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Article

Yield and yield contributing attributes of rice (*Oryza Sativa* L.) under different planting dates in *boro* season

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Abstract: The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka-1207 to find out the yield and yield contributing attributes of rice varieties under different planting times. The experiment comprised of two factors- factor a: Planting time (2): T_1: 24th January planting; T_2: 23th February planting and factor b: Rice variety (5): V_1: BRRI dhan29; V_2: BRRI hybrid 2; V_3: Hera 2; V_4: Tia and V_5: Taj 1. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Among the different planting time and varieties, 24th January planting and Hera 2 were found superior in terms of yield and yield contributing attributes of rice varieties. Irrespective of planting times, the highest panicle length (24.64 cm), number of effective tillers hill^{-1}(13.33), filled grains panicle^{-1} (83.17), 1000-grain weight (25.14 g), grain yield (4.30 t ha^{-1}), straw yield (5.21 t ha^{-1}), biological yield (9.43 t ha^{-1}) and harvest index (45.89%) were achieved. However, Hera 2 provided the highest grain yield (4.64 t ha^{-1}) at 24th January planting compared to other combination. It meant that Hera 2 performed well with 24th January planting.

Keywords: rice; planting date; hybrid; yield

1. Introduction

Rice (*Oryza sativa* L.) isthe staple food for at least 62.8% of total planet inhabitants and it contributes on an average 20% of apparent calorie intake of the world and 30% of Asian populations (Hien *et al.,* 2006). In Asia, more than 90% of this rice is consumed (IRRI, 2013). The population of Bangladesh is increasing at an alarming rate and the cultivable land is decreasing due to urbanization and industrialization resulting in the shortage of food. The nation is still adding about 2.3 million every year to its total of 150 million people (Momin and Husain, 2009). Population growth required a continuous increase in rice production in Bangladesh. So, the highest priority has been given to produce more rice. Rice yields are either stagnating/declining in post-green revolution era mainly due to late or early planting, imbalance use of fertilizer, irrigation and weeding schedule, type of cropping system practiced, lack of suitable rice genotypes for low moisture adaptability and disease resistance (Prakash, 2010).

Planting time for successful rice production widely depends on varietal life duration, sensitivity to photoperiod, temperature, rainfall and other environmental factors. In Bangladesh, planting of boro rice starts in early November and continues up to last May. Such longer period of planting time is associated with inconsistent rainfall, late harvesting of preceding crops, early flood water and other socioeconomic factors (Zaman, 1986). It is assumed that late planting reduces vegetative phase which results from reduced growth and yield of rice (Jhoun, 1989). On the contrary, early planted rice sometimes lodges due to over growth or other natural hazards prevailing in the long growing season. Gangwar and Sharma (1997) also observed a higher number of panicles in early transplanting than in late transplanting. This was due to the fact that rice genotypes planted earlier had the longer period for their vegetative growth compared to those sown later. It is, therefore, essential to generate adequate information relating to planting time to exploit better growth and productivity. Planting time affects

seed quality through affecting seed growth and development as it prevails through different environmental conditions in the processes of seed development and seed maturation (Castillo *et al.,* 1994).

Variety is the key component to produce the higher yield of rice depending upon their differences in genotypic characters, input requirements and of course the prevailing environmental conditions during the growing season (BRRI, 2003). Now a day's different hybrid rice variety is available in Bangladesh which has more yield potential than conventional high yielding varieties (Akbar, 2004). Hybrid rice has high tillering capacity (Zhende, 1988). Hossain and Deb (2003) reported that although farmers got about 16% yield advantage in the cultivation of hybrids compared to the popularly grown inbred varieties, the yield gains were not stable. On the other hand, compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average grain yield increase of 7.27% (Bhuiyan *et al.,* 2014). This variety, however needs further evaluation under the different adaptive condition to interact with different environmental conditions.

Considering the above-mentioned facts and based on the prior observation, an investigation was undertaken to evaluate the yield and yield contributing attributes of the some selected rice varieties at two different planting dates.

2. Materials and Methods

2.1. Experimental site

The experiment was conducted at the Research Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka and it was located in 24.090 N latitude and 90.260 E longitudes.

2.2. Climate and soil

The climate of the experimental site is sub-tropical, wet and humid. Heavy rainfall occurs in the monsoon (mid-April to mid-August) and scanty during rest of the year. The soil of the experimental area was silty clay in texture. Soil pH was 6.7 and has organic carbon 0.45%.

2.3. Experimental treatment and design

Different rice varieties were used as the test crop in this experiment. The experiment comprised two factors. Factor a: planting time (2): T_1: 24th January planting; T_2: 23rd February planting and Factor b: Rice variety (5): V_1: BRRI dhan29; V_2: BRRI hybrid 2; V_3: Hera 2; V_4: Tia and V_5: Taj 1. The experiment was laid out in a randomized complete block design (RCBD) with three replications. There were 10 plots of 5 m^2 in size in each of 3 replications resulting 30 plots in total. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively.

2.4. Crop husbandry

The seeds were sown in the seedbed @ 70 gm-2 in order to have healthy seedlings. The fertilizers N, P, K, S, Zn and B in the form of urea, TSP, MoP, Gypsum, zinc sulphate and borax, respectively were applied @ 80 kg, 60 kg, 90 kg, 12 kg, 2.0 kg and 10 kg (BRRI, 2013). The entire amount of TSP, MoP, gypsum, zinc sulphate and borax were applied during the final preparation of experimental plot. Urea was applied in two equal installments as top dressing at tillering and panicle initiation stages. Two seedlings (21 days) were transplanted in each hill with a plant to plant distance 15 cm and row to row distance 20 cm. Intercultural operations were done to ensure normal growth of the crop. Plant protection measures were followed as and when necessary.

2.5. Data collection

Ten pre-selected hills per plot from which different data were collected. Data on the following parameters were recorded during the course of the experiment such as - panicle length (cm), effective tillers hill^{-1}, filled grains panicle^{-1}, 1000-grain weight (g), grain yield (t ha^{-1}), straw yield (t ha^{-1}), biological yield (t ha^{-1}) and harvest index (%).

The biological yield was calculated with the following formula:

Biological yield = Grain yield + Straw yield.

Harvest index was calculated from the grain and straw yield of rice for each plot and expressed in percentage:

$$\text{Harvest index (HI)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

2.6. Statistical package

All the collected data were tabulated and analyzed statistically using analysis of variance technique and subsequently, Least Significance Difference (LSD at 5%) for comparing the treatment means, by MSTAT-C software (Gomez and Gomez, 1984).

3. Results and Discussion

3.1. Panicle length

Panicle length showed statistically significant differences due to different planting dates (Figure 1). The longer panicle (23.43 cm) was recorded from 24th January planting and the shorter panicle (22.52) was found from 23rd February planting. Reduction in panicle length in delayed transplanting from the early one may be due to lack of full photosynthesis during its growing period, the inability of roots to absorb minerals from soil (Kushwaha *et al.* 2016). Khalifa (2009) found that early date of sowing (20th April) is the best time of sowing for panicle length (cm), and sowing in 1st June has given the lowest value.

Statistically, significant variation was recorded in terms of panicle length due to different rice varieties (Figure 2). The longest panicle (24.64 cm) was observed from Heera 2, while the shortest panicle (20.47 cm) was recorded from BRRI dhan29. Wang *et al.* (2006) reported that compared with conventional cultivars, the hybrids had larger panicles. Idris and Matin (1990) conducted an experiment with six varieties and observed that panicle length differed among varieties and it was greater in IR 20 than in indigenous and high yielding varieties.

Interaction effect of different planting dates and rice varieties showed statistically significant differences on panicle length (Figure 3). The longest panicle (25.23 cm) was recorded from treatment combination of 24th January planting with Heera 2 and the shortest panicle (20.26 cm) was found from treatment combination of 23rd February planting with BRRI dhan29.

3.2. Effective tillers hill^{-1}

Effective tillers hill^{-1} showed statistically significant differences due to different planting dates (Table 1). The maximum number of effective tillers hill^{-1} (13.47) was found from 24th January planting and the minimum number of effective tillers hill^{-1} (11.40) was observed from 23rd February planting. This result reveals the findings of Hussain *et al.* (2005) and Shah (2001) who reported that the maximum number of panicle was produced by line transplanted method in early transplanting. This might be due to adaptation with climate, well-adopted root system and well-adopted leaf structure and canopy having optimum light absorption, nutrients uptake and synthesis of more carbohydrates.

Statistically, significant variation was recorded in terms of effective tillers hill^{-1} due to different rice varieties (Table 1). The maximum number of effective tillers hill^{-1}(13.33) was recorded from Heera 2, while the minimum number of effective tillers hill^{-1} (10.50) was found from BRRI dhan29. Khalifa (2009) reported that H_1 hybrid rice variety surpassed other varieties in consideration of effective tillers hill^{-1}. Murthy *et al.* (2004) recorded a different number of filled spikelets for the different variety.

Interaction effect of different planting dates and rice varieties showed statistically significant differences on effective tillers hill^{-1}(Table 2). The maximum number of effective tillers hill^{-1} (14.67) was recorded from treatment combination of 24th January planting with Heera 2 and the minimum number of effective tillers hill^{-1} (10.00) was observed from treatment combination of 23rd February planting with BRRI dhan29.

3.3. Filled grains panicle^{-1}

Filled grains panicle^{-1} showed statistically significant differences due to different planting dates (Table 1). The maximum filled grains panicle^{-1}(80.73) was recorded from 24th January planting and the minimum filled grains panicle^{-1}(74.20) was found from 23rd February planting. These results resemble the findings of Akram *et al.* (2007) who reported that the number of kernels panicle^{-1}was significantly affected as sowing date is delayed. Khalifa (2009) found that early date of sowing (20th April) is the best time of sowing for the number of grains per panicle and sowing in 1st June has given the lowest value.

Statistically, significant variation was recorded in terms of filled grains panicle^{-1} due to different rice varieties (Table 1). The highest filled grains panicle^{-1}(83.17) was observed from Heera 2, while the lowest filled grains panicle^{-1}(63.00) was recorded from BRRI dhan29. Obulamma *et al.* (2004) recorded the highest number of filled grain panicle^{-1}in hybrid APHR 2 than hybrid DRRH 1. Hosain *et al.* (2014) observed that hybrid rice varieties Heera 2 and Aloron produced the highest number of spikelets panicle^{-1}than that of BRRI dhan48.

Interaction effect of different planting dates and rice varieties showed statistically significant differences on filled grains panicle^{-1}(Table 2). The highest filled grains panicle^{-1} (90.33) was recorded from treatment

combination of 24th January planting with Heera 2 and the lowest filled grains panicle^{-1} (61.33) was found from treatment combination of 23rd February planting with BRRI dhan29.

3.4. Weight of 1000-grain

The weight of 1000-grain showed statistically significant differences due to different planting dates (Table 1). The maximum weight of 1000-grain (23.71 g) was recorded from 24th January planting and the minimum weight of 1000-grain (22.74 g) was found from 23rd February planting. The heavier grains with earlier planting might be due to prolong growing and grain filling period which enable the plant to produce bold and plump grains. These results are in conformity with the findings of Rizzardi *et al.* (1994) who reported the reduction in 1000-grain weight with the delay in sowing date. Khalifa (2009) found that early date of sowing (20th April) is the best time of sowing for 1000 grain weight (g) and sowing in 1st June has given the lowest value.

Statistically, significant variation was recorded in terms of weight of 1000-grain due to different rice varieties (Table 1). The highest weight of 1000-grain (25.14 g) was observed from Heera 2, while the lowest weight of 1000-grain (20.62 g) was recorded from BRRI dhan29. Wang *et al.* (2006) reported that compared with conventional cultivars, the hybrids had heavier seeds. Supporting results were found by Rahman *et al.* (2002), and Singh and Gongwer (1989).

Interaction effect of different planting dates and rice varieties showed statistically significant differences in weight of 1000-grain (Table 2). The highest weight of 1000-grain (25.76 g) was recorded from treatment combination of 24th January planting with Heera 2and the lowest weight of 1000-grain (20.37 g) was found from treatment combination of 23rd February planting with BRRI dhan29.

3.5. Grain yield

Grain yield showed statistically significant differences due to different planting dates (Table 1). The maximum grain yield (4.00 t ha^{-1}) was observed from 24th January planting and the minimum grain yield (3.53 t ha^{-1}) was recorded from 23rd February planting. These results support the findings of Shah and Bhurer (2005) also reported that June 15 seeding recorded significantly the highest paddy yield and decreased with the delay in planting time. In the same way, Iqbal *et al.* (2008) reported that the highest yield was obtained when the rice crop was sown earlier in the season.

Statistically, significant variation was recorded in terms of grain yield due to different rice varieties (Table 1). The highest grain yield (4.30 t ha^{-1}) was found on Heera 2, while the lowest grain yield (2.95 t ha^{-1}) was observed from BRRI dhan29. These results agree with the results of Wang *et al.* (2006) reported that compared with conventional cultivars, the hybrids had larger panicles, heavier seeds, resulting in an average yield increase of 7.27%. Kanfany *et al.* (2014) reported that the grain yield of rice hybrids (bred by the International Rice Research Institute) was not significantly higher than that of the check cultivar. Swain *et al.* (2006) reported that the control cultivar IR64, with high translocation efficiency and 1000-grain weight and lowest spikelet sterility, recorded a grain yield of 5.6 t ha^{-1} that was statistically similar to the hybrid line PA6201. Xie *et al.* (2007) reported a different yield for the different variety.

Interaction effect of different planting dates and rice varieties showed statistically significant differences on grain yield (Table 2). The highest grain yield (4.64 t ha^{-1}) was recorded from treatment combination of 24th January planting with Heera 2 and the lowest grain yield (2.83 t ha^{-1}) was recorded from treatment combination of 23rd February planting with BRRI dhan.

3.6. Straw yield

Straw yield showed statistically significant differences due to different planting dates (Table 1). The maximum straw yield (4.86 t ha^{-1}) was found from 24th January planting, whereas the minimum straw yield (3.67 t ha^{-1}) was recorded from 23rd February planting. Jalil *et al.* (2016) found that transplanting dates induced significant straw yield variation in the varieties. The results reveal that straw yield was maximum on 30th July transplantation and thereafter straw yield gradually declined with the subsequent delay in planting until last transplantation on 15th September.

Statistically, significant variation was recorded in terms of straw yield due to different rice varieties (Table 1). The highest straw yield (5.21 t ha^{-1}) was observed from Tia which was statistically similar (5.06 t ha^{-1}) to Heera 2, while the lowest straw yield (4.06 t ha^{-1}) was recorded from BRRI dhan29. Patel (2000) observed significantly higher grain and straw yield from Kranti than IR36. Jalil *et al.* (2016) found that high straw yield in the hybrid variety compared to the inbred could be attributed to its long-lasting (till maturity) greenness in leaves which might favor the high accumulation of dry matter through photosynthesis till harvesting.

Interaction effect of different planting dates and rice varieties showed statistically significant differences on straw yield (Table 2). The highest straw yield (5.42 t ha^{-1}) was recorded from treatment combination of 24th January planting with Tia and the lowest straw yield (4.05 t ha^{-1}) was found from treatment combination of 23rd February planting with BRRI dhan29.

3.7. Biological yield

Biological yield showed statistically significant differences due to different planting dates (Table 1). The maximum biological yield (8.86 t ha^{-1}) was recorded from 24th January planting and the minimum biological yield (8.20 t ha^{-1}) was found from 23rd February planting. Hosain *et al.* (2014) showed that biological yield shows a decreasing trend with delayed transplanting.

Statistically, significant variation was recorded in terms of biological yield due to different rice varieties (Table 1). The highest biological yield (9.43 t ha^{-1}) was observed from Tia which was statistically similar (9.35 t ha^{-1}) to Heera 2, while the lowest biological yield (7.01 t ha^{-1}) was recorded from BRRI dhan29. Kainth and Mehra (1985) reported that when transplanting is delayed beyond the normal period, the brain development is very poor which results in more quantity of underdeveloped grains and ultimately severe reduction in yield.

Interaction effect of different planting dates and rice varieties showed statistically significant differences on biological yield (Table 2). The highest biological yield (9.79 t ha^{-1}) was recorded from treatment combination of 24th January planting with Tia and the lowest biological yield (6.88 t ha^{-1}) was found from treatment combination of 23rd February planting with BRRI dhan29.

3.8. Harvest index

Harvest index showed statistically significant differences due to different planting dates (Table 1). The maximum harvest index (44.99%) was recorded from 24th January planting, whereas the minimum harvest index (42.94%) was observed from 23rd February planting. Jalil *et al.* (2016) found that high HI was recorded from the transplanting on July 30 and the lowest from September 15. This might correspond to high grain yield from former planting and low grain yield from later planting

Statistically, significant variation was recorded in terms of harvest index due to different rice varieties (Table 1). The highest harvest index (45.89%) was observed from Heera 2, while the lowest harvest index (42.09%) was found from BRRI dhan29. The result reported by Karmakar *et al.* (2002) was similar to the present findings.

Interaction effect of different planting dates and rice varieties showed statistically significant differences on harvest index (Table 1). The highest harvest index (48.38%) was observed from treatment combination of 24th January planting with Heera 2 and the lowest harvest index (41.14%) was recorded from treatment combination of 23rd February planting with BRRI dhan29.

Table 1. Effect of planting dates and variety on yield and yield contributing characters of rice.

Treatment	Panicle length (cm)	Effective tillers $hill^{-1}$ (No.)	Filled grains $panicle^{-1}$ (No.)	Weight of 1000-grain (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological Yield (t ha^{-1})	Harvest index (%)
Planting time								
24th January planting	23.43 a	13.47 a	80.73 a	23.71 a	4.00 a	4.86 a	8.86 a	44.99 a
23rd February planting	22.52 b	11.40 b	74.20 b	22.74 b	3.53 b	3.67 b	8.20 b	42.94 b
$LSD_{(0.05)}$	0.56	0.30	2.52	0.61	0.15	0.18	0.24	1.48
CV(%)	5.84	3.43	4.64	5.73	5.55	4.97	3.72	4.39
Variety								
BRRI dhan29	20.47 c	10.50 c	63.00 b	20.62 d	2.95 d	4.06 d	7.01 d	42.09 c
BRRI hybrid 2	23.21 ab	12.50 b	79.00 a	23.73 b	3.51 c	4.69 c	8.20 c	42.84 bc
Heera 2	24.64 a	13.33 a	83.17 a	25.14 a	4.30 a	5.06 ab	9.35 a	45.89 a
Tia	23.53 ab	13.00 ab	81.67 a	24.06 b	4.21 a	5.21 a	9.43 a	44.71 ab
Taj 1	23.02 b	12.83 ab	80.50 a	22.56 c	3.84 b	4.81 bc	8.65 b	44.29 abc
$LSD_{(0.05)}$	1.12	0.52	4.36	1.05	0.25	0.29	0.39	2.34
CV(%)	5.84	3.43	4.64	5.73	5.55	4.97	3.72	4.39

In a column means having the similar letter(s) are statistically similar and those having the dissimilar letter(s) differ significantly at 0.05 level of probability

Table 2. Interaction effect of planting dates and variety on yield and yield contributing characters of rice.

Treatment	Panicle length (cm)	Effective tillers hill^{-1} (No.)	Filled grains panicle^{-1} (No.)	Weight of 1000-grain (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
24th January planting x								
BRRI dhan29	20.67 d	11.00 d	64.67 d	20.88 c	3.07 ef	4.07 f	7.14 ef	43.05 bc
BRRI hybrid 2	22.85 c	13.33 b	82.00 bc	23.38 b	3.53 d	4.50 de	8.03 cd	43.89 bc
Heera 2	25.23 a	14.67 a	90.33 a	25.76 a	4.64 a	4.95 bc	9.59 ab	48.38 a
Tia	23.92 bc	14.00 ab	85.00 ab	24.48 ab	4.37 ab	5.42 a	9.79 a	44.64 bc
Taj 1	24.49 ab	14.33 a	81.67 bc	24.03 b	4.38 ab	5.35 ab	9.73 a	45.00 b
23rd February planting x								
BRRI dhan29	20.26 d	10.00 e	61.33 d	20.37 c	2.83 f	4.05 f	6.88 f	41.14 c
BRRI hybrid 2	23.58 bc	11.67 cd	76.00 c	24.08 b	3.50 d	4.87 cd	8.37 c	41.79 bc
Heera 2	24.06 ab	12.00 c	76.00 c	24.53 ab	3.95 c	5.16 abc	9.11 b	43.39 bc
Tia	23.14 b	12.00 c	78.33 bc	23.64 b	4.05 bc	5.01 abc	9.06 b	44.78 bc
Taj 1	21.54 cd	11.33 cd	79.33 bc	21.08 c	3.29 de	4.27 ef	7.56 de	43.57 bc
$LSD_{(0.05)}$	1.83	0.73	6.17	1.49	0.36	0.41	0.55	3.314
CV(%)	5.84	3.43	4.64	5.73	5.55	4.97	3.72	4.39

In a column means having the similar letter(s) are statistically similar and those having the dissimilar letter(s) differ significantly at 0.05 level of probability

4. Conclusions

From the above summary of the study, it can be concluded that among the five rice varieties, Heera 2 demonstrated the best performance on yield and yield contributing attributes at different planting dates. The 24th January planting of seedling increased the panicle length, effective tillers hill^{-1}, filled grains panicle^{-1}, 1000-grain weight, grain yield, straw yield, biological yield and harvest index (%). were 4.04%, 18.16%, 8.80%, 4.27%, 13.31%, 32.43%, 8.05% and 4.77%, respectively over the 23rd February planting. Finally, 24th January transplanting with Heera 2 exhibited the superior combinations than most the parameters studied. However, further study may be needed regarding the other rice varieties with different management practices in different Agro-Ecological Zones (AEZ) of Bangladesh for testing the regional compliance and other quality attributes.

Conflict of interest

None to declare.

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