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Effect of Planting Date on the Performance of High Yield Potential Varieties of Rice in Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. Author MAA and MNHS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SN and AKMGM managed the analyses of the study. Author MNHS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was conducted at the Agronomy Field Bangladesh Agricultural University, Bangladesh to investigate the effect of planting dates on the performance of high yield potential varies of rice in Boro season. The experiment consisted of five dates of transplanting viz. 10 and 25 December 2015, 10 and 25 January and 10 February 2016: four high yield potential varieties viz. hybrid rice Sonar Bangla-1, Jagoran, BRRI Dhan-29 and BINA Dhan-6. Results indicated that there was a significant effect of date of transplanting on yield of potential varieties of rice in Boro season. It was observed that plant height, panicle length, grain yield, straw yield, number of tillers per hill-1 gradually increased up to 10 January. After 10 January transplanting yield reduced. The highest grain yield 6.41 t ha-1 was observed in hybrid rice Sonar Bangla-1. The result revealed that Sonar Bangla-1 emerged as the best variety in Boro season regarding grain and straw yields among the varieties studied and it should preferably be transplanted between 25 December to 10 January to obtain appreciable better yield.

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Keywords: Hybrid rice; planting date; growth; yield.

1. INTRODUCTION

Agriculture is the heart rhythm of Bangladesh which provides the ultimate entity of most of her population. The pressing issue of alarming population growth, rapid industrialization and urbanization has emerged as the biggest challenge for Bangladesh to ensure food security and socio-economic development. The economy of Bangladesh depends predominantly on agriculture sector accounting for about 31.08% of its gross domestic product [1]. Rice is grown in 11.79 million hectare of land with total production of 33.80 million tons [2]. Rice is extensively grown in Bangladesh in three season's viz. Aus, Aman and Boro and it covers 74.85% of the total cultivable area of Bangladesh [2].

FAO (Food and Agriculture Organization) considers hybrid rice technology as an important avenue for increasing global rice production. China's success with hybrid rice encourages the prospect of this technology for the tropics and subtropics. Realizing hybrid rice technology as an important option to increase rice yield, IRRI rejuvenated its research on its development and Bangladesh is no exception to it as it is the prime need to increase rice production in Bangladesh.

Planting date is an important factor for obtaining higher yields and there is an optimum plating date to obtain higher yield of a crop [3]. Generally Boro rice is transplanted from early December to mid-March [4,5]. Early transplantation of Boro rice prolongs field duration due to low temperature and involves highs cost of production, particularly for management practices including irrigation while delayed planting reduces the yield in some cases [6,7]. A compromise is therefore, needed between sacrificing grain yield by adjusting plating date or incurring extra expenditure by irrigating the crop for a longer period in case of early planting. Yield is the cumulative effect of the inherent characteristics of a variety as well as management practices under which it is grown. Variety is one of the important factors for increasing yield. In general, it is believed that there are differences in morpho-phyiological aspects among the traditional and modern varieties. Generally speaking modern inbred rice varieties in Bangladesh have a longer growth duration of (150-160 days in Boro season) with a low daily yield (lower than 30 kg/ha/day) while the hybrid one because of its hybrid vigor needs only 120-130 days to mature. If hybrid rice is cultivated, 20-40 days in crop duration can be reduced. This may facilitate the accommodation of succeeding crop in the cropping systems.

Boro rice has been gaining much importance by the farmers for its higher yield per hectare than other rice crops. Recently several private seed traders are introducing rice seeds from India and China. But as introduced plant materials, they need thorough evaluation under the prevailing climatic conditions of Bangladesh for morpho-logical and physiological characteristic before they are going to the end users i.e., for large scale cultivation by the farmers. As per available information regarding the yield and yield contributing characters, both morphological and physiological characteristics of hybrid rice varieties are meager in Bangladesh. That is why, it is a prime need to conduct more research work to find out and develop sustainable technology of hybrid rice cultivation under the prevailing local edaphic conditions. Therefore present study was undertaken to investigate the adaptability of high yield potential rice varieties in boro season in relation to the effect of different planting dates on higher growth and yield.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment was conducted at the Agronomy field, Bangladesh Agricultural University, Bangladesh from November 2015 to June 2016 to study the effect of different planting date on the performance of high yield potential varieties of rice in Boro season. The experimental site is under the Old Brahmaputra Flood Plain of Agro-ecological Zone, AEZ 9 [8]. The land was medium high with sandy loam in texture with pH value of 6.9. The experimental site was under the subtropical climatic condition.

2.2 Planting Material

Two inbreed rice varieties (BRRI Dhan29 and BINA Dhan 6) and two hybrid rice (Sonar bangla-1 and Jagoran) used as the test crops. Seeds were collected from BRRI, BINA for the inbreed varieties. Meanwhile Sonar Bangla-1 was imported from China and approved by the National Seed Board Bangladesh. Jagoran was developed by India and marketed in Bangladesh by BARC, Seed Ltd. Bangladesh.

2.3 Experimental Design and Treatments

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments were comprised of two factors- Factor A: Variety viz. i) BRRI Dhan29, ii) BINA Dhan6, iii) Sonar Bangla-1, iv) Jagoran and Factor B: Planting Date viz., i) 10 December 2015, ii) 25 December 2015, iii) 10 January 2016, iv) 25 January 2016 and v) 10 February 2016. There were 60 unit plots in the experiment. The size of the each plot was 5 m^2 where treatments were allotted at random.

2.4 Growth Condition and Measurement of Parameters

Seeds of each cultivar were soaked in water in separate buckets for 24 hours and then placed under gunny bag for sprouting. After sprouting seeds were sown after 72 hours in the well prepared nursery bed. The 30 day old seedlings were then transplanted in the main field as per planting dates. Fertilizers were applied at the rate of 270, 130, 120, 70, and 10 kg/ha in the form of Urea, Triple Super Phosphate, Murate of Potash and Zinc Sulphate respectively following standard application procedures. Intercultural operations were done as per requirement. Maturity of crops was determined when some 90% of seeds became golden yellow color. The harvest crops were threshed manually and the fresh weights of grain and straw were recorded plot-wise. Finally, grain and straw yield per plot were converted to t/ha.

2.5 Data Collection and Statistical Analysis

Data on individual plant parameters were recorded from the sample $hill^{-1}$ and those on grain yield, straw yield, biological yield and harvest index were recorded from the whole plot at harvest. The collected data were analyzed statistically by MSTAT C software. The mean differences among the treatments were adjudged with Duncan's Multiple Range Test (DMRT) at 5% level of probability [9].

3. RESULTS AND DISCUSSION

3.1 Plant Height

Plant height differed significantly among the varieties (Table 1). Results showed that BINA Dhan6 produced the tallest plants of 99.26 cm while Sonar Bangla-1 produced the shortest plant stature of 84.39 cm whish was statistically identical to that produced by BRRI Dhan29. Significant variation among the varieties was also reported by [10,11] and our results are in consistent with their result. This variation in plant height is probably due to the genetical makeup of the varieties.

Date of planting also exerted significant effect on plant height (Table 1). It was observed that the longest plant height (95.10 cm) when transplanted on 10 January. Plant height gradually decreased with delay in planting after 10 January. The shortest plant (85.47 cm) was observed when transplanted on 10 December.

Plant height was significantly affected by the combined effect of variety and planting time (Table 2). The tallest plant height was recorded in BINA Dhan6, transplanted on 10 January. The shortest plant height was observed in BRRI Dhan29, transplanted on 10 December which was statistically similar to that of Sonar Bangla-1, transplanted on 10 December.

3.2 Number of Effective Tillers $Hill^{-1}$

Number of effective tillers per hill varied significantly due to variety (Table 1). The results showed that the highest number (11.63) of effective tillers per hill was produced by BRRI Dhan29. Number of effective tillers per hill varied significantly for different date of planting (Table1). It was observed that the highest number of effective tillers per hill (11.83) was produced on 10 January transplanting. On the other hand, lowest number of effective tillers per hill (8.46) was produced on 10 February planting. Effect of interaction of variety and planting date on the number of effective tillers per hill (Table 2). Maximum number of effective tillers per hill (15.73) was produced by BRRI Dhan29 planted on 10 January. Meanwhile the lowest number of effective tillers per hill (6.39) was produced from 10 February planting in hybrid rice Jagoran.

3.3 Number of Non-effective Tillers $Hill^{-1}$

The results showed that there were significant differences in the number of non-bearing tillers $hill^{-1}$ among the varieties studied (Table 1). The results revealed that the number of non-effective tillers $hill^{-1}$ ranged from 1.04 to 1.30. It was found that the highest number of non-effective tillers $hill^{-1}$ was produced by hybrid rice Jagoran whereas the lowest number of non-effective tillers $hill^{-1}$ was produced by BRRI Dhan29. This might be due to the genetic makeup of the varieties. This was reported by Murthy et al. [12], Shah and Bhurer [13].

Production of non-effective tillers per hill was found to be significantly affected by the date of planting (Table 1). A maximum number of non-effective tillers per hill (2.03) were produced when planting was done on 10 February whereas production of non-effective tillers was minimum when transplanted on 10 January. Number of non-effective tillers per hill was significantly affected by the interaction between variety and planting date (Table 2). Maximum number of non-effective tillers per hill (2.04) was produced by Sonar Bangla-1 transplanted on 10 February.

3.4 Length of Panicle

Length of panicle was not significantly affected by the variety and the planting date (Table 1). Effect of interaction of variety and planting date was found to be insignificant on panicle length (Table 2).

3.5 Grain Weight Hill^{-1}

Variety exerted significant influence on grain weight hill^{-1} (Table 3). The highest grain weight hill^{-1} (26.31 g) was recorded in hybrid rice Jagoran whereas BINA Dhan6 gave the lowest grain weight hill^{-1} (21.86 g). The grain weight hill^{-1} also varied due to different dates of planting (Table 3). The highest weight (25.58 g) grains hill^{-1} was produced from 10 January whereas the lowest was recorded at 10 February planting. The variation due to interaction between variety and planting date was significant for the parameter grain weight hill^{-1} (Table 4). Maximum grain weight hill^{-1} (27.34 g) was observed in Jagoran on 10 January planting whereas minimum was observed from BRRI Dhan29 on 10 February planting.

3.6 Weight of 1000-grains

Varieties differed significantly among themselves regarding weight of 1000-grains (Table 3). The results revealed that highest 1000-grain weight (30.18 g) was obtained from Sonar Bangla-1. The lowest 1000-grain weight (22.68 g) was found in BRRI Dhan-29.This result is in corroborate with the results of reported by Swain et al. [14], Abou-Khalif [15] who stated that 1000-grain weight differed among the varieties. 1000-grain weight varied significantly due to different dates of planting (Table 3). The highest grain weight was produced from 10 January planting that was statistically at par with 25 December planting. The lowest 1000-grain weight was observed from 10 February planting. However 1000-grain weight did not vary significantly due to the interaction between variety and date of planting (Table 4).

3.7 Grain Yield (t ha^{-1})

Grain yield varied significantly among the varieties (Fig. 1). The results elicited that hybrid rice variety Sonar Bangla-1 produced the maximum grain yield (6.41 t ha^{-1}) which was statistically alike to that of hybrid variety Jagoran (6.11 t ha^{-1}). On the other hand BINA Dhan6 produced the minimum grain yield (4.9 t ha^{-1}). The highest grain yield of hybrid rice Sonar Banga-1 was the consequence of the maximum 1000-grains weight and the second highest number of productive tillers hill^{-1}.Though Jagoran produced the highest grain weight and second highest 1000-grains weight but failed to produce the highest yield because of mainly due to the minimum number of productive tillers hill^{-1}. This was also supported by many researchers [16,17,18,19].

Grain yield varied significantly due to different dates of planting (Fig. 2). The highest graine yield (6.61 t ha^{-1}) was obtained at 10 January planting. The lowest (5.02 t ha^{-1}) yield was recorded on 10 February planting. The highest grain yield on 10 January might be due to the prevailing favorable temperature. The grain yield was significantly influenced by the interaction of variety and date of planting (Table 4). The highest grain yield (6.99 t ha^{-1}) was produced from the combination of Sonar Bangla-1 with 10 January Planted while the lowest (4.21 t ha^{-1}) was in BINA Dhan6 with planted on 10 February.

3.8 Straw Yield

There was significant variation among the varieties in respect of straw yield (Fig. 1.). It is evident that the highest straw yield (7.28 t ha^{-1}) was produced by Sonar Bangla-1 and BRRI Dhan 29. On the other hand the lowest straw yield (6.19 t ha^{-1}) was produced by BINA Dhan6. Straw yield varied significantly due to date of transplanting (Fig. 2). The highest straw yield followed the similar pattern of as that of grain yield. The highest straw yield (7.50 t ha^{-1}) was obtained for 10 January planting. Effect ofinteraction of variety and date of planting on straw yield was significant (Table 4). The highest straw yield (7.90 t ha^{-1}) was observed in interaction of BRRI Dhan 29 planted on 25 January. The lowest (5.64 t ha^{-1}) straw yield of BRRI Dhan29 planted on 10 February.

Table1. Effect of variety and date of planting on the crop characters of rice in Boro season

Treatment	Plant height (cm)	Effective tillers hill^{-1} (no)	Non-effective tillers hill^{-1} (no)	Length of panicle (cm)
Variety				
BRRI Dhan-29	86.03b	11.63a	1.04b	22.19
BINADhan-6	99.26a	9.19c	1.16ab	22.06
Sonar Bangla-1	84.39b	9.96b	1.10ab	20.84
Jagoran	97.19a	8.07d	1.30a	22.33
Significance level	0.01	0.01	0.05	NS
Transplanting date				
10 December	85.47b	9.49b	1.23b	22.00
25 December	92.48a	9.73b	0.83c	22.19
10 January	95.01a	11.83a	0.63c	22.53
25 January	92.63a	9.03bc	1.04b	21.62
10 February	93.33a	8.46c	2.03a	20.95
Significance level	0.01	0.01	0.05	NS
CV (%)	5.27	10.20	15.13	9.76

Means in a same column followed by different letter (s) are significantly different at P<0.05

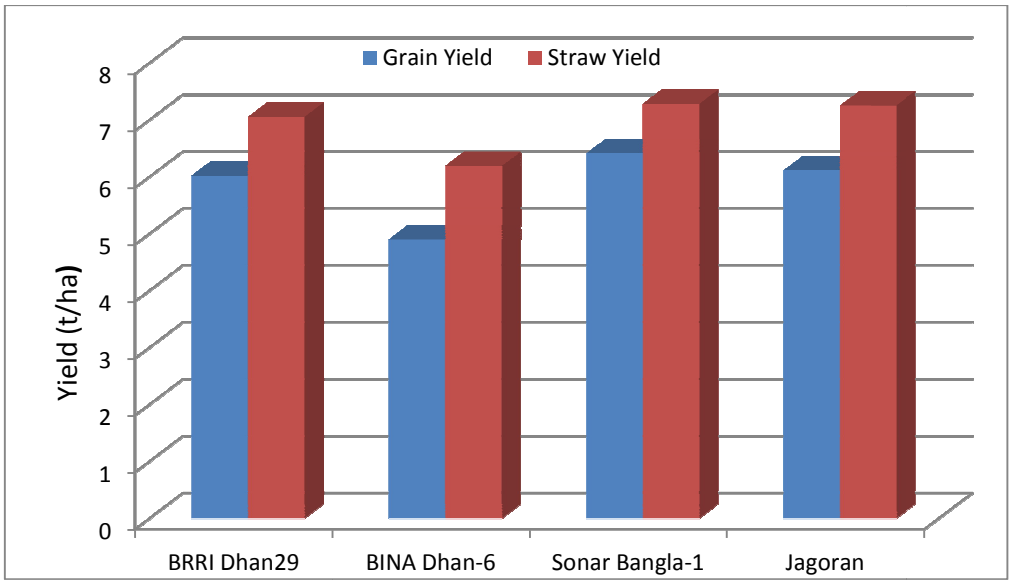

Fig. 1. Effect of variety on the grain yield and straw yield of rice in Boro season

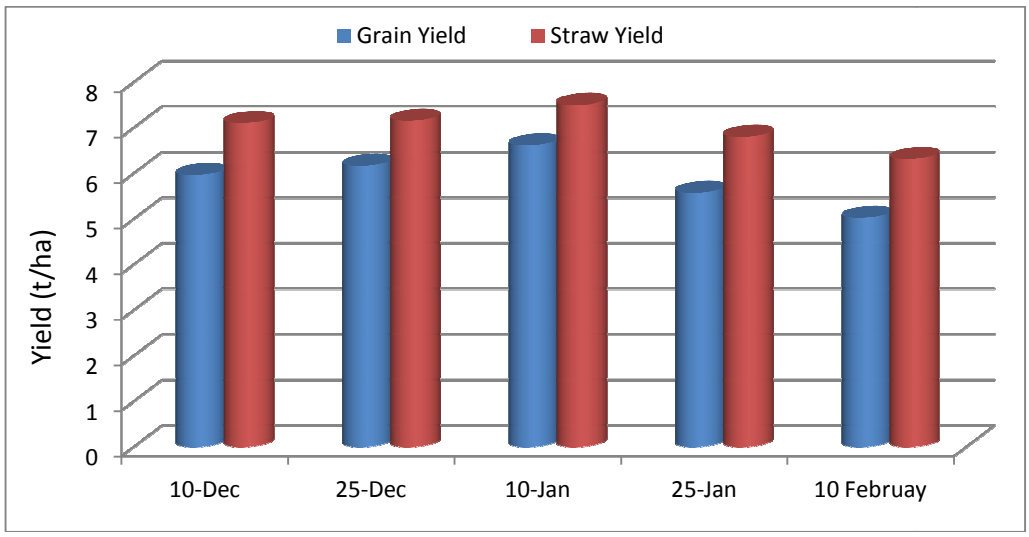

Fig. 2. Effect of planting dates on the grain yield and straw yield of rice in boro season

3.9 Biological Yield

The varietal effect on biological yield was highly significant (Table 3). The highest biological yield (13.76 t ha^{-1}) was recorded from Sonar Bangla-1 which has the highest grain yield producer. The biological yield of Jagoran and BRRI Dhan29 was statistically similar to the hybrid rice Sonar Bangla-1. The lowest biological yield (11.10 t ha^{-1}) was produced by BINA Dhan6. Biological yield was also significantly affected by the date of transplatnig (Table 3). It was observed that the highest biological yield (14.12 t ha^{-1}) was obtained in 10 January planting. Meanwhile the lowest biological yield (11.34 t ha^{-1}) was obtained in 10 February planting. The result is in agreement with the findings of Iqbal et al. [20].

Effect of interaction of variety and date of planting was significant (Table 4). The highest biological yield (14.57 t ha^{-1}) was observed in interaction at Jagoran and on 10 January planting. The lowest biological yield was observed at BRRI Dhan29 on 10 February planting.

Table 2. Combined effect of variety and date of planting on crop characters of rice in Boro season

Treatment	Plant height (cm)	No. of total tillers hill^{-1}	No. of Effective tillers hill^{-1}	No. of Non-Effective tillers hill^{-1}	Length of panicle(cm)
V_1D_1	77.01e	11.66cd	11.00bcd	1.20efg	22.63
V_1D_2	88.45cd	13.27b	11.20bc	0.66hij	22.98
V_1D_3	90.56c	16.93a	15.73a	0.66hij	23.41
V_1D_4	85.49cd	10.86cde	10.27bcde	0.66hij	21.36
V_1D_5	89.99c	10.26defg	9.93bcdef	2.06ab	20.60
V_2D_1	96.68b	10.40def	9.13defgh	1.40def	22.12
V_2D_2	98.55b	10.93cde	9.20defgh	0.60hij	22.24
V_2D_3	105.60a	11.20cde	9.80bcdef	0.40j	22.24
V_2D_4	97.99b	9.60efgh	9.00efgh	1.60cde	21.96
V_2D_5	97.48b	9.60efgh	8.80efgh	1.80bcd	21.77
V_3D_1	77.87e	11.06cde	10.26bcde	0.93fghi	20.97
V_3D_2	85.03cd	12.00bcd	10.26bcde	0.80fghi	20.98
V_3D_3	84.26d	12.53bc	11.60b	0.53ij	21.26
V_3D_4	88.26cd	10.80cde	9.46cdefg	0.86ghij	20.91
V_3D_5	86.56cd	9.06fgh	8.20fghi	2.40a	20.10
V_4D_1	90.32c	9.47efgh	7.60ghi	1.40cdef	22.29
V_4D_2	97.92b	9.66efgh	8.26fghi	1.26efg	22.58
V_4D_3	99.65b	11.13cde	10.20bcde	0.93fghi	23.20
V_4D_4	98.80 b	8.66gh	7.00hi	1.06fgh	22.24
V_4D_5	99.30b	8.00h	6.93i	1.86fgh	21.33
Significance level	0.05	0.01	0.05	0.01	NS
CV (%)	5.27	8.31	10.20	15.13	9.76

Means in a same column followed by different letter (s) are significantly different at P<0.05; (V_1- Sonar Bangla-1, V_2- Jagoran; V_3 - BRRI Dhan-29; V4- BINA Dhan-6 and D_1 -10 December, D_2 -25 December, D_3 -10 January,D_4 -25 January; D_5 -10 February)

Table 3. Effect of variety and planting date on crop characters of rice in Boro season

Treatment	Grain weight hill^{-1}(g)	1000-grain weight (g)	Biological yield(t ha^{-1})	Harvest Index (%)
Variety				
BRRI Dhan-29	22.68c	21.49b	13.32a	44.60ab
BINADhan-6	21.79c	26.02c	11.09b	43.60b
Sonar Bangla-1	24.39b	30.18a	13.75a	46.20a
Jagoran	26.31a	28.35b	13.37a	45.20ab
Level of Significance	0.01	0.01	0.01	NS
Transplanting date				
10 December	23.32b	26.28b	13.16bc	44.75abc
25 December	25.18a	27.01ab	13.36ab	44.75ab
10 January	25.58a	27.71a	14.10a	46.50a
25 January	23.87b	26.39b	12.44c	44.00bc
10 February	21.51c	25.17c	11.34d	43.50c
Significance level	0.01	0.01	0.01	0.05
CV (%)	5.81	4.21	7.11	5.09

Means in a same column followed by different letter (s) are significantly different at P<0.05

Table 4. Combined effect of variety and plating dates on crop characteristics of rice in Boro season

Treatment	Grain weight hill^{-1}	1000-grain weight (g)	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest Index (%)
V_1D_1	22.56 e-h	21.46	6.27 bcd	7.75 ab	14.02 ab	44.00
V_1D_2	23.11 efg	22.03	6.55 abc	7.54 abc	14.09 ab	46.00
V_1D_3	23.61 def	22.62	6.74 ab	7.52 abc	14.26 ab	47.00
V_1D_4	22.08 e-h	21.34	6.18 b-e	7.90 a	14.08 ab	43.00
V_1D_5	22.05 e-h	20.04	4.45 h	5.70 f	10.15 e	43.00
V_2D_1	20.49 hi	26.00	4.81 gh	6.10 ef	10.91 de	44.00
V_2D_2	24.57 b-e	26.71	5.09 fg	6.26 def	11.35 cde	44.00
V_2D_3	24.63 b-e	26.76	5.96 cde	7.17 abc	13.13 ab	45.00
V_2D_4	20.92gh	25.62	4.47 h	5.78 f	10.25 e	43.00
V_2D_5	18.34 i	25.01	4.21 h	5.64 f	9.85 e	42.00
V_3D_1	23.81 def	29.41	6.63 ab	7.60 abc	14.23 ab	46.00
V_3D_2	26.06 a-d	30.77	6.69 ab	7.32 abc	14.31 ab	47.00
V_3D_3	26.75 ab	32.04	6.99 a	7.52 abc	14.51 a	48.00
V_3D_4	23.55 def	30.22	5.88 cde	7.01 abcd	12.89 abc	45.00
V_3D_5	21.79 fgh	28.46	5.88 cde	6.96 bcd	12.84 abc	45.00
V_4D_1	26.41 abc	28.23	6.16 bcde	7.33 abc	13.49 ab	45.00
V_4D_2	26.98 ab	28.54	6.33 ab	7.38 abc	13.71 ab	46.00
V_4D_3	27.34 a	29.43	6.76 ab	7.81 ab	14.57 a	46.00
V_4D_4	26.96 ab	28.40	5.77 de	6.78 cde	12.55 bcd	45.00
V_4D_5	23.89 c-f	27.71	5.56 ef	6.97 bcd	12.53 bcd	44.00
Significance level	0.05	NS	0.05	0.05	0.05	NS
CV (%)	5.81	4.21	6.01	6.82	7.11	5.09

Means in a same column followed by different letter (s) are significantly different at P<0.05; (V_1- Sonar Bangla-1, V_2- Jagoran; V_3 - BRRI Dhan-29; V4- BINA Dhan-6 and D_1 -10 December, D_2 -25 December, D_3 -10 January,D_4 -25 January; D_5 -10 February)

3.10 Harvest Index

Varieties exerted a significant effect on harvest index (Table 3). It is evident that the highest harvest index (46.20%) was recorded from Sonar Bangla-1 which was statistically similar with Jagoran (44.60%) and BRRI Dhan29 (45.20 %). The lowest harvest index (43.60%) was obtained from BINA Dhan6 which led to the lowest grain yield (5.6 t ha^{-1}).

Harvest index also varied significantly due to date of transplanting (Table 3). The highest harvest index (46.50%) was observed in 10 January planting which statistically similar with 25 December and 10 December planting. The lowest harvest index (43.50%) was obtained in 10 February planting. However, interaction of variety and date of planting on harvest index was non-significant.

4. CONCLUSION

The result revealed that there was significant effect of date of transplanting on yield of potential varieties of rice in Boro season. The highest grain yield (6.41 t ha^{-1}) was obtained from Sonar Bangla-1. Therfore, it may be concluded that Sonar Bangla-1 has emerged as the best variety in Boro season regarding grain and straw yields among the varieties studied under the present investigation and it should be preferably be transplanted between 25 December to 10 January to have higher yield.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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