

Original Research Article

Effect of Fertilizers and Irrigation Practices on the Growth and Yield of Boro Rice in *Haor* Area of Bangladesh

ABSTRACT

The experiment was conducted at the farmers' field, Bahadurpur village, Sunamganj Sadar upazila, Sunamganj district, during November 2014 to May 2015 to study the effect of fertilizers and irrigation practices on the growth and yield contributing characters of *boro* rice (cv. BRRI dhan29) in *haor* area. The experiment comprised two level of fertilizers viz. F_1 = Farmers' practice based fertilizers (180-42-42 kg ha⁻¹ of Urea-TSP-MoP) and F_2 = BARC recommended fertilizers (300-112-127-75-11 kg ha⁻¹ of Urea-TSP-MoP-CaSO₄-ZnSO₄); and three irrigation practices viz. I_1 = Farmers' practice, I_2 = Alternate Wetting and Drying Method, and I_3 = Wet method. The experiment was laid out in a randomized complete block design (RCBD) with five farmers' field as replications. The plant height was significantly affected due to fertilizers application at 45, 60, 75, 90 DAT (Days after transplanting) and at harvest. BARC recommended dose of fertilizers gave the longest plant height (87.62 cm) at harvest whereas the shortest plant (83.98 cm) was observed in farmers practice base fertilizer application. Plant height varied significantly due to different irrigation practice at 30 and 90 DAT. The variation of number of total tillers hill⁻¹ 30, 45, 60, 75 and 90 DATs and at harvest was significant due to fertilizers application. BARC recommended dose of fertilizers gave the highest tillers number hill⁻¹ (16.16) at 75 DAT and the lowest number of tillers hill⁻¹ (15.00) was noticed in farmers practices base fertilizer application at 75 DAT. The higher grain yield (8.54 t ha⁻¹) and straw yield (11.09 t ha⁻¹) were recorded due to application of BARC recommended fertilizers over Farmers' practice based fertilizers. Among the three levels of irrigation practices wet irrigation method performed the best in respect of grain yield (8.36 t ha⁻¹). The highest grain yield (8.86 t ha⁻¹) was observed from the interaction of BARC recommended fertilizers with wet irrigation method. Nutrient contents in post-harvest soils were higher compared to initial soils due to application of BARC recommendation guide based fertilizers. Higher doses of fertilizer treated plots in BARC recommended fertilizers with Wet irrigation method provided the gross margin and highest benefit cost ratio (BCR) among the treatments. The overall results indicated that BARC recommended dose of fertilizers influenced the growth and yield characters of rice varieties (cv. BRRI dhan29).

Keywords: *Haor*, BRRI dhan29, Fertilizer, Irrigation, Growth & Yield

1. INTRODUCTION

Rice is one of the important foods for growing population of human. Rice has the second place because of planted area but it serves as the most important food source for Asian countries mainly in south-east parts where it is an economic crop for farmers and workers who grow it on millions of hectares throughout the region. World rice production at 494.4 million tonnes and total rice growing area (boro, aus and aman) was 11.38 million ha in Bangladesh of which 41.94% covers by the boro rice cultivable area and the production of boro rice was 18.94 million metric tonnes [1]. The people in Bangladesh depend on rice as staple food and have tremendous influence on agrarian economy of the country. Geographic location and agronomic conditions of Bangladesh are favorable for rice cultivation. The average yield of rice is almost less than 50% of the world average rice grain yield. The increasing rate of population is 1.37% and decreasing rate of agricultural land by 1% per annum, limit the horizontal expansion of rice area [2]. Though it is not possible to have horizontal expansion of rice area, so rice yield per unit area should be increased to meet this ever increasing demand of food in the country. To overcome this situation, increment of rice production per unit area is only the alternative to keep self-sufficiency in food grain production. In the *haor* area of Bangladesh, there is only one cropping season which is rabi season. The *rabi* crops are affected by natural calamities like flash flood, hailstorm and insect pests. The *haor* area is also one of the major economic production zones of the country. *Boro* rice is the most important and single largest crop (90%) in *haor* area. The yield of *boro* rice production per hectare estimated as 3.968 tonnes ha⁻¹ in 2013-2014, which is lower than the potential yield in boro season [3]. Rice production system depends on a various

management practices such as fertilizers, irrigation, crop management practices, use of high yielding varieties etc. Among them fertilizer is very important input. If the soil nutrient status is not enough to meet up the plant demands, it is necessary to supply the required nutrients to the soil. Judicious use of fertilizers can markedly increase the yield and improve the quality of rice [4]. Wet culture of rice is the normal practice in our cropping practice. It is found that, the conventional flood irrigation for *Boro* rice requires about 3000-5000 liters of water to produce one kilogram of rice, this can be reduced to about 2000 liters by adopting AWD method [5]. About 75 percent of the world's rice is produced using continuous flooding water management practice and the highest yield was obtained in continuous flooding condition [6]. Reduction of water use in rice cultivation is a great challenge throughout the world as well as Bangladesh. *Haor* area of Sunamganj faces critical water crisis during March-April period due to irrigation facilities. Water saving technology use may be one of these solutions. The study was aimed to find out the effect of fertilizers and irrigation practices on the growth and yield contributing characters of *boro* rice (cv. BRRI dhan29) in *haor* area.

2. MATERIALS AND METHOD

The experimental site Bahadurpur village, Sunamganj sadar upazila, Sunamganj district, Bangladesh is lies between 24°34" and 25°12" north latitudes and between 90°56" latitude and 91°49" east longitude. The maximum monthly average air temperature at April 33.5°C and minimum 14.8°C at January, maximum monthly average rainfall 121.2 mm in May during monsoon period and no rainfall in the month of November and December, and maximum relative humidity 80.5% during experimental time. The experiment was conducted at the farmers' field during November 2014 to May 2015. The experimental site was located under AEZ-21 having well drainage facility and the soil was clay type. The experiment comprised two level of chemical fertilizer applications viz. F₁= Farmers' practice based fertilizer (180-42-42 kg ha⁻¹ of Urea-TSP-MoP) and F₂= BARC recommended fertilizer (300-112-127-75-11 kg ha⁻¹ of urea-TSP-MoP-CaSO₄-ZnSO₄) and three level of irrigation viz. I₁= Farmers' practice, I₂= Alternate wetting and drying method, and I₃= Wet method. The experiment was laid out in a randomized complete block design (RCBD) with five farmers' field replications. The unit plot size was 5.0 m × 4.0 m. The field was prepared by three successive ploughings and cross ploughings with a power tiller and subsequently leveled by laddering. All the fertilizers were applied at the time of final land preparation but Urea was applied in three equal splits at 20, 40 and 60 days after transplanting (DAT) as per treatments. The layout of the field was made after final land preparation. Thirty five days old seedlings were uprooted from the nursery bed carefully and then transplanted at the well puddled plots with 2 to 3 seedlings hill⁻¹ on 5 January 2015. Intercultural operations such as drainage, gap filling, weeding was done as and when necessary. Some perforated PVC pipes were used to measure the water level below the ground level in the field. The diameter and the length of the PVC pipes were 7 cm and 25 cm, respectively, having 0.5 cm perforations 2 cm away from each other. The pipe was installed in the AWD fields keeping 10 cm above the soil and the remaining portion (15 cm) below the soil for monitoring the water level. The experimental crop of each plot was harvested on different dates from 05 May to 07 May 2015. Data on plant height, tillers hill⁻¹, yield and yield contributing characters were recorded. Initial and post-harvest soils were collected and analyzed to determine the nutrient status. The data were analyzed statistically with the help of computer package program MSAT-C [7]. Finally, economic analyses were done for net benefit and marginal rate of return.

Table 1. Irrigation schedule of the experiment were performed during the field study of *boro* rice (cv. BRRI dhan29) in *haor* area

No. of irrigation	Date	Farmers' practice	AWD method	Wet irrigation method
1	12.01.15	✓	✓	✓
2	19.01.15	-	-	✓
3	26.01.15	✓	✓	✓
4	03.02.15	-	-	✓
5	10.02.15	✓	✓	✓
6	17.02.15	-	-	✓
7	24.02.15	✓	✓	✓
8	03.03.15	✓	-	✓
9	10.03.15	✓	✓	✓
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Effects of fertilizers on plant height at 45, 60, 75, 90 DATs and at harvest was significant (Table 2). The longer plant was observed at 45 DAT, 60 DAT, 75 DAT, 90 DAT and at harvest due to application of BARC recommendation guide based fertilizers with respective plant height of 49.82 cm, 68.80 cm, 78.85 cm, 84.94 cm and 87.62 cm, respectively. The shorter plant was observed from application of farmers' practice based fertilizers. Similar result also found by Hossain *et al.* [8] and Banu *et al.* [9]. Effect of irrigation practices on plant height of BRRI dhan29 was significantly affected at 30 and 90 DAT but variation of plant height at harvest among the irrigation treatments were not significant (Table 2). Thakur *et al.* [10] stated that rice plants grown under Alternate Wetting and Drying were 22 and 24% taller than rice plants grown under continuous flood. The number of total tillers hill⁻¹ was significantly varied due to application of fertilizer dose at 30, 45, 60, 75 and 90 DATs and at harvest (Table 3). The highest number of total tillers hill⁻¹ (16.16) was produced due to application of BARC recommendation guide based fertilizers. This finding was similar of the findings of Gangwar *et al.* [11]. From the above result, it was observed that in most cases, the growth character named plant height and number of total tillers hill⁻¹ was significantly affected due to the application of BARC recommendation guide based fertilizers compared to Farmers' practice.

97 Table 2. Effect of fertilizers and irrigation practices on the plant height of *boro* rice (cv. BRRI dhan29)
98 in the *haor* area

Treatment	Plant height (cm)						
	Days after transplanting (DAT)						
	15	30	45	60	75	90	At Harvest
Fertilizer							
F ₁	33.37	37.69	46.30	62.71	72.11	83.98	83.98
F ₂	32.92	37.16	49.82	68.80	78.85	84.94	87.62
SD	0.3182	0.3748	2.4890	4.3063	4.7659	0.6788	2.5739
LS	NS	NS	**	**	**	**	**
Irrigation							
I ₁	33.34	36.82	47.48	64.86	74.66	81.60	86.18
I ₂	32.26	37.52	48.24	66.68	75.46	83.84	84.86
I ₃	33.84	37.94	48.48	65.72	76.32	84.23	86.37
SD	0.8075	0.5658	0.5220	0.9104	0.8301	1.4193	0.8224
LS	NS	*	NS	NS	NS	**	NS
Interaction of Fertilizer * Irrigation							
F ₁ I ₁	32.84	36.12	45.32	61.08	69.80	82.72	83.82
F ₁ I ₂	32.52	37.76	46.40	63.72	73.16	80.24	83.52
F ₁ I ₃	34.76	39.20	47.20	63.32	73.36	81.54	84.60
F ₂ I ₁	33.84	37.52	49.64	68.64	79.52	85.74	88.54
F ₂ I ₂	32.00	37.28	50.08	69.64	77.76	82.96	86.20
F ₂ I ₃	32.92	36.68	49.76	68.12	79.28	86.14	88.14
SD	0.9936	1.0536	2.0233	3.4910	3.9522	2.3193	2.1772
LS	NS	NS	NS	NS	NS	NS	NS
CV (%)	-	3.63	3.05	5.09	3.33	1.58	1.97

99 ** = Significant at 1 % level of provability; * = Significant at 5 % level of provability; SD=Standard deviation; LS
100 = Level of significance; CV = Coefficient of Variation; NS = Not significant; F₁ = Farmers' practice based fertilizers
101 (180-42-42 kg ha⁻¹ of urea-TSP-MoP); F₂ = BARC recommendation guide based fertilizers (300-112-127-75-11
102 kg ha⁻¹ of urea-TSP-MoP-CaSO₄-ZnSO₄); I₁ = Farmers' practice of irrigation; I₂ = Alternate Wetting and Drying
103 (AWD) method of irrigation; I₃ = Wet irrigation method.

Table 3. Effect of fertilizers and irrigation practices on number of total tillers hill⁻¹ of *boro* rice (cv. BRRI dhan29) in the *haor* area

Treatment	Number of total tillers hill ⁻¹						
	Days after transplanting(DAT)						
	15	30	45	60	75	90	At Harvest
	Fertilizer						

F ₁	5.64	11.40	14.69	14.96	15.00	14.67	14.52
F ₂	5.47	12.19	16.12	16.12	16.16	15.83	15.73
SD	0.1202	0.5586	1.0112	0.8202	0.8202	0.8202	0.8555
LS	NS	*	**	**	**	**	**
Irrigation							
I ₁	5.20	11.62	15.10	15.30	15.34	14.96	14.82
I ₂	5.98	11.88	15.94	15.94	15.98	15.70	15.58
I ₃	5.48	11.88	15.18	15.38	15.44	15.08	14.98
SD	0.3951	0.1501	0.4636	0.3487	0.3442	0.3971	0.4006
LS	NS	NS	NS	NS	NS	NS	NS
Interaction of Fertilizer * Irrigation							
F ₁ I ₁	5.40	11.56	14.12	14.52	14.46	14.12	13.96
F ₁ I ₂	6.00	11.08	15.20	15.20	15.26	14.96	14.76
F ₁ I ₃	5.52	11.56	14.76	15.16	15.24	14.92	14.84
F ₂ I ₁	5.00	11.68	16.08	16.08	16.20	15.80	15.68
F ₂ I ₂	5.96	12.68	16.68	16.68	16.80	16.44	16.40
F ₂ I ₃	5.44	12.20	15.60	15.60	15.64	15.24	15.12
SD	0.3764	0.5625	0.9196	0.7609	0.8180	0.7985	0.8372
LS	NS	NS	NS	NS	NS	NS	NS
(CV %)	-	7.08	6.01	5.05	5.51	5.63	5.78

** = Significant at 1 % level of provability; * = Significant at 5 % level of provability; SD=Standard deviation; LS = Level of Significance; CV = Coefficient of Variation; NS = Not significant; F₁ = Farmers' practice based fertilizers (180-42-42 kg ha⁻¹ of urea-TSP-MoP); F₂ = BARC recommendation guide based fertilizers (300-112-127-75-11 kg ha⁻¹ of urea-TSP-MoP-CaSO₄-ZnSO₄); I₁ = Farmers' practice of irrigation; I₂ = Alternate Wetting and Drying (AWD) method of irrigation; I₃ = Wet irrigation method.

3.2 Yield Parameters

Yield and yield contributing characters were influenced significantly due to application of different fertilizers practices (Table 4). The higher number of effective tillers hill⁻¹ (14.65), number of grains panicle⁻¹ (178.20), number of sterile spikelets panicle⁻¹ (43.31), panicle length (23.86 cm), 1000-grains weight (23.37 g), grain yield (8.54 t ha⁻¹) and straw yield (09.66 t ha⁻¹) were obtained due to application of BARC recommended fertilizers in comparison to farmers practices. The similar result also found by Hossain *et al.* [8], BRRI [12] and Islam *et al.* [13]. Irrigation practices were influenced significantly the number of grains panicle⁻¹ and grain yield (Table 4). The highest number of grains panicle⁻¹ (173.42) and grain yield (8.36 t ha⁻¹) were obtained due to Wet irrigation method (I₃). The lowest number of grains panicle⁻¹ (161.72) and grain yield (7.80 t ha⁻¹) were obtained due to Farmers' practice of irrigation (I₁). Similar result found by Maiti *et al.* [14] in their field experiment in West Bangal, India. Effect of interaction of fertilizers and irrigation practices was significant in number of grains panicle⁻¹ (Table 4). The highest number of grains panicle⁻¹ (191.12) was obtained due to BARC recommended fertilizers with Wet irrigation method (F₂I₃). Hossain and Alam [15], Ali *et al.* [16] and Rajput *et al.* [17] also found the similar result. BARC Recommended dose of fertilizers was significantly affected the yield and yield contributing characters of boro rice (cv. BRRI dhan29).

Table 4. Effect of fertilizer, irrigation practice and their interaction on yield and yield contributing characters of *boro* rice (cv. BRRI dhan29) in the *haor* area

Treatment	Effective tillers hill ⁻¹ (no.)	Grains panicle ⁻¹ (no.)	Sterile spikelets panicle ⁻¹ (no.)	Panicle length (cm)	1000-grains weight (g)	Grain yield (t ha ⁻¹)	Straw yield (t ha ⁻¹)
Fertilizer							
F ₁	13.52	153.54	36.93	22.66	22.67	7.70	08.96
F ₂	14.65	178.20	43.31	23.86	23.37	8.54	09.66
SD	0.7990	17.4372	4.5113	0.8485	0.4949	0.5939	0.4949
LS	**	**	**	**	**	**	**
Irrigation							
I ₁	13.82	161.72	39.14	23.01	22.80	7.80	08.85
I ₂	13.06	162.47	40.52	23.08	23.10	8.20	09.43

I ₃	14.53	173.42	40.69	23.69	23.15	8.36	09.46
SD	0.7351	6.5492	0.8501	0.3740	0.1892	0.2884	0.3438
LS	NS	**	NS	NS	NS	**	NS
Interaction of Fertilizer * Irrigation							
F ₁ I ₁	12.96	148.48	35.92	22.22	22.20	7.51	08.85
F ₁ I ₂	13.70	156.42	38.22	22.42	22.90	7.74	09.22
F ₁ I ₃	13.78	155.72	36.64	23.34	22.90	7.85	09.06
F ₂ I ₁	14.56	174.96	42.36	23.80	23.40	8.08	09.96
F ₂ I ₂	15.23	168.52	42.82	23.74	23.30	8.67	10.04
F ₂ I ₃	14.08	191.12	44.74	24.04	23.40	8.86	10.26
SD	0.7793	15.6329	3.6609	0.7647	0.4622	0.5368	0.5916
LS	NS	**	NS	NS	NS	NS	NS
(CV%)	5.97	4.90	10.37	2.99	2.12	4.17	3.04

LS = Level of Significance; SD=Standard deviation; CV = Coefficient of Variation, ** = Significant at 1 % level of provability; F₁ = Farmers' practice (180-42-42 kg ha⁻¹ of Urea-TSP-MoP); F₂ = BARC recommendation guide based fertilizers (300-112-127-75-11 kg ha⁻¹ of urea-TSP-MoP-CaSO₄-ZnSO₄); I₁ = Farmers' practice of irrigation, I₂ = Alternate Wetting and Drying (AWD) method of irrigation; I₃ = Wet irrigation method.

3.3 Chemical properties of experimental soil

Chemical properties before and after cropping was changed due to fertilizers application (Table 5). The pH value was reduced in post-harvest soils in comparison to initial soil. Post-harvest soils nutrients such as total N%, soil organic matter % (OM), available P (ppm), exchangeable K (meq100 g⁻¹), available S (ppm), and available Zn (ppm) were higher due to application of BARC recommendation guide based fertilizers treated plots compared to Farmers' practiced plots. It was due to balanced nutrient supply which ensured by the BARC recommendation guide based fertilizers application. The study region occupies the lower, western side of the Surma-Kushiyara Floodplain. The area is mainly smooth, broad basins with narrow rims of higher land along rivers i.e. AEZ-21. 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 (BARC, 2012). This finding was similar of the findings of Maiti *et al.* (2007).

Table 5. Nutrients status of initial and post-harvest soil of experimental field in the Bahadurpur village of Dekar haor area

Treatment	P ^H	Total-N %	OM %	K meq100 g ⁻¹	P ppm	S ppm	Zn ppm
Initial soil	4.80	0.11	2.9	0.16	4.00	24	1.87
post-harvest soil (Fertilizers and Irrigation practice)							
F ₁ I ₁	4.50	0.13	2.84	0.19	4.85	25	1.88
F ₁ I ₂	4.46	0.13	3.21	0.20	5.20	36	1.96
F ₁ I ₃	4.47	0.13	3.56	0.20	5.16	34	2.03
F ₂ I ₁	4.34	0.14	2.98	0.21	5.00	27	1.92
F ₂ I ₂	4.49	0.14	3.56	0.22	5.33	38	2.17
F ₂ I ₃	4.59	0.15	3.70	0.23	5.40	40	2.30

OM = Organic matter; F₁ = Farmers' practice (180-42-42 kg ha⁻¹ of Urea-TSP-MoP); F₂ = BARC recommendation guide based fertilizers (300-112-127-75-11 kg ha⁻¹ of urea-TSP-MoP-CaSO₄-ZnSO₄); I₁ = Farmers' practice of irrigation; I₂ = Alternate Wetting and Drying (AWD) method of irrigation; I₃ = Wet irrigation method.

3.4 Agro-Economic Analysis of BRRI Dhan29 grower

Gross return was calculated from the price of rice grain and straw. Costs that vary were calculated from the cost involved for input used for the experimental treatments. The budget analysis of cost of production showed that the highest cost of cultivation (Tk. 49215 ha⁻¹); gross return (Tk. 148290 ha⁻¹) and gross margin (Tk. 99075 ha⁻¹) was accounted for BARC recommended fertilizers with Wet irrigation method (F₂I₃) because of higher yield though higher cost was involved (Table 6). Higher doses of fertilizer treated plots in BARC recommended fertilizers with Wet irrigation method (F₂I₃) provided the highest benefit cost ratio (BCR) among the treatments. Similar result was also observed by Aziz *et al.* (2015).

Table 6. Agro-economic analysis of BRRI dhan29 grower under different fertilizer and irrigation practices in the Dekar *haor* area

Treatment (Fertilizers × Irrigation practice)	Cost of cultivation (Tk ha ⁻¹)	Gross return (Tk ha ⁻¹)	Gross margin (Tk ha ⁻¹)	BCR
F ₁ I ₁	43799	125925	82126	2.88
F ₁ I ₂	46580	136140	89560	2.92
F ₁ I ₃	43937	129930	85993	2.96
F ₂ I ₁	44267	131340	87073	2.97
F ₂ I ₂	48670	145110	96440	2.98
F ₂ I ₃	49215	148290	99075	3.01

BCR= Benefit Cost Ratio; Gross returns included income from sale of main and by-products (Tk ka⁻¹) of crop, Grain @ 15 Tk. kg⁻¹; Straw @ 1.5 Tk. kg⁻¹. Among field operations, the cost of ploughing was taken as Tk. 10 decimal⁻¹, labour cost of Tk. 300 m⁻¹day⁻¹, Urea @ 20 Tk. kg⁻¹; TSP @ 25 Tk. kg⁻¹; MoP @ 17 Tk. kg⁻¹.

4. CONCLUSION

Geographic location and agronomic conditions of Bangladesh are favorable for rice cultivation. The results revealed in the study indicated that the yield and yield contributing characters were performed best due to application of BARC recommendation based fertilizers with Wet method of irrigation Bahadurpur village in Dekar *haor* under AEZ-21 of Sunamganj Sadar Upazila, Sunamganj district during Boro season. Rice production per unit area is only the alternative to keep self-sufficiency in food grain production in *haor* area of Bangladesh. Farmers' of the *haor* area might be suggested both to apply BARC recommendation based fertilizers and Alternate wetting and drying for getting higher yield boro rice (cv. BRRI dhan29) in the *haor* area.

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