ISSN (Online) = 2522-6754 ISSN (Print) = 2522-6746
WORLD JOURNAL OF BIOLOGY AND BIOTECHNOLOGY
Research Manuscript www.sciplatform.com

Effect of nitrogen on growth and yield of short duration transplanted inbred and hybrid rice varieties

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Authors' Contribution	**Rahman, M. M.,** planning and conducting the experiment, analysis of data and preparation of manuscript**, E. Yasmin,** conducting the field experiment, collection of data and preparation of manuscript**.**
Article History	***Corresponding email address**: rahmanag63@yahoo.com **Digital Object Identifier (DOI): https://doi.org/10.33865/wjb.005.03.0366** **Received: 27 October 2020, Revised: 20 November 2020, Accepted: 04 December 2020, Published Online: 13 December 2020**

ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh during June to December 2015 with a view to finding out the effect of nitrogen levels on the yield performance of short duration inbred and hybrid transplant rainy season rice varieties. Four short duration rice varieties (three inbred viz. BINA dhan7, BRRI dhan39, BRRI dhan56 and one hybrid Dhanigold), and 5 levels of nitrogen viz. 0, 40, 80, 120 and 160 kg N ha^{-1} were included in the experiment under a split–plot design with three replications. The result revealed that variety, nitrogen rate and their interactions had significant on grain yield of short duration transplant rainy season rice. Hybrid variety Dhanigold gave the highest yield (5.13 t ha^{-1}) followed by BRRI dhan56 (4.80 t ha^{-1}) while the lowest was produced by Binadhan-7 (4.28 t ha^{-1}). The highest yield (5.93 t ha^{-1}) was obtained from Dhanigold with 120 kg N ha^{-1} which was followed by BRRI dhan56 at 120 kg N ha^{-1} (5.42 t ha^{-1}). The highest yield was attributed to the increased production of effective tiller and grains panicle^{-1}. The optimum dose of nitrogen estimated for Binadhan-7, BRRI dhan39, BRRI dhan56 and Dhanigold are 131.31, 122.97, 126.50 and 133.14 kg ha^{-1}, respectively. Thus, this study concludes that the highest yield of short duration rice varieties Binadhan-7, BRRI dhan39, BRRI dhan56 and Dhanigold could be obtained by applying nitrogen at 131.31, 122.97, 126.50 and 133.14 kg ha^{-1}, respectively.

Keywords: Nitrogen, plant nutrition, grain yield, optimum nitrogen dose, short duration rice, rainy season, quadratic equation.

INTRODUCTION: Rice (*Oryza sativa* L.) contributes 95% to food production in Bangladesh. About 77% of cropped area of Bangladesh is used for rice production, with the annual production of 37.36 million tons from 11.68 million ha of land (AIS, 2020). Transplant rice–Fallow–Transplant rice is the major cropping pattern in Bangladesh occupying 26.92% of the net cropped area of the country (Nasim *et al.*, 2017). Very recently, initiative has been taken to increase the cropping intensity and diversity by introducing a *rabi* crop in between the two rice crops of the present cropping pattern. Many rabi crops such as mustard, potato, lentil etc. can be cultivated in between the *aman* rice and *boro* rice in the same field. The sowing time of these rabi crops are very crucial and any delay of their sowing would result in yield penalty. Thus, the success of the new cropping pattern depends on the timely planting of the rabi crop which mainly depends on the cultivation of a short duration rice variety in rainy (*aman)* season. Currently a number of short duration high yielding rice varieties have been developed for *aman* season to enable successful introduction of the Transplant *Aman* rice – *Rabi* crop – Transplant *Boro* rice pattern. Moreover, short duration hybrid rice can be cultivated in rainy season towards augmentation of rice yield. Hybrid rice became highly successful in China where more than 50% of the rice area is reported to be under hybrid rice cultivation (Yuan, 2015).

The yield of a rice variety depends on different management practices including judicious fertilization. Nitrogen is a key nutrient element which plays a vital role in vegetative growth, development of yield component and yield of rice (Chaturvedi, 2005). It is required in adequate amount at early and mid tillering stage, at panicle initiation and ripening stages for better grain development (Yesuf and Balcha, 2014). Many research works have been done to know the response of long duration varieties to various nitrogen levels and the farmers of Bangladesh use increased amount of nitrogen fertilizer to get higher yield. Nitrogen use efficiency for rice crop largely ranges between 25% and 35% and seldom exceeds 50%. This lower recovery of applied fertilizer N by rice plant is largely caused by losses of N from the soil-plant system. Nonetheless, nitrogen management is a very important factor because excessive use of nitrogen results in lodging of plant, reduction of yield and also has negative implications for the environment (Jiang *et al.*, 2005; Fageria *et al.*, 2008). On the other hand, deficiency of nitrogen hampers the production of rice. Therefore, application of the optimum rate of nitrogen is necessary to attain higher yield of different short duration rice varieties. Many studies related to the nitrogen application rates for different rice varieties have been done elsewhere but the study on the optimization of N levels for short duration inbrid and hybrid rice varieties are scarce.

OBJECTIVES: The present study was therefore, undertaken with a view (i) to compare the yield of different short duration rice varieties, (ii) to study the effect of rate of nitrogen on grain yield and related attributes of these short duration rice varieties and (iii) to determine the optimum nitrogen rates for different short duration rice varieties.

MATERIALS AND METHODS: Location and soil: An experiment was conducted during rainy season (June-December) of 2015 at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh (latitude 24.75° N, longitude 90.50° E and elevation l8 m). The experimental area was a fairly leveled well drained medium high land belonging to the Sonatola series of non–calcareous

dark grey floodplain soil under the Old Brahmaputra Floodplain agroecological zone. The experimental soil was silty clay loam having bulk density of 1.35 g cc^{-1} and pH 7.30. The soil contained 0.16% total nitrogen, 1.11% organic matter, 13.44 ppm available phosphorus, 14.2 ppm available sulphur and 48.43meq 100 g^{-1} exchangeable potassium.

Experimental treatments and design: The experiment comprised three high yielding (viz. BINA dhan7, BRRI dhan39, BRRI dhan56) and one hybrid (viz. Dhani gold) rice varieties and five nitrogen levels viz. 0, 40, 80, 120 and 160 kg N ha^{-1} in a Split-plot design with three replications assigning the nitrogen level to the main plot and the variety in the sub plots randomly. The size of unit plot was 4.0 × 2.5 m (10 m^2) where block to block and plot to plot distances were 1.0 m and 0.5 m, respectively.

Crop husbandry: Thirty days old seedlings were transplanted on 26 July 2015 at 25cm× 15cm spacing with three seedling $hill^{-1}$. The experimental plots were fertilized with Triple supper phosphate, Muriate of potash, Gypsum, Zinc sulphate and Boron at final land preparation @ 50, 70, 70, 5 and 5 kg ha^{-1}, respectively. Nitrogen was applied as per treatment in the form of urea as top dressing in three equal splits at 15, 30 and 45 days after transplanting (DAT). Crops were infested with different weeds. Weeding was done manually twice at 30 and 45 DAT. Flood irrigation was given in the experimental field to maintain a constant level of standing water up to 6 cm in early stage to enhance tillering and 10–12 cm in later stage to discourage late tillering. The field was finally drained out before 15 days of harvest. The plants were infested with yellow stem borer (*Scirpophaga incertulas*) which was successfully controlled by applying Diazinon 60EC @ 1 L ha^{-1}. At maturity when 90% of the seeds became golden yellow in color, the crop was cut from randomly selected three square meter area of the central portion of each plot manually at the ground level to record grain and straw yields.

Data recording: Data on growth parameters like plant height, number of tillers $hill^{-1}$, dry matter production and crop growth rate were recorded at 40, 50 and 60 days after transplanting (DAT). Four hills were randomly selected and uprooted from each plot excluding border rows to record data on plant height and number of tillers $hill^{-1}$ at 10 day intervals beginning at 40 DAT and continued up to harvesting. BRRI dhan56 and Binadhan-7 were harvested on 31 October and 02 November while BRRI dhan39 and Dhani gold hybrid were harvested on 03 November 2015. The harvested crops of each plot was separately bundled, properly tagged and then brought to the threshing floor. The harvested crops were threshed manually. The grains were cleaned and dried to a moisture content of 14%. After sun drying the final grain and straw yields $plot^{-1}$ were recorded and converted to t ha^{-1}. Grain yield and straw yield were altogether regarded as biological yield. Prior to harvesting, five hills were randomly selected from each plot for recording necessary data on crop growth parameters and yield related attributes.

Statistical analysis of data and determination of optimum nitrogen dose: Data recorded for growth, 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 evaluated with DMRT test. The relationship between grain yield and fertilizer dose were fitted by the following quadratic model using 'R' statistical programme:

$$Y = a + bX + cX^2 \ldots . (1)$$

Where, Y = seed yield (t ha^{-1}), X= the dose of the nitrogen applied (kg ha^{-1}), a, b and c are the parameters of the model. The optimum dose of nitrogen for each of rice varieties were then determined using the parameters of the quadratic equation (equation 1):

$$Optimum\ dose = {}^{-b}/_{2c}.$$

RESULTS AND DISCUSSIONS: Plant height: Plant height varied significantly due to variety and nitrogen level at 40, 50 and 60 days after transplanting (DAT) and also at harvest but the interaction between variety and nitrogen level was not significant. At 40, 50 and 60 DAT, variety BRRI dhan56 exhibited the tallest plant while Binadhan-7 produced the shortest plants. At harvest, the plant height of BRRI dhan56 was 123.80 cm while that for Binadhan-7 was 106.50 cm (table 1). The present result showed that plant heights vary among the varieties and the variation might be caused due their genetic variability (Islam *et al.*, 2013). In case of nitrogen dose, the tallest plant was obtained at 120 kg N ha^{-1} and the shortest with control (no nitrogen) plots. The plant heights obtained with 120 kg N ha^{-1} at 40, 50 and 60 DAT and at harvest were 80.67, 93.02, 117.30 and 125.0 cm, respectively. The plants in the control plots at 40, 50 and 60 DAT and at harvest were 69.57, 83.86, 105.50 and 112.8 cm, respectively. In the present study showed that the plant height increased with increase of nitrogen levels and attained the highest value at 120 kg N ha^{-1} and then declined with further addition of nitrogen fertilizer (table 2). Similar results have been reported by the previous researchers. For example, Das (2007) observed the tallest plant (91.86 cm) with 120 kg ha^{-1} of nitrogen while Ahmed *et al.* (2000) found that with 80 kg N ha^{-1}. On the other hand, Somasundaram *et al.* (2002) found the highest plant height of variety SSRC91216 at 150 kg N ha^{-1}. However, all the authors reported that further increase in N rate decreased the plant height gradually. The increase in plant height might be due to increased amount of nutrients uptake by plants from higher rates of nitrogen applied in the soil. The increased nitrogen uptake may have played a significant role in plant growth, internode elongation, photosynthesis and metabolism and assimilate production (Ghoneim *et al.*, 2018).

Tiller production: The number of total tillers $hill^{-1}$ was significantly influenced by variety and nitrogen level at all the sampling dates but their interaction was not significant. The number of total tiller increased with time and the highest was attained at 60 DAT for all the inbred varieties and then declined at harvest. However, in the hybrid variety Dhanigold the highest value was attained at harvest (table 3). Dhanigold showed the highest number of total tillers $hill^{-1}$ at 60 days and also at harvest which were 13.47 and 14.11 $hill^{-1}$, respectively. Among the inbred varieties, the highest number of tillers $hill^{-1}$ at 60 days and also at harvest was found with variety BRRI dhan56 which were 12.32 and 11.89, respectively. Binadhan-7 produced the lowest number of tillers $hill^{-1}$. The variation in

number of total tillers hill^{-1} might be attributed to varietal characters (Nuruzzaman *et al.*, 2000).

The number of total tillers hill^{-1} was influenced by nitrogen level and highest values were attained at 120 kg N ha^{-1}. Then the number decreased with further increase in the nitrogen level. The highest number of total tillers hill^{-1} (13.95) was recorded at 120 kg N ha^{-1} (table 4). The lowest number of total tillers hill^{-1} (9.28) was recorded in control (0 kg N ha^{-1}). Thus the result showed an increased trend of tiller production hill^{-1} with increase of nitrogen level. However the tiller production decreased with the increase of nitrogen dose above that maximum level. Sultana and Ali (2014) found the highest tiller production with 90 kg N ha^{-1} while Rahman *et al.* (2019) found the highest tiller production with 150 kg N ha^{-1}. Many authors reported that the production of total tillers hill^{-1} was positively correlated with amount of applied nitrogen. The progressive improvement in the formation of tillers might be due to the increased supply of nitrogen. The present study reveals that hybrid variety Dhanigold has the highest tiller production capacity and showed the similar response to nitrogen level like those of other inbred varieties.

Variety	Plant height (cm)			
	Days after transplanting (DAT)			Harvest
	40	50	60	
Binadhan7	68.13 d	80.13 d	102.0 c	106.5 c
BRRI dhan39	71.70 c	86.02 c	111.4 b	119.2 b
BRRI dhan56	84.56 a	99.13 a	123.8 a	123.4 a
Dhanigold (Hybrid)	80.86 b	93.32 b	113.9 b	123.3 a
S $\overline{X}$	1.004	0.421	0.187	1.26
Level of significance	**	**	**	**
CV (%)	5.09	1.82	6.44	4.09

Table 1: Effect of variety on plant height of rice at different days after transplanting.

Level of nitrogen (kg ha^{-1})	Plant height (cm)			
	Days after transplanting (DAT)			Harvest
	40	50	60	
0	69.57 d	83.86 c	105.5 c	112.8 c
40	74.88 c	88.99 b	111.2 b	118.8 b
80	76.95 bc	90.70 ab	114.2 ab	121.4 ab
120	80.67 a	93.02 a	117.3 a	125.0 a
160	79.49 ab	91.68 a	115.7 a	122.8 a
S $\overline{X}$	0.967	0.778	1.05	1.27
Level of significance	**	**	**	**
CV (%)	4.39	3.01	3.24	3.67

Table 2: Effect of level of nitrogen on plant height of rice at different days after transplanting

Variety	No. of total tillers hill^{-1}			
	Days after transplanting (DAT)			Harvest
	40	50	60	
Binadhan7	8.992 b	10.11 c	10.60 d	10.16 d
BRRI dhan39	10.20 a	11.03 b	11.65 c	10.91 c
BRRI dhan56	10.67 a	11.62 b	12.32 b	11.89 b
Dhanigold (Hybrid)	11.05 a	12.61 a	13.47 a	14.11 a
S $\overline{X}$	0.309	0.228	0.097	0.126
Level of significance	**	**	**	**
CV (%)	**11.74**	**7.81**	**3.12**	4.15

Table 3: Effect of variety on number of total tillers hill^{-1} of rice at different days after transplanting.

Level of nitrogen (kg ha^{-1})	No. of total tillers hill^{-1}			
	Days after transplanting (DAT)			Harvest
	40	50	60	
0	9.10	9.641 c	10.23 d	9.28 e
40	9.54	10.35 c	10.90 c	10.55 d
80	10.26	11.46 b	12.29 b	11.85 c
120	11.42	13.12 a	13.79 a	13.95 a
160	10.78	12.13 b	12.82 b	13.20 b
S $\overline{X}$	0.270	0.254	0.218	0.157
Level of significance	**	**	**	**
CV (%)	9.16	7.78	6.31	4.63

Table 4: Effect of level of nitrogen on number of total tillers hill^{-1} of rice at different days after transplanting.

Total dry matter (TDM) accumulation: Total dry matter (TDM) of rice plant (g m^{-2}) was significantly influenced by variety and nitrogen level for all the sampling dates including at harvest. The interaction effect of variety and nitrogen level was significant for TDM at 60 DAT and at harvest but not at 40 and 50 DAT (table 5). The TDM production of all the four varieties increased with the age of rice plant. Among the varieties, Dhanigold hybrid showed the highest TDM (31.75, 41.74, 68.85 and 111.30 g m^{-2}) respectively. TDM production is influenced by nitrogen rates and the highest TDM at 40, 50 and 60 DAT and at harvest were 27.91, 40.34, 69.74 and 116.80 g m^{-2} with 120 kg N ha^{-1} (table 6). The second highest values were found with 160 kg N ha^{-1} which were 27.47, 38.21, 66.87 and 110.70 gm^{-2}, respectively. The lowest TDM $hill^{-1}$ was 24.98, 34.13, 56.27 and 86.00 gm^{-2}, respectively in the control plots at different dates, respectively. Azarpour *et al.* (2014) and Mo *et al.* (2013) reported that above ground TDM at maturity was highest in 225 kg ha^{-1}. The interaction effect showed that the highest dry matter (g m^{-2}) at 60 DAT in Dhani gold (hybrid) was with 120 kg N ha^{-1} while that at harvest was the highest with BRRI dhan56 with 120 kg N ha^{-1} which was similar to that of Dhani gold (hybrid) at 120 kg N ha^{-1} (table 7).

Variety	Total dry matter (gm^{-2})			
	Days after transplanting (DAT)			Harvest
	40	50	60	
Binadhan7	20.64 d	31.51 d	58.22 d	95.00 c
BRRI dhan39	25.99 c	36.33 c	62.03 c	100.3 b
BRRI dhan56	28.50 b	39.22 b	65.87 b	111.6 a
Dhanigold (Hybrid)	31.75 a	41.74 a	68.85 a	111.3 a
S $\overline{X}$	0.243	0.601	0.581	0.96
Level of significance	**	**	**	**
CV (%)	**3.52**	**6.26**	**3.53**	3.55

Table 5: Effect of variety on total dry matter of rice at different days after transplanting.

Level of nitrogen (kg ha^{-1})	Total dry matter(gm^{-2})			
	Days after transplanting (DAT)			Harvest
	40	50	60	
0	24.98 d	34.13 d	56.27 e	86.00 e
40	26.20 c	36.18 c	60.55 d	102.3 d
80	27.03 b	37.16 bc	65.29 c	107.0 c
120	27.91 a	40.34 a	69.74 a	116.8a
160	27.47 ab	38.21 b	66.87 b	110.7 b
S $\overline{X}$	0.279	0.472	0.453	0.80
Level of significance	**	**	**	**
CV (%)	3.61	4.41	2.46	2.63

Table 6: Effect of level of nitrogen on total dry matter of rice at different days after transplanting

Interaction (variety × level of nitrogen)	Total Dry matter(g m^{-2})			
	Days after transplanting (DAT)			Harvest
	40	50	60	
V_1N_0	18.67	29.65	50.62 k	81.2k
V_1N_1	20.05	30.39	55.88 j	92.6ij
V_1N_2	21.25	31.02	60.67 hi	97.6gh
V_1N_3	21.86	35.30	62.46 gh	104.3f
V_1N_4	21.39	31.19	61.48 ghi	99.1gh
V_2N_0	24.82	32.96	52.95 k	82.50k
V_2N_1	25.43	34.81	59.47 i	97.00hi
V_2N_2	26.43	36.28	63.25gh	102.0fg
V_2N_3	26.71	39.66	67.97 cde	114.2cd
V_2N_4	26.55	37.96	66.52ef	106.0ef
V_3N_0	26.83	35.47	59.06 i	89.4j
V_3N_1	28.05	38.29	62.93 gh	109.8de
V_3N_2	28.45	39.45	67.35 de	114.1cd
V_3N_3	29.77	42.29	71.20 b	125.7a
V_3N_4	29.40	40.61	68.79 bcde	118.8bc
V_4N_0	29.60	38.42	62.44 gh	90.8j
V_4N_1	31.26	41.22	63.92fg	109.7de
V_4N_2	32.01	41.90	69.89 bcd	114.1cd
V_4N_3	33.31	44.10	77.31a	123.1ab
V_4N_4	32.55	43.07	70.69 bc	118.7bc
S $\overline{X}$	0.557	0.942	0.906	1.59
Level of sig.	NS	NS	*	*
CV (%)	3.61	4.41	2.46	2.63

Table 7: Interaction effect of variety and N level on total dry matter of rice at different days after transplanting (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); * =Significant at 5% level of probability; NS = Not significant, V_1 = Binadhan7, V_2 = BRRI dhan39, V_3 = BRRI dhan56 V_4 = Dhanigold (Hybrid); N_0 = Zero = (Control), N_1 = 40 N, N_2 = 80 N; N_3 = 120 N, N_4 = 160 N).

Thus, the present study reveals that the highest TDM could be accumulated at 120 kg N ha^{-1} in both Dhanigold and BRRI dhan56. The TDM accumulation differed in different varieties due to their difference in the genetic makeup. The highest TDM production in the hybrid variety Dhanigold probably attributed to its taller height and higher number of tillers hill^{-1}. It has been reported that modern inbred and hybrid transplant *Aman* rice varieties produces highest TDM as the plants are tallest and are having maximum number of leaves and tillers (Islam, 2011; Mia and Shamsuddin, 2011; Panwar *et al.*, 2012).

Yield contributing characters: Number of effective tiller hill^{-1}, number of non-effective tiller hill^{-1}, number of total grain, filled grain and unfilled grain panicle^{-1} were affected significantly by variety, nitrogen rate and their interaction. The interaction between variety and nitrogen level showed that the highest number of effective tillers hill^{-1} (13.87) was recorded in Dhanigold hybrid with 120 kg N ha^{-1} and the lowest (6.20) was found in Binadhan-7 with no nitrogen control plots (table 8).

Interaction (variety x level of nitrogen)	No. of effective tillers hill^{-1}	No. of non-effective tillers hill^{-1}	Total grains panicle^{-1} (no.)	Filled grains panicle^{-1} (no.)	Unfilled grains panicle^{-1} (no.)	1000 grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
V_1N_0	6.20l	1.80hi	106.8m	87.97j	18.80efgh	22.41	3.50k	4.50i	44.63
V_1N_1	6.73kl	2.20g	108.0m	88.53j	19.43defgh	22.78	4.16i	5.10g	44.89
V_1N_2	8.07j	2.66ef	109.6lm	90.33ij	19.27defgh	23.28	4.36hi	5.40f	44.71
V_1N_3	9.00gh	2.87de	116.3k	99.90gh	16.43h	23.99	4.79efg	5.64e	45.94
V_1N_4	8.60hij	2.67ef	112.0l	93.70hij	18.30fgh	23.80	4.58fgh	5.33f	46.25
V_2N_0	6.533l	1.79hi	124.1 j	96.53hi	27.60b	23.21	3.62jk	4.75h	42.42
V_2N_1	7.267k	2.00gh	129.0 hi	107.6 ef	21.43cdef	23.61	4.40hi	5.30f	45.34
V_2N_2	8.270ij	2.47f	131.8 h	111.6 e	20.17def	23.76	4.53gh	5.67e	44.42
V_2N_3	10.13e	3.27b	141.6f	124.7d	16.90gh	24.15	5.23cd	6.19c	45.81
V_2N_4	8.800ghi	4.00a	136.9 g	112.6 e	24.33c	23.85	4.73fg	5.87d	44.60
V_3N_0	8.200ij	1.73i	127.1ij	104.8fg	22.27cd	23.60	3.68jk	5.10g	42.95
V_3N_1	8.970gh	1.77hi	129.7hi	109.8ef	19.83defg	23.67	4.79efg	5.91d	46.18
V_3N_2	9.400fg	2.47f	136.3 g	114.2 e	22.03cd	23.89	4.91def	6.26c	45.12
V_3N_3	10.87cd	3.00cd	145.7 e	125.3d	20.34def	24.42	5.42bc	6.64b	47.19
V_3N_4	10.13e	2.93cd	140.1 fg	120.7d	19.40defgh	24.27	5.20cd	6.25c	47.40
V_4N_0	9.66ef	1.20j	151.0d	107.9ef	43.03a	24.15	3.84j	5.40f	40.55
V_4N_1	10.80d	2.47f	154.9c	133.0c	21.87cde	24.52	5.07de	6.18c	43.66
V_4N_2	11.40c	2.67ef	160.1b	139.9b	20.17def	24.64	5.15cd	6.50b	43.05
V_4N_3	13.87a	2.80de	169.0a	149.8a	19.23defgh	24.99	5.93a	6.89a	44.04
V_4N_4	12.53b	3.13bc	162.7b	144.1ab	18.67fgh	24.76	5.63b	6.67b	43.81
S $\bar{x}$	0.196	0.075	1.27	2.13	0.933	0.415	0.102	0.066	0.645
Level of sig.	**	**	*	**	**	NS	*	*	NS
CV (%)	3.65	5.16	1.65	3.27	7.53	3.01	3.74	1.97	2.50

Table 8. Interaction effect of variety and level of nitrogen on yield and yield contributing characters of rice (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). ** =Significant at 1% level of probability, * =Significant at 5% level of probability, NS = Not significant; V_1 = Binadhan7, V_2 = BRRI dhan39, V_3 = BRRI dhan56, V_4 = Dhanigold (Hybrid); N_0 = Zero (Control), N_1 = 40 N, N_2 = 80 N, N_3 = 120 N, N_4 = 160 N).

It was found that cultivation of Dhani gold hybrid at 120 kg N ha^{-1} produced the highest number of total grains panicle^{-1} (169.00) and filled grains panicle^{-1} (149.80). The lowest number of total (106.80) and filled grain panicle^{-1} (87.97) was obtained from Binadhan-7 with no nitrogen control (0 kg N ha^{-1}) treatment. The highest weight of 1000-grain (24.39 g) was found with 120 kg N ha^{-1} which was followed by that (24.17g) at 160 kg N ha^{-1}. The lowest one (23.34 g) was recorded from the control. The variation in effective tiller production in varieties and nitrogen rates could be associated with the variation in genetic makeup of the variety (Panwar *et al.*, 2012). The adequate nitrogen probably favored the cellular activities during panicle initiation and development which led to increased number of productive tillers hill^{-1}. The results indicate that the number of effective tillers hill^{-1} increased with the increase of nitrogen dose up to certain limit. The improvement in the formation of effective tillers with increasing nitrogen level might be due to availability of higher amount of nitrogen that enhanced tillering up to specific dose (Ahmed *et al.*, 2000). The difference in number of total and filled grains panicle^{-1} among the varieties might be due to their differences in genetic constitution. It might be noted that the supply of nitrogen contributed to spikelet formation which probably contributed to increased number of grains panicle^{-1} and the maximum was achieved at the optimum level of nitrogen of 120 kg N ha^{-1}. Significant increase in the number of filled grains panicle^{-1} with increase in level of nitrogen was reported by Mendhe *et al.* (2002). Thousand grains weight varied significantly by nitrogen level only but not by the variety and the interaction between variety and nitrogen level. The previous study reveals that the weight of 1000-grain increased with the increased of N level and showed a quardratic relationship with the nitrogen levels.

Grain and straw yields: Grain and straw yields were significantly influenced by variety, nitrogen rate and their interaction. The highest grain yield (5.93 t ha^{-1}) was recorded in Dhanigold hybrid at 120 kg N ha^{-1} (table 8). The lowest one (3.50 t ha^{-1}) was found in Binadhan-7 at control (0 kg N ha^{-1}). The highest grain yield (5.34 t ha^{-1}) was obtained with 120 kg ha^{-1} and the lowest grain yield (3.66 t ha^{-1}) from control plots

(without N levels). The highest yield in Dhani gold hybrid might be attributed to the production of maximum effective tillers m^{-2} and filled grains $panicle^{-1}$. The previous workers reported that the varieties which produced higher number of effective tillers $hill^{-1}$ and higher number of grains $panicle^{-1}$ exhibited higher grain yield ha^{-1} (Ali *et al.*, 2014). The grain yield increased with the increase of nitrogen application. Mo *et al.* (2013) reported that increment of application of nitrogen up to 187.5 kg N ha^{-1} increased the grain yield and then declined. The highest straw yield (6.89 t ha^{-1}) was recorded in Dhanigold yield at 120 kg N ha^{-1} and the lowest one (4.50 t ha^{-1}) was found in Binadhan-7 at control (0 kg N ha^{-1}) . In the present study, the short duration hybrid rice variety Dhanigold responded best at 120 kg N ha^{-1}. BRRI dhan56 and many other varieties gave the highest yield at 75 kg N ha^{-1} in another study by Jisan *et al.* (2014).

Determination of optimum nitrogen dose: The yield response of the short duration four *aman* rice varieties in relation to nitrogen rates can be best explained by the quadratic equations (figure 1). The test analysis indicated that more than 96, 88, 94 and 92% of the variation in crop performance occurred in variety Binadhan-7, BRRI dhan39, BRRI dhan56 and Dhani gold hybrid, respectively. The estimated coefficients of the polynomial regression models showed significant variation (table 9). The estimated optimum dose of nitrogen for Binadhan-7, BRRI dhan39, BRRI dhan56 and Dhani gold hybrid are 131.31, 122.97, 126.50 and 133.14 kg ha^{-1}, respectively.

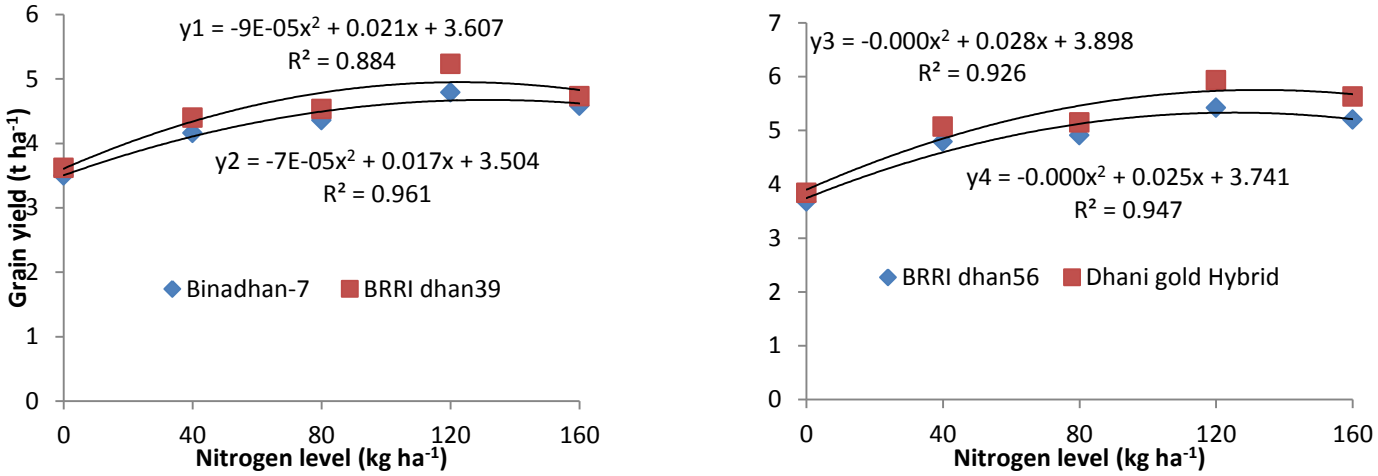

Figure 1: Grain yield response of four short duration rice varieties to different levels of nitrogen.

Variable	Coefficients	Standard error	t-value	p-value	R^2-value
	Binadhan-7				
Constant	3.5040	0.12970	27.011	0.0013**	
X	0.0177	0.00384	4.623	0.0437*	96.12*
X^2	-0.0000674	0.000023	-2.928	0.0995	
	BRRI dhan39				
Constant	3.6080	0.2645	13.64	0.00533**	
X	0.02184	0.00783	2.788	0.1081	88.48
X^2	-0.000088	0.00004694	-1.892	0.1989	
	BRRI dhan56				
Constant	3.7417	0.2062	18.143	0.00302**	
X	0.02538	0.0061	4.157	0.05329	94.70
X^2	-0.000101	0.0000366	-2.768	0.10946	
	Dhani gold hybrid				
Constant	3.899	2.891	13.486	0.0054**	
X	0.0279	0.00856	3.265	0.0824	92.62
X^2	-0.000105	0.0000513	-2.053	0.1764	

Table 9: Estimation of the model determining the relationship between the nitrogen dose applied and yield of four short duration rice varieties.

CONCLUSION: The present study concludes that the highest grain yield of short duration aman rice could be obtained by growing a hybrid rice variety Dhani gold at 133 kg N ha^{-1} applied in three equal splits at 15, 30 and 45 days after transplanting. The estimated optimum dose of nitrogen for Binadhan-7, BRRI dhan39, BRRI dhan56 and Dhani gold hybrid are 131.31, 122.97, 126.50 and 133.14 kg ha^{-1}, respectively.

CONFLICT OF INTEREST: Authors have no conflict of interest.

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