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Growth and yield of transplanted aman rice under different nitrogen levels

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Abstract

Nitrogen is not only a major nutrient but also the most limiting nutrient element for rice cultivation. Application of appropriate level of nitrogen can increase growth and yield of rice. Considering this, an experiment was conducted at the Agronomy farm, Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh during July 2017 to December 2017 in Aman season to examine the effect of different nitrogen levels on yield and yield attributes of transplanted aman rice. The experiment consisted of three nitrogen levels (*viz.* 50, 100 and 150 kg N ha^{-1}) and four varieties/lines (*viz.* SAU ADL1, BRRI dhan70, BRRI hybrid dhan6 and SAU ADL11). Results revealed that growth; yield and yield contributing characters of transplanted aman rice were significantly influenced by nitrogen, variety and their interactions. Increasing trend was observed with the increasing level of nitrogen from 50 to 150 kg ha^{-1} for all growth characters. Maximum grain yield (4.50 t ha^{-1}) and straw yield (8.00 t ha^{-1}) were obtained from 150 kg N ha^{-1} which were statistically at par with 100 kg N ha^{-1}. The highest harvest index (36.58%) was recorded at 100 kg N ha^{-1}. SAU ADL1 produced highest dry matter $hill^{-1}$ (99.85 g), 1000-grains weight (31.49 g) and SAU ADL11 gave highest SPAD value. The highest grain yield (5.24 t ha^{-1}) and harvest index (45.44%) were recorded in BRRI hybrid dhan6. Interaction of 150 kg N ha^{-1} with BRRI hybrid dhan6 gave maximum value of all studied parameters but BRRI dhan70, SAU ADL1 and SAU ADL11 were more responsive to 100 kg N ha^{-1} to produce better yield of rice.

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Introduction

Bangladesh is predominantly an agrarian country. Rice is the most dominant food crop of Bangladesh occupying about 75% of total cultivable area (BBS, 2017). It contributes a lot to GDP, employment generation and food requirement. Rice provides about 48% of rural employment, two-third of total calorie and one-half of the total protein ingestion of an average person in the country (BBS, 2013). Bangladesh occupies third position in rice area and fourth position in rice production (BRRI, 2017). But the average yield is relatively low compared to top rice producing countries. The yield of rice is about 4.5 t ha^{-1} in Bangladesh whereas it is about 6-6.5 t ha^{-1} in Japan, Korea, China (BRRI, 2017). On the other hand, population of Bangladesh is increasing rapidly. So to ensure food security of increasing population, yield of rice per unit area should be increased. Variety itself is a genetic factor which contributes a lot in yield and yield components of a particular crop (Mahmud *et al.,* 2013). Variety has marked influence on number of tillers, 1000-grain weight, filled grain percentage which ultimately influences yield of rice. Rice has three growing seasons in Bangladesh, aus, aman and boro. Aman occupies about 49% of total cultivable land area (BBS, 2017). Aman is mostly monsoon rain dependent rice which requires less irrigation and so it reduces ground water depletion. So considering the population pressure and vast potential of aman rice, it can be a great option for ensuring food security.

Nitrogen is one of the most important nutrients for rice cultivation. Nitrogen is integral part of structural and functional protein, chlorophyll and nucleic acid (Tilahun, 2019). It has positive influence on tillers development, yield and yield components of rice (Djaman *et al.*, 2016). Generally farmers apply higher rate of N fertilizer than the recommended dose considering that increasing N would result in higher yields (Fan *et al.*, 2012) but that can negatively affect the sustainability of the production system and increase the production cost. Higher dose of N fertilizer makes plants vulnerable to lodging, insect and diseases (Kumar, 2016). So, a suitable combination of nitrogen fertilizer and variety is required for better growth and yield of rice.

Although, a number of experiments were conducted on the effects of nitrogen on the yield and yield components of rice but comparative study on the performance of rice genotypes with modern inbred and hybrid varieties for different levels of nitrogen is very few in Bangladesh. Keeping above facts in view, the present investigation was planned to compare the performance of promising rice genotypes with modern inbred and hybrid varieties, to know the response of rice genotypes to different levels of nitrogen compared with modern inbred and hybrid varieties and to find out better combination of nitrogen and rice genotypes to increase growth and yield of rice.

Materials and methods

Experimental site

The experimental area was situated at 23°77′N latitude and 90°33′E longitude. The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soils under Tejgaon Series. Top soils are clay loam in texture, olive-gray with common fine to medium distinct dark yellowish-brown mottles. Soil pH ranges from 5.4-5.6.The total rainfall of 1540 mm was recorded during the cropping period.

Treatments

The experiment consisted of three nitrogen levels (*viz.* 50, 100 and 150 kg N ha^{-1}) and four varieties/lines (*viz.* SAU ADL1, BRRI dhan70, BRRI hybrid dhan6 and SAU ADL11).

Planting materials

Initially seeds of a line were collected from an NGO named Suranjana from which two lines SAU ADL1 (SAU ADL- Sher-e-Bangla Agricultural University Agronomy Department) and SAU ADL11 were named under various field observations by the Agronomy department of Sher-e-Bangla Agricultural University. Seeds of another two varieties BRRI dhan70 and BRRI hybrid dhan6 were collected from Bangladesh Rice Research Institute, Gazipur.

Experimental design and layout

The experiment was laid out in a split-plot design with three replications having nitrogen in the main plots and variety/line in the sub-plots. The size of unit plot was 3.0 m × 2.2 m.

Crop management

The experimental field was fertilized with 80, 80 and 20 kg ha^{-1} of P_2O_5, K_2O and S during final land preparation. Urea was top-dressed in three installments, after seedling recovery, during the vegetative stage and at 7 days before panicle initiation as per treatment. 30 days old seedlings were transplanted on 5th August, 2017 with 20 cm × 20 cm spacing on the well-puddled plots. Irrigation, weeding and other agronomic practices were done whenever necessary.

Data collection

Five preselected plants were used to recorded data on plant height and number of tillers $hill^{-1}$, number of effective and ineffective tillers $hill^{-1}$ after harvest. Leaf area index was estimated measuring the length and average breadth of leaf and multiplying by a factor of 0.75 followed by Yoshida (1981). The plants of 2 hills $plot^{-1}$ uprooted from second line were oven dried until reached to a constant weight and then the weight was measured and calculated as g $hill^{-1}$ to obtain dry matter $hill^{-1}$. Total grains $panicle^{-1}$ and weight of 1000 grains were recorded from 10 randomly selected panicles. The crop was harvested from an area of 3.96 m^2 excluding the border area. The harvested yield was converted into t ha^{-1} at 14% moisture content.

Statistical analysis

All the collected data were analyzed following the analysis of variance (ANOVA) technique and using Statistix 10 package and the mean differences were adjudged by LSD technique (Gomez and Gomez, 1984).

Results and discussion

Growth characters

Effect of nitrogen

Nitrogen had significant influence on crop growth characters. A trend of increase was observed at all the sampling dates with the increasing levels of nitrogen from 50 kg to 150 kg N ha^{-1} in case of all growth parameters (Table 1, 2, 3, 4). Hossain *et al.* (2008) stated that the increase in plant height was due to various physiological processes including cell division and cell elongation of the plant.

Table 1. Effect of nitrogen and variety on plant height of transplanted aman rice at Different crop growth stages.

Treatments	Plant height (cm) at different days after transplanting (DAT)				
	20	40	60	80	Harvest
Nitrogen					
N_1	27.23 c	55.61 c	93.69 b	122.26 b	133.79 b
N_2	36.36 b	71.59 b	98.93 ab	134.91 a	140.52 a
N_3	39.73 a	76.70 a	106.64 a	142.98 a	146.48 a
$LSD_{(0.05)}$	1.72	3.26	10.84	9.29	6.28
CV (%)	4.41	4.24	9.59	6.15	3.95
Variety					
V_1	40.56 a	78.77 a	122.48 a	176.08 a	190.95 a
V_2	32.80 bc	66.36 b	98.03 b	139.65 b	143.24 b
V_3	30.83 c	60.22 c	88.94 c	108.87 c	113.12 c
V_4	33.58 b	66.52 b	89.57 c	105.94 c	113.74 c
$LSD_{(0.05)}$	2.45	3.29	6.28	5.29	8.94
CV (%)	7.18	4.88	6.36	4.00	6.25

N_1= 50 kg N ha^{-1}, N_2= 100 kg N ha^{-1}, N_3= 150 kg N ha^{-1}, V_1= SAU ADL1, V_2= BRRI dhan70, V_3= BRRI hybrid dhan6, V_4= SAU ADL11 (SAU ADL-Sher-e-Bangla Agricultural University Agronomy Department line).

Progressive increment in LAI might be due to the fact that addition of nitrogen triggers increased number of leaves plant^{-1} and expansion of individual leaf. Elevated nitrogen supply can boost dry matter content through production of photo assimilates via leaves which is the center of plant growth during vegetative stage and later distribution of assimilates to the reproductive organs (Azarpour *et al.,* 2014). Adhikari *et al.* (2018) and Murthy *et al.* (2015) also found significant effect of nitrogen on plant height, number of tillers hill^{-1}, LAI and dry matter hill^{-1}. Maqsood *et al.* (2013) reported that nitrogen rate had a significant effect on chlorophyll content.

Table 2. Effect of nitrogen and variety on number of tillers hill^{-1} of transplanted aman rice at different crop growth stages.

Treatments	Number of tillers hill^{-1} at different days after transplanting (DAT)				
	20 DAT	40 DAT	60 DAT	80 DAT	At harvest
Nitrogen					
N_1	2.93 c	7.69 b	11.53 c	11.62 c	10.63 c
N_2	3.98 b	9.97 a	13.04 b	13.39 b	11.30 b
N_3	4.39 a	10.4 a	14.23 a	14.38 a	12.48 a
LSD $_{(0.05)}$	0.401	0.8	0.95	0.33	0.31
CV (%)	9.4	7.57	6.50	2.25	3.35
Variety					
V_1	2.91 c	6.74 d	11.92 b	11.61 c	10.11 c
V_2	3.76 b	10.79 b	13.21 a	13.90 b	11.62 b
V_3	5.09 a	11.68 a	14.21 a	14.94 a	13.60 a
V_4	3.31 bc	8.2 c	12.08 b	12.07 c	10.56 c
LSD $_{(0.05)}$	0.63	0.85	1.01	0.66	0.55
CV (%)	16.82	9.12	7.89	5.08	4.82

N_1= 50 kg N ha^{-1}, N_2= 100 kg N ha^{-1}, N_3= 150 kg N ha^{-1}, V_1= SAU ADL1, V_2= BRRI dhan70, V_3= BRRI hybrid dhan6, V_4= SAU ADL11 (SAU ADL-Sher-e-Bangla Agricultural University Agronomy Department line).

Table 3. Effect of nitrogen and variety on leaf area index (LAI) and SPAD value of transplanted aman rice at different crop growth stages.

Treatments	Leaf area index (LAI) at different days after transplanting (DAT)			SPAD value at different days after transplanting (DAT)	
	40 DAT	60 DAT	80 DAT	50 DAT	70 DAT
Nitrogen					
N_1	3.10 c	4.58 c	5.68 c	41.01 c	35.46 c
N_2	3.65 b	5.38 b	6.31 b	42.57 b	40.31 b
N_3	4.62 a	6.40 a	7.93 a	44.14 a	45.01 a
LSD $_{(0.05)}$	0.24	0.60	0.38	1.39	1.74
CV (%)	5.66	9.78	5.15	2.88	3.81
Variety					
V_1	4.29 a	6.01 a	7.40 a	41.87 b	43.44 b
V_2	4.04 b	5.43 b	6.29 c	42.12 b	40.09 c
V_3	3.66 c	5.15 b	6.23 c	41.75 b	29.99 d
V_4	3.17 d	5.21 b	6.61 b	44.55 a	47.53 a
LSD $_{(0.05)}$	0.17	0.33	0.25	0.92	3.2
CV (%)	4.53	6.19	3.87	2.17	8.03

N_1= 50 kg N ha^{-1}, N_2= 100 kg N ha^{-1}, N_3= 150 kg N ha^{-1}, V_1= SAU ADL1, V_2= BRRI dhan70, V_3= BRRI hybrid dhan6,V_4= SAU ADL11 (SAU ADL-Sher-e-Bangla Agricultural University Agronomy Department line).

Effect of variety

Crop growth characters of transplanted aman rice significantly varied among studied materials. The line SAU ADL1 showed superiority over other three studied materials in case of plant height (Table 1). Tiller number in all the studied materials increased almost exponentially up to 60 days after transplanting after that a gradual decline in tiller number was noticed towards maturity due to side tiller mortality and initiation of panicle primordia. The maximum number of tillers hill^{-1} was observed in the variety BRRI hybrid dhan6 and minimum was recorded in SAU ADL1 at all sampling dates (Table 2). The highest LAI was observed in SAU ADL1 at all the dates of taking observation the lowest LAI was observed in SAU ADL11 at 40 DAT and in BRRI hybrid dhan6 at 80 DAT which was statistically at par with BRRI dhan70 (6.29) (Table 3).

Table 4. Effect of nitrogen and variety on dry matter hill^{-1} of transplanted aman rice at different crop growth stages.

Treatments	Dry matter hill^{-1} at different days after transplanting (DAT)			
	50	70	90	At harvest
Nitrogen				
N_1	22.30 c	35.54 c	60.15 c	74.87 b
N_2	29.38 b	46.60 b	77.81 b	97.06 a
N_3	37.85 a	56.99 a	86.98 a	101.14 a
LSD $_{(0.05)}$	4.85	8.83	8.27	4.88
CV (%)	14.37	16.79	9.74	4.73
Variety				
V_1	31.52 a	46.12 b	68.20 bc	99.85 a
V_2	26.09 b	41.16 b	71.29 b	86.25 c
V_3	30.51 a	51.80 a	94.88 a	92.36 b
V_4	31.13 a	46.44 ab	65.55 c	85.64 c
LSD $_{(0.05)}$	3.96	5.46	4.45	3.20
CV (%)	13.42	11.88	5.99	3.56

N_1= 50 kg N ha^{-1}, N_2= 100 kg N ha^{-1}, N_3= 150 kg N ha^{-1}, V_1= SAU ADL1, V_2= BRRI dhan70, V_3= BRRI hybrid dhan6, V_4= SAU ADL11 (SAU ADL-Sher-e-Bangla Agricultural University Agronomy Department line)

Table 5. Interaction effect of nitrogen and variety on plant height of transplanted aman rice at different crop growth stages.

Treatment combinations	Plant height (cm) at different days after transplanting (DAT)				
	20	40	60	80	At harvest
N_1V_1	36.42 cd	62.33 e	117.27 ab	168.51 b	187.34 a
N_1V_2	26.50 e	54.90 f	86.99 ef	124.89 d	134.43 cd
N_1V_3	19.68 f	45.77 g	81.98 f	95.96 g	100.07 g
N_1V_4	26.33 e	59.43 ef	88.53 ef	99.67 fg	113.31 efg
N_2V_1	42.40 ab	83.43 b	125.07 a	182.16 a	192.33 a
N_2V_2	33.50 d	69.39 cd	99.84 cd	146.32 c	145.19 bc
N_2V_3	33.93 d	64.30 de	84.63 ef	107.21 ef	111.40 fg
N_2V_4	35.60 cd	69.27cd	86.17 ef	103.95 fg	112.33 fg
N_3V_1	42.87 a	90.53 a	125.09 a	186.56 a	193.18 a
N_3V_2	38.40 bc	74.80 c	107.27 bc	147.73 c	150.10 b
N_3V_3	38.87 abc	70.60 c	100.20 cd	123.45 d	127.91 de
N_3V_4	38.80 abc	70.87 c	94.01 de	114.19 e	115.57 ef
LSD $_{(0.05)}$	4.24	2.71	10.88	9.16	15.04
CV (%)	7.18	4.88	6.36	4.00	6.25

N_1= 50 kg N ha^{-1}, N_2= 100 kg N ha^{-1}, N_3= 150 kg N ha^{-1}, V_1= SAU ADL1, V_2= BRRI dhan70, V_3= BRRI hybrid dhan6, V_4= SAU ADL11 (SAU ADL-Sher-e-Bangla Agricultural University Agronomy Department line).

The variation in leaf area might be due to the variation in leaf number and length and breadth of leaves in plant. Both at 50 and 70 DAT, highest SPAD value (44.55 and 47.53, respectively) was observed in SAU ADL11 and the lowest SPAD value (41.75 and 29.99) was observed in BRRI hybrid dhan6 (Table 3).BRRI hybrid dhan6 produced maximum dry matter hill^{-1} at 70 and 90 DAT but SAU ADL1 produced maximum at 50 DAT and at harvest (Table 4). Varietal variation in case of crop growth characters might be due to their genetic variability.

These results were also consistent with the findings of Chowhan *et al.* (2017) and Murshida *et al.* (2017).

Table 6. Interaction effect of nitrogen and variety on number of tillers hill^{-1} of transplanted aman rice at different crop growth stages.

Treatment combinations	Number of tillers hill^{-1} at different days after transplanting (DAT)				
	20	40	60	80	At harvest
N_1V_1	2.47 e	5.80 g	11.20 fg	10.20 f	9.8 hi
N_1V_2	2.73 de	8.2 c-f	11.67 efg	12.50 d	10.93 efg
N_1V_3	3.67 cd	9.40 c	12.27 d-g	12.67 d	12.33 cd
N_1V_4	2.86 de	7.37 ef	10.97 g	11.10 ef	9.20 i
N_2V_1	3.5 cde	7.67 def	11.70 efg	12.17 de	10.06 ghi
N_2V_2	4.20 c	11.77 b	13.93 bcd	13.87 c	11.27 ef
N_2V_3	5.33 ab	12.10 ab	14.50 abc	15.30 b	13.33 b
N_2V_4	2.87 de	8.33 cde	12.03 efg	12.23 de	10.80 efg
N_3V_1	2.77 de	6.77 fg	12.87 c-f	12.47 d	10.47 fgh
N_3V_2	4.33 bc	12.40 ab	14.93 ab	15.33 b	12.67 bc
N_3V_3	6.27 a	13.53 a	15.87 a	16.87 a	15.13 a
N_3V_4	4.20 c	8.90 cd	13.23 b-e	12.87 cd	11.67 de
LSD $_{(0.05)}$	1.09	1.46	1.75	1.14	0.95
CV (%)	16.82	9.12	7.89	5.08	4.82

N_1= 50 kg N ha^{-1}, N_2= 100 kg N ha^{-1}, N_3= 150 kg N ha^{-1}, V_1= SAU ADL1, V_2= BRRI dhan70, V_3= BRRI hybrid dhan6, V_4= SAU ADL11 (SAU ADL-Sher-e-Bangla Agricultural University Agronomy Department line).

Table 7. Interaction effect of nitrogen and variety on leaf area index (LAI) of transplanted aman rice at different crop growth stages.

Treatment combinations	LAI at different days after transplanting (DAT)			SPAD value at different days after transplanting (DAT)	
	40	60	80	50	70
N_1V_1	3.41 d	5.21 d	6.30 d	40.69 de	40.58 c-f
N_1V_2	3.25 de	4.23 e	4.98 f	40.92 cd	35.78 fg
N_1V_3	3.11 e	4.42 e	5.51 e	39.20 e	20.57 h
N_1V_4	2.61 f	4.45 e	5.91 de	43.23 b	44.90 bcd
N_2V_1	4.28 b	5.61 cd	6.94 c	42.00 bcd	43.87 b-e
N_2V_2	3.40 de	5.51 cd	6.12 d	42.23 bcd	40.10 def
N_2V_3	3.83 c	5.19 d	6.05 d	42.47 bc	30.97 g
N_2V_4	3.11 e	5.20 d	6.12 d	43.55 b	46.31 ab
N_3V_1	5.19 a	7.21 a	8.96 a	42.92 b	45.86 abc
N_3V_2	5.47 a	6.54 b	7.80 b	43.19 b	44.38 bcd
N_3V_3	4.04 bc	5.86 c	7.13 c	43.58 b	38.42 f
N_3V_4	3.80 c	5.99 bc	7.81 b	46.86 a	51.39 a
LSD $_{(0.05)}$	0.29	0.58	0.44	1.59	5.55
CV (%)	4.53	6.19	2.17	2.17	8.03

N_1= 50 kg N ha^{-1}, N_2= 100 kg N ha^{-1}, N_3= 150 kg N ha^{-1}, V_1= SAU ADL1, V_2= BRRI dhan70, V_3= BRRI hybrid dhan6, V_4= SAU ADL11 (SAU ADL-Sher-e-Bangla Agricultural University Agronomy Department line).

Interaction effect of nitrogen and variety

Interaction between nitrogen and variety played an important role on crop growth characters. A trend of increase in all studied growth parameters with the increasing levels of nitrogen was observed among all the tested varieties. The tallest plant (42.87 cm) was obtained from SAU ADL1 fertilized with 150 kg N ha^{-1} (N_3V_1) and shortest from BRRI hybrid dhan6 fertilized with 50 kg N ha^{-1} (N_1V_3) (Table 5). Interaction of 150 kg N ha^{-1} with BRRI hybrid dhan6 (N_3V_3) produced maximum number of tillers $hill^{-1}$ at all sampling dates (6.27, 13.53, 15.87, 16.87 and 15.13 at 20, 40, 60, 80 DAT and at harvest, respectively) which was statistically similar with the combination of 100 kg N ha^{-1} with BRRI hybrid dhan6 (N_2V_3) at all sampling dates except 80 DAT and at harvest (Table 6). At 60 and 80 DAT, Maximum LAI (7.21 and 8.96, respectively) was also observed in SAU ADL1 fertilized with 150 kg N ha^{-1} (Table 7). At these two sampling dates, Minimum LAI was observed in BRRI dhan70 fertilized with 50 kg N ha^{-1} (4.23 and 4.98, respectively). SAU ADL11 with 150 kg N ha^{-1} (N_3V_4) showed superiority over other treatment combination in case of SPAD value at 50 and 70 DAT (Table 7).

At 70 and 90 DAT, BRRI hybrid dhan6 with 150 kg N ha^{-1} showed superiority than other treatment combinations but at harvest, SAU ADL1 with 150 kg N ha^{-1} produced maximum dry matter $hill^{-1}$ which was statistically similar with this combination (Table 8). Saha *et al.* (2017) and Paul *et al.* (2016) also reported increasing trend of growth with increasing nitrogen levels along with varieties.

Table 8. Interaction effect of nitrogen and variety on dry matter $hill^{-1}$ of transplanted aman rice at different crop growth stages.

Treatment combinations	Dry matter $hill^{-1}$ (g) at different days after transplanting (DAT)			
	50	70	90	At harvest
N_1V_1	26.17 cd	36.47 ef	57.03 f	84.84 c
N_1V_2	17.45 e	28.12 f	52.82 f	68.38 d
N_1V_3	22.74 de	40.07 de	76.77 d	73.85 d
N_1V_4	22.85 de	37.52 def	53.97 f	72.39 d
N_2V_1	30.53 bc	46.49 bcd	70.92 de	107.21 a
N_2V_2	24.99 cd	41.53 de	74.90 de	94.04 b
N_2V_3	30.67 bc	52.43 bc	97.77 b	95.77 b
N_2V_4	30.94 bc	45.96 cd	67.66 e	90.95 b
N_3V_1	37.88 a	55.39 abc	76.66 d	107.49 a
N_3V_2	35.82 ab	53.82 abc	86.14 c	96.32 b
N_3V_3	38.11 a	62.90 a	110.11 a	107.45 a
N_3V_4	39.59 a	55.83 ab	75.02 de	93.59 b
LSD $_{(0.05)}$	6.86	9.45	7.71	5.55
CV (%)	13.42	11.88	5.99	3.56

N_1= 50 kg N ha^{-1}, N_2= 100 kg N ha^{-1}, N_3= 150 kg N ha^{-1}, V_1= SAU ADL1, V_2= BRRI dhan70, V_3= BRRI hybrid dhan6, V_4= SAU ADL11 (SAU ADL-Sher-e-Bangla Agricultural University Agronomy Department line).

Yield and yield contributing characters

Effect of nitrogen

Result revealed that nitrogen had significant effect on all studied parameters. Yield contributing characters were significantly different due to nitrogen effect (Table 9). There was a trend to increase yield and yield attributes with the increase of nitrogen levels but nitrogen levels 100 and 150 kg ha^{-1} statistically similar in case of grain yield, straw yield and biological yield (Table 10). The grain yield at 100 kg and 150 kg N ha^{-1} indicated that the studied materials were highly efficient in nitrogen use at 100 kg N ha^{-1}

that caused corresponding increase in growth and yield components and after that the efficiency reached almost at plateau except hybrid variety. It revealed that excess N rates did not give extra benefit regarding to grain yield. The increase in grain yield at higher nitrogen levels might be due to accumulation of more dry matter and translocation from source to sink (Morteza *et al.*, 2011). Number of ineffective tillers decreased with the increasing nitrogen levels (Table 9). The highest weight of 1000-grains (27.19 g) were obtained from 150 kg N ha^{-1} which were statistically similar with 100 kg N ha^{-1}(Table 9). The highest harvest index (36.58%) was obtained from 100 kg N ha^{-1} (Table 10). Similar results were corroborated by Gewaily *et al.* (2018) and Shukla *et al.* (2015).

Table 9. Effect of nitrogen and variety on yield contributing characters of transplanted aman rice.

Treatments	Effective tillers hill^{-1}	Ineffective tillers hill^{-1}	Total grain panicle^{-1}	1000- grains Weight (g)
Nitrogen				
N_1	9.17 c	1.47 a	179.74 b	24.42 b
N_2	10.18 b	1.12 b	191.22 b	26.66 a
N_3	11.9 a	0.58 c	217.81 a	27.19 a
LSD $_{(0.05)}$	0.39	0.10	13.75	0.76
CV (%)	3.28	8.36	6.18	2.58
Variety				
V_1	9.09 c	1.02ab	186.32 b	31.49 a
V_2	10.47 b	1.16 a	210.04 a	20.50 d
V_3	12.53 a	1.07 ab	204.06 a	21.56 c
V_4	9.58 c	0.98 b	184.60 b	30.80 b
LSD $_{(0.05)}$	0.55	0.14	16.17	0.59
CV (%)	5.34	13.27	8.32	2.32

N_1= 50 kg N ha^{-1}, N_2= 100 kg N ha^{-1}, N_3= 150 kg N ha^{-1}, V_1= SAU ADL1, V_2= BRRI dhan70, V_3= BRRI hybrid dhan6, V_4= SAU ADL11 (SAU ADL-Sher-e-Bangla Agricultural University Agronomy Department line).

Table 10. Effect of nitrogen and variety on yield of transplanted aman rice.

Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
Nitrogen				
N_1	2.96 b	5.97 b	8.94 b	33.42 c
N_2	4.43 a	7.76 a	12.19 a	36.58 a
N_3	4.50 a	8.00 a	12.78 a	35.25 b
LSD $_{(0.05)}$	0.25	0.72	0.95	1.25
CV (%)	5.24	8.78	7.37	3.13
Variety				
V_1	3.33 c	9.33 a	12.66 a	26.00 c
V_2	4.12 b	7.44 b	11.56 b	35.56 b
V_3	5.24 a	6.20 c	11.44 b	45.44 a
V_4	3.17 c	6.01 c	9.55 c	33.33 b
LSD $_{(0.05)}$	0.20	0.42	0.75	2.38
CV (%)	5.19	5.81	6.68	6.85

N_1= 50 kg N ha^{-1}, N_2= 100 kg N ha^{-1}, N_3= 150 kg N ha^{-1}, V_1= SAU ADL1, V_2= BRRI dhan70, V_3= BRRI hybrid dhan6, V_4= SAU ADL11 (SAU ADL-Sher-e-Bangla Agricultural University Agronomy Department line).

Effect of variety

Variety had significant effect on yield and yield contributing characters (Table 9, 10).The maximum number of effective tillers hill^{-1} (12.53), grain yield (5.24 t ha^{-1}) and harvest index (45.44%) were obtained from BRRI hybrid dhan6. The line SAU ADL1 produced maximum weight of 1000-grains (31.49 g), straw yield (9.33 t ha^{-1}) and biological yield (12.66 t ha^{-1}). The maximum number of ineffective tillers hill^{-1} (1.16) was produced by BRRI dhan70 which was statistically similar with SAU ADL1 and BRRI hybrid dhan6. The lowest number of ineffective

tillers hill^{-1} (0.98) was produced by SAU ADL11. The lowest grain yield (3.17 t ha^{-1}) was obtained from SAU ADL11 which was statistically similar with SAU ADL1 (3.33 t ha^{-1}). SAU ADL1 and SAU ADL11 gave 36.45% and 39.5% lower grain yield than BRRI hybrid dhan6, respectively. Variation in yield and yield contributing characters might be due to genetic variability and environmental adaptability of the varieties. More number of grains panicle^{-1}, less number of non-effective tillers of BRRI hybrid dhan6 may have resulted in higher grain yield. Poor tillering, less number of grains panicle^{-1}, lodging tendency and more straw yield could be the reasons for such lower yield in SAU ADL1 and SAU ADL11. Similar results were reported by Chowhan *et al.* (2017) and Murshida *et al.* (2017).

Table 11. Interaction effect of nitrogen and variety on yield contributing characters of transplanted aman rice.

Treatment combinations	Effective tillers hill^{-1}	Ineffective tillers hill^{-1}	Total grains panicle^{-1}	Weight of 1000- grains (g)
N_1V_1	8.67 gh	1.40 bc	179.67 de	30.41 b
N_1V_2	9.27 fg	1.67 a	188.13 cde	19.19 g
N_1V_3	10.80 de	1.53 ab	147.60 f	20.04 fg
N_1V_4	7.93 h	1.27 c	170.50 ef	28.02 c
N_2V_1	8.80 gh	1.00 d	180.33 de	32.10 a
N_2V_2	10.00 ef	1.27 c	221.20 b	20.80 ef
N_2V_3	12.33 b	1.00 d	211.33 bc	21.53 e
N_2V_4	9.6 fg	1.20 cd	185.07 cde	32.22 a
N_3V_1	9.8 f	0.67 e	198.97 bcd	31.97 a
N_3V_2	12.13 bc	0.53 e	220.80 b	21.52 e
N_3V_3	14.47 a	0.67 e	253.23 a	23.12 d
N_3V_4	11.20 cd	0.47 e	198.23 bcd	32.15 a
LSD $_{(0.05)}$	0.95	0.24	28.00	1.04
CV (%)	5.34	13.27	8.32	2.32

N_1= 50 kg N ha^{-1}, N_2= 100 kg N ha^{-1}, N_3= 150 kg N ha^{-1}, V_1= SAU ADL1, V_2= BRRI dhan70, V_3= BRRI hybrid dhan6, V_4= SAU ADL11 (SAU ADL-Sher-e-Bangla Agricultural University Agronomy Department line).

Table 12. Interaction effect of nitrogen and variety on yield of transplanted aman rice.

Treatment combinations	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
N_1V_1	2.52 g	8.09 b	10.61 d	23.67 e
N_1V_2	2.98 f	5.80 d	8.78 ef	33.67 bc
N_1V_3	3.82 de	5.01 e	8.83 e	43.00 a
N_1V_4	2.53 g	4.98 e	7.52 f	33.33 bc
N_2V_1	3.84 d	9.90 a	13.73 a	27.67 de
N_2V_2	4.67 c	8.18 b	12.84 ab	36.33 b
N_2V_3	5.70 b	6.44 cd	12.13 bc	46.33 a
N_2V_4	3.54 de	6.53 c	10.06 de	35.33 bc
N_3V_1	3.64 de	9.99 a	13.64 a	26.67 e
N_3V_2	4.70 c	8.34 b	13.04 ab	36.67 b
N_3V_3	6.22 a	7.15 c	13.37 ab	47.00 a
N_3V_4	3.44 e	6.53 c	11.07 cd	31.33 cd
LSD $_{(0.05)}$	0.35	0.72	1.30	4.12
CV (%)	5.19	5.81	6.68	6.85

N_1= 50 kg N ha^{-1}, N_2= 100 kg N ha^{-1}, N_3= 150 kg N ha^{-1}, V_1= SAU ADL1, V_2= BRRI dhan70, V_3= BRRI hybrid dhan6, V_4= SAU ADL11 (SAU ADL-Sher-e-Bangla Agricultural University Agronomy Department line).

Interaction effect of nitrogen and variety

Interaction effect of nitrogen and variety significantly influenced yield and yield contributing characters of aman rice (Table 11, 12). Number of effective tillers hill^{-1} and total grains panicle^{-1} increased but number of ineffective tillers hill^{-1} decreased with increasing nitrogen levels among all the varieties (Table 11). Haque and Haque (2016) opined that the number of effective tillers contributes more to enhance productivity of rice plant than total number of tillers.

BRRI hybrid dhan6 with 150 kg N ha^{-1} produced highest number of effective tillers $hill^{-1}$ (14.47), total grains $panicle^{-1}$ (253.53), grain yield (6.22 t ha^{-1}) and harvest index (47%). But number of total grains $panicle^{-1}$, 1000-grains weight, grain yield, straw yield and harvest index of SAU ADL1, SAU ADL11 and BRRI dhan70 with 150 kg N ha^{-1} were statistically similar with 100 kg N ha^{-1}. The maximum 1000-grains weight (32.22 g) was recorded from SAU ADL11 fertilized with 100 kg N ha^{-1} (N_2V_4) which was statistically at par with N_3V_4 (32.15 g), N_2V_1 (32.10 g) and N_3V_1 (31.97 g). The lowest value of all studied parameters was found from the interaction of 50 kg N ha^{-1} with all the varieties. Hossain *et al.* (2018) and Saha *et al.* (2017) also found significant effect due to interaction of nitrogen and variety.

Conclusion

On the basis of present research, it can be concluded that BRRI hybrid dhan6 with 150 kg N ha^{-1} performed better for all studied parameter but SAU ADL1 and SAU ADL11 with 100 kg N ha^{-1} appeared as the promising combination in respect of yield of rice as BRRI dhan70. So, SAU ADL1 and SAU ADL11 with 100 kg N ha^{-1} can be suggested for further research under different agro-ecological zones to reach a specific conclusion and recommendation.

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