Influence of date of transplanting on the growth and yield performance of high yielding varieties of Boro rice

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ABSTRACT

An experiment was conducted to find out the effect of variety, date of transplanting and its interaction on the growth and yield performance of high yielding Boro rice. The experiment comprised five varieties viz., BRRI dhan28, BRRI dhan58, BRRI dhan67, BRRI dhan69, BRRI dhan74 and five dates of transplanting viz., 15 December, 30 December, 15 January, 30 January and 15 February. The experiment was laid out in a randomized complete block design with three replications. Results revealed that growth parameters, crop characters, yield components and yield were significantly influenced by variety, date of transplanting and their interactions. The leaf area index (LAI) and dry matter production hill−1 were highest in BRRI dhan69 when transplanted on 15 January whereas the lowest value was found in BRRI dhan28 when transplanted on 15 February. The number of effective tillers hill−1 (11.80), number of grains panicle−1 (130.90), 1000-grain weight (22.07 g), grain yield (4.96 t ha−1) and straw yield (6.64 t ha−1) were highest in BRRI dhan69 whereas corresponding lowest values were recorded in BRRI dhan28. The crop transplanted on 15 January produced the highest number of effective tillers hill−1 (12.81), highest number of grains panicle−1 (131.20), heaviest 1000-grain weight (21.93 g), highest grain yield (5.36 t ha−1) and highest straw yield (7.71 t ha−1). In case of interaction, the highest grain (5.90 t ha−1) and straw yields (7.87 t ha−1) were recorded in BRRI dhan69 transplanted on 15 January whereas the lowest grain and straw yields were recorded in BRRI dhan28 transplanted on 15 February. Therefore, it can be concluded that BRRI dhan69 along with 15 January transplanting appears as the promising combination in terms of grain and straw yields.

Introduction

Rice (Oryza sativa L.) is one of the most important cereal crops in the world. It is the principal food grain for the people of Bangladesh. About 74.85% cropped area of Bangladesh is used for rice cultivation, with annual production of 34.71 million tons from 11.39 million ha of land (BBS, 2017). In Bangladesh, rice is mainly grown in three seasons namely; Boro (post-monsoon) from January to June, Aus (pre-monsoon) from April to August and Aman (monsoon) from August to December. On an average Aus, Aman and Boro seasons account for 8.94%, 49.12% and 41.94%, respectively of annual paddy production (BBS, 2017). Boro rice is characterized by long duration, therefore requires huge amount of water, less rain, low temperature and other inputs compared to other ones. Farmers are very much interested to grow Boro rice due to its high yielding capacity. The average rice yield (husked rice) in Bangladesh is 3.97 t ha−1 (BBS, 2017), which is much lower compared to other Asian rice growing countries, viz., China, South Korea, Indonesia, Japan and Vietnam. High yielding varieties (HYV) are highly responsive to management practices such as water and fertilizer management and also responsive to temperature during growth period. It requires a particular temperature for its phenological processes such as panicle initiation; flowering, panicle exertions from flag leaf sheath and maturity, which are very much influenced by the transplanting dates.

Date of transplanting has profound influence on the performance of different cultivars of photo and thermo-sensitive in nature; many of them obtained better results from early transplanting than late transplanting (Ali et al., 2012; Darko et al., 2013). The growth parameters viz. leaf area index (LAI), chlorophyll content, dry matter production and yield contributing characters especially number of effective tillers hill−1, number of grains panicle−1, grain yield and straw yield were significantly affected compared to late transplanting (Nila et al., 2018). Yield

Cite this article

of late sown crop is invariably low due to reduction in field duration, poor plant stand and growth of the crop, more weed infestation and higher sterility percentage of grains. Fifteen and thirty days delay in sowing from the optimum sowing time reduces the yield on an average by 16 and 45%, respectively (Chopra et al., 1993), the corresponding per dry reduction in yield being 1 and 1.5 percent.

With this view in mind, the study was undertaken to evaluate the agronomic performance of five high yielding varieties of Boro rice to find out the suitable Boro rice variety and the optimum date of transplanting for high yield.

Materials and Methods

Experimental site

The experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, during the period from November 2016 to May 2017. The experimental site is located at 24.75°N latitude and 90.50°E longitude at an altitude of 18 m. The site belongs to the non-calcareous dark grey floodplain soil under the Agro-ecological Zone of the Old Brahmaputra Floodplain (AEZ-9). The soil contains 1.29% organic matter having pH 6.8.

Experimental Design

The study consisted of five HYV of Boro rice viz., BRRI dhan28, BRRI dhan58, BRRI dhan67, BRRI dhan69 and BRRI dhan74, and five transplanting dates viz., 15 December, 30 December, 15 January, 30 January and 15 February. The experiment was laid out in a factorial randomized complete block design with three replications. The size of unit plot was 4.0 m × 2.5 m.

Plant management

Healthy sprouted seeds were sown in nursery bed on 15 November, 30 November, 15 December, 30 December and 15 January, respectively with proper care. The field layout was made on 10 December according to experimental specification immediately after final land preparation. Triple super phosphate (TSP), Muriate of potash (MoP), Gypsum and Zinc sulphate (ZnSO4) were applied at the rate of 180 kg, 160 kg, 130 kg and 10 kg, respectively at the time of final land preparation. Urea was top dressed in three equal splits at 15, 30 and 45 days after transplanting (DAT). Thirty-day old seedlings were transplanted on 15 December 2016, 30 December 2016, 15 January 2017, 30 January 2017 and 15 February 2017, respectively in the well puddled plot. Transplanting was done by using two seedlings hill⁻¹ with 25 cm × 15 cm spacing between rows and hills, respectively. Different intercultural operation namely, gap filling and thinning, weeding, irrigation and drainage and bund repairing were done whenever needed.

Data collection

Dry matter production and leaf area index (LAI) were measured at maximum tillering stage (60 DAT). To determine dry matter production, two hills were taken excluding border rows and central 1 m × 1 m harvest area. The roots of each plant were removed, then the plants were washed with tap water and the destructive plant samples were packed in labelled brown paper bags and dried in the oven at 85±5°C for 72 hours until constant weight was reached. The samples were weighed carefully after oven drying to measure the dry matter plant⁻¹. The leaf area was measured by an automatic leaf area meter (Type AAN-7, Hayashi Dam Ko Co., Japan). Leaf area index was calculated as the ratio of total leaf area and total ground area of the sample as described by Hunt (1978) and as per following formula (1981) Yoshida

$$LAI = \frac{LA}{P}$$

Where, LA= Total leaf area of the leaves of all sampled plants (cm²), and P= Area of the ground surface covered by the plant (cm²).

The crops were harvested at different dates because of variety and different date of transplanting. The maturity of crops was determined at the time when 90% of the grains became golden yellow in colour. Five hills (excluding border rows and central 1.0 m²) were selected randomly from each unit plot and uprooted before harvesting for recording the data of crop characters, yield and yield components of rice. After sampling, the pre-selected harvest area of central 1.0 m × 1.0 m in each unit plot was harvested. Then the harvested crops of each plot were bundled separately, properly tagged and brought to the threshing floor. Grains were separated from the plants by pedal thresher. The grains and straw were then cleaned, weighed and dried in the sun. Then the grain moisture content was adjusted to 14% moisture content. Finally grain and straw yields unit⁻¹ area were converted to t ha⁻¹.

Statistical analysis

Analysis of variance (ANOVA) was done to investigate the significant differences in the recorded parameters resulting from different dates of transplanting. Mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984). Statistical analyses were performed using the software package MSTAT.

Results and Discussion

Leaf area index

Leaf area index was significantly affected by variety at 60 DAT. Results showed that the highest LAI (3.54) was recorded in BRRI dhan69 followed by BRRI dhan74 and the lowest LAI (2.31) was recorded in BRRI dhan28 (Figure 1). This variation might be depending on tillering
and leaf production ability of varieties. Similar result was reported by (Ali et al., 2017) who reported that leaf area index varied due to varietal differences of rice. Different transplanting dates were found to exert significant effect on LAI. The highest LAI (4.65) was recorded on 15 January transplanting followed by 30 December and the lowest one (2.00) was recorded in 15 February transplanting (Figure 2). Interaction effect between variety and date of transplanting exhibited significant influence on LAI. In this case, the highest leaf area index (5.32) was recorded in BRRI dhan69 along with 15 January transplanting, which was at par with BRRI dhan74 along with 15 January transplanting whereas the lowest LAI (1.27) was recorded in BRRI dhan28 transplanted on 15 February, which was statistically identical with BRRI dhan28 transplanted on 30 January (Figure 3).

**Dry matter production**

Different high yielding varieties showed significant difference in terms of dry matter production at 60 DAT. The highest amount of dry matter hill\(^1\) (16.26 g) was recorded in BRRI dhan69 followed by BRRI dhan74 and the lowest amount of dry matter weight (11.15 g) was recorded in BRRI dhan28 (Figure 1).

![Fig. 1 Effect of variety on leaf area index (LAI) and dry matter weight Boro rice](image1)

![Fig. 2 Effect of date of transplanting on leaf area index (LAI) and dry matter weight of Boro rice](image2)

![Fig. 3 Effect of interaction between variety and date of transplanting](image3)
These were with consonance with Ray et al. (2015) who reported that dry matter production hill\(^1\) differed due to varietal characteristics, which might be due to variation in crop growth rate of different varieties at different growth stages. Dry matter was also significantly affected by different transplanting dates. The highest dry matter (19.61 g) was recorded on 15 January transplanting followed by 30 December transplanting whereas the lowest dry matter (8.56 g) was found 15 February transplanting (Figure 2). Similar results were found by Ahmed et al. (2010) and Hossain et al. (2011). The interaction effect of variety and date of transplanting also exhibited significant influence in case of dry matter production of HYV Boro rice (Figure 3). It was found that the highest dry matter (20.57 g) was observed in BRRI dhan69 with 15 January transplanting while the lowest dry matter (5.50 g) was recorded in 15 February transplanting.

**Plant height**

Plant height was significantly influenced by different high yielding varieties (Table 1). The tallest plant (96.88 cm) was recorded in BRRI dhan69 which was at par with BRRI dhan67 whereas the shortest one (89.20 cm) was recorded in BRRI dhan74. Similar results were reported by Ray et al. (2015) and Kirttania et al. (2013) who observed that plant height was significantly influenced by rice variety. Different transplanting dates also found to exert significant influence on plant height (Table 1). The highest plant height (97.75 cm) was recorded from 30 January transplanting which was statistically identical with the crops on 15 January transplanting. The shortest plant (89.91 cm) was recorded when crops were transplanted on 15 December. The interaction effect between variety and date of transplanting was significant in case of plant height (Table 2). The highest plant height (110.90 cm) was recorded in BRRI dhan74 transplanted on 15 January followed by BRRI dhan58 with 30 December transplanting. The shortest plant (78.27 cm) was recorded in BRRI dhan28 when it was transplanted on 30 December (Table 2). This result was also supported by Mannan et al. (2012) who reported that delayed planting enhance premature flowering because of strong photoperiod sensitivity of the variety which forced the plants to switch from vegetative stage to the reproductive stage, thus might be responsible for reduction of plant height.

**Number of total tillers hill\(^1\)**

Variety exerted significant influence on total tillers (Table 1). The highest number of total tillers hill\(^1\) (13.39) was recorded in BRRI dhan69 followed by BRRI dhan74 while the lowest number of total tillers hill\(^1\) (11.35) was recorded in BRRI dhan28. Similar results were reported by Jisan et al. (2014) who reported that number of total tillers varied among the varieties. The production of total tillers hill\(^1\) differed significantly at 1% level of significance due to different date of transplanting (Table 1). The highest number of total tillers hill\(^1\) (14.49) was recorded on 15 January transplanting followed 30 December transplanting. The lowest number of total tillers hill\(^1\) (10.43) was recorded on 15 February transplanting. These results are in conformity with the findings of BRRI (2003) that number of total tillers drastically reduced when transplanted lately due to temperature variation. Therefore, the highest number of total tillers hill\(^1\) (15.80) was recorded in BRRI dhan69 transplanted on 15 January which was at par with BRRI dhan74 when transplanted on 15 January and the lowest one (10.00) was recorded in BRRI dhan28 transplanted on 15 February, which was at par with BRRI dhan58 and BRRI dhan74 transplanted on 15 February (Table 2).

**Number of effective tillers hill\(^1\)**

Number of effective tillers hill\(^1\) varied significantly due to different high yielding varieties (Table 1). The highest number of effective tillers hill\(^1\) (11.80) was recorded in BRRI dhan69 followed by BRRI dhan74 and the lowest number of effective tillers hill\(^1\) (10.23) was recorded in BRRI dhan28. Similar results were also found by Shaha et al. (2014) who reported that number of effective tillers hill\(^1\) varied among the varieties. Different transplanting dates were found to exert significant effect on the production of effective tillers hill\(^1\) (Table 1). The highest number of effective tillers hill\(^1\) (12.81) was recorded on 15 January transplanting followed by 30 December transplanting. The lowest number of effective tillers hill\(^1\) (9.28) was recorded when it was transplanted on 15 February. Number of effective tillers hill\(^1\) possessed significant influence in case of interaction. The highest number of effective tillers hill\(^1\) (13.73) was recorded in BRRI dhan69 with 15 January transplanting followed by the variety BRRI dhan74 on 15 January transplanting. The lowest number of effective tillers hill\(^1\) (8.80) was recorded in BRRI dhan28 transplanted on 15 February because of transplanting lately due to shorter vegetative period (Table 2).

**Number of grains panicle\(^1\)**

Number of grains panicle\(^1\) was significantly affected by different high yielding varieties (Table 1). The highest number of grains panicle\(^1\) (130.90) was recorded in BRRI dhan69, which was statistically identical with BRRI dhan58 and the lowest number of grains panicle\(^1\) (119.50) was recorded in BRRI dhan28, which was at par with BRRI dhan67. This trend could be explained by the varietal differences in genetic make-up (Shaha et al., 2014; Jisan et al., 2014; Sarkar et al., 2014). Date of transplanting showed significant variation in number of grains panicle\(^1\) at 1% level of probability (Table 1). The highest number of grains panicle\(^1\) (131.20) was recorded on 15 January transplanting which was statistically identical with transplanting on 15 December and 30 December. The lowest number of grains panicle\(^1\) (116.40) was recorded on 15 February transplanting. These finding are similar to Islam et al. (2015) who...
reported that early transplanting produced a greater number of grains/panicles than the late transplanting. Significant differences were also found in case of interaction between variety and date of transplanting. The highest number of grains panicle$^{-1}$ (137.9) was recorded in BRRI dhan69 transplanted on 15 January and the lowest number of grains panicle$^{-1}$ (110.9) was recorded in BRRI dhan28 transplanted on 15 February (Table 2).

1000-grain weight

Weight of 1000 grains weight differed significantly due to different varieties (Table 1). The heaviest 1000-grain weight (22.07 g) was recorded in BRRI dhan69, which was at par with BRRI dhan74 and the lowest 1000-grain weight (20.29 g) was recorded in BRRI dhan28, which was statistically identical with BRRI dhan58. Similar results were reported by Kabir et al. (2008) who noticed that the weight of 1000-grain varied among varieties. Weight of 1000 grains was also significantly affected by date of transplanting. The heaviest 1000-grain weight (21.93 g) was recorded on 15 January transplanting which was statistically identical with 30 December transplanting. The lowest 1000-grain weight (20.29 g) was recorded on 15 February transplanting (Table 2).

Grain yield

Variety exerted significant influence on grain yield (Table 1). The highest grain yield (4.96 t ha$^{-1}$) was recorded in BRRI dhan69 followed by BRRI dhan74 and the lowest grain yield (3.91 t ha$^{-1}$) was recorded in BRRI dhan28. These results agreed with Jisan et al. (2014) who reported significant variation among the rice genotypes in terms of grain yield. Date of transplanting also exerted significant influence on grain yield among the five dates of transplanting, the highest grain yield (5.36 t ha$^{-1}$) was recorded in 15 January followed by 30 December and the lowest grain yield (3.55 t ha$^{-1}$) was recorded in 15 February (Table 1). Kabir et al. (2004) reported that grain yield differed due to genetic characteristics of the varieties which indicated that grain yield decreased when transplanted lately due to increasing temperature. The variety and date of transplanting was significantly interacted in case of grain yield (Table 2). The highest grain yield (5.90 t ha$^{-1}$) was recorded in BRRI dhan69 transplanted on 15 January and the lowest grain yield (3.00 t ha$^{-1}$) was recorded in BRRI dhan28 transplanted on 15 February (Table 2). Similar result also observed by Safdar et al. (2013) and Mannan et al. (2012).

Table 1. Effect of variety on crop characters, yield and yield components of Boro rice

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>No. of tillers hill$^{-1}$</th>
<th>No. of effective tillers hill$^{-1}$</th>
<th>Non-effective tillers hill$^{-1}$</th>
<th>Panicle length (cm)</th>
<th>No. of grains panicle$^{-1}$</th>
<th>Ster. spik. pan$^{-1}$</th>
<th>TGW (g)</th>
<th>Grain yield (t ha$^{-1}$)</th>
<th>Straw yield (t ha$^{-1}$)</th>
<th>HI (%)</th>
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<tr>
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<tr>
<td>V1</td>
<td>92.56b</td>
<td>11.35e</td>
<td>10.23e</td>
<td>1.12e</td>
<td>22.95b</td>
<td>119.50c</td>
<td>13.31a</td>
<td>20.29c</td>
<td>3.91d</td>
<td>5.50e</td>
<td>41.70</td>
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<tr>
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<td>93.65b</td>
<td>12.20c</td>
<td>10.84c</td>
<td>1.36c</td>
<td>23.10b</td>
<td>125.90ab</td>
<td>12.26b</td>
<td>20.94bc</td>
<td>4.47b</td>
<td>6.17c</td>
<td>42.09</td>
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<td>10.60d</td>
<td>1.21d</td>
<td>23.77a</td>
<td>121.80bc</td>
<td>12.37b</td>
<td>20.63c</td>
<td>4.33c</td>
<td>5.86d</td>
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<td>22.57bc</td>
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<td>10.22d</td>
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<td>42.76</td>
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<td>12.84b</td>
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<td>1.48b</td>
<td>21.97c</td>
<td>126.10ab</td>
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<td>4.58b</td>
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<td>41.95</td>
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<td>6.69b</td>
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<td>12.81a</td>
<td>1.68a</td>
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<td>131.20a</td>
<td>9.67d</td>
<td>21.93a</td>
<td>5.36a</td>
<td>7.31a</td>
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<td>11.08d</td>
<td>10.05 d</td>
<td>1.02e</td>
<td>22.74 b</td>
<td>120.90bc</td>
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<td>20.81bc</td>
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<td>5.60d</td>
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<td>116.40c</td>
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<td>20.29c</td>
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<tr>
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</table>

V1= BRRI dhan28, V2= BRRI dhan58, V3= BRRI dhan74, V4= BRRI dhan69, V5= BRRI dhan74, T1= 15 December, T2= 30 December, T3= 15 January, T4= 30 January, T5= 15 February; TSW= 1000-grain weight, HI= harvest index; ** = Significant at 1% level of probability, CV = Coefficient of variation
**Straw yield**

Straw yield differed significantly due to different variety (Table 1). Among the five varieties the highest straw yield (6.64 t ha\(^{-1}\)) was recorded in BRRI dhan69 followed by BRRI dhan74 and the lowest straw yield (5.50 t ha\(^{-1}\)) was recorded in BRRI dhan28. These results are consistent with those obtained by Chowdhury and Gaha (2000) and Jisan et al. (2014). The straw yield also significantly affected by date of transplanting (Table 1). The highest straw yield (7.30 t ha\(^{-1}\)) was recorded on 15 January transplanting followed by 30 December and the lowest straw yield (4.71 t ha\(^{-1}\)) was recorded on 15 February transplanting. Therefore, the highest straw yield (7.87 t ha\(^{-1}\)) was recorded in BRRI dhan69 transplanted on 15 January and the lowest straw yield (3.93 t ha\(^{-1}\)) was recorded in BRRI dhan28 transplanted on 15 February (Table 2).

**Harvest index**

Effect of variety had no significant influence on harvest index (Table 1). The harvest index was significantly affected by date of transplanting at 5% level of probability (Table 1). Among the five dates of transplanting, the highest harvest index (43.03 %) was recorded on 15 February transplanting, which was statistically identical with 15 January transplanting. The lowest harvest index (41.35%) was recorded on 30 December transplanting, which was statistically identical with transplanting on 15 January. The highest harvest index (44.28 %) was recorded in BRRI dhan69 when transplanted on 30 January and the lowest harvest index (39.65 %) was recorded in BRRI dhan28 transplanted on 30 December (Table 2).
Functional relationship between grain yield and leaf area index at 60 DAT

Leaf area index is an important growth parameter for the determination of yield of HYV Boro rice. It is closely related to the amount of photosynthetic surface which is available for plant photosynthesis, the basic process of higher yield. Experimental results reveal that grain yield showed significant positive correlation ($R^2 = 0.882^{**}$) with LAI at 60 DAT (Figure 4). This means increase of LAI will results in corresponding increase in the grain yield of HYV Boro rice which indicates that LAI might be critical growth characteristic in yield performance of HYV Boro rice.

Functional relationship between grain yield and total dry matter at 60 DAT

Total dry matter is also an important parameter for determination of grain yield of HYV Boro rice. Partitioning of dry matter in sink organs i.e. grains are responsible for the yield which is harvested from the rice plant. Experimental results reveal that grain yield showed significantly positive correlation ($R^2 = 0.904^{**}$) with total dry matter production at 60 DAT (Figure 5). The functional relationship reveals that 90% of the variation in yield could be explained from the variation in total dry matter production. This means an increase in dry matter production results in an increase in grain yield. This indicated that total dry matter production might be critical characteristics in yield performance of HYV Boro rice.
Similar results were reported by Ray et al. (2015) and Paul et al. (2019), who noticed that grain yield of rice positively correlated with its dry matter production.

Conclusion

The highest grain and straw yields were recorded in BRRI dhan69 transplanted on 15 January whereas lowest grain and straw yields were recorded in BRRI dhan28 transplanted on 15 February. Therefore, it can be concluded that BRRI dhan69 along with 15 January transplanting appears as the promising combination in terms of grain and straw yields.

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