
Growth and Yield Performance of Boro Rice (BRRI dhan58) Under Different Fertilizer and Agronomic Management in Wetland

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Abstract

Background and Objective: Agriculture is the largest food producing sector of the economy of Bangladesh. It is essential to adopt more steps for increasing the production level of rice. Fertilizers are inevitable for the crop production systems of modern agriculture. Among the factors that affect crop production, fertilizer is the most significant factor that plays a crucial role in yield increase. The experiment was conducted to observe the effect of fertilizer and agronomic management on growth, yield and yield contributes of boro rice. **Materials and Methods:** The experimental site was located under the Agroecological Region Sylhet Basin (AEZ-21) having moderately acidic soils. The experiment was designed with seven treatments including T_1: Farmers' practiced based fertilizer (180-42-42 kg ha^{-1} of urea-TSP-MoP), T_2: BARC recommended dose based fertilizer (300-112-127-75-11 kg ha^{-1} of urea-TSP-MoP-$CaSO_4$-$ZnSO_4$), T_3: T_2+Wet Irrigation, T_4: T_2+Wet and dry irrigation, T_5: T_2+Proper seedling age, T_6: T_2+PSA (proper seedling age), T_7: IPNS (integrated plant nutrient system)+proper seedling age+IPM. The test crop was BRRI dhan58. The experiment was laid out in a randomized complete block design (RCBD) with five farmers' replications. Data were taken on growth, yield and yield contributing characters of BRRI dhan58 and analysed with the help of MSTAT-C program. **Results:** The plant height varied significantly and found the longest plants due to T_7. Tillering followed the similar pattern of plant height where the highest number of tillers hill^{-1} were recorded in T_7 IPNS (integrated plant nutrient system)+proper seedling age and spacing+IPM. The yield and yield contributing characters of BRRI dhan58 varied significantly due to application of balanced fertilizers according to BARC recommendation guide with proper agronomic management. The highest grain yield (8.74 t ha^{-1}) and straw yield (11.77 t ha^{-1}) were recorded from IPNS (integrated plant nutrient system)+proper seedling age and spacing+IPM over farmers' practice based fertilizers (T_1). Post-harvest soils showed the higher nutrient content in comparison to initial soil due to application of balanced fertilizers. **Conclusion:** It was concluded that balanced fertilizer application with proper agronomic management may be recommended for higher yield of BRRI dhan58 in the hoar area.

Key words: Agronomic management, balance fertilizer, modern agriculture, growth, haor, boro rice, BRRI dhan58, yield

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Agriculture is the largest food producing sector of the economy of Bangladesh since it comprises of about 16.17% of the country's GDP and employs around 45% of the total labor forces[1]. The performance of this sector has a conquering impact on major macroeconomic objectives of the country like employment generation, poverty alleviation, human resource development and food security. In Bangladesh, rice (*Oryza sativa* L.) is the major food crop which contributes 95% of annual food grain production[1]. Crop sector of Bangladesh is dominated by intensive rice (*Oryza sativa* L.) cultivation as soil and climatic conditions are suitable for that. Total rice growing area in the year 2015-16 was 11.38 million ha in Bangladesh which covers 74.85% of the total cultivable area and the total production[2] was 36.05 million metric tons. In respect of production, it ranks 6th place among the rice producing countries of the world followed by China, India, Indonesia, Vietnam and Thailand[3]. Over the last few years, Bangladesh has acquired startling production in the agricultural sector and rice plays the most momentous role. So, it is essential to adopt more steps for increasing the production level of rice. Sylhet is residing in the North-East portion of Bangladesh which is an area of relatively higher rainfall. The major cropping patterns of this area are Boro rice-Fallow-Fallow (17%), Fallow-Fallow-T. Aman rice (20%), Boro rice–Fallow-T. Aman rice (20%) and Fallow-Aus rice-T. Aman rice (20%)[4]. But Fallow-Fallow-Boro rice is predominantly practiced more than 80% area in haor areas of Sylhet. So there is a scope to enhance the rice production by adopting proper fertilizer management and agronomic practices in this region which will contribute in national rice production. Fertilizers are inevitable for the crop production systems of modern agriculture. Among the factors that affect crop production, fertilizer is the most significant factor that plays a crucial role in yield increase. That is why N, P, K, S and Zn fertilizer today hold the growth of the crop production systems of Bangladesh agriculture sector which is responsible for increasing the production about 50%, BFR[5]. Nitrogen, phosphorus and potassium are the macronutrients which play key roles to increase the production of rice to a great extent. Among the plant nutrients, nitrogen deserves special concern because of its large requirement by crop and instability in soil. Nitrogen plays a good role on growth, yield and yield components of rice through the process of photosynthesis, N-fixation, flowering, fruiting and maturation. Phosphorus has marked impact on seedling establishment, root biomass production, flowering and maturity of the crop[6] and decreased floret sterility. Potassium is also a primary nutrient element for plant. Potassium is essential for several basic physiological functions, such as the synthesis of protein and starch, normal cell division and growth[7]. Sulfur is a component of amino acids cystine, methionine and plays an important role in protein formation, structure and function of protein in rice as well as other crops. Zinc is classified as micronutrient but deficit of Zn is the 3rd most important nutritional factor after nitrogen and phosphorus limiting the growth of rice[8]. Continuous application of N, P, K, S and Zn fertilizers causes the depletion of soil organic matter and impairs physical and chemical properties of soil in addition to micronutrient deficiencies. Now it is true that use of fertilizers acts as a major agent of environmental pollution. In addition, these fertilizers are costly input for crop production, especially in a developing country like Bangladesh. Judicious application of N, P, K, S and Zn not only maintains soil health for sustainable agriculture but also reduces cost of crop production. Moreover, steps should be taken to promote the production through the use of modern production technologies, such as planting methods, use of quality seeds, high yielding varieties, optimum age of seedling, proper spacing as well as integrated pest management (IPM), adopting plant protection measures and seedling raising techniques[9]. The objectives of the study was to observe the effect of fertilizer and agronomic management on growth, yield and yield contributes of BRRI dhan58.

MATERIALS AND METHODS

The experiment was conducted in five farmers' fields at Bahadurpur village under union Lakshanshri of Sadarupazila of Sunamganj district during November, 2015 to May, 2016. The experimental site lies between 24°34'' and 25°12'' North latitudes and between 90°56'' and 91°49'' East longitude. The climate of sunamganj district is warmer in the summer and cooler in the winter. The annual maximum temperature was maximum 31.0°C and minimum 15.6°C and the mean monthly relative humidity was 73.43% in 2015-16. Heavy rainfall occurs during the monsoon and annual rainfall of 3250 mm was also recorded during 2015-2016. Seven treatments were tried with fertilizers and agronomic practices in the five farmers' fields. The treatments were: T_1 = Farmers' practiced based fertilizer (180-42-42 kg ha^{-1} of urea-TSP-MoP), T_2 = Bangladesh Agricultural Research Council (BARC) recommended dose based fertilizer (300-112-127-75-11 kg ha^{-1} of urea-TSP-MoP-Gypsum-$ZnSO_4$), T_3 = T_2+Wet Irrigation, T_4 = T_2+Wet and dry irrigation, T_5 = T_2+Proper seedling age, T_6 = T_2+PSA (proper seedling age), T_7 = IPNS (integrated plant nutrient system)+proper seedling age+integrated pest management. The test variety was BRRI dhan58. Seeds were sown on the seedbed on 30 November, 2015 for raising nursery seedlings. Seedlings

were transplanted on 1 January, 2016 at 25 cm×15 cm spacing. The fertilizers were applied as basal dose except urea. Urea was applied as top dressing in three equal splits at 15, 30 and 45 days after transplanting. Integrated pest management was hand picking of harmful insects after 20 days intervals, weeding and net sweeping are done to remove diseased infected plants by hands when necessary. Diazinon at 1.2 ha^{-1} was used once on 25 February, 2016 to control insects. Irrigation was done as per treatments. Five hills were tagged for counting the tillers and measuring the plant heights. Harvesting was done on 30 April, 2016. Ten sample hills were collected for variety from each farmer's plot to record the agronomic characters. The grain and straw yields were recorded from 1 m^2 area. The initial and post-harvest soil samples were collected from the experimental field before land preparation and after harvest from 0-15 cm soil depth. The samples were collected by an auger from different spots covering the whole plot and mixed thoroughly to make a composite sample. The samples were then air dried and sieved through a 10 mesh sieve and stored in a clean plastic container for analysis from Soil Resource Development Institute (SRDI), Sylhet.

Statistical analysis: The recorded data was compiled for statistical analysis. Analysis of variance was done with the help of computer package, MSTAT-C with 1% significance level. The mean differences among the treatments were adjudged by Duncan's Multiple Range Test[10].

RESULTS AND DISCUSSION

Plant height: Plant height of BRRI dhan58 was significantly taller due to application of fertilizer and agronomic management at all dates of data collection (Table 1). The tallest plant were 27.10, 47.50, 57.92, 77.10, 97.85 and 96.25 at 30, 45, 60, 75, 90 and at harvest observed in T_7 and the shortest plant was observed in farmers practice T_1 at all days after transplanting (DAT). The result revealed that when recommended doses chemical fertilizers and agronomic practices was applied in combination with integrated plant nutrient system, the effect showed better performance on growth and yield rather than applying other treatments. Banu *et al.*[11] carried out a field experiment at the experimental field of BINA, Mymensingh, Bangladesh. They obtained the highest plant height (105.67 cm) from the doses of 140-30-40-15-5 kg N-P-K-S-Zn ha^{-1} where the plant height for control treatment was 91.44 cm. Similar results were also observed by Hossain *et al.*[12].

Number of tillers/hill: Total number tillers/hill were significantly affected by fertilizer and agronomic management at 30, 45, 60, 75 and 90 days after transplanting (DAT) and at harvest (Table 2). The IPNS (integrated plant nutrition system)+proper seedling age+IPM (T_7) produced the highest number of tillers/hill (18.25at 75 DAT) and the lowest number of tillers/hill in respect of Farmers' practice based fertilizer (T_1) 13.00 at harvest. The number of total tillers/hill was the highest at 75 DAT, thereafter they were declined. Sarfaraz *et al.*[13] conducted a field experiment with the application of 110-90-70-20 kg ha^{-1} N-P-K-S in rice. They observed that the number of tillers m^{-2}, 1000-grain weight, grain and straw yield significantly increased with the application of N-P-K-S over control. This finding was similar of the findings of Hossain *et al.*[12] and Arivazhagan and Ravichandran[14].

Yield contributing characters: The number of effective tillers/hill, grains/panicle, panicle length, 1000 grains weight, grain yield and straw yield were influenced significantly but the number of sterile spikelets/panicle was not influenced significantly due to application of fertilizers and agronomic management (Table 3). The IPNS (integrated plant nutrition

Table 1: Effect of fertilizer and agronomic management on plant height (cm) of BRRI dhan58 in haor area

Fertilizer treatments	Plant height (cm) at different DAT					
	30	45	60	75	90	At harvest
T_1	22.65^b	42.50^b	51.65^b	72.25^b	91.10^b	90.25^b
T_2	25.92^b	44.58^b	54.85^b	75.92^b	94.85^b	93.50^b
T_3	26.78^a	45.92^{ab}	54.50^b	75.85^b	94.25^b	93.00^b
T_4	25.50^b	45.40^b	55.94^{ab}	75.94^{ab}	95.92^{ab}	94.25^b
T_5	26.50^{ab}	46.11^a	56.25^a	76.11^a	96.20^a	95.10^a
T_6	26.85^a	46.78^a	56.85^a	76.78^a	96.50^a	95.50^a
T_7	27.10^a	47.50^a	57.92^a	77.10^a	97.85^a	96.25^a
LS	**	**	**	**	**	**
LSD	2.06	2.08	2.07	2.03	2.03	1.96

LS: Level of significance, **Significant at 1% level of probability, T_1: Farmers' practiced based fertilizer (180-42-42 kg ha^{-1} of urea-TSP-MoP), T_2: BARC recommended fertilizer dose (300-112-127-75-11 kg ha^{-1} of urea-TSP-MoP-$CaSO_4$-$ZnSO_4$), T_3: T_2+Wet irrigation, T_4: T_2+Wet and dry irrigation, T_5: T_2+Proper seedling age, T_6: T_2+PSA (proper seedling age), T_7: IPNS (integrated plant nutrition system)+proper seedling age+IPM, DAT: Days after transplanting

Table 2: Effect of fertilizer and agronomic management on total number of tillers hill^{-1} of BRRI dhan58 in *haor* area

Fertilizer treatments	Total number of tillers/hill at different DAT					
	30	45	60	75	90	At harvest
T_1	9.00^{c}	11.00^{b}	12.25^{c}	15.00^{b}	14.25^{b}	13.00^{b}
T_2	11.70^{b}	12.50^{b}	14.50^{b}	16.25^{b}	15.25^{b}	14.25^{b}
T_3	12.00^{b}	13.60^{ab}	15.50^{a}	17.00^{b}	16.25^{ab}	15.25^{ab}
T_4	12.50^{ab}	13.75^{a}	14.75^{ab}	17.50^{ab}	16.50^{ab}	15.50^{a}
T_5	11.80^{b}	13.50^{ab}	15.00^{a}	17.75^{a}	16.00^{b}	15.00^{ab}
T_6	12.75^{a}	13.75^{a}	14.75^{ab}	16.50^{b}	15.50^{b}	14.50^{b}
T_7	13.05^{a}	14.00^{a}	15.50^{a}	18.25^{a}	17.00^{a}	16.00^{a}
LS	**	**	**	**	**	**
LSD	1.47	1.50	1.90	1.48	2.16	2.08

LS: Level of significance, **Significant at 1% level of probability, T_1: Farmers' practiced based fertilizer (180-42-42 kg ha^{-1} of urea-TSP-MoP), T_2: BARC recommended fertilizer dose (300-112-127-75-11 kg ha^{-1} of urea-TSP-MoP-$CaSO_4$-$ZnSO_4$), T_3: T_2+Wet irrigation, T_4: T_2+Wet and dry irrigation, T_5: T_2+Proper seedling age, T_6: T_2+PSA (proper seedling age), T_7: IPNS (integrated plant nutrition system)+proper seedling age+IPM, DAT: Days after transplanting

Table 3: Effect of fertilizer and agronomic management on the yield and yield contributing characters of BRRI dhan58 in haor area

Fertilizer treatments	Effective tillers/hill (No.)	Grains/panicle (No.)	Sterile spikelets/panicle (No.)	Panicle length (cm)	1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	14.40^{b}	122.17^{c}	23.48	19.85^{b}	20.87^{c}	6.22^{b}	9.69^{b}
T_2	15.56^{ab}	134.52^{b}	20.00	21.05^{a}	22.82^{b}	8.36^{b}	10.19^{b}
T_3	14.72^{b}	136.78^{ab}	22.84	21.05^{a}	23.14^{a}	8.34^{b}	10.78^{ab}
T_4	15.08^{b}	136.44^{ab}	22.32	20.70^{b}	23.20^{a}	8.36^{b}	10.79^{ab}
T_5	15.68^{ab}	136.25^{b}	20.72	20.80^{ab}	22.97^{b}	8.44^{a}	11.06^{a}
T_6	15.08^{b}	135.15^{b}	22.16	20.65^{b}	22.97^{b}	8.56^{a}	10.59^{b}
T_7	16.52^{a}	141.35^{a}	20.28	21.20^{a}	24.15^{a}	8.74^{a}	11.77^{a}
LS	**	**	NS	**	**	**	**
LSD	1.788	3.224	-	0.829	0.901	0.427	0.582

LS: Level of significance, NS: Non-significance, **Significant at 1% level of probability, T_1: Farmers' practiced based fertilizer (180-42-42 kg ha^{-1} of urea-TSP-MoP), T_2: BARC recommended fertilizer dose (300-112-127-75-11 kg ha^{-1} of urea-TSP-MoP-$CaSO_4$-$ZnSO_4$), T_3: T_2+Wet irrigation, T_4: T_2+Wet and dry irrigation, T_5: T_2+Proper seedling age, T_6: T_2+PSA (proper seedling age), T_7: IPNS (integrated plant nutrition system)+proper seedling age+IPM, DAT: Days after transplanting

Table 4: Nutrient status of initial and post-harvest soil of experimental field in haor area

Fertilizer treatments	pH	Total N (%)	OM (%)	Available P (ppm)	Exchangeable K (meq/100 g)	Available S (ppm)
Post-harvest soils						
T_1	4.34	0.17	2.92	5.05	0.18	30.70
T_2	4.42	0.17	2.95	5.21	0.20	32.68
T_3	4.40	0.18	2.98	5.30	0.21	35.50
T_4	4.32	0.19	2.95	5.89	0.20	33.10
T_5	4.43	0.20	2.94	5.51	0.22	31.70
T_6	4.46	0.21	2.97	5.56	0.21	30.95
T_7	4.35	0.19	3.10	5.50	0.19	31.50
Initial soil	4.90	0.11	2.90	4.01	0.17	28.35

OM: Organic matter, T_1: Farmers' practiced based fertilizer (180-42-42 kg ha^{-1} of urea-TSP-MoP), T_2: BARC recommended fertilizer dose (300-112-127-75-11 kg ha^{-1} of urea-TSP-MoP-$CaSO_4$-$ZnSO_4$), T_3: T_2+Wet irrigation, T_4: T_2+Wet and dry irrigation, T_5: T_2+Proper seedling age, T_6: T_2+PSA (proper seedling age) and spacing (S), T_7: IPNS (integrated plant nutrition system)+proper seedling age and spacing+IPM, DAT: Days after transplanting

system)+proper seedling age+IPM (T_7) also produced the highest number of effective tillers/hill (16.52), number of grains/panicle (141.35), panicle length (21.20 cm), 1000-grains weight (24.15 g), grain yield (8.74 t ha^{-1}) and straw yield (11.77 t ha^{-1}) in comparison to Farmers' practice based fertilizer (T_1). The BARI[15] conducted an experiment in farmers' field at Singpurhaor, Nikli, Kishoreganj district and reported higher grain yield (9.67 t ha^{-1}) from 318-63-130-29-5-1.25 kg N-P-K-S-Zn-B ha^{-1} in comparison to farmers' practice (6.26 t ha^{-1}) with 60-30-40-25 kg N-P-K-S ha^{-1}. The result was observed by Islam *et al.*[16] and Wang *et al.*[17].

Nutrient status of soil in haor area: Initial and post-harvest soils were analyzed to observe the status of before and after cropping differences of nutrients present in soil (Table 4). The pH value was 4.90 of initial soil. Post-harvest soil analysis showed that the pH values were lower than initial sample. The pH values were decreased slightly might be due to residual effect of fertilizer in post-harvest soil. Nutrients such as total N, soil organic matter, available P, exchangeable K, available P and available S of post-harvest soils were higher than initial soils. Soils of the area are grey, silty clay loams and clay loam in the higher parts that dry

out seasonally and grey clays in the wet basins. This study area soil reaction is mainly slightly acidic, BARC[5].

CONCLUSION

Results of the experiment stated that the yield and yield contributing characters of boro rice (BRRI dhan58) were performed best (8.74 t ha^{-1}) due to application of IPNS+Proper Seedling Age and Spacing+IPM over Farmers' practice fertilizers. Therefore, balanced fertilizer application with proper agronomic management may be recommended for higher yield of BRRI dhan58 in the hoar area.

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