J Bangladesh Agril Univ 17(3): 301–308, 2019 https://doi.org/10.3329/jbau.v17i3.43201

ISSN 1810-3030 (Print) 2408-8684 (Online)

Journal of Bangladesh Agricultural University

Journal home page: http://baures.bau.edu.bd/jbau, www.banglajol.info/index.php/JBAU

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

Tapas Kumar Roy, Swapan Kumar Paul ✉, Md. Abdur Rahman Sarkar

Department of Agronomy, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

ARTICLE INFO

Article history:
Received: 02 July 2019
Accepted: 06 August 2019
Published: 30 September 2019

Keywords:
Rice,
Planting date,
Growth,
Yield,
HYV

Correspondence:
Swapan Kumar Paul
✉: skpaul@bau.edu.bd

OPEN ACCESS

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

Roy, T.K., Paul, S.K. and Sarkar, A.R. 2019. Influence of date of transplanting on the growth and yield performance of high yielding varieties of *Boro* rice. *Journal of Bangladesh Agricultural University*, 17(3): 301–308. https://doi.org/10.3329/jbau.v17i3.43201

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 1m × 1m 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±5ºC 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 (cm^2), and P= Area of the ground surface covered by the plant (cm^2).

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 m^2) 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).

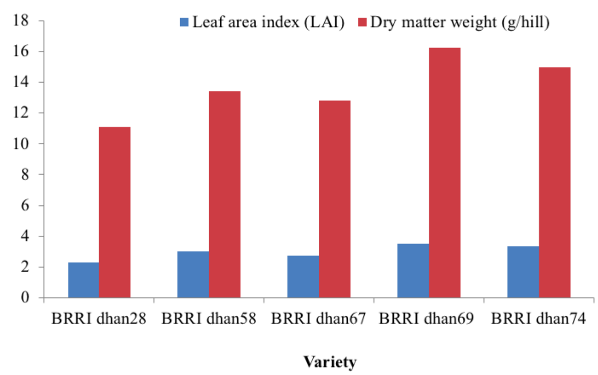

Fig. 1 Effect of variety on leaf area index (LAI) and dry matter weight *Boro* rice

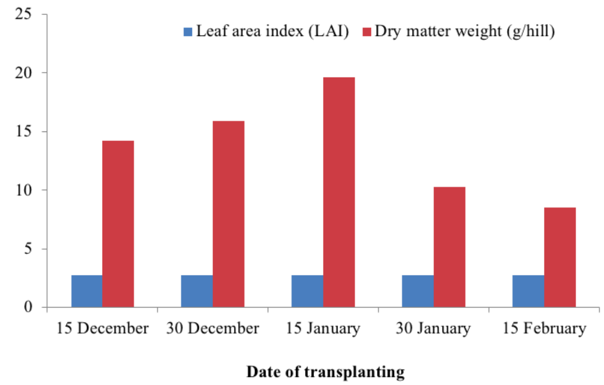

Fig.2 Effect of date of transplanting on leaf area index (LAI) and dry matter weight of *Boro* rice

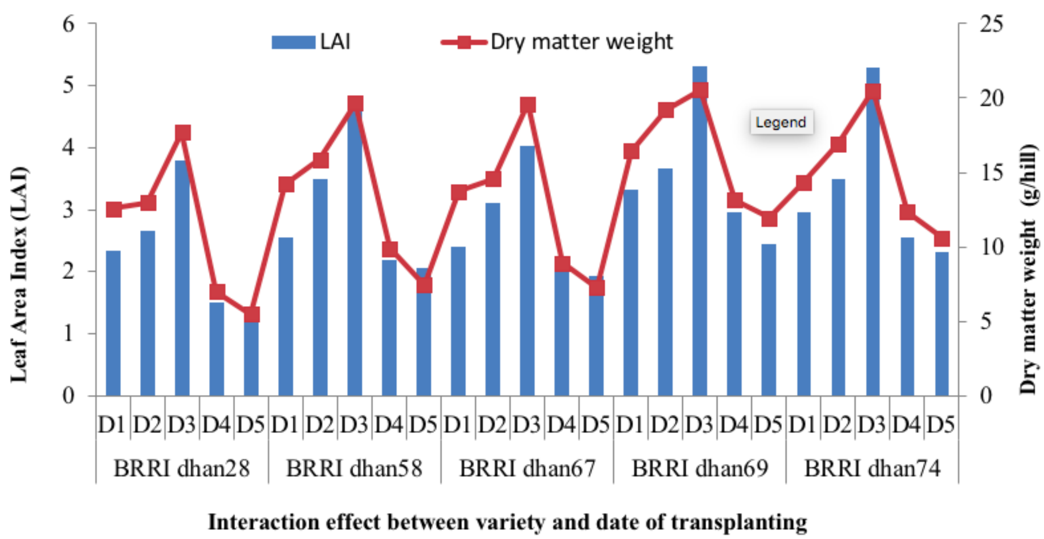

Fig. 3 Effect of interaction between variety and date of transplanting on leaf area index (LAI) and dry matter weight of Boro rice at 60 DAT

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 dhan67 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^{-1} (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 1).

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

Treatment	Plant height (cm)	No. of tillers hill^{-1}	No. of effective tillers hill^{-1}	Non-effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	Ster. spik. pan^{-1}	TGW (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	HI (%)
Variety											
V1	92.56b	11.35e	10.23e	1.12e	22.95b	119.50c	13.31a	20.29c	3.91d	5.50e	41.70
V2	93.65b	12.20c	10.84c	1.36c	23.10b	125.90ab	12.26b	20.94bc	4.47b	6.17c	42.09
V3	95.07ab	11.81d	10.60d	1.21d	23.77a	121.80bc	12.37b	20.63 c	4.33c	5.86d	42.60
V4	96.88a	13.39a	11.80a	1.59a	22.57bc	130.90a	10.22d	22.07a	4.96a	6.64a	42.76
V5	89.20c	12.84b	11.36b	1.48b	21.97c	126.10ab	11.09c	21.63ab	4.58b	6.35b	41.95
Sig. lev.	**	**	**	**	**	**	**	**	**	**	NS
CV (%)	4.39	3.30	2.58	8.12	3.66	6.14	9.72	4.52	3.87	3.25	3.11
Time of sowing											
T1	89.91b	12.32c	10.99c	1.33c	22.01c	126.60ab	11.94b	21.11b	4.50c	6.22c	41.97bc
T2	91.45b	13.27b	11.69b	1.57b	23.61a	129.10a	10.69c	21.43ab	4.72b	6.69b	41.35c
T3	95.85a	14.49a	12.81a	1.68a	23.26 ab	131.20a	9.67d	21.93a	5.36a	7.31a	42.3abc
T4	97.75a	11.08d	10.05 d	1.02e	22.74 b	120.90bc	12.76b	20.81bc	4.13d	5.60d	42.44ab
T5	92.40b	10.43e	9.28e	1.15d	22.75b	116.40 c	14.17a	20.29c	3.55e	4.718e	43.03a
Sig. lev.	**	**	**	**	**	**	**	**	**	**	**
CV (%)	4.39	3.30	2.58	8.12	3.66	6.14	9.72	4.52	3.87	3.25	3.11

V1= BRRI dhan28, V2= BRRI dhan58, V3= BRRI dhan67, V4= BRRI dhan69, V5= BRRI dhan74, T1=15 December, T=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

Table 2. Interactions effects of irrigation interval and fertilizer on growth and yield contributing characters of carrot

	Plant height (cm)	No. of tillers hill^{-1}	No. of effective tillers hill^{-1}	Non-effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	Ster. spik. pan^{-1}	TGW (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	HI (%)
$V_1 \times D_1$	94.60c-f	10.53jk	9.53g-j	1.00ij	21.64fg	121.7	13.39	20.37	4.26g-i	6.00h	41.55
$V_1 \times D_2$	78.27h	12.53e-g	11.13e	1.40d-f	23.90bc	123.5	11.39	20.50	4.26g-i	6.50ef	39.65
$V_1 \times D_3$	95.67b-e	13.53bcd	12.27c	1.26fgh	23.28cdef	124.8	10.65	20.87	4.85e	6.67de	42.10
$V_1 \times D_4$	97.80bcd	10.13k	9.40hij	0.73l	23.03 c-f	116.7	14.51	19.97	3.20kl	4.43l	41.93
$V_1 \times D_5$	96.47b-e	10.00k	8.80k	1.20fghi	22.89 c-g	110.9	16.60	19.77	3.00l	3.93m	43.27
$V_2 \times D_1$	95.47b-e	12.20fg	10.80e	1.40def	22.20d-gg	125.2	12.73	20.63	4.43fgh	6.13g	41.96
$V_2 \times D_2$	100.7bcd	13.00de	11.67d	1.33efg	21.88d-g	131.4	11.36	21.33	4.82e	6.60de	42.20
$V_2 \times D_3$	93.00def	14.13b	12.53c	1.59cd	24.85b	132.5	10.09	21.93	5.30bc	7.40b	41.72
$V_2 \times D_4$	96.40b-e	11.33hi	10.00fg	1.33efg	23.20 c-f	123.4	13.15	20.47	4.17hi	5.90hi	41.40
$V_2 \times D_5$	82.67gh	10.33k	9.20ijk	1.13hij	23.37 cd	117.1	13.97	20.33	3.67j	4.83k	43.16
$V_3 \times D_1$	81.80gh	11.87gh	10.73e	1.13ghij	22.23d-g	122.2	12.58	20.63	4.33ghi	6.03h	41.80
$V_3 \times D_2$	88.80efg	12.80ef	11.20de	1.60cd	27.62a	126.4	11.37	20.67	4.70ef	6.60de	41.60
$V_3 \times D_3$	110.9a	13.87bc	12.47c	1.40ef	22.75c-g	126.8	10.30	21.83	5.20cd	6.93cd	42.84
$V_3 \times D_4$	95.80b-e	10.33k	9.53ghij	0.80kl	23.00cdef	118.3	13.36	20.10	4.13hi	5.50j	42.89
$V_3 \times D_5$	98.00bcd	10.20k	9.07jk	1.13ghij	23.27cdef	115.3	14.25	19.93	3.30k	4.23l	43.87
$V_4 \times D_1$	94.93b-e	13.80bc	12.20c	1.60cd	22.29c-g	137.6	10.33	22.20	4.97de	6.50ef	43.33
$V_4 \times D_2$	102.1bc	14.07b	12.27c	1.80b	23.34cde	132.3	9.347	22.33	4.97de	7.07c	41.28
$V_4 \times D_3$	100.3bcd	15.80a	13.73a	2.06a	22.95cdef	137.9	8.080	22.60	5.90a	7.87a	42.83
$V_4 \times D_4$	102.9b	12.20fg	11.07e	1.13ghij	22.50c-g	126.7	10.47	21.83	4.90de	6.17fg	44.28
$V_4 \times D_5$	84.13gh	11.07ij	9.73gh	1.33efg	21.78defg	119.9	12.87	21.37	4.07i	5.60ij	42.09
$V_5 \times D_1$	82.73gh	13.20cde	11.67d	1.53de	21.68efg	126.1	10.66	21.70	4.50fg	6.43ef	41.18
$V_5 \times D_2$	87.40fg	13.93bc	12.20c	1.73bc	21.28g	132.0	10.01	22.30	4.83e	6.67de	42.03
$V_5 \times D_3$	79.33h	15.13a	13.07b	2.06a	22.47c-g	134.0	9.253	22.43	5.57b	7.67ab	42.07
$V_5 \times D_4$	95.80b-e	11.40hi	10.27f	1.13ghij	21.98defg	119.7	12.34	21.67	4.27ghi	5.97h	41.69
$V_5 \times D_5$	100.7bcd	10.53jk	9.60ghi	0.93jk	22.45c-g	118.7	13.19	20.07	3.73j	5.00k	42.76
Sig. lev.	**	**	**	**	**	NS	NS	NS	**	**	NS
CV (%)	4.39	3.30	2.58	8.12	3.66	6.14	9.72	4.52	3.87	3.25	3.11

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 transplanted 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).

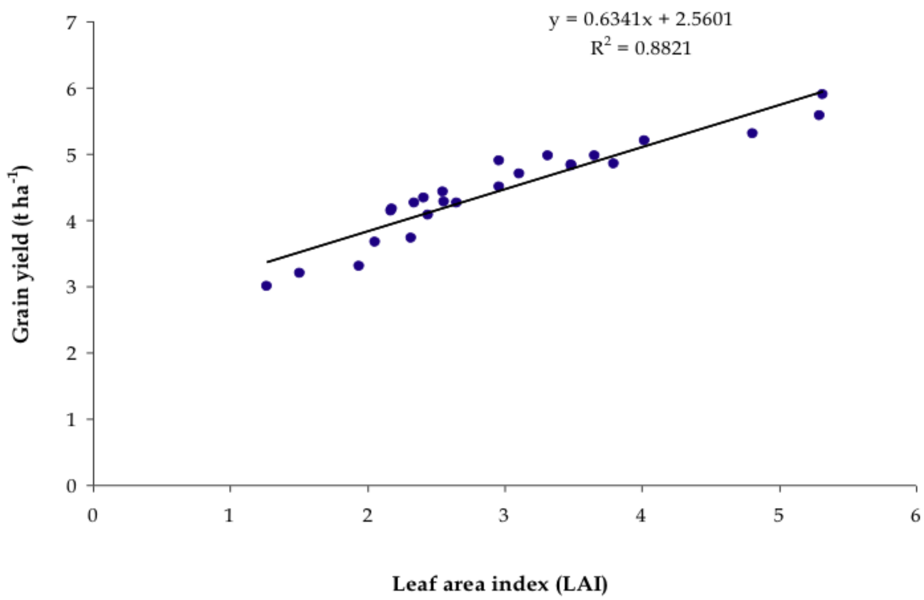

Fig. 4 Functional relationship between grain yield and leaf area index of *Boro* rice at 60 DAT

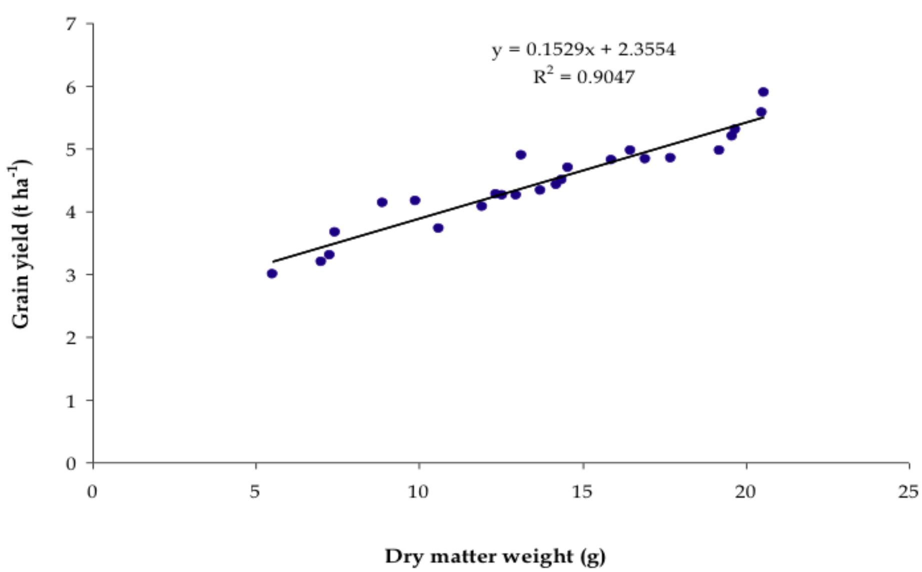

Fig. 5 Functional relationship between grain yield and dry matter weight of *Boro* rice at 60 DAT

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.

Acknowledgement

The financial assistance of Ministry of Science and Technology, Government of the People's Republic of Bangladesh to carry out this research work is thankfully acknowledged.

References

Ahmed, I., Ahmed, B., Amin, R., Ullah, J. and Sarker. K. U. 2010. Performance of advanced genotype of aromatic rice under different transplanting dates. *Journal of Agroforestry and Environment*, 3: 141–44.

Ali, A. A., Abou, K. and El-Rewainy, I. M. 2012. Study some physiological characters, yield and yield component for five new rice varieties under different sowing dates. *Advances in Applied Science Research*, 3(1): 440–445.

Ali, M. I., Sarkar, M. A. R. and Paul, S.K. 2017. Impact of nutrient management on the growth performance of transplant *Aman* rice. *Journal of Agroforestry and Environment*, 11 (1 & 2): 223–226.

BBS (Bangladesh Bureau of Statistics) 2017. The Yearbook of Agricultural Statistics of Bangladesh. Stat. Div., Minis. Plan., Govt. People's Repub., Bangladesh. Dhaka. p. 34–68.

BRRI (Bangladesh Rice Research Institute) 2003: Annual Internal Review held on 19 October-23 October, Genetic Resource and Seed Division. Bangladesh Rice Research Institute, Gazipur. pp. 6–8.

Chopra, N.K. and Chopra. N. 1993. Seed yield and quality of 'Pusa 44' rice (*Oryza sativa)* as influenced by nitrogen fertilizer and row spacing. *Indian Journal of Agricultural. Science,* 74(3): 144–146.

Chowdhaury, P. K. D. and Gaha, B. 2000. Performance of rice varieties under different time of planting in boro season. *Annals of Biology Ludhiana*, 16(1): 41–44.

Darko, B. S. and Singh, M. 2013. Effect of green manuring and nitrogen on the yield and uptake of micronutrient by rice. *Journal of the Indian Society of Soil Science*, 50(2): 178–180.

Gomez, K. A. and Gemez, A. A. 1984. Statistical Procedure for Agricultural Research. 2nd Edition. John Wiley and Sons. New York. pp. 97–111.

Hossain, M. A., Sarkar, M. A. R. and Paul. S. K. 2011. Growth analysis of late transplant Aman rice (cv. BR23) raised from tiller seedlings. *Libyan Agriculture Research Center Journal International*, 2(6): 265–273.

Hunt, R. 1978. Plant Growth Analysis. Study in Biology No.96. Edward Arnold, London. pp.27–30.

Islam, M. S., Sarkar, M. A. R., Ullah, M. A. and Khanam, S. 2015. Effect of transplanting date on the growth and yield of aromatic rice in irrigated ecosystem. *IOSR Journal of Agriculture and Veterinary Science*, 8(1): 59–65.

Jisan, M. T., Paul, S. K. and Salim, M. 2014: Yield performance of some transplant *Aman* rice varieties as influenced by different level of nitrogen. *Journal of Bangladesh Agricultural University*, 12(2): 321–324. https://doi.org/10.3329/jbau.v12i2.28691

Kirttania, B. Sarkar, M. A. R., Paul, S. K. and Islam, M. S. 2013. Morpho-physiological attributes of transplant *Aman* rice as influenced by variety, age of tiller seedlings and nitrogen management. *Journal of Agroforestry and Environment*, 7 (2):149–154.

Kabir, M. H., Bari, M. N., Haque, M. M., Ahmad, G. J. U. and Islam, A. J. M. S. 2008. Effect of water management and weed control treatments on the performance of transplanted *Aman* rice. *Bangladesh Journal of Agricultural Research*, 33(3): 399–408. https://doi.org/10.3329/bjar.v33i3.1599

Kabir, M. E., Kabir, M. R., Jahan, M. S. and Das, G. G. 2004. Yield performance of three aromatic fine rice in a coastal medium high land. *Asian Journal of Plant Science,* 3(5): 561–563. https://doi.org/10.3923/ajps.2004.561.563

Mannan, M. K., Bhuiya, M. S. U., Akhand, M. M. and Rang, M. M. 2012. Influence of Date of Planting on the Growth and Yield of Locally Popular Traditional Aromatic Rice Varieties in *Boro* Season. *Journal of Science foundation,* 10(l): 20–28. https://doi.org/10.3329/jsf.v10i1.16275

Nila, N.Y., Paul, S.K. and Sarkar, M.A.R. 2018. Growth, yield and grain protein content of aromatic *Boro* rice (cv. BRRI dhan50) as influenced by date of transplanting and nutrient management. *Archives of Agriculture and Environmental Science*, 3(2): 116-122. https://doi.org/10.26832/24566632.2018.030203

Paul, S. K., Nahar, L.S., Paul, N.C. and Begum, M. 2019. Influence of weeding regime on the performance of aromatic *Boro* rice (*Oryza sativa* L.). *Archives of Agriculture and Environmental Science*, 4(2): 133–140. https://dx.doi.org/10.26832/24566632.2019.040202

Ray, S., Sarkar M. A. R., Paul S. K., Islam, A. K. M. M. and Yeasmin, S. 2015. Variation of growth, yield and protein content of transplant *Aman* rice by three agronomic practices. *Agricultural and Biological Sciences Journal,* 1 (4): 167–176.

Shaha, U., Bhuiya, M. S. U. and Paul, S. K. 2014. Integrated use of cowdung and inorganic fertilizer on the performance of modern varieties of transplanted *aman* rice. *Journal of Agroforestry and Environment*, 8(2): 81–84.

Sarkar, S. K., Sarkar, M. A. R., Islam, N. and Paul, S. K. 2014. Yield and quality of aromatic fine rice as affected by variety and nutrient management. *Journal of Bangladesh Agricultural University*, 12(2): 279–284. https://doi.org/10.3329/jbau.v12i2.28683

Safdar, M. E. Noorka, I. R. Tanveer, A. Tariq, S. A. and Rauf, S. 2013. Growth and yield of advanced breeding lines of medium grain rice as influenced by different transplanting dates. *Journal of Animal and Plant Sciences*, 23(1): 227–231.

Tyeb, A., Paul, S. K. and Samad, M. A. 2013. Performance of variety and spacing on the yield and yield contributing characters of transplanted *Aman* rice. *Journal of Agroforestry and Environment*, 7 (1): 57–60.

Yoshida, S. 1981. Physiological Analysis of Rice Yield. In: "Fundamentals of Rice Crop Science''. p. 269. Intl. Rice Res. Ins., Los Banos, Phillippines.