International Journal of Natural and Social Sciences, 2018, 5(3):75-86 ISSN: 2313-4461

International Journal of Natural and Social Sciences
ISSN: 2313-4461
IJNSS

Effects of irrigation approaches on growth and yield of different varieties of *boro* rice

Md. Shariful Hasan Khan[1,5], Tahmina Akter[2]*, Md. Al- Ekram[3], Amit Malaker[4], Abul Hossain[5]

[1]Bangladesh University of Professionals (BUP), Mirpur Cantonment, Dhaka, Bangladesh
[2]Department of Biochemistry and Molecular Biology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[3]Department of Horticulture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[4]Department of Seed Science and technology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[5]Department of Soil Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

ARTICLE INFO

Article history

Accepted 07 July 2018
Online release 29 July 2018

Keyword

Crop Production
Environment and Natural Resources
Irrigation Management
Food Security
Critical Stage Irrigation

***Corresponding Author**

T Akter
tahminataniabmb@gmail.com

ABSTRACT

A field experiment was carried out at the field laboratory of the Department of Soil Science, Bangladesh Agricultural University (BAU), Mymensingh during boro season (January 2014-May 2014) to find out the growth and yield performance of 5 *boro* rice varieties under two irrigation approaches. The experiment was laid out in a two factors Randomized Complete Block Design (RCBD) with varieties V_1 (BRRI dhan 28), V_2 (BRR1 dhan 29), V_3 (BINA dhan 8), V_4 (BINA dhan 10) and V_5 (BR 47) at two irrigation approaches, I_1 (application of irrigation at physiological stages), I_2 (application of irrigation at critical stages). The experimental field was divided into 30 plots to apply 10 treatments with 3 replications for each treatment. The area of each unit plot was 4.0 m x 2.5 m. Recommended dose of all fertilizers and pesticides were applied. The different varieties showed variable results on different physiological attributes. For different parameters such as 1000 seed weight; the effects of varieties are statistically significant. Highest 1000-grain weight (25.95g) obtained in I_2 (application of irrigation at critical stages) and lowest (25.53g) obtained in I_1 (application of irrigation at critical stages). Experimental result showed that the weight of 1000-grain was slightly increased under irrigation approaches, I_2 (application of irrigation at critical stages) over irrigation approaches, I_1 (application of irrigation at physiological stages). The variety, V_5 (BR 47) is the tallest variety (79.54cm) and variety, V_3 (BINA dhan 8) is the shortest variety (74.20 cm) among the five varieties. Statistical variation is found in 1000 seed weight obtained in two different irrigation approaches. Grain yield is slightly decreased in I_2 (application of irrigation at critical stages) over I_1 (application of irrigation at physiological stages). The highest grain yield (6.87 t ha^{-1}) was observed in the combination of $V_3 \times I_1$ and lowest grain yield (5.83 t ha^{-1}) observed in the combination of $V_5 \times I_2$. The highest grain yield (6.63 t ha^{-1}) was attained in V_3 (BINA-8) and the lowest grain yield (6.01 t ha^{-1}) was attained in V_5 (BR-47) and it's higher in I_2 (irrigation at physiological stages).

INTRODUCTION

Rice is the most important and extensively cultivated staple food or crop that constituted about 90% of the total food grain production of Bangladesh (Huda, 2001). Among that boro rice, an irrigated crop alone supplies approximately 60% of total food grains (BBS, 2011). Bangladesh has 9.03 million hectares of cultivable land, out of which only 42% land is brought under irrigation (BBS, 2000). About 88% of the irrigated rice cultivation area is being covered by boro rice during dry winter period (BBS, 2000). Due to shortage of land in Bangladesh, it is not possible to increase rice production by bringing more area under cultivation

Irrigation is a critical factor for boro rice production in Bangladesh which consumed 73 percent of total crop irrigation which can make a crop either successful or unsuccessful. Though almost 97% of the world's water occurs in the oceans but due to their high salinity its unusable for crop production. Surface and groundwater resources are not easily available as a reliable source of water supply for crop production where about almost 50% of irrigation water is lost through leakage, seepage and percolation.Approximately 1.3 million shallow

How to cite this article: Khan MSH, Akter T, Ekram MA, Malaker A and Hossain A (2018). Effects of irrigation approaches on growth and yield of different varieties of *boro* rice. International Journal of Natural and Social Sciences, 5(3): 75-86.

tube-wells and 31,000 deep tube-wells functioning in Bangladesh and account for 3.98 million ha, or about 80 percent of the total irrigated area in the dry season (GoB, 2008). Being an irrigated-agriculture based country, Bangladesh depends onadequate water supply from both groundwater (80.60%) and surface water (19.40%) of usable quality (Rahman et. al., 2014). So, due to gradual depletion of ground water table, the irrigation in boro season has been and will remain a major concern. A single rice crop is cultivated in wet season by mainly harvesting the rain water as ground water irrigation as a single source of irrigation imposes a persistent threat with possibility of salinity intrusion from coastal rivers into the groundwater (Bahar et. al., 2010). The situation becomes worse when monsoon precipitation is delayed due to prolonged dry period and it is a matter of issue to choose the secured source of water for irrigation (Mondal et. al., 2006)

Although the monsoon climate, with its high humidity and temperature, is favorable for rice cultivation in Bangladesh but the rainfall is not evenly distributed throughout the year. About 96% of the total rainfall occurs during the months of April to October, leaving the remaining five months of the year essentially dry. When potential evaporation far exceeds rainfall, drought conditions or limited availability of water prevail over most of the regions of Bangladesh during the months from November to April. The annual mean precipitation varies from 140 cm in the west to more than 430 cm in the east of the country (Shahid, 2010). The average annual rainfall of Bangladesh is 203 cm of which only 20% occurs during boro season but huge amount of irrigation water is required to produce rice in this season.

Climate change has a profound impact on precipitation intensity and variability in Bangladesh (Wasimi, 2009; May 2004). Regional projections also revealed that climate change would strengthen monsoon circulation, increase surface temperature, and increase the magnitude and frequency of extreme precipitation events (Murshed et. al., 2011). In Bangladesh, the agriculture region of the southwest is adversely affected by extreme water shortages and severe moisture stress during the dry months (Faruque et. al., 2005). In the north- western part of Bangladesh, drought is also a common phenomenon (Shahid, 2010). The seasonal variation of precipitation will affect crop production that solely depends on precipitation, while also affecting the irrigation processes (Shahid, 2011).

Boro rice in Bangladesh, either HYV (High Yielding Variety) or traditional variety covering more than 4.5 million ha, is entirely irrigated production, mostly with underground water. Irrigation has become a very costly input in rice production. Farmers pay about 25-30% of the price. For producing 1 kg of paddy, it is estimated that a farmer need to use 3-4 thousand liters of water for maintaining pond water during the growing stage of plants. As a result, besides the increased cost of irrigation, groundwater level is also declining due to excessive withdrawal threatening the environment. So, the economic irrigation through the different growth stages should be ensured to minimize the water loss. Besides, different varieties can also contribute greatly to the yield of boro rice. Therefore, to achieve desired plant growth and crop yield, balanced irrigation should be a key factor for different varieties of *boro* rice.

With all of the above views in mind, the present piece of research work was conducted to evaluate the suitable variety to cultivate in *boro* season based on plant growth and crop yield; to assess the suitable irrigation approaches and finally,the interaction (if any) between variety and different irrigation approaches in boro season with the degree of response.

MATERIALS AND METHODS

An experiment was conducted at the Soil Science farm, Bangladesh Agricultural University (BAU), Mymensingh during the period from January to June 2014 with boro rice (cv. BRRI dhan-28, BRRI dhan-29, BINA-8, BINA-10, BR-47).

Experimental area

The experimental site was located at the Soil Science farm, Bangladesh Agricultural University (BAU), Mymensingh. The specified area for the experiment was located at 24° 75' N latitude and 90° 50' E longitude and at a mean elevation of 18 m above the mean sea level. The experimental soil was Sonatala Soil Series,non-calcareous dark grey floodplain soils with silt loam texture. The pH 6.7, 1.41% organic matter, 09% Total N, 9.10ppm available P, 0.14 meq./100g soil exchangeable K, 10.43 ppm available S were recorded as per source (Soil Survey, BAU, Farm, Mymensingh). The climate of the experimental area was sub-tropical which was characterized by high temperature, high humidity and heavy rainfall with occasional gusty wind in the *kharif* season (April-September) and scanty rainfall associated with moderately low temperature during the *rabi* season (October-March) (Biswas, 1987).

The experiment

The experiment was laid out in a Randomized Complete Block Design (RCBD). The entire field was divided into 3 rows, each row again divided into 10 plots, so total field contained 30 plots to apply 10 treatments and 3 replications for each treatment. The size of the unit plot was 4.0 m x 2.5 m = 10 m^2. There was 1.0 m width and 10 cm depth drains among the rows and 50cm width ail between two unit plots.

The experiment was performed with 5 varieties where V_1= BRRI dhan 28, V_2= BRRI dhan 29, V_3= BINA dhan 8, V_4= BINA dhan 10, V_5= BR 47 and two irrigation approaches, I_1= Irrigation at Physiological Stages (Early tillering, panicle initiation, flowering, milk and doug stage), I_2= Irrigation at Critical Stages (Early tillering and flowering stage). The variety treatment combinations were V_1I_1, V_2I_1, V_3I_1, V_4I_1, V_5I_1, V_1I_2, V_2I_2, V_3I_2, V_4I_2 and V_5I_2.Fertilizers such as urea (46% N) @ 275, TSP (20% P) @ 110, MoP (50% K) @ 90 and Gypsum (18% S) @ 135 kg ha-^{1} were applied to experimental plots.

Planting methods giving variable plant spacing has significant effects on grain yield, tillers per unit area, paniclesper hill and total spikelets per unit area (Yang et. al 2014).Thirty-seven-day-old seedlings were uprooted carefully from the seedbed in the morning and then transplanted on the same day in the main field on February 02, 2014. The spacing was 20 cm x 20 cm and three seedlings were transplanted in each hill.

Intensive care was taken during the growing period to ensure adequate growth and development of the crop. Seedlings in some hills died off and these were replaced by seedlings from the same source.The experimental plots were infested with some common weeds which were removed twice by hand weeding.

Plots were irrigated at the physiological stages (Early tillering, panical initiation, flowering, milk and dough stages) of rice and some of the plots were irrigated only at the critical stages such as early tillering stage and flowering stage. There was no serious incident of disease in the field and therefore, no chemical was applied to the field for controlling pathogen. Curaterr 5G 9.88 Kg ha^{-1} was used to control stem borers.

Collection of data

Data for Plant height (cm), Number of effective tillers $hill^{-1}$, Number of non-effective tillers $hill^{-1}$, Panicle length (cm), Number of filled grains $panicle^{-1}$,Number of unfilled grains $panicle^{-1}$, Thousand (1000) grain weight (g), Grain yield (t ha^{-1}), Straw yield (t ha^{-1}) and Biological yield (t ha^{-1}) were collected and recorded from five representative hills per plot.

Statistical analysis

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package SPSS and mean differences were adjudged by Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Plant height

Performance of variety

Results revealed that the plant height was evidently significant by variety at 1% level of probability (Table 1). The tallest plant height (79.54 cm) was observed in V_5 (BR 47). The second highest plant height (77.50 cm) was observed in V_2 (BRRI dhan 29). The plant height (75.71 cm) was observed in V_4 (BINA dhan 10) and (74.66 cm) was observed in V_1 (BRRI dhan 28). In contrast, the lowest plant height (74.20 cm) was found in V_3 (BINA dhan 8).

Effect of irrigation approaches on plant height

The effect of irrigation approaches on plant height was found significant at 5% level of probability (Table 2). The highest plant height (76.59 cm) was observed in I_1 (application of irrigation at physiological stages) and the lowest plant height (76.07 cm) was observed in I_2 (application of irrigation to field at critical stages).

Interaction effects of variety and irrigation approaches on height

The tallest plant height (79.83 cm) was observed in the treatment combination of V_5xI_1 which was obtained with the application of irrigation at physiological stages. The second tallest plant height was observed in the treatment combination of $V_5 \times I_2$ (79.25 cm), followed by the plant height 77.79 cm, 77.26 cm, 75.77 cm was found in the combination of $V_2 \times I_2$, $V_2 \times I_1$, and $V_4 \times I_1$ respectively. The shortest plant height (73.82 cm) was observed in the treatment combination of V_3xI_2.

Number of effective tillers hill^{-1}

Performance of variety

The effective tiller hill^{-1} was significantly influenced by variety ($p<0.001$) (Table 1).The maximum number (10.9) of effective tillers hill^{-1} was recorded in V_1 (BRRI dhan 28). Second maximum number was 10.73 recorded in V_5 (BR 47) which is statistically identical the number of effective tillers hill^{-1} was 10.14 and 9.87 recorded in V_3 (BINA dhan 8)and V_4 (BINA dhan 10) respectively. The minimum number (9.46) of effective tillers hill^{-1} was recorded in V_2 (BRRI Dhan 29).

Effect irrigation approaches

The effects of irrigation approaches on effective tillers counts were statistically significant (($p<0.005$)(Table 2). The maximum number of effective tillers (10.31) was obtained in I_1 (irrigation applied at physiological stages) and the minimum number of effective tillers (10.13) was obtained in I_2 (irrigation applied at critical stages).

Interaction effect of variety and different levels of irrigation

The interaction effect of variety and different levels of irrigation on the effective tillers hill^{-1} was statistically significant (($p<0.001$) (Table 3). However, the highest number of effective tillers (11.87) was observed in the treatment combination of V_1xI_1. The second highest number of effective tillers hill^{-1}(11.07) was observed in the combination of $V_{5\times}I_2$. The lowest number of effective tillers (8.73) was found in the treatment combination of V_2xI_1.

Number of non-effective tillers hill-1

Performance of variety

Experimental results exposed that the effect of variety on non-effective tillers hill^{-1} were found non-significant at 5% level of probability (Table 1). The highest number of non-effective tillers hill^{-1} (1.2) was found in V_4 (BINAdhan 10) where V_2 (BRRI Dhan 29) and V_3 (BINA dhan 8) were statistically similar 1.130 and 1.132 respectively. The lowest number of non-effective tillers hill^{-1} (1.06) was found in V_5 (BR 47).

Effect of irrigation approaches

The effects of irrigation approaches on non-effective tillers hill^{-1} counts were statistically significant at 5% level of probability (Table 2). The highest number of non-effective tillers (1.17) was obtained in I_1 (application of irrigation at physiological stages). The lowest number of non-effective tillers hill^{-1} (1.10) was found in I_2 (application of irrigation at critical stages).

Interaction effect of variety and irrigation approaches

The interaction effects of variety and different irrigation levels on the number of non-effective tillershill^{-1} were also significant at 1% level of probability. However, the highest number of non-effective tillers hill^{-1} (1.47) was observed in the treatment combination of $V_1 \times I_1$ followed by the number of non-effective tillers hill^{-1} (1.13) was observed in the treatment combination of $V_2xI_{1,}$ V_3xI_1 V_2xI_2 V_3xI_2 and the lowest number of non-effective tillers (0.87) was found in the treatment combination of V_1 xI_2.

Panicle length (cm)

Performance of variety

The performance of variety on the panicle length was significant at 1% level of probability. The tallest panicle length (22.74 cm) was observed in V_5 (BR 47) and the lowest panicle length (21.56 cm) was obtained in both V_3 (BINA Dhan 8). The second highest panicle length (22.64 cm) was found in V_2 (BRRI dhan 29) followed by the panicle length 22.29 cm was recorded in V_4 (BINA dhan 10).

Effect of irrigation approaches

From the experimental results (Table 2) it was found that the effect of different levels of irrigation on the panicle length was statistically significant at 5% level of probability. The highest panicle length (22.36 cm) was observed in I_2 (application of irrigation at critical stages) and the lowest panicle length (21.99 cm) recorded in I_1 (application of irrigation at physiological stages).

Interaction effect of variety and different levels of irrigation

Experimental results (Table 3) revealed that the interaction effect variety and irrigation approaches on the panicle length were statistically significant at 1% level of probability. However, the highest panicle length (23.20 cm) was observed in the treatment combination of $V_2 \times I_2$ and the lowest panicle length (21.00 cm) was found in the treatment combination of $V_3 \times I_1$.

Table 1
Effect of different boro rice varieties on plant height, numbers of effective tillers, number of non-effective tillers and panicle length of rice.

Variety	Plant height(cm)	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	Panicle length(cm)
V_1(BRRI dhan 28)	74.66 d	10.90 a	1.170 a	21.66 b
V_2(BRRI dhan 29)	77.50 b	9.467 d	1.130 ab	22.64 a
V_3(BINA dhan 8)	74.20 d	10.14 b	1.132 ab	21.56 b
V_4(BINA dhan 10)	75.71 c	9.870 c	1.200 a	22.29 a
V_5(BR 47)	79.54 a	10.73 a	1.065 b	22.74 a

The figures in a column with common letters do not differ significantly but dissimilar letters differ significantly ($p<0.001$).

Table 2
Effect irrigation approaches on plant height, numbers of effective tillers, and number of non-effective tillers and panicle length of rice.

Irrigation approaches	Plant height(cm)	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	Panicle length(cm)
I_1	76.59 a	10.31 a	1.172 a	21.99 b
I_2	76.07 b	10.13 b	1.107 b	22.36 a

The figures in a column with common letters do not differ significantly but dissimilar letters differ significantly ($p<0.001$).

Table 3
Interaction effects on plant height, number of effective tillers, number of non-effective tillers and panicle length of rice.

Interaction	Plant height(cm)	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	Panicle length(cm)
V_1I_1	75.48	11.87 a	1.470 a	21.46 de
V_2I_1	77.26	8.733 f	1.130 b	22.08 bcd
V_3I_1	74.59	10.27 cd	1.130 b	21.00 e
V_4I_1	75.77	10.27 cd	1.200 b	22.77 ab
V_5I_1	79.83	10.40 c	0.9300 c	22.66 abc
V_1I_2	73.84	9.930 d	0.8700 c	21.85 cde
V_2I_2	77.79	10.20 cd	1.130 b	23.20 a
V_3I_2	73.82	10.00 d	1.133 b	22.12 bcd
V_4I_2	75.65	9.470 e	1.200 b	21.82 cde
V_5I_2	79.25	11.07 b	1.200 b	22.83 ab

The figures in a column with common letters do not differ significantly but dissimilar letters differ significantly ($p<0.001$).

Number of filled grains panicle^{-1}

Performance of variety

The data on filled grains panicle^{-1} are presented in (Table 4) Performance of variety on the number of filled grains panicle^{-1} was statistically significant at 1% level of probability. The highest number of filled grains panicle^{-1} (120.4) was obtained in V_2 (BRRI Dhan 29) which is statistically similar number of filled grains panicle^{-1} (118.4) in V_5 (BR 47). The lowest number of filled grains panicle^{-1} (96.83) was found in V_4 (BINA Dhan 10).

Effect of different levels of irrigation

From the experimental results (Table 5) it was observed that the irrigation approaches to the different varieties of boro rice on the number of filled grains panicle^{-1} was statistically insignificant. The highest number of filled grains panicle^{-1} (108.7) was observed in I_1 (application of irrigation at physiological stages) and the lowest number of filled grains panicle^{-1} (108.6) recorded in I_2 (application of irrigation at critical stages).

Interaction effect of variety and different levels of irrigation

Interaction as well as combined effect of variety and different levels of irrigation on number of filled grains panicle^{-1} was statistically significant at 1% level of probability (Table 6). The highest number of filled grains panicle^{-1} (124.2) was found in $V_2 \times I_2$. The second highest number of filled grain panicle^{-1} (120.2) was recorded in $V_5 \times I_2$ and the lowest number of filled grains panicle^{-1} (92.67) found in $V_4 \times I_2$.

Number of unfilled grains panicle^{-1}

Performance of variety

Performance of variety on the number of unfilled grains panicle^{-1} was statistically significant at 5% level of probability (Table 4). The highest number of unfilled grains panicle^{-1} (14.65) was obtained in V_2 (BRRI dhan 29). The second highest number of unfilled grains panicle^{-1} (14.11) was found in V_3 (BINA dhan 8) and the lowest number of un-filled grains panicle^{-1}(13.14) was found in V_5 (BR 47)

Effect of irrigation approaches

From the experimental results (Table 5) it was conspicuous that the effect of irrigation approaches on the number of unfilled grains panicle^{-1} was non-significant. The highest number of unfilled grains panicle^{-1}(13.73) was observed in I_2 (application of irrigation at critical stages) which is statistically similar to the lowest number of grain panicle^{-1} (13.69) found in I_1 (application of irrigation at physiological stages).

Interaction effect of variety and irrigation approaches

Data recorded in (Table 6) showed that the interaction effect of variety and different levels of irrigation on the number of un-filled grains panicle^{-1} was statistically significant at 5% level of probability. The highest number of unfilled grains panicle^{-1} (14.77) was found treatment combination of $V_2 \times I_2$ which was statistically similar to the combination of $V_2 \times I_1$ (14.53) and the lowest number of unfilled grains panicle^{-1} (12.17) was found in treatment combination of V_5xI_2.

Thousand (1000) grain weight (g)

Performance of variety

From the table (Table 4), it was obtained that the performance of variety on 1000 grain weight was statistically significant at 1% level of probability. However, the highest 1000 grain weight (30.86 g) was attained in V_2 (BRRRI dhan 29). The second highest 1000 grain weight (26.02 g) was found in V_3 (BINA dhan 8), and the lowest 1000 grain weight (20.47 g) was found in V_1 (BRRI dhan 28).

Effect of irrigation approaches

The data on 1000 grain weight are presented in Table 5. From the table it was obtained that the performance of irrigation approaches on 1000 grain weight was statistically significant at 5% level of probability. However, the highest 1000 grain weight (25.95 g) was attained in I_2 (application of irrigation at critical stages) and 1000 grain weight (25.53 g) was found in I_1 (application of irrigation at physiological stages).

Interaction effect of variety and irrigation approaches

The data on interaction effect of variety and irrigation approaches are presented in Table 6. From the tabulated data it was found that the effect of interaction between variety and different irrigation approaches on the weight of 1000 grain was statistically non-significant. However, the highest 1000 grain weight (31.54 g) was found in treatment combination of $V_2 \times I_2$ and the lowest 1000 grain weight (20.28 g) was found in treatment combination of V_1xI_1.

Grain yield (t ha^{-1})

Performance of variety

From the experimental result it was obtained that varietals performance on grain yield was statistically significant at 1% (Table 4). The highest grain yield (6.63 t ha^{-1}) was attained in V_3 (BINA dhan 8). The second highest grain yield (6.43 t ha^{-1}) was attained in V_2 (BRRI dhan 29). The lowest grain yield (6.01 t ha^{-1}) was attained in V_5 (BR 47).

Effect of irrigation approaches

Experimental results revealed that the effect of irrigation approaches to the different varieties of boro rice on the grain yield was statistically significant at 1% level of probability. The highest grain yield (6.50 t ha^{-1}) was found in I_1 (application of irrigation at Physiological stages) and the lowest grain yield (6.12 t ha^{-1}) was found in I_2 (application of irrigation at critical stages).

Interaction effects of variety and irrigation approaches

From the tabulated data (Table 6) the interaction effect between variety and irrigation approaches on the grain yield was statistically significant at 5% level of probability. The highest grain yield (6.87 t ha^{-1}) was found in treatment combination of $V_3 \times I_1$ and the lowest grain yield (5.83 t ha^{-1}) found in treatment combination of V_5xI_2 which is similar to V_4xI_2 (5.93 t h^{-1}).

Straw yield (t ha^{-1})

Performance of variety

From the tabulated data (Table 4) it was found that performance of variety on the straw yield was statistically significant at 1% level of probability. The highest straw yield (14.70 t ha^{-1}) was observed in V_3 (BINA dhan 8). The second highest straw yield (13.42 t ha^{-1}) was observed in V_4 (BINA dhan 10). The lowest straw yield (11.58 t ha^{-1}) was produced in V_1 (BRRI Dhan 28).

Effect of irrigation approaches

Results indicated that the effect of irrigation approaches of boro rice on the straw yield was statistically significant at 5% level of probability (Table 5). The highest straw yield (13.80 t ha^{-1}) was observed in the treatment I_1 (application of irrigation at physiological stages) and the lowest straw yield (12.51 t ha^{-1}) was recorded in the treatment I_2 (application of irrigation at critical stages).

Interaction effect of variety and irrigation approaches

The interaction effect between variety and irrigation approaches on the straw yield was statistically significant (Table 6) at 5% level of probability. However, the highest straw yield (15.33 t ha^{-1}) was found in the treatment combination of $V_3 \times I_1$, and the lowest straw yield (11.33 t ha^{-1}) was found in treatment combination of $V_1 \times I_2$.

Table 4
Effects of different boro rice varieties on number of filled grain, number of unfilled grain, 1000 grain weight and grain yield of rice.

Variety	No. of filled grains	No. of unfilled grains	1000 grains wt.(g)	Grain yield (t ha^{-1})	Straw yield yield (t ha^{-1})
V1(BRRI dhan 28)	100.2 c	13.37 b	20.47 c	6.168 cd	11.58 d
V2(BRRI dhan 29)	120.4 a	14.65 a	30.86 a	6.435 ab	13.16 bc
V3(BINA dhan 8)	107.2 b	14.11 ab	26.02 b	6.635 a	14.70 a
V4(BINA dhan 10)	96.83 c	13.27 b	25.86 b	6.330 bc	13.42 b
V5(BR 47)	118.4 a	13.14 b	25.50 b	6.015 d	12.92 c

The figures in a column with common letters do not differ significantly but dissimilar letters differ significantly($p<0.001$).

Table 5
Effects of irrigation approaches on number of filled grain, number of unfilled grain, 1000 grain weight and grain yield of rice.

Irrigation approaches	No. of filled grains	No. of unfilled grains	1000 grains wt.(g)	Grain yield(t ha^{-1})	Straw yield yield(t ha^{-1})
I_1	108.7	13.69	25.53 b	6.508 a	13.80 a
I_2	108.6	13.73	25.95 a	6.125 b	12.51 b

The figures in a column with common letters do not differ significantly but dissimilar letters differ significantly($p<0.001$).

Table 6
Interaction effects of varieties and irrigation approaches on number of filled grain, number of unfilled grain, 1000 grain weight and grain yield of rice.

Interaction	No. of filled grains	No. of unfilled grains	1000 grains wt.(g)	Grain yield(t ha^{-1})	Straw yield yield(t ha^{-1})
V_1I_1	96.33 ef	12.87 bc	20.28	6.170 def	11.83 de
V_2I_1	116.7 bc	14.53 a	30.18	6.570 abc	14.00 b

V_3I_1	112.6 c	14.13 ab	25.94	6.870 a	15.33 a
V_4I_1	101.0 de	12.80 bc	26.05	6.730 ab	14.17 b
V_5I_1	116.6 bc	14.10 ab	25.23	6.200 de	13.67 b
V_1I_2	104.0 d	13.87 ab	20.66	6.167 def	11.33 e
V_2I_2	124.2 a	14.77 a	31.54	6.300 cd	12.33 cd
V_3I_2	101.8 de	14.10 ab	26.10	6.400 bcd	14.07 b
V_4I_2	92.67 f	13.73 ab	25.67	5.930 ef	12.67 c
V_5I_2	120.2 ab	12.17 c	25.77	5.830 f	12.17 cd

The figures in a column with common letters do not differ significantly but dissimilar letters differ significantly ($p<0.005$).

Biological yield (t ha^{-1})

Performance of variety

From the experimental result (Table 7) it was found that the performance of different levels of irrigation to the boro rice on the biological yield was statistically significant at 1% level of probability. The highest biological yield (21.34 t ha^{-1}) was attained in V_3 (BINA dhan 8). The second highest biological yield (19.75 t ha^{-1}) was attained in V_4 (BINA Dhan 10) which was statistically identical to that obtained in V_2 (BRRI dhan 29). The lowest biological yield (17.75 t ha^{-1}) was found in V_1 (BRRI dhan 28).

Effect of irrigation approaches

Result exposed that the effect of irrigation approaches on the biological yield of different varieties of boro rice was statistically significant 1% level of probability (Table 8). The highest biological yield (20.31 t ha^{-1}) was observed in treatment, I_1 (application of irrigation at physiological stages) and 19.32 t ha^{-1} was observed in treatment, I_2 (application of irrigation at critical stages).

Interaction effect of variety and irrigation

It was observed that the effect of interaction between variety and irrigation on the biological yield was statistically significant (Table 9) at 5% level of probability. However, the highest biological yield (22.20 t ha^{-1}) was found in treatment combination of $V_3 \times I_1$. The second highest biological yield 20.90 t ha^{-1} was found in the combination of $V_4 \times I_1$. The lowest biological yield (17.50 t ha^{-1}) was found in treatments combination of $V_1 \times I_2$.

Harvest index (%)

Variety performance

From the experimental result it was obtained that varietals performance on harvest index was statistically significant (Table 7) at 1% level of probability. The highest harvest index (34.75%) was attained in V_1 (BRRI dhan 28). The second highest harvest index (32.87%) was attained in V_2 (BRRI dhan 29). The lowest harvest index (31.10%) was attained in V_3 (BINA dhan 8).

Effect of irrigation approaches

Result exposed that the effect of irrigation approaches on harvest index of different varieties of boro rice was statistically significant at 5% level of probability (Table 8). The highest harvest index (32.92%) was observed in treatment, I_2 (application of irrigation at critical stages). Harvest index (32.11%) was observed in treatment, I_1 (application of irrigation at physiological stages).

Interaction effect of variety and irrigation approaches

It was observed that the effect of interaction between variety and irrigation on the harvest index was statistically non-significant (Table 9). However, the highest harvest index (35.24%) was found in treatment combination of $V_1 \times I_2$. The lowest harvest index (30.93%) was found in treatment combination of $V_3 \times I_1$.

Table 7
Effect of different boro rice varieties on biological yields and harvest index of rice.

Variety	Biological yield(t ha^{-1})	Harvest Index (%)
V1(BRRI dhan 28)	17.75 d	34.75 a
V2(BRRI dhan 29)	19.60 b	32.87 b
V3(BINA dhan08)	21.34 a	31.10 c
V4(BINA dhan 10)	19.75 b	32.06 bc
V5(BR 47)	18.94 c	31.80 bc

The figures in a column with common letters do not differ significantly but dissimilar letters differ significantly ($p<0.005$).

Table 8
Effects of irrigation approaches on biological yields harvest index of rice.

Irrigation approaches	Biological yield(t ha^{-1})	Harvest Index (%)
I_1	20.31 a	32.11 b
I_2	18.64 b	32.92 a

The figures in a column with common letters do not differ significantly but dissimilar letters differ significantly ($p<0.005$).

Table 9
Interaction effects of varieties and irrigation approaches on biological yields and harvest index of rice.

Interaction	Biological yield(t ha^{-1})	Harvest Index (%)
V_1I_1	18.00 de	34.27
V_2I_1	20.57 bc	31.93
V_3I_1	22.20 a	30.93
V_4I_1	20.90 b	32.22
V_5I1	19.87 c	31.21
V_1I_2	17.50 e	35.24
V_2I_2	18.63 d	33.81
V_3I_2	20.47 bc	31.27
V_4I_2	18.60 d	31.89
V_5I_2	18.00 de	32.40
S.E.	0.279	0.591

The figures in a column with common letters do not differ significantly but dissimilar letters differ significantly ($p<0.005$).

The different varieties showed variable results on different physiological attributes. For different parameters such as plant height; the effects of varieties are statistically significant at 1% level of probability. From this experiment, it has been observed that variety, V_5 (BR-47) is the tallest variety (79.54 cm) and variety, V_3 (BINA dhan 8) is the shortest variety (74.20 cm) among those five varieties. The effects of variety on plant height can be arranged as $V_5>V_2>V_4>V_1>V_3$. Variation in plant height of the varieties also indicates different genetic make-up of the varieties.

Statistically variation also found on number of effective tillers $hill^{-1}$ among different varieties. From the analyzed data, the effects of variety on number of effective tillers per hill may be arranged as $V_1>V_5>V_3>V_4>V_2$.

The non-effective tillers $hill^{-1}$ in V_4 (1.2) and V_1 (1.17) produced the highest number of non-effective tiller $hill^{-1}$ which were statistically identical to V_2 (1.130) and V_3 (1.132) respectively. The lowest no of non-effective tillers $hill^{-1}$ was found in V_5 (1.06).

Effects of variety on panicle length are also significant at 1% level of probability. Highest panicle length was found in V_5 (BR 47) which is statistically similar to V_4 (BINA dhan 10) and V2 (BRRI dhan 29). Variation in panicle length in different varieties is due to genetic make-up of different varieties.

Statistical variations found on the effects of variety on number of filled grain among the varieties. Sequence of in descending order of their number of filled grains panicle^{-1} is as: $V_2>V_5>V_3>V_1>V_4$. BRRI (1994) reported that number of filled grains panicle^{-1} was varied due to variety.

Effects of varieties on unfilled grains panicle^{-1}, 1000-grains weight, grain yields, straw yields, biological yields and harvest index are statistically significant i.e. different varieties shows variation in these parameters due to variation in their genetic make-up.

Considering the numbers of unfilled grains panicle^{-1}, varieties may be arranged in descending order as $V_2>V_3>V_1>V_4>V_5$, considering 1000-grains weight as $V_2>V_3>V_4>V_5>V_1$, considering grain yields as $V_3>V_2>V_4>V_1>V_5$, considering straw yields as $V_3>V_4>V_2>V_5>V_1$, considering biological yields as $V_3>V_4>V_2>V_5>V_1$ and considering harvest index as $V_1>V_2>V_4>V_5>V_3$.

Considering all the parameters, it may be concluded that variety, V_3 (BINA dhan 8) showed better performance considering physiological attributes in compare to other varieties. Variety, V_1 (BRRI dhan 28) showed to be an inferior variety and the overall sequences of performance may be arranged as $V_3>V_4>V_5>V_5>V_1$.

Effects of irrigation approaches on 1000-grain weight are statistically significant at 5% level of probability i.e. there is statistical variation in 1000-grain weight obtained in two irrigation approaches. Highest 1000-grain weight (25.95 g) obtained in I_2 (application of irrigation at critical stages) and lowest (25.53 g) obtained in I_1 (application of irrigation at critical stages). Experimental result showed that the weight of 1000-grain was slightly increased under irrigation approaches, I_2 (application of irrigation at critical stages) over irrigation approaches, I_1 (application of irrigation at physiological stages).

Statistical variation is found in grain yield obtained in two different irrigation approaches. Grain yield is slightly decreased in irrigation approaches, I_2 (application of irrigation at critical stages) over irrigation approaches, I_1 (application of irrigation at physiological stages).

Interaction effects of varieties and irrigation approaches also have significant effects on grain yield. Varieties interacted with irrigation approaches, I_1 (application of irrigation at critical stages) obtain slightly more grain yields over the varieties interacted with the irrigation approaches, I_2 (application of irrigation at critical stages).

Statistically variations are found in straw yield, biological yield and harvest index with respect to the two irrigation approaches. Straw yield, biological yield and harvest index are significantly changed with those two treatments.

However, there was no statistical variation of the effects of irrigation approaches on number of filled grains panicle^{-1}, number of unfilled grainspanicle^{-1}**.**

CONCLUSION

Finally, it may be concluded that, V_3 (BINA dhan 8) is more suitable variety among the 5 varieties under study. As the objectives of the study were to evaluate the suitable variety to cultivate in boro season and the irrigation approaches suitable for boro rice cultivation as well as as study the interaction, if any, between variety and different irrigation approaches in boro season and the degree of response.

Irrigation approaches at critical stages which can reduce the use of water even though the yield which is slightly reduced. Some yield contributing character specially plant height, 1000 grain weight, grain yield, straw yield and harvest index are influenced by the variety and treatment interactions and the higher yield is found in the interaction of V3I1 (BINA dhan-8 with the application of irrigation at physiological stages)

LIMITATIONS

Suitability of the crop is related with several factors like genetic make-up, nutrient availability, environmental or climatic condition, soil characteristics and regional adaptability. Genetic variations play an important role in determining the yield of crops and potential of varieties within genetic limit. It is set up by adaptability with the studied area.

REFERENCES

Bahar MM and Reza MS (2010). Hydro-chemical Characteristics and Quality Assessment of Shallow Groundwater in a Coastal Area of Southwest Bangladesh. Environmental EarthSciences, 61, 1065-1073.

Bangladesh Bureau of Statistics (BBS) (2006). Statistical Yearbook of Bangladesh, Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

Bangladesh Bureau of Statistics (BBS) (2011). "Area, Yield Rates and Productions of Major Crops 2007-2010, Summary Crop Statistics 2011," Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

Biswas BC and Mahapatra IC (2001). Effect of moisture regimes, phosphatic fertilizer and weather on growth and yield of direct seeded rice. Oryza.16 (2): pp. 100-104

Faruque HSM and Ali ML (2005). "Climate Change and Water Resources in South Asia," In: M. M. Q. Mirza and Q. K. Ahmad, Eds., Climate Change and Water Resources in South Asia, A. A. Balkema Publishers, Leiden, pp. 231-254.

Government of Bangladesh (GoB) (2008). Minor irrigation survey report, 2007–08. Dhaka: Bangladesh Agriculture Development Corporation, Ministry of Agriculture.

Huda MZ (2001). "Regional development of irrigation technologies and its impact on food grain production in Bangladesh," MS Thesis, Department of Agricultural Economics, BAU Mymensingh, Bangladesh.

May W (2004). "Simulation of the Variability and Extremes of Daily Rainfall during the Indian Summer Monsoon for Present and Future Times in a Global Time-Slice Experiment," Climate Dynamics, 22(2-3):183-204.

Mondal MK,Tuong TP,Ritu SP, Choudhury MHK, Chasi AM, Majumder PK, Islam MM and Adhikary SK (2006). Coastal Water Resource Use for Higher Productivity: Participatory Research for Increasing Cropping Intensity in Bangladesh. In: Hoanh, C.T., Tuong, T.P., Gowing, J.W. and Hardy, B., Eds., Environment and Livelihoods in Tropical Coastal Zones: Managing Agriculture - Fishery -Aquaculture Conflicts, CABI Publishing, London, 72-85.

Murshed SB, Islam AKM and Khan MSA (2011). "Impact of Climate Change on Rainfall Intensity in Bangladesh," Proceedings of the 3rd International Conference on Water & Flood Management, Dhaka, 8-10 January, p. 8.

Rahman M, Das R., Hassan N and Roy K (2014). Environmental Study on Water Quality of Mayur River with Reference to Suitability for Irrigation. International of Environmental Sciences, 4, 1150-1167.

Shahid S (2010). "Rainfall Variability and the Trends of Wet and Dry Periods in Bangladesh"International Journal of Climatology, Vol. 30, No. 15, pp. 2299-2313.

Shahid S (2011). "Impact of Climate Change on Irrigation Water Demand of Dry Season *Boro*Rice in Northwest Bangla-desh," Climatic Change, Vol. 105, No. 3-4,pp. 433-453.

Wasimi SA (2009). "Climate Change Trends in Bangladesh" Proceedings of the 2nd International Conference on Water and Flood Management, Institute of Water and Flood Management, BUET, Dhaka, Vol. 1, pp. 203-210.

Yang ZY, Li N, Ma J, Sun YZ and Xu H (2014). High-Yielding Traits of Heavy Panicle Varieties under Triangle Planting Geometry: A New Plant Spatial Configuration for Hybrid Rice in China. Field Crops Research, 168, 135-147.