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Response of transplant aman rice varieties to planting spacing

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ABSTRACT

The experiment was conducted at the Field Laboratory of the Department of Agriculture, Noakhali Science and Technology University (NSTU), Sonapur, Noakhali, during July to December 2017 to study the effect of variety and spacing on yield performance of transplant aman rice. The experiment consisted of three varieties *viz.* BINA dhan7, BRRI dhan56 and BRRI dhan71 and four spacings *viz.* 25 cm × 15 cm, 25 cm × 10 cm, 20 cm × 15 cm and 20 cm × 10 cm. The experiment was laid out in a randomized complete block design (RCBD) with three replications. In case of variety, the highest grain yield (4.502 t ha^{-1}) was obtained from BRRI dhan71 and the lowest grain yield (4.313 t ha^{-1}) was obtained from BINA dhan7. In case of spacing, the highest grain yield (4.701 t ha^{-1}) was obtained from 20 cm × 10 cm spacing and the lowest grain yield (4.146 t ha^{-1}) was obtained from 25 cm × 10 cm spacing. In case of interaction between variety and spacing, the highest grain yield (4.850 t ha^{-1}) was obtained from the interaction of BRRI dhan71 at 20 cm × 10 cm spacing and the lowest grain yield (3.963 t ha^{-1}) was from BINA dhan7 at 20 cm × 15 cm spacing. The study also found that among all three varieties and four spacings used in this experiment, grain yield were not significantly influenced by the interaction of variety and spacing.

Keywords: Transplant aman rice, cultivar, spacing, yield, variety

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1 Introduction

Bangladesh is predominantly an agrarian country. Due to its very fertile land and favorable weather, varieties of crops grow abundantly in this country. Agriculture sector contributes about 17 percent to the country's Gross Domestic Product (GDP) and employs more than 45 percent of total labour force (BBS, 2016).

Rice (*Oryza sativa* L.) is cultivated in Bangladesh throughout the year as Aus, Aman or Boro. Aman (broadcast and transplanted) is generally cultivated from June-July to October-November, Boro from December-January to April-May, and Aus from March-April to June-July. Rice covered an area of 11381.379 thousand hectares during the year 2015-2016 with a production of 34710 thousand metric tons. Among them aus rice covers 1018 thousand hectares with a production of 2288 thousand metric tons, aman rice covers 5590 thousand hectares with a production of 13484 thousand metric tons and boro rice covers 4773 thousand hectares with a production of 18938 thousand metric tons (BBS, 2016).

Aman rice is one of the main rice crops in Bangladesh. It is the second largest rice crop in the country in respect to the volume of production while boro rice tops the production. It is notable that the area coverage of aman rice is the largest as a single crop and boro rice remains the second. Total Aman production of 2015-16 has been estimated 1,34,83,437 metric tons compared to 1,31,90,163 metric tons of 2014-15 which is 2.22% higher. And it covers 55,90,340

hectares of land area. Average yield rate of Aman for the Financial Year 2015-16 has been estimated 2.412 metric tons per hectare which is 1.13% higher than that of last year (BBS, 2016).

Variety is an important factor in order to obtain high yield. Yield components are directly related to the variety and the neighboring environments in which it grows (Tyeb et al., 2013). Optimum plant spacing is also another important factor to obtain higher yield. Plant spacing directly affects the normal physiological activities through intra-specific competition (Oad et al., 2001). Optimum spacing allows plant populations to utilize solar radiation and nutrients efficiently. When the planting density exceeds an optimum level, competition among plants for light above ground or for nutrients below the ground become severe, consequently the plant growth slows down and the grain yield decreases (Hossain et al., 2003; Rashid et al., 2007). Closer plant spacing results in more competition among plants for air, light and nutrients. It also hampers the intercultural operations, as a result plants become weaker and thinner and finally yield is reduced. The tillering habit and production of grains panicle^{-1} depends to a great extent on the spacing of transplanting which is responsible for the variation of yield in rice (Tyeb et al., 2013).

In the southern part of Bangladesh, local varieties are being cultivated more than modern varieties. The farmers of this region usually do not maintain optimum plant spacing and seed rate. As a result, they are not getting proper yield due to lack of proper information on spacing and varieties. Although various experiments on spacing of rice have been carried out in Bangladesh and other parts of the world, it is still important to find out the suitable spacing for obtaining maximum yield. The optimum plant density was found to be well designated to obtain high yield. Improper spacing reduces the yield up to 20-30 per cent (IRRI, 1977). Therefore, the study was undertaken to find out the effect of variety, spacing and their interaction on yield performance of transplant aman rice.

2 Materials and Methods

2.1 Description of experimental site

The experiment was carried out at the Field Laboratory of the Department of Agriculture, Noakhali Science and Technology University (NSTU), Sonapur, Noakhali, during the period from July 2017 to December 2017. Geographically the experimental field was located at 22°47′33.8″N, 91°6′8.0″E. The experimental field belongs to the agro-ecological zone of the Young Meghna Estuarine Floodplain (AEZ-18). The experiment field was almost level land having sandy loam soil and was moderately alkaline. The soils become saline in dry season.

2.2 Experimental treatments and design

The experiment consisted of three varieties *viz.* BINAdhan7, BRRI dhan56 and BRRI dhan71 and four spacings *viz.* 25 cm × 15 cm, 25 cm × 10 cm, 20 cm × 15 cm and 20 cm × 10 cm. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The size of the unit plot was 4.0 m × 2.5 m, having an area of 10 m^2. Twelve treatment combinations were randomly assigned in each replication. Total number of plots was 36. A spacing of 1.0 m in between the replications and 0.5 m in between the unit plots were maintained.

2.3 Conduction of the experiment

Seedlings were raised in well prepared nursery bed at the Field Laboratory of Department of Agriculture, NSTU, Noakhali. The experimental land was first opened with a power tiller on 08 August 2017. Later on, the land was prepared by ploughing and cross-ploughing and subsequently leveled by laddering. All weeds and stubble were removed from the land by hand. The field layout was done according to the experimental design. The field was fertilized with urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate at the rate of 180, 100, 60, 70 and 8 kg ha^{-1} respectively as the source of nitrogen, phosphorus, potassium, sulphur and zinc. The entire amounts of triple super phosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate were applied at the time of final land preparation. Urea was applied as top dressing in three equal splits at 15, 30 and 45 days after transplanting (DAT). Thirty days old seedlings were uprooted from the nursery bed carefully and then transplanted to the main field on 15 August 2017 at the rate of two seedlings hill^{-1} maintaining spacing as per experimental treatments. Intercultural operations were done in order to ensure and maintain the normal growth of the crop. Rainfall was available throughout the whole cultivation period so there was no needed for additional irrigation.

2.4 Data collection and analysis

From each plot, five hills were selected randomly and data on individual plant parameters were recorded. Data on grain yield, straw yield, and harvest index were recorded from the whole plot. The crop was harvested at full maturity and the harvesting date was confirmed when more than 90% of the grains became golden yellow in color. Grains were then sun dried at 14% moisture level. The recorded data on yield and yield contributing characters were compiled and tabulated in proper form for statistical analyses. Analysis of variance was done with the help of MSTAT–C

computer package programme. The mean differences among the treatments were adjudged by DMRT test (Gomez and Gomez, 1984).

3 Results and Discussion

3.1 Effect of variety on yield and yield components

Effect of variety on yield and yield contributing characters of transplant aman rice has been presented in Table 1. Variety had significant influence on plant height. The tallest plant (125.1 cm) was obtained in variety BRRI dhan71 and the shortest one (102.0 cm) was obtained in BINA dhan7. Tyeb et al. (2013) conducted an experiment with four varieties of rice and reported that plant height differed significantly among the varieties. The number of total tillers hill^{-1} significantly influenced by variety of transplant aman rice. The highest number of total tillers hill^{-1} (12.28) was obtained from BINA dhan7. On the other hand, the lowest number of total tillers hill^{-1} (9.183) was found in BRRI dhan71.

Variety had significant influence on effective tillers hill^{-1}. The highest number of effective tillers hill^{-1} (12.22) was obtained from BINA dhan7. On the other hand, the lowest number of effective tillers hill^{-1} (9.017) was found in BRRI dhan71. Alam et al. (2012) observed that the number of effective tillers hill^{-1} was significantly influenced by varieties. The panicle length was not significantly influenced by variety of transplant aman rice. The longest panicle (23.85 cm) was found in BRRI dhan71. The shortest panicle (23.10 cm) was obtained from BINA dhan7 which was statistically similar with BINA dhan7. Hossain et al. (2003) conducted an experiment with rice cv. Sonar Bangla1, BRRI dhan39 and Nizershail and reported that the cultivars did not differ significantly in panicle length. Variety had significant influence on the production of number of grains panicle^{-1} of transplant aman rice. The highest number of grains panicle^{-1} (144.6) was found in BRRI dhan56, while the lowest one (113.9) from BINA dhan7. Niu et al. (2001) observed variation in grains panicle^{-1} among the varieties.

Variety exerted significant influence on the production of sterile spikelets panicle^{-1} in transplant aman rice. The highest number of sterile spikelets panicle^{-1}(39.12) was obtained from BRRI dhan71. The lowest number of sterile spikelets panicle^{-1} (26.23) was produced from BRRI dhan56. Kabir et al. (2004) reported that variety had statistically significant effects on sterile spikelets panicle^{-1}. 1000-grain weight was significantly influenced by variety. The highest 1000-grain weight (23.39 g) was found from BRRI dhan71 and the lowest one (21.73 g) from BINA dhan7. The grain yield was not significantly influenced by variety of transplant aman rice. The highest grain yield (4.502 t ha^{-1}) was obtained from BRRI dhan71, whereas the lowest grain yield (4.313 t ha^{-1}) was recorded from BINA dhan7. The highest grain yield in BRRI dhan71 might be due to the result of longest panicle and highest 1000-grain weight. Significant variation was observed in straw yield in transplant aman rice due to varieties. The highest straw yield (4.759 t ha^{-1}) was obtained from BRRI dhan71. On the other hand, the lowest straw yield (4.011 t ha^{-1}) was obtained from BINA dhan7. The highest straw yield obtained in BRRI dhan71 might be due to the tallest plant in BRRI dhan71. Rajaul (2005) stated that straw yield was significantly affected by varieties. Variety had significant effect on harvest index of transplant aman rice. The highest harvest index (51.74%) was obtained from BINA dhan7. The lowest harvest index (48.59%) was recorded from BRRI dhan71.

3.2 Effect of spacing on yield and yield components

Wider space allows the individual plants to produce more tillers but it provides the smaller number of hills per unit area which results in low grain yield (Baloch et al., 2002; Vijayakumar et al., 2005). Therefore, it is important to find out optimum plant spacing for a specific crop. Effect of spacing on yield and yield contributing components of transplant aman rice has been presented in Table 1. Plant height was not significantly influenced by spacing. S1 (25 cm × 15 cm) spacing produced the tallest plant (117.1 cm) and S3 (20 cm × 15 cm) spacing produced the shortest plant (115.0 cm). Tyeb et al. (2013) found the highest plant height from the spacing of 25 cm × 15 cm and the lowest plant height from 20 cm × 10 cm spacing.

Number of total tillers hill^{-1} was significantly influenced by spacing. The highest number of total tillers hill^{-1} (11.89) was obtained from S1 (25 cm × 15 cm) spacing. On the other hand, the lowest number of tillers hill^{-1} (9.244) was found in S4 (20 cm × 10 cm) spacing. The production of effective tillers hill^{-1} was significantly influenced by spacing. The highest number of effective tillers hill^{-1} (11.73) was obtained from S1 (25 cm × 15 cm) spacing. On the other hand the lowest number of effective tillers hill^{-1} (9.20) was found in S4 (20 cm × 10 cm) spacing. Tyeb et al. (2013) also found that spacing 25 cm × 15 cm produced the highest number of effective tillers hill^{-1} and spacing 20 cm × 10 cm produced the lowest number of effective tillers hill^{-1}. Spacing had no significant effect on panicle length. The longest panicle (23.90 cm) was found in S1 (25 cm × 15 cm) spacing and the smallest one (22.92 cm) from S4 (20 cm × 10 cm) spacing. Spacing had no significant influence on the production of number of grains panicle^{-1}. The highest number of grains panicle^{-1} (137.8) was found in S1 (25 cm × 15 cm) spacing. On the other hand, the lowest number

Table 1. Effect of variety, spacing and their interactions on yield and yield components of transplant aman rice

	Plant height (cm)	Total tillers hill^{-1} (num.)	Effect. tillers hill^{-1} (num.)	Pani. length (cm)	Grains pani.$^{-1}$ (num.)	Sterile spikel. pani.$^{-1}$ (num.)	1000-grain wt. (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harv. index (%)
Variety (V)										
BINA dhan7 (V1)	102.0b	12.28a	12.22a	23.1	113.9c	31.78b	21.73c	4.313	4.011b	51.74a
BRRI dhan56 (V2)	121.5a	9.950b	9.750b	23.4	144.6a	26.23b	22.43b	4.388	4.658a	48.61b
BRRI dhan71 (V3)	125.1a	9.183c	9.017c	23.85	129.1b	39.12a	23.39a	4.502	4.759a	48.59b
CV (%)	3.68	7.87	8.3	3.1	11.91	25.49	2.69	15.19	13.33	5.16
LS	**	**	**	NS	**	**	**	NS	**	**
Spacing (S)										
25 cm × 15 cm (S1)	117.1	11.89a	11.73a	23.9	137.8	28.04	22.58ab	4.369	4.398	49.82
25 cm × 10 cm (S2)	116.4	10.29b	10.04b	23.57	120.6	33.82	22.17b	4.146	4.334	48.87
20 cm × 15 cm (S3)	115	10.47b	10.33b	23.41	130.4	33.22	22.99a	4.389	4.377	50.1
20 cm × 10 cm (S4)	116.4	9.244c	9.200c	22.92	128	34.42	22.33b	4.701	4.754	49.8
CV (%)	3.68	7.87	8.3	3.1	11.91	25.49	2.69	15.19	13.33	5.16
LS	NS	**	**	NS	NS	NS	*	NS	NS	NS
Interactions										
V1 × S1	104.7	13.93	13.8	23.54	112.5	33.07	21.77	4.377	4.057	51.88
V2 × S1	122.3	11.2	11.2	23.3	158.4	19.07	22.7	4.523	4.53	49.8
V3 × S1	124.2	10.53	10.2	24.84	142.5	32	23.27	4.207	4.607	47.79
V1 × S2	103.3	11.87	11.73	23.28	111.4	34	21.43	4.063	3.907	50.91
V2 × S2	121.6	10.2	9.733	23.83	127.8	28	22.03	4.09	4.383	48.04
V3 × S2	124.3	8.8	8.667	23.59	122.7	39.47	23.03	4.283	4.713	47.64
V1 × S3	99.93	12.67	12.67	22.71	111.1	29.53	21.7	3.963	3.783	51.06
V2 × S3	119.7	9.533	9.2	23.68	150.4	28.53	23.43	4.463	4.587	49.35
V3 × S3	125.5	9.2	9.133	23.85	129.7	41.6	23.83	4.74	4.76	49.9
V1 × S4	100.1	10.67	10.67	22.87	120.5	30.53	22	4.777	4.957	49.02
V2 × S4	122.5	8.867	8.867	22.79	141.8	33.07	21.57	4.477	5.01	47.26
V3 × S4	126.5	8.2	8.067	23.11	121.7	19.07	23.43	4.85	4.297	53.1
CV(%)	3.68	7.87	8.3	3.1	11.91	25.49	2.69	15.19	13.33	5.16
LS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

In a column, figures with same letter (s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT); ** and * designate significant at 1% and 5% levels of probability, NS= Not significant and LS = Level of significance

of grains panicle^{-1} (120.6) was found from S2 (25 cm × 10 cm) spacing. Tyeb et al. (2013) also reported that 25 cm × 15 cm spacing produced the highest number of grains panicle^{-1}.

Spacing had no significant influence on the production of sterile spikelets panicle^{-1}. The highest number of sterile spikelets panicle^{-1} (34.42) was obtained from S4 (20 cm × 10 cm) spacing. The lowest number of sterile spikelets panicle^{-1} (28.04) was produced from S1 (25 cm × 15 cm) spacing. 1000-grain weight was significantly influenced by spacing. The highest 1000-grains weight (22.99 g) was found from S3 (20 cm × 15 cm) spacing and the lowest one (22.17 g) from S2 (25 cm × 10 cm) spacing. The results of the study reveal that spacing had no significant effect on grain yield. The highest grain yield (4.701 t ha^{-1}) was obtained from S4 (20 cm × 10 cm) spacing whereas the lowest grain yield (4.146 t ha^{-1}) was recorded from S2 (25 cm × 10 cm) spacing. Geethdevi et al. (2000) stated that higher grain yield was obtained with 20 cm × 10 cm spacing. Significant variation on straw yield was not observed in transplant aman rice due to the influence of spacing. The highest straw yield (4.754 t ha^{-1}) was obtained from S4 (20 cm × 10 cm) spacing. On the other hand the lowest straw yield (4.334 t ha^{-1}) was obtained from S2 (25 cm × 10 cm) spacing. It was found that spacing had no significant effect on harvest index. The highest harvest index (50.10%) was obtained from S3 (20 cm × 15 cm) spacing and the lowest one (48.87%) from S2 (25 cm × 10 cm) spacing.

3.3 Interaction effect of variety and spacing on yield and yield components

Interaction effect of variety and spacing on yield and yield contributing components of transplant aman rice has been presented in Table 1. Plant height was not significantly influenced by the interaction of variety and spacing. The tallest plant (126.5 cm) was found in V3 × S4 (BRRI dhan71 at 20 cm × 10 cm spacing) and the smallest plant (99.93 cm) was found in V1 × S3 (BINA dhan7 at 20 cm × 15 cm spacing). Total tillers hill^{-1} was not significantly influenced by the interaction of variety and spacing. The highest number of total tillers hill^{-1} (13.93) was found from interaction of V1 × S1 (BINA dhan7 at 25 cm × 15 cm spacing). The lowest number of total tillers hill^{-1} (8.200) was noticed at V3 × S4 (BRRI dhan71 at 20 cm × 10 cm spacing). Tyeb et al. (2013) also observed the highest number of tillers hill^{-1} with BRRI dhan46 × (25 cm × 15 cm) spacing. Number of effective tillers hill^{-1} was not significantly influenced by the interaction of variety and spacing. The highest number of effective tillers hill^{-1} (13.80) was obtained from the interaction of V1 × S1 (BINA dhan7 at 25 cm × 15 cm spacing) and the lowest number of effective tillers hill^{-1} (8.067) at V3 × S4 (BRRI dhan71 at 20 cm × 10 cm spacing).

Panicle length was not significantly influenced by the interaction of variety and spacing. The longest panicle (24.84 cm) was resulted in V3 × S1 (BRRI dhan71 at 25 cm × 15 cm spacing). The smallest panicle (22.71 cm) was obtained from V1 × S3 (BINA dhan7 at 20 cm × 15 cm spacing). Gains panicle^{-1} of transplant aman rice was not significantly influenced by the interaction of variety and spacing. The highest number of grains panicle^{-1} (158.4 cm) was recorded due to the combination of V2 × S1 (BRRI dhan56 at 25 cm × 15 cm spacing) and the lowest number of grains panicle^{-1} (111.1 cm) was observed from the combination of V1 × S3 (BINA dhan7 at 20 cm × 15 cm spacing) which was statistically similar with V1 × S2 (BINA dhan7 at 25 cm × 10 cm spacing). The interaction effect of variety and spacing showed non-significant effect on sterile spikelets panicle^{-1}. The highest number of sterile spikelets panicle^{-1} (41.60) was found from V3 × S3 (BRRI dhan71 at 20 cm × 15 cm spacing) and the lowest one (19.07) was observed from the interaction of V2×S1 (BRRI dhan56 at 25 cm × 15 cm spacing) and V3×S4 (BRRI dhan71 at 20 cm × 10 cm spacing). Tyeb et al. (2013) obtained the highest number of sterile spikelets panicle^{-1} from BRRI dhan41 at 20 cm × 10 cm spacing and the lowest number of sterile spikelets panicle^{-1} were found from BRRI dhan52 at 25 cm × 15 cm spacing. The weight of 1000-grain was not vary significantly due to the interaction effect of variety and spacing. The highest 1000-grain weight (23.83 g) was observed from the interaction of V3×S3 (BRRI dhan71 at 20 cm × 15 cm spacing) and the lowest 1000-grain weight (21.43 g) was observed from the interaction of V1×S2 (BINA dhan7 at 25 cm × 10 cm spacing). Tyeb et al. (2013) observed no significant effect on the weight of 1000-grain due to interaction of variety and spacing in their experiment.

The interaction of variety and spacing had no significant effect on grain yield. The highest grain yield (4.850 t ha^{-1}) was recorded from the interaction of V3 × S4 (BRRI dhan71 at 20 cm × 10 cm spacing). On the other hand, the lowest grain yield (3.963 t ha^{-1}) was observed from the interaction of V1 × S3 (BINA dhan7 at 20 cm × 15 cm spacing). The result is different from that of Tyeb et al. (2013) who obtained the highest grain yield in BRRI dhan52 at 25 cm × 15 cm spacing and the lowest grain yield in BRRI dhan41 at 20 cm × 10 cm spacing. The interaction of variety and spacing had no significant effect on straw yield. The highest straw yield (5.010 t ha^{-1}) was obtained from the interaction of V2 × S4 (BRRI dhan56 at 20 cm × 10 cm spacing), while the lowest straw yield (3.783 t ha^{-1}) was found from the interaction of V1 × S3 (BINA dhan7 at 20 cm × 15 cm spacing). Interaction of variety and spacing had no significant influence on harvest index. The highest harvest index (53.10%) was found from V3 × S4 (BRRI dhan71 at

20 cm × 10 cm spacing) and the lowest one (47.26%) was observed from the interaction of V2 × S4 (BRRI dhan56 at 20 cm × 10 cm spacing).

4 Conclusions

The study found no significant effect on the grain yield due to interaction of varieties and spacings used in this experiment. However, BINA dhan7 with 20 cm × 10 cm spacing, BRRI dhan56 with 25 cm × 15 cm spacing, BRRI dhan71 with 20 cm × 15 cm spacing and BRRI dhan71 with 20 cm × 10 cm spacing performed well in the fiend and also with their yield.

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Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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