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RESEARCH ARTICLE

INFLUENCE OF VARIETY AND SOWING DATES ON THE YIELD AND YIELD ATTRIBUTES OF BORO SEASON RICE IN AEROBIC CONDITION

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ABSTRACT

Suitable variety selection in combination with adopting optimum sowing dates could have great impacts on the crop physiology and yield performance. Bangladesh has three distinct rice growing seasons in a year namely; Aus, Aman and Boro. Boro rice growing in an aerobic condition is a modern concept which is eco-friendly and requires less water. It helps to grow rice like an upland rice crop with adequate inputs and supplementary irrigation when rainfall is insufficient and can save 50-60% irrigation water in Boro season rice production. The objectives of this study is therefore to select the suitable Boro season rice variety and optimum sowing date of Boro rice for maximization of yield in aerobic condition. To achieve these objectives, an experiment was conducted in a completely randomized block design consisted of five varieties trearmens viz. BR16 (Shahibalam), BRRI dhan 28, BRRI dhan29, BRRI dhan 47 and BRRI dhan 55 and three sowing dates namely; January 01, January 11 and January 21respectively. The results showed that BRRI dhan 29 sowing in January 01 produced the highest grain yield (7.31 t ha^{-1}), highest gross return, net return and benefit-cost ratio (2.63). On the other hand, the lowest grain yield (3.74 t ha^{-1}) was found from BRRI dhan28 sowing in January 21with less benefit- cost ratio (2.49) respectively. Thus, BRRI dhan 29 in combination with early sowing (01 January) can be used to for better yield performance in aerobic condition during Boro rice cultivation.

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important and broadly cultivated staple food crop for more than half of the world's population (Bashir *et al*., 2010). It is the second highest consumed cereal crop in the world after wheat (Kumari *et al.,* 2014). Bangladesh agriculture is predominantly rice based and the economy of the country mainly depends on good production of rice. Among the rice growing countries of the world, Bangladesh ranks fourth in respect of both area and production and earns about 16.33% of her gross familial production from agriculture (BBS, 2014).Bangladesh has three distinct rice growing seasons in a year namely; Aus, Aman and Boro.

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According to (BBS, 2014) Boro rice covers larger area of about 4.79 million hectares with a production of 19.01 million tons in 2013-2014.Boro rice is habitually cultivated crop using puddled transplanting system with full irrigation. Joshi *et al.*(2009) and Tao *et al.*(2006) reported that usually rice crop uses approximately 3,000 to 5,000 liters of irrigation water to produce one kilogram of rice. The scarcity of irrigation water in Bangladesh is escalating due to downstairs movement of water level and this situation will be continued to be worsen in future due to climate change. Under this situation, there is a necessity of increasing water saving technology for rice cultivation to keep up the Boro rice production system to ensure food security of the country (Rahman and Masood, 2012). In aerobic condition, cultivation of Boro rice is a modern concept that requires less water and helps to grow rice like an upland rice crop with adequate inputs and supplementary irrigation when rainfall is insufficient

(Bouman, 2001). In this system, rice crop is established by direct sowing (dry or water-soaked seed) into non-puddled soil near saturation or field capacity which required as much as 50% less water due to absence of water use for puddling, less percolation and seepage and less evaporation (Bouman *et al*., 2005).Adoption of aerobic rice varieties also offer water savings and increase net economic returns (400-600 US$ ha^{-1}) beyond those achieved in lowland rice production(Bouman *et al*., 2002).To meet the increased rice demand with attenuation resources, it will be indispensable to increase yield in a unit area through adoption of suitable variety in aerobic condition (Zhao, 2006).In aerobic condition, sowing dates of rice plant can also play a vital role to its growth, development and yield of this plants. Farrell *et al*. (2003) reported that optimum sowing time is important key to ensure better establishment during cold sensitive stage, maximum vegetative growth and ultimately maximum spikelet yield. Aerobic rice technology allows planting of rice at the right time under dry land condition, replacing conventional transplanting (Kabaki, 1998). It can result faster and easier planting, earlier maturity of rice by 7-10 days (Malik *et al.,* 1998). The delayed sowing gives in the poor emergence and reduced number of heading panicle per meter square and spikelets per panicle and ultimately yield was affected (Hayat *et al.,* 2003).Various experiments and research works linking to the effect of planting date on transplanted flooded rice cultivation system in Boro season are available but under aerobic condition are limited. So, the specific objective of the study was to find out the interaction effect of suitable variety and sowing dates on the yield performance and related characters of Boro rice under aerobic condition.

MATERIALS AND METHODS

The experiment was conducted at the Agronomy Research Field Laboratory of Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh during the period from December 2014 to June 2015 to study the performance of suitable variety and optimum date of sowing of five varieties of Boro rice under aerobic condition. The experimental field was a medium high land having sandy loam soil with pH 5.35.Treatments included five varieties namely, BR16 (V_1), BRRI dhan28 (V_2), BRRI dhan29 (V_3), BRRI dhan47 (V_4) and BRRI dhan55 (V_5) and three dates of sowing namely, January 01(D_1), January 11(D_2) and January 21(D_3). The experiment was laid out in a Randomized Complete Block Design (RCBD) with three (3) replications. All the treatments combinations were randomly distributed to the experimental plots within each block. Lay out of the experiment was done maintaining plot to plot distance 75 cm and replication to replication distance 1.0 m and various intercultural operations were done for maintaining the normal growth and development of the crop. The total numbers of plots were 45 and the size of unit plot was 10 m^2 (4.0 m x 2.5 m). The crop was harvested when 90% of the spikelets became golden yellow in colour. Five hills (excluding border hills) were selected randomly from each unit plot and collected by uprooted prior to harvesting for recording necessary data on various plant characters. Data were statistically analyzed by using the "Analysis of Variance" (ANOVA) technique and mean differences were adjudged by Duncan's Multiple Range Test (DMRT) with the help of a computer package (MSTATC) program (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height

The results showed that the variety, date of sowing and the interaction effect of variety and date of sowing had significant effect on plant height (Table 1, 2 and 3). It was observed that BRRI dhan 29 produced the tallest plant (107.3 cm) and the smallest plant (95.67 cm) was produced by BRRI dhan 55. It was evident that plant height differed significantly from variety to variety. This result was in agreement with those of Roy *et al.* (2014) and Das *et al*. (2012) who observed variable plant height among the rice varieties. The tallest plants (105.7 cm) were obtained from directly sowing in January 21 and the shortest ones (97.23 cm) were obtained from sowing in January 01. It was evident that plant height significantly increased with delay in sowing. This result was in consistent with Mannan *et al*. (2012*)* and Pathak *et al.* (2003). They found stunted growth of crop at the early stage which may be attributed to cold temperature for long period at the vegetative growth stage in Boro season and with the rise of air temperature the plant height gradually increased.

Number of tillers $hill^{-1}$

It was observed (Table 1, 2 and 3) that the variety, date of sowing and the interaction effect of variety and date of sowing had a highly significant effect on the number of tillers $hill^{-1}$. The highest number of total tillers $hill^{-1}$ (17.07) was produced by the variety BRRI dhan29 and the lowest number of total tillers $hill^{-1}$(14.58) was found from the variety BRRI dhan28. It was evident that the number of total tillers $hill^{-1}$ differed significantly due to varietal characteristics (Mannan *et al*., 2012). The highest number of total tillers (17. 54) was found from the sowing in January 01 and the lowest number of total tillers (14.07) was obtained from the sowing in January 21 (Table 2). The results are in agreement with those of Akter (2012), Rahman and Yeasmin (2008) and Islam *et al.* (2004) and they observed that number of total tillers $hill^{-1}$ reduced with delay in sowing. It was also observed that BRRI dhan 29 produced the maximum number of tillers $hill^{-1}$ (18.87) from sowing in January 01 and minimum number of tillers $hill^{-1}$ (13.07 cm) was observed by BRRI dhan28 from sowing in January 21.

Number of effective tillers $hill^{-1}$

It was evident from (Fig. 1 and 2) that the variety, date of sowing and the interaction effect of variety and date of sowing exerted significant effect on the number of effective tillers $hill^{-1}$. It was observed from the results that BRRI dhan29 produced the maximum number of effective tillers $hill^{-1}$ (15.72) and BRRI dhan28 produced the lowest number of effective tillers $hill^{-1}$ (13.29). It was evident that the number of effective tillers $hill^{-1}$ differed significantly from variety to variety due to genetic makeup (Dawadi and Chaudhary, 2013). The number of tillers, specially the number of effective tillers $hill^{-1}$ $^{-1}$ is one of the most important yield contributing characters in rice. The highest number of effective tillers $hill^{-1}$ (16.38) was obtained from January 01 sowing then January 21 sowing. Significantly higher effective tillers $hill^{-1}$ in January 01 sowing might be due to favorable environmental conditions which enabled the plant to improve its growth and development as compared to other sowing dates (Dawadi and Chaudhary, 2013). BRRI dhan29

produced the maximum number of effective tillers hill^{-1} (17.73) at January 01 sowing and sowing in January 21 produced minimum number of effective tillers hill^{-1} (11.47).

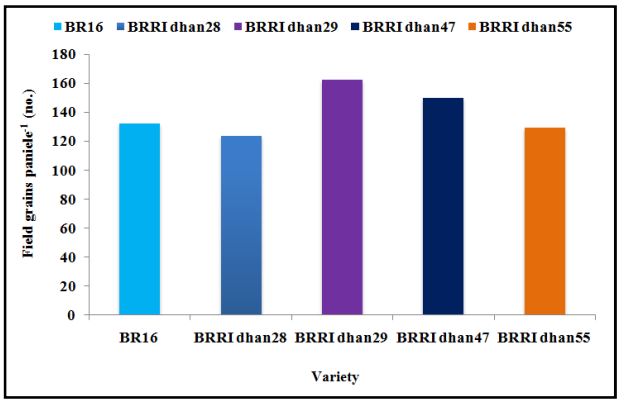

Fig. 3. Number of grains panicle^{1} of Boro rice as influenced by date of sowing under aerobic condition

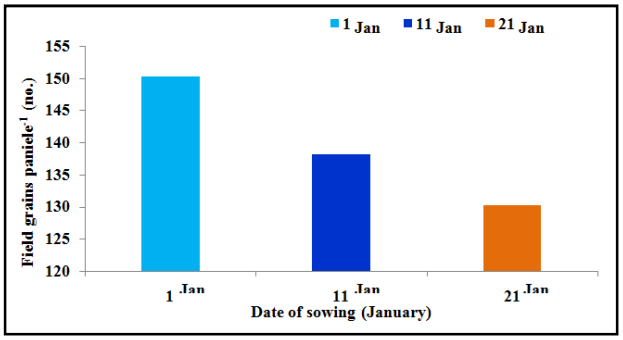

Fig. 4. Number of filled grains of Boro rice as influenced by date of sowing under aerobic condition

Number of sterile spikelets panicle^{-1}

Number of sterile spikelets panicle^{-1} was significantly influenced by the variety and date of sowings. The highest number of sterile spikelets (26.18) was produced by BRRI dhan47 and the lowest one (17.77) was produced by BRRI dhan55 (Table 1). Chowdhury *et al*. (1993) and BINA (1993) also reported that varietal differences in number of unfilled grains panicle^{-1}. Table 2 showed that the highest number of sterile spikeletspanicle^{-1}(25.71) was obtained from January 21 sowing and the lowest one (20.23) was obtained from January 01 sowing. Number of sterile spikelets might be affected by air temperature during the critical growing stage, namely at the time of meiosis (9-12 days before flowering) and flowering (Shihua *et al.,* 1991). Dawadi and Chaudhary (2013) also reported that high temperature during meiosis or hot or cold temperature at flowering caused higher number of sterile spikelets.

Weight of 1000 grains (g)

It was observed that 1000 grain weight was significantly varied due to variety but date of sowing and the interaction effect of variety and date of sowing had no significant effect on 1000 grain weight. It was found that the highest 1000 grain weight (27.03 gm) was obtained from BRRI dhan47; might be its large grain size and the lowest one (23.34 gm) from BRRI dhan28. Miri (2011) reported that 1000 grain weight an important yield determining component least influenced by environment that differed significantly among the cultivars due to genetic make-up which supported the present experimental result. BRRI (2003) also stated that the 1000 grain weight is stable varietals character, which remained unaffected due to the manipulation of management practices.

Grain yield (t ha^{-1})

It was evident from analysis of variance that the variety, date of sowing and the interaction effect of variety and date of sowing had significant effect on grain yield. The highest grain yield (6.07 t ha^{-1}) was achieved from BRRI dhan 29 where as lowest grain yield (5.30 t ha^{-1}) was obtained from BRRI dhan 28 which was statistically identical to BRRI dhan55, BR16 and BRRI dhan47 shown in (Fig. 5). It was evident that the differences in grain yield might be due to the differences in the number of effective tillers hill^{-1}, grains panicle^{-1} and 1000-grain weight which was mostly dependent on genetic make-up of the studied varieties(Mondal *et al*., 2005; Jianchang *et al*., 2006; Yang *et al*., 2007). The highest grain yield (6.72 t ha^{-1}) was obtained from the sowing in January 01 which was superior to the other sowing dates and the lowest grain yield (4.35 t ha^{-1}) was obtained from the sowing in January 21 (Fig.6).Hosain*et al.* (2014) reported that the higher grain yield at earlier planting dates was associated with higher number of panicles hill^{-1}, number of filled grains panicle^{-1}.On the other hand, the highest grain yield (7.31 t ha^{-1}) was obtained from BRRI dhan 29 sowing in January 01 (V_3D_1) which was statistically identical with the treatment combinations of V_1D_1 and V_2D_1. The lowest grain yield (3.74 t ha^{-1}) was obtained from BRRI dhan28 sowing in January 21 (V_2D_3) which was statistically similar with the treatment combinations of V_1D_3 and V_5D_3.

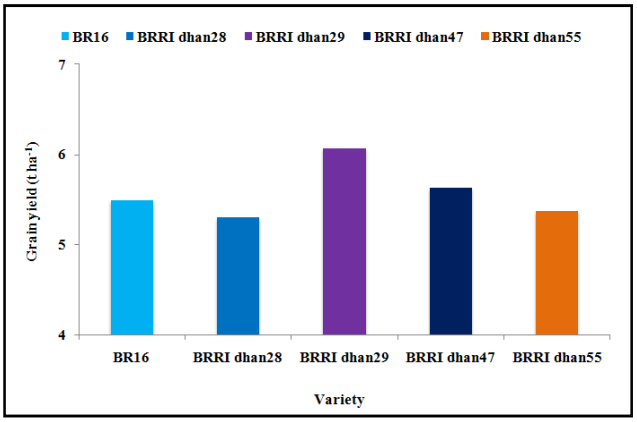

Fig. 5. Grain yield of Boro rice as influenced by variety under aerobic condition

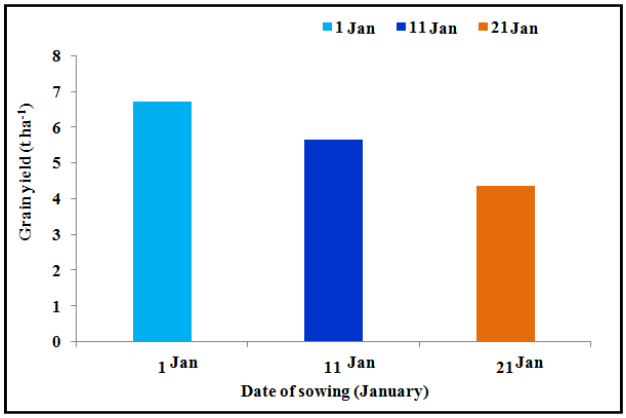

Fig. 6. Grain yield of Boro rice as influenced by date of sowing under aerobic condition

Straw yield (t ha^{-1})

BRRI dhan 29 produced the highest straw yield (6.86 t ha^{-1}) and BRRI dhan 28 produced the lowest straw yield (5.95 t ha^{-1}) which was significantly influenced by the variety, date of sowing and the interaction effect of variety and sown in (Table 1). According to Roy *et al.* (2014) and Mannan *et al.* (2013), variable straw yields was shown among varieties due to the combined effect of plant height and tiller numbers. It is also evident that January 01 sowing produced the highest straw yield (7.02 t ha^{-1}).

The straw yield decreased with the advancement of the planting dates and less amount of straw was found in late planted crops (Mannan *et al.,* 2012).The highest straw yield (7.50 t ha^{-1}) was recorded from BRRI dhan29 from sowing in January 01 (V_3D_1) and lowest one (5.40 t ha^{-1}) was produced by BR16 from sowing in January 21 (V_1D_3).

Biological yield

Biological yield was significantly influenced by the variety, date of sowing and the interaction effect of variety.

Table 1. Effect of variety on the yield and yield contributing characters of boro rice under aerobic method of cultivation

Variety	Plant height (cm)	Total tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Panicle length (cm)	Total spikelets panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (gm)	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
BR16	97.74c	16.29ab	1.356	25.09b	155.7c	23.39ab	25.95bc	6.44b	11.93b	45.70
BRRI dhan28	103.0b	14.58c	1.333	24.04c	145.7d	22.09b	23.34d	5.95c	11.26c	46.50
BRRI dhan29	107.3a	17.07a	1.344	26.85a	187.8a	25.14ab	26.39ab	6.86a	12.93a	46.56
BRRI dhan47	103.9b	15.83b	1.356	26.24a	176.0b	26.18a	27.03a	6.55ab	12.18b	46.14
BRRI dhan55	95.67d	15.62bc	1.544	24.13c	147.1d	17.77c	25.56c	6.21bc	11.58bc	46.05
Level of significance	**	**	NS	**	**	**	**	**	**	NS
CV %	5.99	7.31	13.85	3.91	4.70	15.28	3.03	5.39	5.15	5.05

In a column, figures having similar or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test

Table 2. Effect of date of sowing on the yield and yield contributing characters of *boro* rice under aerobic method of cultivation

Date of sowing	Plant height (cm)	Total tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Panicle length (cm)	Total spikelets panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000-grain weight (gm)	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
January 01	97.23b	17.54a	1.160c	26.27a	170.6a	20.23b	25.94	7.02a	13.73a	48.89a
January 11	101.6ab	16.03b	1.353b	24.99b	161.0b	22.79b	25.74	6.43b	12.08b	46.84b
January 21	105.7a	14.07c	1.647a	24.56b	155.8b	25.71a	25.29	5.76c	10.11c	42.84c
Level of significance	**	**	**	**	**	**	NS	**	**	**
CV %	5.99	7.31	13.85	3.91	4.70	15.28	3.03	5.39	5.15	5.05

In a column, figures having similar or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test
Note:
** = Significant at 1% level of probability
NS = Not significant

Table 3. Interaction effect of variety and date of sowing on the yield and yield contributing characters of boro rice under aerobic method of cultivation

Treatment combination	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective Tillers hill^{-1} (no.)	Non-effective tillershill^{-1} (no.)	Panicle length (cm)	Total grains panicle^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000-grain weight (gm)	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1D_1	93.09cd	17.77ab	16.63ab	1.133	26.33	164.4d	143.1de	21.30	26.27	7.12ab	13.85ab	48.57
V_1D_2	98.51bcd	16.33bcd	15.07b-e	1.267	24.45	151.7e	130.4fg	21.30	26.13	6.81bc	12.37cd	45.05
V_1D_3	101.6a-d	14.77de	13.10def	1.667	24.50	150.9e	123.3g	27.57	25.46	5.39g	9.56gh	43.49
V_2D_1	99.47bcd	16.67a-d	15.60a-d	1.067	25.15	150.2e	130.7fg	19.53	23.71	6.61bcd	13.55b	51.27
V_2D_2	102.4a-d	15.13cde	13.80c-f	1.333	23.92	145.2e	121.4g	23.77	23.20	5.74fg	11.00ef	47.85
V_2D_3	107.2ab	13.30e	11.70f	1.600	23.07	141.5e	118.6g	22.97	23.10	5.51g	9.24h	40.40
V_3D_1	103.1abc	18.87a	17.73a	1.133	27.73	198.0a	174.8a	22.60	26.67	7.50a	14.81a	49.39
V_3D_2	106.4ab	17.43abc	16.13abc	1.300	26.63	186.5abc	161.4bc	25.07	26.44	7.12ab	13.47bc	47.08
V_3D_3	112.5a	14.90cde	13.30def	1.600	26.18	179.0bc	151.2cd	27.77	26.07	5.95efg	10.50fg	43.23
V_4D_1	99.74bcd	17.37abc	16.20abc	1.167	27.03	188.7ab	164.8ab	23.90	27.25	6.97abc	13.17bc	47.08
V_4D_2	104.4abc	16.23bcd	14.90b-e	1.333	26.22	174.2cd	148.2de	25.97	27.07	6.13def	11.80de	48.01
V_4D_3	107.5ab	13.57e	12.67ef	1.567	25.48	165.3d	136.9ef	28.67	26.77	6.55b-e	11.57def	43.32
V_5D_1	90.70d	16.60a-d	15.30a-d	1.300	25.08	151.4e	137.6ef	13.83	25.81	6.89abc	13.30bc	48.13
V_5D_2	96.53bcd	15.13cde	13.60def	1.533	23.74	147.6e	129.7fg	17.87	25.83	6.33c-f	11.77de	46.23
V_5D_3	99.77bcd	13.37e	11.57f	1.800	23.58	142.3e	120.7g	21.60	25.03	5.40g	9.68gh	43.79
Level of significance	*	**	**	NS	NS	**	**	NS	NS	**	**	NS
CV %	5.99	7.31	8.02	13.85	3.91	4.70	4.78	15.28	3.03	5.39	5.15	5.05

In a column, figures having similar or no letter (s) do not differ significantly at 5% level of significance by Duncan's Multiple Range Test
Note:
V_1 = BR16
V_2 = BRRI dhan28
V_3 = BRRI dhan29
V_4 = BRRI dhan47
V_5 = BRRI dhan55
D_1 = January 01
D_2 = January 11
D_3 = January 21
** = Significant at 1% level of probability
* = Significant at 5% level of probability
NS = Not significant

Table. 4. Effect of variety on total cost of production, gross return, net return and B:C ratio in of *boro* rice under aerobic method of cultivation

Treatment	Total cost of production Tk.ha^{-1} ('000)	Return due to produced Tk.ha^{-1} ('000) a	Return due to by-product Tk.ha^{-1} ('000) b	Gross return Tk.ha^{-1} (' 000) (a+b)	Benefit cost ratio (BCR)
Variety					
BR16	42.88b	98.78b	6.440b	105.2b	2.44a
BRRI dhan28	40.38e	95.57b	5.953c	101.5b	2.49a
BRRI dhan29	43.85a	109.3a	6.856a	116.2a	2.63a
BRRI dhan47	41.32c	84.43c	6.550ab	90.98c	2.19b
BRRI dhan55	40.58d	96.74b	6.208bc	102.9b	2.52a
Date of sowing					
January 01	44.08a	117.2a	7.019a	124.2a	2.82a
January 11	41.75b	98.38b	6.426b	104.8b	2.51b
January 21	39.57c	75.34c	5.759c	81.10c	2.05c
Level of significance	**	**	**	**	**
CV %	0.00	7.84	5.39	7.44	7.77

In a column, figures with similar or no letter (s) do not differ significantly whereas figures with dissimilar letter differ significantly at 5% level of significance by Duncan's Multiple Range Test
Note: ** = Significant at 1% level of probabilit

The highest biological yield (12.93 t ha^{-1}) was obtained from BRRI dhan 29 and the lowest one (11.26 t ha^{-1}) was recorded from BRRI dhan 28 which was statistically parallel to BRRI dhan 55 (11.58 t ha^{-1})shown in (Table 1). Chowdhury *et al.* (1999) reported that biological yield was positively correlated with grain and straw yield in rice. This result was supported by (Islam, 2014). The highest biological yield (13.73 t ha^{-1}) was obtained from the sowing date in January 01 and the lowest biological yield (10.11 t ha^{-1}) was observed from the sowing date in January 21which was shown in(Table 2).The highest biological yield (14.81 t ha^{-1}) was observed from BRRI dhan 29 sowing in January 01 (V_3D_1) which was statistically identical with the treatment combination of V_1D_1 and the lowest one (9.24 t ha^{-1}) from BRRI dhan28 sowing in January 21 (V_2D_3).

Harvest index

Harvest index was significantly influenced by date of sowing but variety and the interaction effect of variety and date of sowing had no significant effect on harvest index. The highest harvest index (48.89%) was observed from the sowing in January 01 and the lowest one (42.84%) was obtained from the sowing in January 21which was shown in (Table 2).Similar result was obtained by (Dawadi and Chaudhary, 2013; Hossain *et al.,* 2008).

Effect of varieties and date of sowing on economic parameters of Boro rice under aerobic condition

Among the varieties, BRRI dhan29 recorded significantly higher gross return, net return and benefit cost ratio. There was significantly higher gross return, net return and b: c ratio with January 01 sowing. Table 3 indicates clearly the economic analysis of aerobic rice. Regarding the interaction of varieties and date of sowing on economic parameter, highly significant interaction was observed. The interaction of BRRI dhan29and January 01 sowing revealed comparatively higher gross return, net return and benefit cost ratio and at the same time, combination of BRRI dhan 28 and January 21 sowing deserved lower value of economic parameters.

Conclusion

From the results, the present study concluded that BRRI dhan 29 produced higher grain and straw yield along with higher gross return, higher net profit, and more benefit-cost ratio. On the other hand, January 01 sown crop produced higher grain and straw yield along with higher gross return, higher net profit, and more benefit-cost ratio. So, it would be better to use the variety BRRI dhan 29 and follow January 01 as optimum sowing date for Boro rice cultivation along with the other elements for crop management under aerobic condition.

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