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PERFORMANCE OF TWO AMAN RICE VARIETIES USING VARYING PLANT DENSITY IN THE NORTHEASTERN REGION OF BANGLADESH

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Abstract

The experiment was conducted to assess the performance of two popular rice varieties with varying spacing at a farmer's field in Darbost union of Jaintapur Upazila under the Sylhet district of Bangladesh during aman season 2016. Two aman rice varieties (BRRI dhan34 and Binadhan-17), and four levels of plant density (15×10 cm, 20×10 cm, 20×15 cm, and 25×15 cm) were tested in a factorial randomized complete block design (RCBD) with three replications. The results indicated that yield and yield attributes of rice differed significantly due to varieties, spacing, and their interaction. It was recorded that var. Binadhan-17 showed maximum flag leaf length (34.33 cm), maximum number of filled grains m^{-2} (27855), maximum grain weight m^{-2} (654.58) contributed to increase grain yield (6.55 t ha^{-1}) in closer spacing (20×10 cm), which ultimately increased grain yield. Therefore, the results of the present study suggested that rice var. Binadhan-17 could be transplanted at 20×10 cm spacing for getting maximum yield (6.55 t ha^{-1}) in northeastern region of Bangladesh.

Introduction

In Bangladesh, approximately 11.61 million hectares land is under rice cultivation and producing 36.28 million tons (BBS, 2019). In 2018-19, the country acquired a rice surplus of about 2 MT (BBS, 2019). Therefore, exporting rice from the current surplus as well as maintaining the productivity and quality is a great challenge for the rice growers in the coming decades, where the high yielding could be an option.

The aromatic rice is known for its quality, fragrance, and demand in the domestic as well as international markets (Bajpai and Singh, 2010). But the fact is that farmers preferred coarse and medium rice varieties, whereas a minimal land space is covered by the fine and aromatic rice varieties (Bajpai and Singh, 2010). Due to a higher price, the aromatic rice is gaining popularity in Bangladesh. Some locally adapted varieties like Chinigura, Kalizira, and Kataribhog, etc. are covering rice-growing areas. Bangladesh Rice Research Institute (BRRI) and Bangladesh Institute of Nuclear Agriculture (BINA) has released some high yielder aromatic rice varieties like BRRI dhan34 and Binadhan-17 for the aman season.

Although the average yield per unit area increased, but, there is a wide yield gap between farmers' fields and on- station research results. This yield gap could be attributed to either the endogenous drivers, like genetic makeup and agronomic practices (Imade *et al.*, 2015) or exogenous forces like climatic condition, which affects the genetic capability (Lesk *et al.*, 2016).

Some previous reports suggested that, a suitable variety is an important key to produce a higher return, together with a proper spacing, which plays a vital role in increasing growth development and yield of a specific rice variety to a great extent (Rahman *et al.*, 2007; Thakur *et al.*, 2009; Bozorgi *et al.*, 2011). A sufficient spacing increases the performance of individual plants, while improper spacing reduced yield up to 20-30% (IRRI, 1997). An optimum spacing ensures proficient exploitation of solar radiation and nutrients (Mohaddesi *et al.*, 2011). In contrast, beyond the optimum level, severe competitions (for light, nutrients, and water) slow down plant growth and decrease grain yield (Bozorgi *et al.*, 2011). Considering these facts, the study was carried out with the objectives to find out the variety specific spacing for maximizing yield and yield contributing characters of transplanted Aman rice.

Materials and Methods

Experimental site and climatic conditions

The experiment was conducted at a farmer's field at Darbost union of JaintapurUpazila, Sylhet. The geographical location of the experimental plot lies between 24°59' and 25°11' north latitudes and in between 92°03' and 92°14' east longitudes at an elevation of 30m above the sea level. The experimental area was situated under sub-tropical climate, characterized by the heavy rainfall during Kharif season (April to September), and lower in Rabi season (October to March). The soil of the experimental site was sandy loam having medium fertility, belongs to the "Khadimnagar" series under eastern Surma-Kushiyara floodplain (FRG,2012). The soil contains 1.45% organic matter, 0.8% N, 0.07 m mol K, 25 µg P and 10 µg S per 100 gof soil with a pH value of 5.0.

Experimental treatments and design

The experiment included two factors, factor A-two varieties viz. BRRI dhan34 (V_1) and Binadhan-17 (V_2), and factor B- four spacing viz. 15×10 cm (S_1), 20×10 cm (S_2), 20×15 cm (S_3), 25×15 cm (S_4); laid out in a factorial randomized complete block design (RCBD factorial) with three replications.

Input use and intercultural operations

A piece of land was selected as nursery bed for raising seedlings. The experimental field was ploughed with a power tiller. Weeds, stubbles and residues were removed and cleaned from the field. Ploughing and cross ploughing was done thrice followed by laddering to prepare the land. The recommended fertilizers dose was $N_{80}P_{30}K_{40}S_{10}Zn_{25}$ ha^{-1} according to SRDI, Sylhet. One third of the urea and the whole amount of triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulfate were applied as basal dose at the time of final land preparation and thoroughly incorporated into the soil. After uprooting the seedlings were similar sized 23 days old seedlings transplanted at the rate of three seedlings $hill^{-1}$ maintaining spacing as per treatments. The rest of the urea fertilizer was applied in two equal splits; one at the maximum vegetative growth stage at 30 days after transplanting (DAT), and another at 45 DAT before panicle initiation stage. Weeding was done at 30 DAT in order to keep the crop weed free. Irrigation water was applied during the cropping season as when necessary. Plant protection measures were done as per requirements.

Sampling, harvesting and processing

Hills from the middle portion (1×1 m) of each unit plot excluding border rows were randomly selected soon after transplanting and marked with bamboo sticks for determining growth parameters as well as yield and yield components. The crop was harvested at full maturity confirming 80% golden yellow colored grains. After harvested the sampled area the crop of each plot was separately bundled, properly tagged and then brought to the threshing floor. After drying, the grains 14% moisture level was confirmed in the grains. The straws are also sun dried.

Data measurements

The data on the plant height, flag leaf length, panicle length, the number of panicles, productive tillers and ineffective tillers were collected before harvesting. The data on filled, empty grain was counted from randomly selected 20 panicles from different random hills. Thousands grain weight, grain yield, and straw yield were measured by an electric balance after the drying process.

Harvest index is basically the ratio of grain yield to total above ground biomass. Finally harvest index was calculated according to the following equation (Karki et al., 2018).

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Above ground biomass}} \times 100$$

Statistical Analysis

The recorded data were compiled and analyzed statistically using Statix10 computer package program and the analysis of variance were separated for significant difference by LSD test at 5% level of probability.

Results and Discussion

Effect of spacing on growth parameters of rice varieties

Significant variations were observed between two varieties, BRRI dhan34 attains maximum plant height (126.08 cm) whereas Binadhan-17 was shorter (81.83 cm). (Table 1). Similarly, plant spacing influences the plant height significantly. Among the four spacing; tallest plant (111.50 cm) was recorded at 15×10 cm spacing, while, the shortest plant (94.50 cm) from 25×15 cm spacing (Table 1). The combined effect of variety and spacing showed a significant variation where highest plant height (135.00 cm) was obtained from BRRI dhan34 planted at 15×10 cm spacing.. Contrary the lower plant height (75.67 cm) was obtained when Binadhan-17 planted at widest spacing (25×15 cm), which was statistically similar with Binadhan-17 (80.33cm) planted at 20×15cm spacing

The flag leafof Binadhan-17 produced the longest flag leaf (32.58cm) in comparison to BRRI dhan34 (22.58 cm) (Table 1). On the other hand, maximum flag leaf (29.00cm) was observed at 20×15cm spacing, which was statistically similar with 20×10 cm (28.83cm) and 15×10 cm (26.83cm) spacing while, the shortest flag leaf (25.67cm) at wider spacing (25×15cm) (Table 1). Maximum flag leaf length (34.33cm) was recorded from Binadhan-17 planted at 20×10 cm spacing. On the other hand shortest flag leaf (19.67cm) was found from BRRI dhan34 planted in a spacing of 25×15cm. Furthermore, grain yield is positively correlated to the length, width, and area of flag leaf (Rahman *et al.*, 2013). In our study, BRRI dhan34 produced the maximum flag leaf length at wider spacing (20×15 cm) but Binadhan-17 produced maximum flag leaf length at closer spacing (20×10 cm), which might be attributed to the genetic makeup of the varieties.

Table 1. Individual effect of varieties and spacing on plant height, flag leaf length, panicle length and number of panicle m^{-2} of rice

Treatments	**Plant height (cm)**	**Flag leaf length (cm)**	**Panicle length (cm)**	**Panicle (No. m^{-2})**
Variety				

BRRI dhan34	126.08±3.69 a	22.58 ±0.80 b	24.17 ±0.29a	265.73 ±3.02 a
Binadhan-17	81.83 ±2.75 b	32.59 ±0.52 a	19.92 ± 0.38b	265.95 ±3.53 a
$LSD_{(0.05)}$	1.84	1.33	1.48	5.73
Spacing				
15×10 cm	111.50 ±3.97 a	26.833±0.58 ab	23.00 ±1.73 a	334.00 ±4.58 a
20×10 cm	106.50 ±3.78 b	28.833 ±0.29 a	22.00 ±1.00 a	311.67 ±3.82 b
20×15 cm	103.33 ±1.90 b	29.000 ±1.32 a	21.83 ± 0.76 a	232.50 ± 1.5 c
25×15 cm	94.50 ±2.65 c	25.667 ±1.44 b	21.33 ± 0.76 a	185.20 ±1.83 d
$LSD_{(0.05)}$	3.52	2.55	2.83	10.98

Means with dissimilar letters are significantly different at $P \leq 0.05$ at LSD test.

Both maximum number of paniclesm^{-2} (265.95) and length of panicles were also high (24.17 cm) in Binadhan-17 compared to BRRI dhan34 (265.73) and (19.92cm), respectively (Table 1). Notably, panicle length was not affected due to varied spacing, whereas, maximum number of panicle (334.00) was recorded at 15×10 cm spacing, where the lowest (185.20)at the wider spacing (25×15 cm) (Table 1). Moreover, BRRI dhan34 produced the longest panicle (25.33cm) when grown under 15×10 cm spacing, while Binadhan-17 at 20×15cm and 25×15cm spacing produced the shortest panicle (19.33cm).Combined effect of variety and spacing also showed that Binadhan-17 produced the highest number of panicles m^{-2} (336.00) when planted by 15×10 cm, which was similar to BRRI dhan34 (332.00) planted by 15×10 cm spacing. On the other hand BRRI dhan34 planted 25×15 cm spacing produced the lowest number of panicles m^{-2} (181.60) planted 25×15 cm spacing, which was statistically similarto Binadhan-17 (188.80) planted 25×15 cm spacing. On the other hand BRRI dhan34 produced longer panicle compared to Binadhan-17, which might be due to genetic makeup of the variety. Therefore, the result of our study corroborates with the findings of previous reports (Sarker, 2012; Ali *et al.*, 2014; Hossain *et al.*, 2014; Shiyam *et al.*, 2014).

Effect of spacing on yield attributes of rice varieties

Both the varieties were indifferent regarding number of productive and infertile tillers hill^{-1}. Binadhan-17 produced higher number of productive tillers hill^{-1} (6.84) but lower number of infertile tillers hill^{-1} (3.34). On the other hand BRRI dhan34 produced lower number of productive tillers hill^{-1} (6.79) but higher number of infertile tillers hill^{-1} (3.52) (Table 2). The maximum number of productive tillers hill^{-1} (7.75) was found at 20×15 cm spacing followed by 25×15 cm spacing (7.72) and the lowest number of productive tillers hill^{-1} (5.57) at 15×10 cm spacing. The result also shows that maximum number of sterile tillers hill^{-1} (4.30) was found at 15×10 cm spacing followed by 20×10 cm (3.97) spacing and the lowest number of sterile tillers hill^{-1} (2.58) at 25×15 cm spacing (Table2). In case of interaction effects, Binadhan-17 recorded maximum number of productive tillers (7.87) planted 25×15 cm but was statistically at par with (7.80) planted 20×15cm, and BRRI dhan34 (7.70) planted 20×15cm. Contrary the lowest number of Effective tillers (5.53 was found at BRRI dhan34 planted 15×10 cm. Again, maximum number of infertile tillers (4.50) was recorded at BRRI dhan34 with

15×10 cm, which is statistically at par with Binadhan-17 (4.20) with 20×10 cm and 15×10 cm (4.10). On the other side Binadhan-17 produced the lowest number of sterile tillers (2.33) with 20×15 cm.

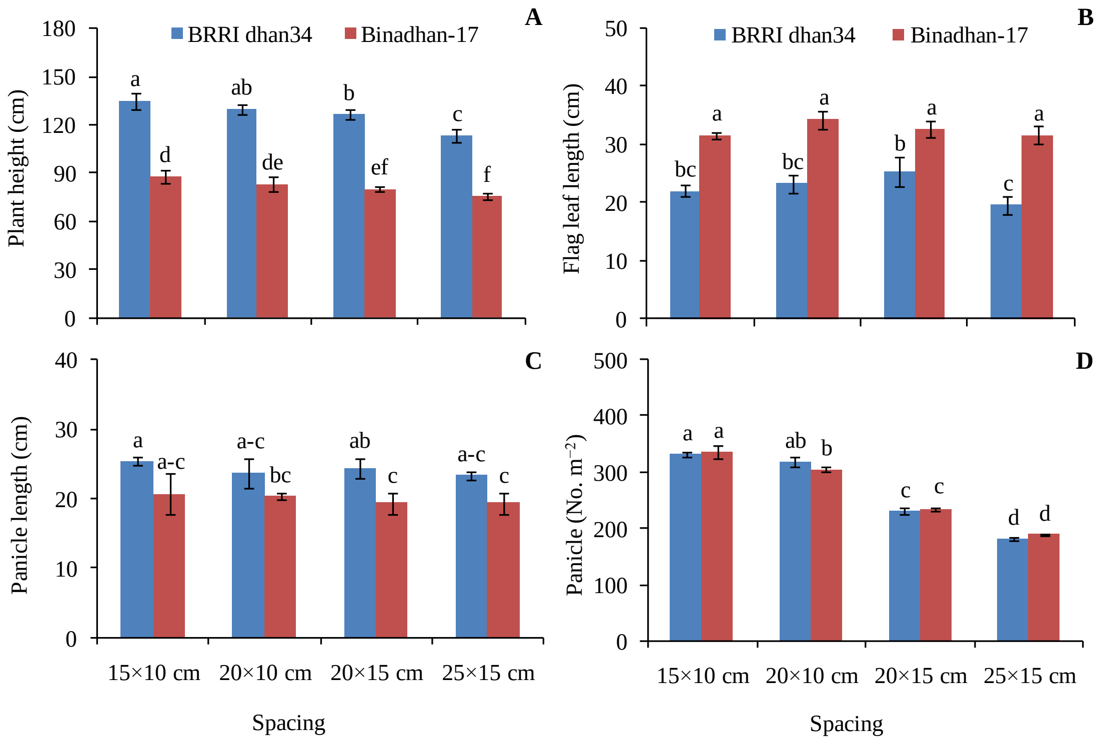

Fig.1. Combined effect of varieties and spacing on plant height, flag leaf length, panicle length and number of panicle m^{-2} of rice. Means with dissimilar letters are significantly different at $P \leq 0.05$ by LSD test.

Table 2. Individual effect of varieties and spacing on number of productive tillers $hill^{-1}$, number of sterile tillers $hill^{-1}$, number of filled and empty grains $panicle^{-1}$ of rice

Treatments	**Effective tillers (No. hill^{-1})**	**Infertile tillers (No. hill^{-1})**	**Filled grains (No. panicle^{-1})**	**Empty grains (No. hill^{-1})**
Variety				
BRRI dhan34	6.79 ±0.07a	3.53 ± 0.07a	71.42 ± 1.23b	50.67 ±1.01a
Binadhan-17	6.84 ± 0.06a	3.34 ±0.09a	84.41 ± 0.52a	40.58 ±1.18b
LSD (0.05)	0.13	0.21	2.51	2.75
Spacing				
15×10 cm	5.57 ±0.08 c	4.30 ±0.09 a	54.50 ±2.78c	67.83 ±1.04a
20×10 cm	6.23 ±0.08b	3.97 ±1.76a	76.00 ±0.5b	50.17 ±1.04b
20×15 cm	7.75 ±0.05a	2.88 ±1.19b	90.33 ±2.57a	36.00 ± 2.29c
25×15 cm	7.72 ± 0.08a	2.58 ±0.10b	90.83 ±2.84a	28.50 ±2.78d
LSD (0.05)	0.25	0.40	4.80	5.28

Means with dissimilar letters are significantly different at $P \leq 0.05$ by LSD test.

Binadhan-17 produced higher number of filled grain panicle^{-1} (84.42) but lower number empty grain panicle^{-1} (40.58). On the other hand lower number of filled grain panicle^{-1} (71.41) and higher number of empty grain panicle^{-1} (50.67) was recorded from BRRI dhan34 (Table 2). Maximum number of filled grain panicle^{-1} (90.83) was noticed at 25×15 cm spacing, which was statistically similar with 20×15 cm spacing (90.33), but the lowest number of filled grain panicle^{-1} (54.50) at 15×10 cm spacing. Moreover, maximum number of empty grain hill^{-1} (67.83) was recorded at 15×10 cm spacing, while the lowest number of empty grain hill^{-1} (28.50) was recorded at 25×15 cm spacing (Table 2).. The highest number filled grain (95.67) was obtained at Binadhan-17 with 20×15 cm and 25×15 cm but the lowest number of filled grain (54.00) with 15×10 cm. The interaction effect showed significant variation for empty grain. The highest no of empty grain (69.67) was recorded at Binadhan-17 with 15×10 cm, which is statistically similar with BRRI dhan34 (66.00) at 15×10 cm and (65.00) at 20×10 cm. On the other hand the lowest number of empty grain (23.00) was recorded at Binadhan-17 than with 25×15 cm. In case of Binadhan-17 did not found any variation regarding number of filled grains among 20×10 cm, 20×15 cm and 25×15 cm of spacing, which might be due to the intrinsic capacity of this variety under the competitive condition for natural resources (water, nutrients, air and light). On the other hand number of empty grains increased drastically under closer spacing in BRRI dhan34. Sarker *et al.* (2002) found that under increased number of plants per unit area under closer spacing reduced the number of grains per panicle as well as increased the number of empty grains, which supports the results (Figure2).

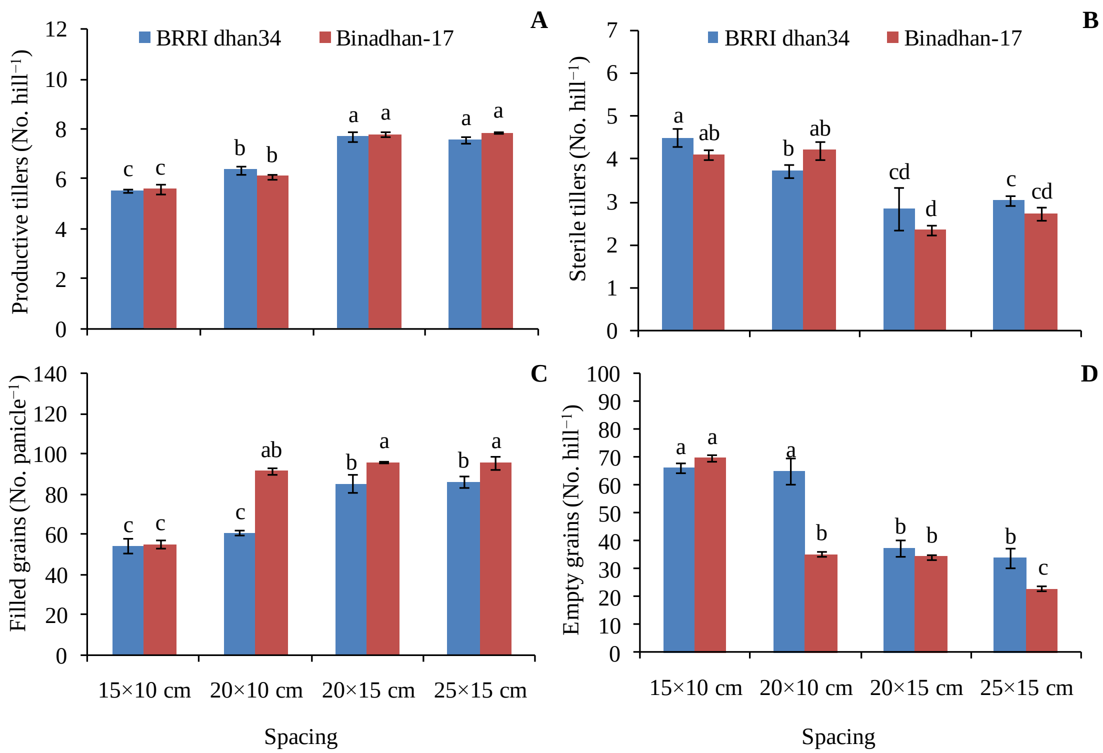

Fig. 2. Combined effect of varieties and spacing on number of productive tillers hill^{-1}, number of sterile tillers hill^{-1}, number of filled and empty grains panicle^{-1} of rice. Means with dissimilar letters are significantly different at P ≤ 0.05 by LSD test.

Effect of spacing on grain weight, yield and harvest index of rice.

Grain weight is one of the important factors for increasing rice grain yield (Huang *et al.*, 2013). Thousands grain weight of any variety is dependent on both grain size and grain filling rate. Although grain size is regulated by genetic factors, grain filling rate is governed by the macro and micro climate of the field (Xie *et al.*, 2015). Binadhan-17 had statistically heavier thousands grain weight (23.83) than BRRI dhan34 (17.32) (Table3).. The heavier thousands grain weight (21.28g) was noticed at 25×15 cm which is statistically similar with 20×15 cm (21.23g) while lower thousands grain weight (19.42g) at 15×10 cm (Table 3). Binadhan-17 produces the same thousands grain weight (24.80g) at 20×15 cm and 25×15 cm. On the other hand, BRRI dhan34 produces the lower thousands grain weight (16.63g) at 15×10 cm.

Rice grain yield depended on the length and number of panicles, number of fertile and sterile tillers, number of filled and empty grains per panicle as well as thousand grain weights (Melkie and Takele, 2020). Varieties had significant effect on grain yield. Binadhan-17 produced statistically higher grain yield (5.17 t ha^{-1}) than BRRI dhan34 (3.14 t ha^{-1}) (Table 3). It was found that spacing had significant effect on grain yield. The highest grain yield (4.93 t ha^{-1}) was found at 20×10 cm followed by 20×15 cm (4.51 t ha^{-1}) and the lowest grain yield (3.54 t ha^{-1}) at 15×10 cm. (Table3). The interaction effect showed significant variation grain yield.Binadhan-17 produced maximum grain yield (6.55 t ha^{-1}) with 20×10 cm followed by 20×15 cm (5.55 t ha^{-1}) and the lowest grain yield (4.10 t ha^{-1}) at 15×10 cm. On the other side, BRRI dhan34 produced maximum grain yield (3.47 t ha^{-1}) with 20×15 cm followed by 20×10 cm (3.32 t ha^{-1}) and the lowest grain yield (2.77 t ha^{-1}) with 25×15 cm.Grain yield was significantly influenced by varieties and spacing. Binadhan-17 produced maximum grain yield at closer spacing (20×10 cm) but BRRI dhan34 produced maximum grain yield at wider spacing (20×15cm). In wider spacing (20×15cm) flag leaf length is maximum, maximum number of effective tiller hill^{-1}, least number of sterile tillers hill^{-1}, maximum number of filled grains m^{-2} contributed to increase grain weight m^{-2}, which ultimately increased grain yield of BRRI dhan34. Similar findings were also obtained by other researchers, who reported that an increased number of effective tillers hill^{-1}, as well as higher number of grains panicle^{-1} increased grain yield ha^{-1} (Uddin *et al.*, 2011, Shiyam *et al.*, 2014). On the other hand Binadhan-17 achieved significantly maximum flag leaf length, maximum number of filled grains m^{-2}, maximum grain weight m^{-2}, helped to increase grain yield in closer spacing (20×10 cm). Similar finding had also been reported by Bhowmick and Nayak (2000) and Boling *et al.* (2004)(Figure 3).

Table 3. Individual effect of varieties and spacing on thousands grain weight, grain and straw yield ha^{-1}, and harvest index of rice

Treatments	**Thousands grain weight (g)**	**Grain yield (t ha^{-1})**	**Straw y (t ha^{-1})**	**Harvest index (%)**
Variety				
BRRI dhan34	17.32 ±0.52b	3.1357 ±0.08b	4.7350± 0.13b	39.818 ±0.14b
Binadhan-17	23.83 ±0.04a	5.1691 ±0.04 a	7.0731±0.06a	42.097 ±0.02a
LSD (0.05)	0.12	0.11	0.19	0.30
Spacing				

15×10 cm	19.42 ±0.03c	3.5408 ±0.11c	5.3882 ±0.22c	39.480 ±0.23d
20×10 cm	20.35±0.09b	4.9334 ±0.04a	6.8551± 0.08a	41.296±0.22b
20×15 cm	21.23 ±0.03a	4.5089 ±0.11b	6.1342 ±0.18b	42.415 ±0.32a
25×15 cm	21.28 ±0.03a	3.6266 ±0.09c	5.2387 ±0.13c	40.639 ±0.04c
LSD (0.05)	0.24	0.21	0.36	0.57

Means with dissimilar letters are significantly different at $P \leq 0.05$ by LSD test.

The variety Binadhan-17 produced highest straw yield (7.07 t ha^{-1}) whereas BRRI dhan34 produced straw yield of 4.74 t ha^{-1} (Table 3).Spacing was also significantly influenced by straw yield. The highest straw yield (6.86 t ha^{-1}) was found at 20×10 cm followed by 20×15 cm (6.13 t ha^{-1}) and the lowest straw yield (5.24 t ha^{-1}) at 25×15 cm. (Table 3). The interaction effect showed significant variation on straw yield. The maximum straw yield (8.58 t ha^{-1}) was recorded at Binadhan-17 with 20×10 cm followed by 20×15 cm (7.60 t ha^{-1}) and the lowest straw yield (5.91 t ha^{-1}) with 15×10 cm. On the other hand, BRRI dhan34 produced maximum straw yield (5.13 t ha^{-1}) with 20×10 cm followed by 15×10 cm (4.87 t ha^{-1}) and 20×15 cm (4.67 t ha^{-1}) but the lowest straw yield (4.28 t ha^{-1}) with 25×15 cm. On the other hand Binadhan-17 produced higher amount of straw compared to BRRI dhan34 (Figure 3), which might be due to the genetic makeup of the variety that favored the production of maximum straw.

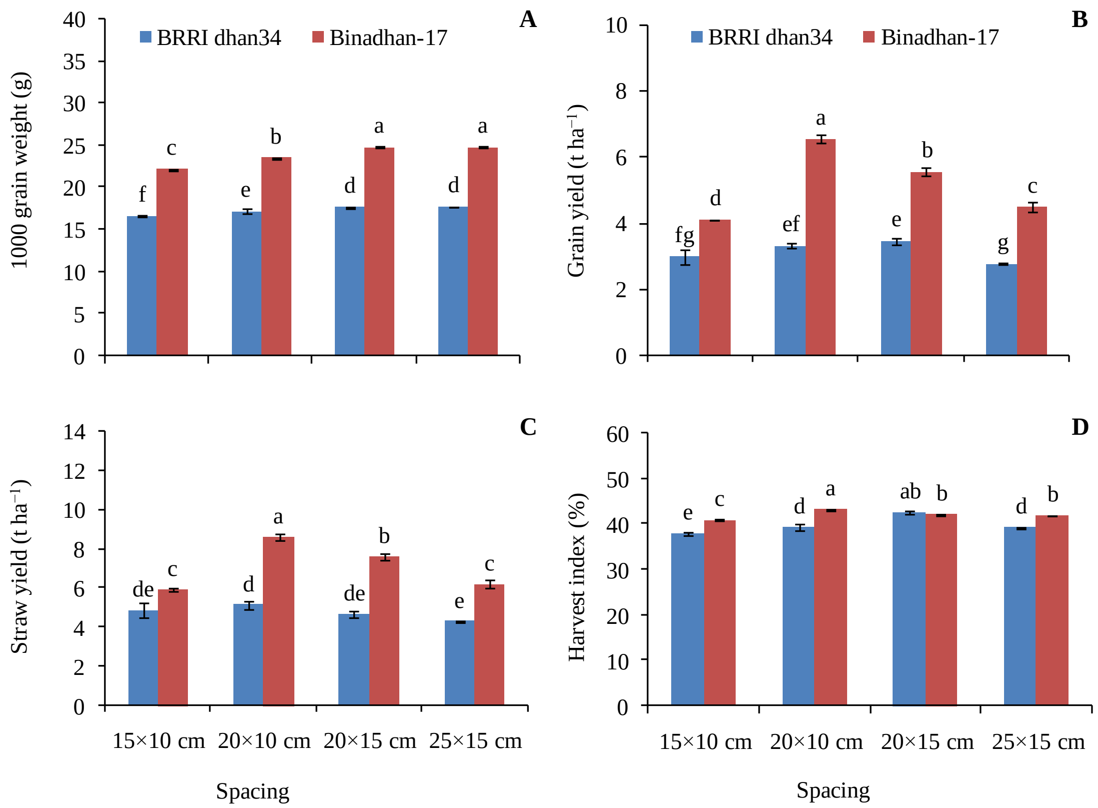

Fig. 3. Combined effect of varieties and spacing on thousands grain weight, grain and straw yield ha^{-1}, and harvest index of rice. Means with dissimilar letters are significantly different at $P \leq 0.05$ by LSD test.

The varieties with higher harvest index produced higher grain yield due to higher dry matter accumulation and partitioning into the panicles (Hay, 1995). Varieties showed significant influence on harvest index. Binadhan-17 gave higher harvest index (42.09) than BRRI dhan34 (39.82) (Table3). Maximum harvest index (42.42) was found at 20×15 cm followed by 20×10 cm (41.29) but the lowest harvest index (39.48) at 15×10 cm. (Table 3). Harvest index significantly affected by varieties and spacing. Binadhan-17 had the maximum harvest index (43.27) with 20×10 cm, which is statistically similar to BRRI dhan34 (42.62) with 20×15 cm. On the other side the lowest harvest index (38.01) was recorded at BRRI dhan34 with 15×10 cm. Moreover, the yield and harvest index differed due to genetic differences among varieties. Grain yield increases because of higher dry matter production due to maximum number of effective tillers, longest flag leaf length, maximum number of filled grain, as well as heavier grain weight. In general harvest index was higher in those rice varieties efficient in translocation of assimilates to the sink (grain) for higher economic yield (Alam *et al.*, 2009)(Figure3).

Conclusion

From the study, it is revealed that both variety and plant density are important factors for better yield of Aman rice in north- eastern region of Bangladesh. The results showed that Binadahn-17 produced higher yield compared to BRRI dhan34. Among the plant density treatments 20×10 cm and 20×15 cm spacing showed better results in terms of yield contributing characters. The interaction effect showed that Binadahn-17 produced higher yield when grown under 20×10 cm spacing, while BRRI dhan34 produced maximum yield with 20×15 cm spacing. Therefore, it can be suggested t T.aman var. Binadhan-17 could be transplanted at 20×10 cm spacing for getting maximum yield in northeastern region of Bangladesh.

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