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GROWTH AND YIELD OF T. AMAN RICE AS AFFECTED BY VARIETY AND SEEDLING NUMBER

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ABSTRACT

A field experiment was conducted at the experimental field of Sher-e-Bangla Agricultural University during July to December 2010 to find out the effect of 1, 2 or 3 seedling(s) per hill on growth, yield and yield components of a modern inbred (BRRI dhan49) and four hybrid (BRRI hybrid dhan2, Heera2, Tia and Aloron) transplant *Aman* rice varieties. The experiment was laid out in randomized complete block design with four replications. Results showed that rice cultivars differed significantly in some characters at different growth stages, such as, tillers number, total dry matter weight, unfilled grain, grain filling percentage and insignificantly in some characters at different growth stage, such as, chlorophyll content, yield etc due to different seedling densities per hill. Numerically the higher grain yield was attributed mainly to the number of effective tillers per hill, filled grains per panicle and 1000-grain weight. Remarkable grain and straw yield were found from the interaction of BRRI dhan49 planted 1 seedling and 3 seedlings per hill respectively. Among the hybrid rice varieties, the maximum grain yield was observed from the combination of BRRI hybrid dhan2 with 1 seedling per hill (V_2S_1).

Keywords: transplant aman rice, seedling density, grain yield

INTRODUCTION

Rice (*Oryza sativa* L.) is the second most widely grown cereal in the world and it is the staple food for more than half of the world's population. Asia is the leading producer of rice and most Asians get 60% of their calories from rice. Bangladesh ranks 4th in both area and production and 6th in the production of per hectare yield of rice in the world. It is the staple food of about 160 million people of Bangladesh. Rice cultivation is favored by the hot, humid climate and the large number of deltas across Asia's vast tropical and subtropical areas. Rice is extensively grown in Bangladesh in three seasons namely, *Aus, Aman* and *Boro*, which covers 80% of the total cultivable area of the country (AIS, 2011). The population of Bangladesh is growing by two million every year and may increase by another 30 million over the next 20 years. During this time total rice area will also shrink to 10.28 million hectares. Rice yield therefore, needs to be increased by 53.3% (BRRI, 2006). In Bangladesh, rice yield level is far below than that of many other countries like China, Japan, Korea and Egypt where yield is 7.5, 5.9, 7.3 and 7.5 t ha^{-1}, respectively (FAO, 2009). Horizontal expansion of rice area is not possible in Bangladesh due to limited land resources and high population density. So, the only avenue left is to increase production of rice by vertical means, that is, management practices. Planting density as a management practice in transplanted rice culture constitutes the number of seedling per hill or per unit area. Number of productive tillers and their greater growth both quantitative and qualitative growth are influenced by number of seedling per hill. Optimum seedling(s) per hill enables rice plants to grow properly both in their aerial and underground parts by proper utilization of radiant energy, nutrients, space and water. However, controversy is found regarding the number seedlings planted per hill. Nakano and Mizushima (1994) reported that grain yield is negatively correlated with increasing the number of seedling per hill, while Shah *et al.* (1991) found that the different number of seedling per hill had no effect on the number of panicles per hill, grains per panicle and grain yield. Wen and Yang (1991) found that effective panicles, the number of grains per panicle and the 1000- grain weight were also higher with only one seedling per hill. Obulamma *et al.* (2002) recorded the highest grain yield, crop growth rate and net assimilation rate from one seedling per hill. Excess number of seedling hill^{-1} may produce more tillers per unit of land area resulting in mutual shading, lodging and lead to production of

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more straw instead of grain. While the least number of seedlings per hill may produce insufficient tiller, keeping space and nutrients unutilized resulting in less number of panicles per unit area, resulting poor yield (Miah *et al.*, 2004). For the ever-increasing population of Bangladesh, the increasing demand for rice will have to meet with lesser area of land, lesser amount of water, lesser number of labour and lesser amount of pesticides. Hybrid rice offers to break the yield ceiling of conventional semi-dwarf rice varieties. Hybrid rice technology has been introduced through IRRI, BRRI and commercial seed companies of India and China during the last ten years and has already gained positive experience in the *Boro* season. In *Aman* season, however, available information regarding the yield and yield contributing characters, both morpho-physiological characteristics of hybrid rice varieties are meager in Bangladesh. That is why, it is a prime need to conduct more research work to find out and develop sustainable technologies regarding hybrid rice cultivation under the prevailing local conditions in the *Aman* season.

Considering the above proposition, the present study was undertaken to investigate the combined effect of cultivars and seedling densities on the growth, yield and yield contributing characters of *Aman* rice.

MATERIALS AND METHODS

The field experiment was conducted at the research farm of Sher-e-Bangla Agricultural University (SAU), Dhaka in *Aman* season of 2010 (July to December, 2010). The experiment was laid out in randomized complete block design with four replications using BRRI dhan49 and four hybrid varieties, *viz.* BRRI hybrid dhan2, Heera, Tia and Aloron. The size of unit plot was 5 m x 5 m. Thirty days old seedlings were transplanted maintaining 25 cm x 15 cm spacing. At the time of first ploughing, cowdung was applied at the rate of 10 t ha^{-1}. The crop was fertilized @ 115-26-60-12-4 kg/ha of NPKSZn, in the form of urea, triple superphosphate (TSP), muriate of potash (MoP), gypsum and zinc sulphate respectively according to BRRI. The entire amounts of TSP, MoP, gypsum and zinc sulphate were applied at the time of final land preparation as basal dose. Urea was top-dressed in three equal splits at 10, 30 and 50 days after transplanting (DAT). Intercultural operations were done as and when necessary. Ten hills in each plot were randomly selected and tagged for recording tillering data. Total dry matter at panicle initiation, booting, flowering and maturity stages were collected from randomly selected 10 hills in each stage leaving the harvest area. Data on yield components *viz.* grains m^{-2}, percent filled grains, and 1000-grain weights were also recorded. An area of 6 m^2 was harvested from centre of each plot and the grain and straw yield as well as harvest index were computed. Flag leaf chlorophyll content was determined according to Witham *et al.* (1986). All the data were statistically analyzed using the computer package program, MSTAT-C (Russell, 1994). The mean differences among the treatments were compared by least significant difference (LSD) test at 5% level of significance.

RESULTS AND DISCUSSION

Interaction effect of variety and seedling per hill was observed to be insignificant at panicle initiation, booting and harvesting stage but significant at tillering and flowering stage (Table 1). At tillering stage, the highest (337.81) tillers m^{-2} per hill were found from the combination of BRRI dhan49 (V_1) with 3 seedlings. The second highest tiller (260.03) m^{-2} were found from the combination of BRRI hybrid dhan2 (V_2) with 3 seedlings which was statistically at par with the combination of V_1S_2, V_3S_3, V_4S_3, V_2S_2, V_3S_2 and V_5S_3 and minimum (142.24) was found from Tia with 1 seedling which was statistically similar with BRRI hybrid dhan2 (V_2) with 1 seedlings. At panicle initiation stage, numerically maximum (405.60) tillers $hill^{-1}$ was found from the combination of BRRI hybrid dhan2 (V_2) with 3 seedlings and minimum (248.92) was found from Tia (V_4) with 1 seedling. At booting stage, numerically maximum (400.05) tillers m^{-2} was found from the combination of BRRI dhan49 (V_1) with 3 seedlings and minimum (235.59) was found from Tia (V_4) with 1 seedling. At flowering stage, the highest (372.27) tillers m^{-2} was found from the combination of BRRI hybrid dhan2 (V_2) with 2 seedlings $hill^{-1}$ which was statistically similar to V_1S_3 and V_2S_3. The second highest tillers m^{-2} were found with the combination of BRRI dhan49 (V_1) with 3 seedlings which were

statistically similar with V_2S_3, V_3S_3 and minimum (215.59) was found from the combination of Tia (V_4) with 1 seedling. At harvesting stage, numerically maximum (312.26) tillers hill^{-1} were found from the combination of BRRI hybrid dhan2 (V_2) with 3 seedlings and minimum (167.8) was found from Heera2 (V_3) with 2 seedlings.

Table 1. Tiller number of transplanted *Aman* rice as influenced by combined effect of variety and seedling(s) number hill^{-1}

Treatments	Tiller no. m^{-2} at tillering stage	Tiller no.m^{-2} at panicle initiation stage	Tiller no. m^{-2} at booting stage	Tiller no. m^{-2} at flowering stage	Tiller no. m^{-2} at harvesting stage
V_1S_1	160.02 ef	372.28	323.38	315.60 de	291.15
V_1S_2	253.23 b	404.50	368.94	332.26 cd	310.04
V_1S_3	337.81 a	422.28	400.05	364.49 ab	312.26
V_2S_1	151.13 f	342.26	330.04	317.82 de	222.25
V_2S_2	234.48 bc	395.61	390.05	372.27 a	250.03
V_2S_3	260.03 b	405.60	382.27	350.05 abc	255.59
V_3S_1	168.91 ef	344.49	302.26	282.26 f	185.58
V_3S_2	233.36 bc	382.27	345.60	326.71 cd	167.80
V_3S_3	250.03 b	397.82	368.93	338.93 bcd	203.36
V_4S_1	142.24 f	248.92	235.59	215.59 g	192.24
V_4S_2	206. 70 cd	324.48	310.04	286.71 f	177.80
V_4S_3	245.59 b	347.81	353.38	322.37 d	197.80
V_5S_1	184.47 de	340.04	316.71	294.48 ef	187.80
V_5S_2	206.69 cd	384.49	354.49	327.82 cd	217.81
V_5S_3	227.80 bc	393.38	301.15	321.15 d	227.81
LSD (0.05)	32.76	ns	ns	26.14	ns
CV (%)	9.0	6.03	8.12	5.13	11.6

Note: V_1 = BRRI dhan49, V_2= BRRI hybrid dhan2, V_3 = Heera2, V_4 = Tia, V_5 = Aloron, S_1= 1 seedling hill^{-1}, S_2= 2seedlings hill^{-1}, S_3= 3 seedlings hill^{-1} (Values followed by same letter(s) in a column do not differ by MSTAT range test)

The interaction effect of variety and seedling numbers hill^{-1} had no significant effect on chlorophyll content of leaf (Table 2). Numerically maximum chl a (3.53mgg^{-1}) was measured from the combination

Table 2. Chlorophyll content of flag leaf of transplanted *Aman* rice as influenced by combined effect of variety and seedling number hill^{-1}

Treatments	Chlorophyll a (mgg^{-1})	Chlorophyll b (mgg^{-1})	Chlorophyll (a+b) (mgg^{-1})	Chlorophyll a/ Chlorophyll b
V_1S_1	2.78	1.94	4.72	1.44
V_1S_2	2.81	1.96	4.77	1.43
V_1S_3	2.86	2.02	4.87	1.42
V_2S_1	3.42	2.47	5.89	1.39
V_2S_2	3.51	2.46	5.97	1.42
V_2S_3	3.50	2.50	6.01	1.40
V_3S_1	3.40	2.47	5.88	1.38
V_3S_2	3.46	2.49	5.95	1.39
V_3S_3	3.53	2.55	6.08	1.38
V_4S_1	3.37	2.40	5.78	1.41
V_4S_2	3.38	2.43	5.82	1.39
V_4S_3	3.41	2.47	5.89	1.38
V_5S_1	3.49	2.46	5.94	1.42
V_5S_2	3.37	2.40	5.77	1.41
V_5S_3	3.44	2.51	5.95	1.37
LSD (0.05)	ns	ns	ns	ns
CV (%)	5.30	6.48	5.74	1.80

Note: V_1 = BRRI dhan49, V_2= BRRI hybrid dhan2, V_3 = Heera2, V_4 = Tia, V_5 = Aloron, S_1= 1 seedling hiil^{-1}, S_2= 2 seedlings hill^{-1}, S_3= 3 seedlings hill^{-1} Total dry matter production

of Heera2 with 3 seedlings and the minimum chl a (2.78mgg^{-1}) from the combination of BRRI dhan49 with 1 seedling hill^{-1}. Similar trend was found in chlorophyll b, cumulative value of chlorophyll a and chlorophyll b content and also in chlorophyll a and b ratio. Total dry matter production was significantly affected due to the interaction of variety and seedling hill^{-1} at tillering, panicle initiation and flowering stage but unaffected at booting stage (Table 3). At tillering stage, the highest total dry matter weight m^{-2} (111.90 g) was obtained from the combination of Heera2 with 3 seedlings per hill (V_3S_3) which was statistically at par with the combination of Aloron with 3 seedlings (V_5S_3). The second highest total dry matter weight m^{-2} (99.57 g) was obtained from the combination of Tia with 2 seedlings per hill (V_4S_2). The minimum total dry matter weight m^{-2} (45.56 g) was obtained from the combination of BRRI dhan49 with 1 seedling hill^{-1} (V_1S_1). At panicle initiation stage, the highest total dry matter weight m^{-2} (482.3 g) was obtained from the combination of BRRI dhan49 with 3 seedlings hill^{-1} (V_1S_3) which was statistically at par with the combination of BRRI hybrid dhan2 with 3 seedlings hill^{-1} (V_2S_3). The second highest total dry matter weight m^{-2} (416.4 g) was obtained from the combination of BRRI hybrid dhan2 with 2 seedlings per hill (V_2S_2) which was statistically similar with V_1S_2 and V_3S_1. The minimum total dry matter weight m^{-2} (256.7 g) was obtained from the combination of Tia with 1 seedling hill^{-1} (V_4S_1) statistically similar with V_4S_2, V_4S_3 and V_5S_1. At booting stage, numerically maximum total dry matter weight m^{-2} (876.6 g) was obtained from the combination of BRRI dhan49 with 3 seedlings hill^{-1} (V_1S_3) and minimum total dry matter weight m^{-2} (290.9 g) was obtained from the combination of Aloron with 1 seedling hill^{-1} (V_5S_1). At flowering stage, the highest total dry matter weight m^{-2} (1086.0 g) was obtained from the combination of BRRI dhan49 with 3 seedlings hill^{-1} (V_1S_3) which was statistically at par with the combination of BRRI dhan49 with 2 seedlings hill^{-1} (V_1S_2). The second highest total dry matter weight m^{-2} (841.4 g) was obtained from the combination of BRRI dhan49 with 1 seedlings hill^{-1} (V_1S_1). The minimum total dry matter weight m^{-2} (444.6 g) was obtained from the combination of Aloron with 2 seedling hill^{-1} (V_5S_2) which was statistically at par with the combination of V_5S_1 and V_5S_3.

Table 3. Total dry matter weight of transplanted *Aman* rice as influenced by combined effect of variety and seedling(s) number hill^{-1}

Treatments	Dry matter weight m^{-2} at tillering stage (g)	Dry matter weight m^{-2} at panicle initiation stage (g)	Dry matter weight m^{-2} at booting stage (g)	Dry matter weight m^{-2} at flowering stage (g)
V_1S_1	45.56 j	359.8 cde	811.2	811.4 b
V_1S_2	57.16 hi	407.3 bc	750.5	999.3 a
V_1S_3	62.32 gh	482.3 a	876.6	1086.0 a
V_2S_1	53.94 i	347.8 de	478.7	673.4 cd
V_2S_2	70.95 ef	416.4 bc	507.2	714.6 bc
V_2S_3	77.32 de	425.9 ab	512.3	647.3 cd
V_3S_1	65.87 fg	406.8 bc	362.1	653.7 cd
V_3S_2	96.90 d	383.2 bcd	379.1	647.4 cd
V_3S_3	111.9 a	335.9 def	479.7	699.0 c
V_4S_1	59.88 ghi	256.7 h	448.8	618.8 cd
V_4S_2	99.57 b	285.3 fgh	491.0	593.2 d
V_4S_3	83.03 cd	290.2 fgh	398.0	632.3 cd
V_5S_1	58.76 ghi	279.1 gh	290.9	448.5 e
V_5S_2	88.95 c	317.8 efg	297.9	444.6 e
V_5S_3	111.6 a	316.2 efg	339.6	472.5 e
LSD (0.05)	7.76	56.87	ns	100.0
CV (%)	6.08	9.60	11.97	8.84

Note: V_1 = BRRI dhan49, V_2= BRRI hybrid dhan2, V_3 = Heera2, V_4 = Tia, V_5 = Aloron, S_1= 1 seedling hill^{-1}, S_2= 2seedlings hill^{-1}, S_3= 3 seedlings hill^{-1} (Values followed by same letter(s) in a column do not differ by MSTAT range test)

Results presented in Table 4 showed that interaction effect of variety and seedling numbers hill^{-1} was not significant on filled grains m^{-2}. The maximum (39953.88) filled grains m^{-2} was found from the combination of BRRI dhan49 with 1 seedlings (V_1S_1) and the minimum (14025.09) was found from Heera2 with 2 seedlings hill^{-1} (V_3S_2).

Interaction of variety and seedling numbers hill^{-1} had significant effect on unfilled grains m^{-2} (Table 4). The highest (11289.63) unfilled grains m^{-2} was obtained from BRRI dhan49 with 3 seedlings hill^{-1} (V_1S_3) which was statistically similar to the combination of BRRI dhan49 with 2 seedlings hill^{-1} (V_1S_2). The lowest (1468.85) unfilled grains m^{-2} was obtained from the combination of Tia with 1 seedlings hill^{-1} (V_4S_1) which was statistically similar to the combination of Aloron with 2 seedlings per hill (V_5S_2).
Interaction of variety and seedling numbers hill^{-1} had significant effect on percent grain filling (Table 4). The lowest percent filled grain (72.91%) was obtained from the combination of BRRI hybrid dhan2 with 3 seedlings hill^{-1} (V_2S_3) which was statistically similar to the combination of Heera2 with 2 seedlings hill^{-1} (V_3S_2) and Tia with 3 seedlings hill^{-1} (V_4S_3). The highest percent filled grain (93.41%) was obtained from Tia with 1 seedling hill^{-1} (V_4S_1) which was statistically similar to the combination of Aloron with 2 seedlings hill^{-1} (V_5S_2) and Aloron with 1 seedlings hill^{-1} (V_5S_1).
Interaction effect of variety and seedling numbers hill^{-1} on 1000-grain weight was not observed significant (Table 4). Numerically the maximum 1000-grain weight (27.20 g) was obtained from the combination of Aloron with 1 seedling hill^{-1} (V_5S_1) and the minimum (18.80 g) 1000-grain weight was found in the combination of BRRI dhan49 with 3 seedlings hill^{-1} (V_1S_3).

Table 4. Filled grain, unfilled grain, percent filled grain and 1000-grain weight of transplanted *Aman* rice as influenced by combined effect of variety and seedling(s) number hill^{-1}

Treatments	Filled grain/m^2	Unfilled grain/m^2	Percent filled grain	1000 grain weight(g)
V_1S_1	39953.88	6095.43 bc	86.77 bcd	18.93
V_1S_2	39444.04	10332.62 a	79.14 efg	18.87
V_1S_3	35756.25	11289.63a	76.00 gh	18.80
V_2S_1	22289.90	5138.87 cd	80.97 efg	26.87
V_2S_2	25960.35	5778.06 c	81.91 def	27.00
V_2S_3	21180.43	7680.29 b	72.91 h	26.67
V_3S_1	20227.41	5117.75 cd	79.80 efg	25.47
V_3S_2	14025.09	3927.82 de	77.66 fgh	25.67
V_3S_3	1777.11	2578.55 ef	87.39 bcd	25.27
V_4S_1	21019.52	1468.85 f	93.41 a	23.07
V_4S_2	17882.01	4918.84 cd	78.80 fg	23.53
V_4S_3	18903.25	5219.10 cd	77.91 fgh	24.73
V_5S_1	20570.57	2791.68 ef	87.97 abc	27.20
V_5S_2	19324.42	1804.00 f	91.34 ab	26.73
V_5S_3	15475.49	2772.35 ef	84.63 cde	26.67
LSD (0.05)	ns	1599	5.67	ns
CV (%)	14.01	18.63	4.11	3.95

Note: V_1 = BRRI dhan49, V_2= BRRI hybrid dhan2, V_3 = Heera2, V_4 = Tia, V_5 = Aloron, S_1= 1 seedling hill^{-1}, S_2= 2seedlings hill^{-1}, S_3= 3 seedlings hill^{-1} (Values followed by same letter(s) in a column do not differ by MSTAT range test)

Grain yield was not significantly influenced by the interaction of variety and seedlings hill^{-1} (Table 5). Numerically the maximum (5.75 t ha^{-1}) grain yield was observed from the combination of BRRI dhan49 with 1 seedling hill^{-1} (V_1S_1). The result was in conformity with the findings of Masum *et al.* (2010) who observed BRRI dhan44 with 1 seedling hill^{-1} produced the highest grain yield. The minimum grain yield (3.2 t ha^{-1}) was found with the combination of hybrid Tia with 1 seedling hill^{-1} (V_4S_1) which was contradictory with the findings of Obulamma *et al.* (2004) who found hybrid APHR 2 gave the highest grain yield with one seedling hill^{-1}.
It was evident from the table 5 that interaction of variety and seedling numbers hill^{-1} had no significant effect on straw yield. Numerically the maximum (8.54 t ha^{-1}) straw yield was found from the combination of BRRI dhan49 with 3 seedlings hill^{-1} (V_1S_3) and the minimum (4.27 t ha^{-1}) from the combination of Aloron with 1 seedling hill^{-1} (V_5S_1).

Interaction effect of variety and seedling numbers hill^{-1} had no significant effect on biological yield (Table 5). Numerically maximum (14.21 t ha^{-1}) biological yield was found from the combination of BRRI dhan49 with 3 seedlings hill^{-1} (V_1S_3) and minimum (7.62 t ha^{-1}) biological yield was observed from the combination of Tia with 1 seedling (V_4S_1) hill^{-1}.

The interaction effect of variety and seedling numbers hill^{-1} was not found significant on harvest index (Table 5). Numerically maximum (48.29%) harvest index was found from the combination of Aloron with 1 seedling (V_5S_1). Numerically minimum (38.08%) harvest index was found from the combination of Tia with 3 seedlings (V_4S_3).

Table 5. Grain yield, straw yield, biological yield and harvest index of transplanted *Aman* rice as influenced by combined effect of variety and seedling(s) number hill^{-1}

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
V_1S_1	5.75	7.65	13.0	42.94
V_1S_2	5.30	8.20	13.50	39.17
V_1S_3	5.67	8.54	14.21	39.93
V_2S_1	4.62	5.37	9.99	46.21
V_2S_2	4.43	5.59	10.02	44.09
V_2S_3	4.31	5.65	9.96	43.15
V_3S_1	3.41	4.58	7.99	43.04
V_3S_2	3.40	5.42	8.81	38.47
V_3S_3	3.95	5.68	9.64	41.00
V_4S_1	3.21	4.41	7.62	42.26
V_4S_2	3.62	5.11	8.72	41.44
V_4S_3	3.34	5.35	8.68	38.08
V_5S_1	3.98	4.27	8.25	48.29
V_5S_2	3.60	4.65	8.25	43.66
V_5S_3	3.24	4.84	8.08	40.12
LSD (0.05)	ns	ns	ns	ns
CV (%)	9.97	7.57	7.43	5.56

Note: V_1 = BRRI dhan49, V_2= BRRI hybrid dhan2, V_3 = Heera2, V_4 = Tia, V_5 = Aloron, S_1= 1 seedling hill^{-1}, S_2= 2seedlings hill^{-1}, S_3= 3 seedlings hill^{-1}

Based on the results of the study it can be concluded that transplanting 1 seedling hill^{-1} for modern variety of transplant Aman cv. BRRI dhan49 will be a promising practice for good yield than the hybrid rice varieties (BRRI hybrid dhan2, Heera2, Tia and Aloron) in Aman season. However, to reach a specific conclusion and recommendation, more research work on modern and hybrid rice varieties with different seedling densities hill^{-1} should be done over different Agro-ecological zones.

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