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Effect of Seedling Number Hill^{-1} on the Yield of Modern T. Aman Rice Varieties under Tidal Non-Saline Ecosystem

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Abstract: The present experiment was conducted at the Agronomy Field, Patuakhali Science and Technology University, Patuakhali during the period from July to December 2012 to study the effect of modern varieties and number of seedlings hill^{-1} on the yield of Transplant Aman rice where six modern varieties *viz.* BR 11, BR 23, BRRI dhan40, BRRI dhan44, BINA dhan7 and BRRI dhan52 and three levels of seedlings number hill^{-1}*viz.* 3, 5 and 7 seedlings hill^{-1} were used under the tidal non-saline ecosystem. Results revealed that the interaction between varieties and seedling number hill^{-1}, the highest grain yield (6.15 t ha^{-1}) and straw yield (8.10 t ha^{-1}) were recorded from the variety BR 23 with 5 seedlings hill^{-1}. The highest number of effective tillers hill^{-1} (9.067) and 1000 grain weight (29.31 g) contributed to the highest yield in this treatment combination. Results suggested that the variety BR 23 is suitable with 5 seedlings hill^{-1} for higher yield under tidal non-saline ecosystem of Patuakhali. These significant variation results on yield and yield components may also be attributed to variation in genetic performance and the variation in their seedlings number hill^{-1} under regional adaptability of tidal non saline ecosystem of Patuakhali region.

Key words: Modern varieties, Seedling number, Transplant Aman rice, Yield

Introduction

Rice is the major staple food in Bangladesh and the majority of its food grain comes from paddy rice. The average yield of rice in Bangladesh is around 2.74 tons per hectare which is much lower than the world average of 4.25 tons per hectare (BBS, 2010). Agriculture is the single largest producing sector of Bangladesh economy since it comprises about 20% of the country's Gross Domestic Product (GDP) and employs around 45% of the total labor force (Rahman, 2011). Tidal wetlands are the areas where the land meets the sea. These areas are periodically flooded by seawater during high or spring tides or, are affected by the cyclic changes in water levels caused by the tidal cycle. About 13 million hectares are under deep water and tidal wetlands rice. The tidal wetlands of Bangladesh represent a major less favorable agro-ecological region in Bangladesh, covering a large area (about 2 M ha) of tidal floodplain land in the Southern especially the Southern-Western region of the country along the coastline. The major environmental problems affect crop production in the tidal situation such as twice daily tidal inundation of land over a period of 4-8 months (April-November). About 80% of the cultivable land of greater Barisal and Patuakhali is inundated up to a range of 6-90 cm during this period (BRRI, 1995). Under tidal ecosystem, it is not easy to cultivate modern variety of T. Aman rice as because the height of seedling is comparatively shorter than the depth of water. That is why tidal wetlands lag far behind in modern rice adoption. Productivity of this ecosystem is very low mainly due to cultivation of traditional varieties with low yielding ability 2.0-2.5 t ha^{-1} (BRRI, 2004). Bangladesh Rice Research Institute (BRRI) has released 45 modern varieties of rice suitable for cultivation in one or more rice growing seasons of Bangladesh in different agro ecological zones. However a few of the released modern varieties are suitable under non saline tidal ecosystem of Bangladesh. Among the improved cultural practices, number of seedlings hill^{-1} can play a important role in boosting yield of rice (Alam *et al*., 2012) because it influences the tiller formation, solar radiation interception, total sunshine reception, nutrient uptake, rate of photosynthesis and other physiological phenomena and ultimately affects the growth development and yield of rice plant (Roshan *et al*., 2011). Considering the above fact, the present study was under taken to identify the suitable variety and seedling number hill^{-1} under tidal non-saline ecosystem

Materials and Methods

The experiment was conducted at Patuakhali Science and Technology University (PSTU), Dumki, Patuakhali during the period from July 2012 to December 2012 to investigate the performance of some modern rice varieties and seedling number hill^{-1} under non-saline tidal ecosystem of Bangladesh. Geographically, the experimental area is located at $22^0$37′ N latitude and $89^0$10′ E longitudes. The area is covered Gangetic Tidal Flood Plains. The area lies at 0.9 to 2.1 meter above mean sea level (Iftekhar & Islam, 2004). The experimental field belongs to the Agro–ecological zone of AEZ–13 (UNDP, 1988). This region occupies a vast area of tidal floodplain land in the south–west part of Patuakhali district. Total coverage of this region is 17066 km^2 with a total land volume of 17, 06,600 ha where the western coastal zone surrounded by the Sundarbans. The seeds of six modern Aman rice varieties were used as planting materials which were collected from the farmers of the different villages of Patuakhali, BRRI, Joydebpur,

Gazipur–1701 and BINA, Mymensingh. Three seedling number treatments were also used for this study *viz.* S_1: 3 seedlings hill^{-1}, S_2: 5 seedlings hill^{-1} and S_3: 7 seedlings hill^{-1}. The experiment consisted was laid out in a split–plot (Variety in the main plot and spacing in the sub–plot) design with three replications. The size of plot was 4.0 × 2.5 m where block to block and plot to plot distance were 1.0 and 0.5 m, respectively. Row to row and plant to plant distance were also 20 and 20 cm, respectively, in each plot. The seeds were sown in the previously prepared wet seed bed on 14 July 2012. The tidal free land was opened on 22 August, 2012 and the 45 day–old seedlings were transplanted in the tidal free puddled land on 28th August 2012. After transplanting, proper intercultural operations were done for better growth and development of the plant. Harvesting was done when 80–90% of the grains became golden in color. Data were recorded at plant height (cm), number of total tillers hill^{-1}, number of effective tiller hill^{-1}, number of non effective tiller hill^{-1}, number of grain panicle^{-1}, number of sterile spikelets panicle^{-1}, length of panicle (cm), 1000 grain's weight (g), grain yield (t ha^{-1}) and straw yield (t ha^{-1}). Analysis of variance was done following the split plot design with the help of MSTAT–C computer package programme developed by Russel (1986) and the mean differences among the treatments were evaluated with DMRT test (Gomez and Gomez, 1984).

Results and Discussion

Plant height (cm)

Interaction effect between modern rice varieties and seedling number hill^{-1} was significant for plant height at different days after transplanting (Appendix VI and Table 1). Among the treatment combinations, the tallest plant (62.83, 89.38, 124.0, 135.1and 138.9 cm, respectively) was found from the interaction between the variety BR 23 and 5 seedlings hill^{-1} at 20, 40, 60, 80and at harvest, respectively. Similarly, the shortest plant (42.00, 68.61, 98.80, 109.41, 114.0 cm,) was recorded from the interaction effect between BINA dhan7 and 7 seedlings hill^{-1} at 20, 40, 60, 80and at harvest, respectively. The variation in plant height was found to be due to the genetic variation of rice varieties and seedling number hill^{-1} (Table 1).

Number of total tillers hill^{-1}

Number of total tillers hill^{-1} value presented in Table 1 indicated significant differences due to interaction effect between the varieties and seedling no. hill^{-1} at different growth stages. Among the interaction effects, the BR 23 recorded the maximum number of total tillers hill^{-1} (5.07) while 5 seedlings were transplanted in a hill (BR 23 × 5 seedlings hill^{-1}) at 20 DAT which was statistically similar with BR 23 × 3 seedlings hill^{-1} and BR 11 × 5 seedlings hill^{-1}. However, the minimum number of total tillers hill^{-1} (3.00) was recorded in the interaction between the variety BINA dhan7 and 3 seedlings hill^{-1} (BINA dhan7 × 3 seedlings hill^{-1}) which was statistically similar with the interaction effect between the variety BRRI dhan52 and 5 seedlings hill^{-1} (BRRI dhan52 × 5 seedlings hill^{-1}) at 20 DAT (Table 1). Similarly, BR 23 × 5 seedlings hill^{-1} recorded the maximum number of total tillers hill^{-1} (8.27, 9.00, 9.27 and 9.40) at 40, 60, 80 and at harvest, respectively. In contrast, the minimum number of total tillers hill^{-1} (5.53, 6.00 and 6.20) was recorded from BRRI dhan40 × 7 seedlings hill^{-1} at 40, 60 and 80 DAT, respectively. At harvest, the interaction effect of BRRI dhan52 × 3 seedlings hill^{-1} produced the minimum number of total tillers hill^{-1} (7.20).

Table 1. Interaction effect of variety and seedling number hill^{-1} on plant height and tiller number at different days after transplanting (DAT)

Variety× seedling no. hill^{-1}	Plant height (cm)					Number of total tiller hill^{-1}				
	20	40	60	80	At harvest	20	40	60	80	At harvest
BR 11 × 3	46.87 g	73.48 g	101.7 h	111.1 kl	116.1 ef	2.67 j	5.80 j	7.00 ef	7.53 ef	7.60 g
BR 11 × 5	52.07 def	78.95 de	113.3 c	124.4 c	128.1 b	4.93 a	6.40 h	7.00 ef	7.60 e	7.67 fg
BR 11 × 7	43.87 hi	71.16 i	101.8 h	112.5 jk	117.1 def	4.33 cde	7.07 d	7.47 c	8.33 c	8.60 c
BR 23 × 3	56.83 b	83.44 b	111.6 cd	121.1 e	126.1 bc	4.93 a	6.73 ef	7.07 de	7.33 hi	7.87 de
BR 23 × 5	62.83 a	89.38 a	124.0 a	135.1 a	138.9 a	5.07 a	8.27 a	9.00 a	9.27 a	9.40 a
BR 23 × 7	61.92 a	89.21 a	119.9 b	130.5 b	135.2 a	4.43 bcd	6.20 i	6.93 fg	7.27 i	7.53 g
BRRI dhan40× 3	51.00 ef	77.61 ef	105.8 e	115.3 hi	120.3 cdef	4.20 def	7.00 d	7.47 c	7.73 d	7.93 de
BRRI dhan40× 5	53.00 cde	80.07 cd	112.8 c	123.8 cd	127.6 b	4.47 bc	7.67 b	8.20 b	8.47 b	8.67 c
BRRI dhan40× 7	50.13 f	76.50 f	106.9 e	117.9 fg	122.2bcde	4.13 efg	5.53 k	6.00 j	6.20 l	7.87 de
BRRI dhan44 × 3	50.67 f	77.85 ef	109.3 d	118.7 f	123.7 bcd	3.93 g	6.73 ef	7.40 c	7.60 e	8.00 d
BRRI dhan44 × 5	53.93 cd	81.17 c	112.5 c	123.5 cd	127.3 b	4.63 b	6.73 ef	6.87 gh	7.13 j	7.33 h
BRRI dhan44 × 7	54.40 c	80.76 c	111.2 cd	121.8 de	126.4 bc	3.40 h	6.80 e	6.87 gh	7.47 fg	7.67 fg

BINA dhan7× 3	44.60 h	71.78 hi	103.2 fgh	112.8 jk	117.8 def	3.00 i	6.53 g	6.93 fg	7.40 gh	7.53 g
BINA dhan7× 5	44.53 h	71.77 hi	105.3 efg	114.1 ij	117.9 def	4.07 fg	6.67 f	6.73 i	7.27 i	7.60 g
BINA dhan7× 7	42.00 i	68.61 j	98.80 i	109.4 l	114.0 f	3.40 h	6.67 f	7.13 d	7.27 i	7.53 g
BRRI dhan52 × 3	45.80 gh	73.22 gh	102.5 h	112.1 jk	117.1 def	3.47 h	6.33 h	6.80 hi	6.93 k	7.20 h
BRRI dhan52 × 5	45.95 gh	72.44 ghi	105.4 ef	116.4 gh	120.2 cdef	3.13 i	7.33 c	8.27 b	8.40 bc	8.87 b
BRRI dhan52 × 7	44.67 gh	71.54 i	102.8 gh	113.4 ijk	118.1 def	4.27 cdef	7.07 d	7.40 c	7.47 fg	7.80 ef
Level of sig.	**	**	**	*	**	**	**	**	**	**
CV (%)	**2.40**	**1.16**	**1.28**	**2.77**	**0.83**	**3.43**	**1.07**	**0.88**	**1.05**	**1.11**

**= significant at 1% level of probability and *= significant at 5% level of probability. Figures followed by same letter(s) are statistically similar as per DMRT at 5%

Number of effective tillers hill^{-1}

Number of effective tillers hill^{-1} was significantly influenced by the interaction effect between rice varieties and number of seedlings hill^{-1} at harvest (Table 2). The maximum number of effective tillers hill^{-1} (9.07) was found from the interaction effect of BR 23 × 5 seedlings hill^{-1}. In contrast, the minimum number of effective tillers hill^{-1} (4.33) was recorded from the variety BINA dhan7 with 3 seedlings hill^{-1} (BINA dhan7 × 3 seedlings hill^{-1}). The variation in effective tillers production was found due to the genetic variation of these modern varieties and also due to variation in different number of seedlings hill^{-1} (Table 2).

Number of non effective tillers hill^{-1}

Number of non effective tillers hill^{-1} also differed significantly among the interaction effect between modern rice varieties and different number of seedlings hill^{-1} at harvest (Table 2). The maximum number of non effective tillers hill^{-1} (3.20) was found from the interaction effect between BINA dhan7 with 3 seedlings hill^{-1} which was followed by the same variety in 7 seedlings hill^{-1} (3.00). Similarly, the minimum number of non effective tillers hill^{-1} (0.27) was recorded from the variety BR 23 with 5 seedlings number hill^{-1} (BR 23 × 5 seedlings hill^{-1}) which was statistically similar with the interaction effect of BR 23 × 7 seedlings hill^{-1} (0.33). The variation of non effective tiller production was found due to the genetic variation of these modern varieties and also due to the variation in different number of seedlings hill^{-1} (Table 2).

Number of grains panicle^{-1}

Number of grains panicle^{-1}was significantly different among the interaction effect between varieties and seedling number hill^{-1} at harvest (Table 2). The maximum number of grains panicle^{-1} (114.90) was recorded in 3 seedlings hill^{-1}with the variety BR23 (BR 23 × 3 seedlings hill^{-1}) followed by the similar variety with 5 seedlings hill^{-1} (107.30). In contrast, the minimum number of grains panicle^{-1} was observed in 7 seedlings hill^{-1} of the variety BINA dhan7 (33.72) which were statistically different from other treatments (Table 2).

Number of sterile spikeletspanicle^{-1}

The significant variation was found due to the interaction effect between modern rice varieties and their seedling number hill^{-1} in respect of sterile spikelets panicle^{-1} (Table 2). The maximum number of sterile spikelets panicle^{-1} (46.94) was observed in 3 seedlings hill^{-1} of BRRI dhan52 that similar with the variety BINA dhan7 with 7 (46.18), 5 (45.82) and 3 (44.32) seedlings hill^{-1} and also with the variety BRRI dhan44 with 3, 5 and 7 seedling (40.82, 41.34, 44.98 respectively), BRRI dhan40 with 3 (43.44), 5 (46.86) and 7 (39.82) seedlings hill^{-1}. On the other hand, the minimum number of sterile spikelets panicle^{-1} (14.96) was observed in 5 seedlings hill^{-1} of the variety BR 23 (14.96) which was also statistically similar with the variety BR 11 in 7 seedlings (17.04) (Table 2).

Panicle length

There was a significant variation observed in panicle length due to the interaction effect of different modern varieties and their seedling number hill^{-1}(Table 2). The longest panicle (26.18 cm) was found in BR 23 with 5 seedlings hill^{-1} which was closely followed by the similar variety in 7 seedlings hill^{-1} (25.68 cm) and also with the interaction of BRRI dhan44 × 7 seedlings hill^{-1} (25.36 cm). In contrast, the shortest panicle (16.60 cm) was noticed in the interaction of the variety BINA dhan7 with 3 seedlings hill^{-1} and it was statistically at par with the interaction of the same variety with 7 seedlings hill^{-1} (BINA dhan7 × 7 seedlings hill^{-1}) (16.63 cm) (Table 2).

Thousand–grain weight

Interaction effect of different modern varieties and seedling number hill^{-1} showed significant variation in respect of weight of 1000–grains (Table 2). The high yielding modern variety BR 23 produced the highest 1000–grains weight (29.31 g) with 5 seedlings hill^{-1} (BR 23 × 5 seedlings hill^{-1}). On the other hand, the lowest weight of 1000–grains (22.05 g) was obtained from the interaction of BINA dhan7 with 3 seedlings hill^{-1} (Table 2).

Table 2. Effect of variety and seedling number hill^{-1} on yield and yield contributing characters of rice

Variety× seedling no. hill^{-1}	Number of effective tiller hill^{-1}	Number of non effective tiller hill^{-1}	Number of grains panicle^{-1}	Number of sterile spikelets panicle^{-1}	Panicle length (cm)	1000–grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
BR 11 × 3	5.933 j	1.667 e	94.20 d	27.08 cd	21.70 g	24.53 j	4.97 d	6.27 f
BR 11 × 5	7.200 c	0.467 k	93.92 d	26.62 d	22.08 fg	24.97 i	4.10 h	6.90 d
BR 11 × 7	7.000 de	1.567 ef	87.10 f	17.04 e	20.42 h	24.35 k	5.83 b	4.57 j
BR 23 × 3	7.067 d	0.800 j	114.90 a	27.48 cd	24.38cd	28.19 c	6.10 a	8.03 a
BR 23 × 5	9.067 a	0.267 l	107.30 b	14.96 e	26.18 a	29.31 a	6.15 a	8.10 a
BR 23 × 7	7.200 c	0.333 l	90.26 e	27.78 cd	25.68 ab	27.63 e	4.47 ef	7.57 b
BRRI dhan40× 3	6.933 e	1.000 i	80.92 gh	43.44 a	22.88 efg	24.17 l	3.80 i	6.57 e
BRRI dhan40× 5	7.333 b	1.000 i	79.84 gh	46.86 a	23.32 def	25.86 g	5.30 c	6.20 f
BRRI dhan40× 7	6.733 f	1.133 h	78.60 h	39.82 ab	23.08 ef	25.50 h	3.67 j	7.267 c
BRRI dhan44 × 3	6.533 g	1.467 f	82.18 g	40.82 ab	24.90 bc	28.07 d	4.20 g	5.87 g
BRRI dhan44 × 5	6.067 i	1.267 g	78.10 h	41.34 ab	23.10 ef	28.79 b	4.20 g	4.90 i
BRRI dhan44 × 7	6.400 h	1.267 g	72.28 i	44.98 a	25.36 abc	28.23 c	1.50 n	5.57 h
BINA dhan7× 3	4.333 m	3.200 a	53.20 j	44.32 a	16.60 j	22.05 n	1.45 m	2.60 l
BINA dhan7× 5	5.400 k	2.200 c	37.38 k	45.82 a	17.95 i	22.95 m	1.73 k	2.60 l
BINA dhan7× 7	4.533 l	3.000 b	33.72 l	46.18 a	16.63 j	22.11 n	4.40 f	2.73 k
BRRI dhan52 × 3	6.067 i	1.133 h	98.12 c	46.94 a	22.56 efg	25.81 g	4.53 f	5.87 g
BRRI dhan52 × 5	7.000 de	1.867 d	93.42 d	34.98 bc	22.72 efg	26.48 f	4.50 f	6.87 d
BRRI dhan52 × 7	6.800 f	1.000 i	78.34 h	46.72 a	23.36 de	25.87 g	4.97 e	5.77 g
Level of sig.	**	**	**	**	**	**	**	**
CV (%)	**0.83**	**4.97**	**2.28**	**11.95**	**2.96**	**0.30**	**1.06**	**1.18**

**= significant at 1% level of probability. Figures followed by same letter(s) are statistically similar as per DMRT at 5%

Grain yield

Grain yield presented in (Table 2) indicated significant variation due to the interaction effect of modern varieties and their seedling number hill^{-1}. The highest grain yield (6.15 t ha^{-1}) was found from the interaction of BR 23 with 5 seedlings hill^{-1} which was statistically similar with the same variety in 3 seedlings hill^{-1} (6.10 t ha^{-1}). In contrast, the lowest grain yield (1.45 t ha^{-1}) was obtained from the interaction of BINA dhan5 with 3 seedlings hill^{-1} which was statistically differed from other interactions (Table 2).

Straw yield

Straw yield varied significantly among the interaction effect between varieties and their seedlings number hill^{-1} (Table 2). The highest straw yield (8.100 t ha^{-1}) was found from the interaction effect between BR 23 with 5 seedlings hill^{-1} which was statistically similar with the interaction of BR 23 with 3 seedlings hill^{-1} (8.03 t ha^{-1}). In contrast, the similar lowest straw yield (2.60 t ha^{-1}) was found from the both interactions of BINA dhan7 with 3 seedlings hill^{-1} and BINA dhan7 with 5 seedlings hill^{-1} (Table 2).

From the above investigation, it can be concluded that the variety BR 23 with 5 seedlings number hill^{-1} had outstanding superiority for plant growth, yield components and yield over other modern varieties and seedling number hill^{-1} in tidal ecosystem of Bangladesh in the present study.

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