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Growth and yield response of drought tolerant transplant *aman* rice cultivars to nitrogen fertilization

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ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from July to December 2018 to evaluate the effect of different levels of nitrogen on growth and yield of drought tolerant transplant *aman* rice cultivars. The experiment was consisted of one check variety BRRI dhan49 and three drought tolerant rice varieties BRRI dhan56, BRRI dhan66 and BRRI dhan71 along with five nitrogen levels such as no nitrogen (control treatment), 50%, 100%, 125% and 150% of recommended dose (RD) where the recommended dose was 150 kg N ha^{-1}. Nitrogen was applied in the form of urea (46.66% N) as top dressing in three equal splits at 15 days after transplanting, 30 DAT and 45 DAT. The experiment was laid out in a randomized complete block design with three replications. The result of the study reveals that BRRI dhan66 produced the highest number of total tillers $hill^{-1}$, effective tillers $hill^{-1}$ and grains $panicle^{-1}$. The highest 1000-grain weight and grain yield was recorded in BRRI dhan71 which was statistically identical to BRRI dhan66. In case of level of nitrogen, the highest number of total tillers $hill^{-1}$ was observed in 125% RD of N. The highest number of effective tillers $hill^{-1}$ was found in 100% of RD of N and the maximum number of grains $panicle^{-1}$ was observed in 150% of RD of N. The highest grain yield was obtained from 125% RD of N which was statistically identical to 100% and 150% of RD of N. In case of interaction the highest number of total tillers $hill^{-1}$ was recorded in BRRI dhan56 with 125% RD of N which was statistically identical to BRRI dhan66 with 100% RD of N. The highest number of grains $panicle^{-1}$ was observed in BRRI dhan66 with 150% of RD of N. BRRI dhan56 with 150% RD of N produced the highest 1000-grain weight. The highest number of effective tillers $hill^{-1}$, grain yield and straw yield were recorded in BRRI dhan66 with 100% RD of N. In conclusion, the result of the study revealed that application of 100% recommended dose of N (150 kg ha^{-1}) is suggested as the best nitrogen management approach for the drought tolerant rice cultivar BRRI dhan66 for its better performance.

Keywords: Drought tolerance, nitrogen fertilization, T. *aman* rice, yield

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1 Introduction

Rice (*Oryza sativa* L.) is one of the most important and popular field crops among the other cereals in the world. Rice is consumed by the half of the world's population and is grown in a wide range of climatic conditions covering one-third of the world's total cropped area (Jahan et al., 2020). Bangladesh is an agrarian country and it has a long history of rice cultivation. Mostly rice is consumed as staple food in Bangladesh. Bangladesh stands in third position globally in rice production. The annual production of rice is 37.6 million metric tons from 11.70 million ha of land. Transplant *aman* rice covers 5.61 million ha of land with a production of 14.44 million metric tons (BBS, 2022). Though Bangladesh is self-sufficient in food production, rice production must be increased either by increasing area under rice cultivation or by increasing per hectare yield to feed the ever-increasing population of Bangladesh. However, horizontal expansion of arable area in our densely populated country is quite difficult. Rather rice production can be increased by increasing yield.

In Bangladesh, there are three distinct growing seasons of rice according to change in seasonal conditions such as *aus*, *aman* and *boro*. The largest area is covered with *aman* rice accounting for more than half of the area coverage. *Aman* rice is generally cultivated under rainfed condition during July-December. It passes through vegetative stage during August to September when rainfall is sufficient. This crop suffers from moisture stress when the rainfall ceases by the first week of October. It passes through reproductive stages (panicle initiation, booting, flowering and grain filling) in October and November. The total rainfall in these two months is very irregular and inadequate which fails to meet the evapotranspiration demand of *aman* rice and consequently water stress develops and badly affects translocation of assimilates and grain development in rice.

Global climate change accelerated the intensity and frequency of occurring different abiotic stresses, and drought is one of them. In recent years, drought stress has become a big challenge for the rice farmers and recurrent phenomenon in some parts of the country mainly northwestern region (Rajshahi, Chapai-Nawabganj, Naogaon, Rangpur, Bogura, Pabna, Dinajpur and Kustia). The country experiences long spells of dry weather during which moderate to severe drought spreads over a region of 7.15 million hectares of land which is 91% of total T. *aman* rice area. Water stress during reproductive stage leads to spikelet sterility of rice and high impact on its growth duration, growth and yield. Rahman and Biswas (1995) reported that the drought led to decrease in rice production of 3.5×106 tons in 1994-95. Data from 2006 indicated that drought caused 25 to 30% crop reduction in the northwestern part of Bangladesh (Rahman et al., 2008). To face the challenge of drought stress, drought tolerant rice varieties have been developed by Bangladesh Rice Research Institute (BRRI). The drought tolerant rice cultivars have the potentiality to offer up to 1.2 t ha^{-1} additional yield than the presently cultivated varieties despite three weeks of no rainfall. The drought tolerant rice cultivars developed by BRRI are BRRI dhan56, BRRI dhan66 and BRRI dhan71, those can be grown within 100-110 days in order to escape drought.

The potential for increased rice production strongly depends on the ability to integrate a better crop management for the different varieties into the existing cultivation system. Among the crop management practices, nitrogen is the key element which plays a vital role in vegetative growth, development of yield components and yield of rice. Judicious application of nitrogenous fertilizer is paramount important for yield enhancement of rice. In addition, application of relatively high N concentration results in better growth (Wang et al., 2016; Ferdous et al., 2019) and nitrogen metabolism, which enhances plant tolerance against stresses (Zhong et al., 2017). Similarly supply of nitrogen increases plasticity of root development under drought stress in rice (Tran et al., 2014). High N concentration also improves photosynthetic traits, which helps mitigate drought stress by increasing sensitivity of stomatal conductance and maintaining a higher photosynthetic rate (Otoo et al., 1989). As nitrogen fertilizer is a costly input and its response varies from variety to variety, it is important to optimize nitrogen rate for the newly released varieties under a particular agro-climatic condition. Non-judicious application of nitrogen fertilizer not only increases production cost but also reduces the quality of product. Under these circumstances, it is essential to determine the optimum nitrogen dose to obtain maximum rice yield. Development of proper fertilizer management strategy is one of the most important agronomic practices for the successful adoption of drought tolerant rice cultivars in Bangladesh. Therefore, the present study was designed, (i) to identify the performance of drought tolerant transplant *aman* rice cultivars, (ii) to observe the effect of nitrogen fertilizer on the yield of drought tolerant T. *aman* rice cultivars, and (iii) to optimize the N level for drought tolerant rice cultivars for maximum yield performance of rice.

2 Materials and Methods

2.1 Experimental duration and site

The experiment was conducted during the period from July to December 2018 at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh. The experimental area belongs to Non-Calcareous Dark Gray Flood Plain soil under the Sonatola soil series of Old Brahmaputra Flood plain (AEZ- 9) (UNDP and FAO, 1988). The soils of this series are pre-dominantly silty loam, dark grey in color having pH value 6.5, low in organic matter and its general fertility level is low. Salient characteristics of the experimental soil: organic matter content 1.29%, total nitrogen 0.10 %, available sulphur 14.12 ppm, available Phosphorus 16.72 ppm, exchangeable potassium 0.12 me/ 100 g soil and Zinc 2.5 ppm. The climate of the experimental site is under sub-tropical in nature and is characterized by high temperature, high humidity and heavy rainfall with occasional gusty winds during *kharif* (April to September) season and scanty rainfall associated with moderately low temperature and plenty of sunshine during *rabi* season. During the experimental period the maximum, minimum and average temperature ranges between 27.5 °C and 33.2 °C, 14.4 °C and 26.8 °C and 21.2 °C and 30.0 °C, respectively. While the average relative humidity, total sunshine and total rainfall ranged from 81-87%, 101.8-204.8 h month^{-1} and 0.0-522.7 mm, respectively

2.2 Experimental treatments

The experiment was consisted of one check variety BRRI dhan49 and three drought tolerant rice varieties BRRI dhan56, BRRI dhan66 and BRRI dhan71 along with five nitrogen levels such as no nitrogen (control), 50%, 100%, 125% and 150% of recommended N dose (RD) where the recommended dose was 150 kg N ha^{-1}.

2.3 Experimental design and layout

The experiment was laid out in a randomized complete block design (RCBD) with three replications. Treatment combinations were assigned at random to each block. Total number of unit plots were $4 \times 5 \times 3 = 60$ and each plot size was 4.0 m × 2.5 m. The spacing between the blocks and unit plots were 1 m and 0.75 m, respectively.

2.4 Crop husbandry

Seeds of rice variety BRRI dhan49, BRRI dhan56, BRRI dhan66 and BRRI dhan71 were collected from Bangladesh Rice Research Institute, Joydebpur, Gazipur. The sprouted seeds were sown in the nursery bed on 30 June 2018. Proper care was taken to raise the healthy seedlings in the nursery bed. The field was prepared by a power tiller followed by laddering. Weeds and stubbles were removed and cleaned from individual plots. The land was fertilized with triple superphosphate, muriate of potash, gypsum and zinc sulphate during final land preparation at the rate of 75, 60, 60, 10 kg ha^{-1}, respectively. Seedlings were transplanted in the well-prepared puddle field on 29 July 2018 at the rate of two seedlings hill^{-1}, maintained row and hill distance of 25 cm and 15 cm, respectively. Nitrogen was applied as per treatment specification in the form of urea as top dressing in three equal splits at 15, 30 and 45 days after transplanting (DAT), respectively. Two hand weeding were done at 20 and 35 DATs to control weeds, which ultimately ensured better growth and development of rice. All other agronomic practices including water management and crop protection measures were adopted according to the common recommendations for this crop

2.5 Sampling and harvesting

The crop was harvested at full maturity. The date of harvesting was confirmed when 90% of the seed became golden yellow in color. Before harvesting, five hills (excluding border rows and central 1 m^2 area) were selected randomly from each plot and uprooted carefully for recording data of different yield components. One square meter area from each plot was selected from the central portion and cut manually from the ground level to take grain and straw yield. Rice cultivar BRRI dhan56, BRRI dhan66 and BRRI dhan71 were harvested on 29 October and BRRI dhan49 was harvested on 15 November 2018. The grains were cleaned and finally the weight was adjusted to a moisture content of 14%. The straw was sun dried and the yields of grain and straw plot^{-1} were converted to t ha^{-1}.

2.6 Statistical analysis

The collected data were compiled and tabulated in proper form and were subjected to statistical analysis. Data were analyzed using the analysis of variance (ANOVA) technique with the help of a computer package program MSTAT-C and mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984).

3 Results and Discussion

3.1 Effect of cultivar on yield parameters and yield of transplant *aman* rice

All the yield attributing characters (except plant height) and yield were significantly influenced by rice cultivars. Tillering is an important trait for rice production (Badshah et al., 2014). The highest number of total tillers hill^{-1} (10.87) and effective tillers hill^{-1} (10.24) were recorded from the rice cultivar BRRI dhan66 which were statistically identical to BRRI dhan56 and BRRI dhan71 (Table 1). BRRI (1985) found varietal differences of tillering in the medium and traditional varieties. Differences in number of effective tillers hill^{-1} among the varieties was also found by Tyeb et al. (2013) and Chamely et al. (2015). The reasons for differences in producing effective tillers hill^{-1} might be due to the variation in genetic makeup of the variety that might be influenced by their heredity. The highest number of grains panicle^{-1} (107.50) was also obtained from the rice cultivar BRRI dhan66 (Table 1). Chamely et al. (2015) and Afroz et al. (2019) reported that the number of grains panicle^{-1}

Table 1. Effect of drought tolerant rice cultivar on the performance of transplant *aman* rice

Cultivar (V)	PH (cm)	Tot. tillers $hill^{-1}$	Eff. tillers $hill^{-1}$	Grains pan^{-1}	WTS (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	HI (%)
BRRI dhan49†	102.45	8.74b*	8.07b	100.50b	18.28b	2.92c	4.41b	39.57b
BRRI dhan56	107.32	10.67a	9.94a	106.00a	23.98a	3.90b	5.43a	46.09a
BRRI dhan66	102.21	10.87a	10.24a	107.50a	23.68a	4.77a	5.33a	47.47a
BRRI dhan71	108.31	10.24a	9.48a	105.62a	24.02a	4.99a	5.18a	46.27a
Level of sig.	NS	0.01	0.01	0.01	0	0.01	0.01	0.01
CV (%)	13.43	9.85	11.36	4.3	10.61	18.63	17.3	7.69

† Check cultivar; In a column, figures having common letter(s) do not differ significantly; PH = plant height, Tot. tiller $hill^{-1}$ = number of total tillers $hill^{-1}$, Eff. tillers $hill^{-1}$ = number of effective tillers $hill^{-1}$, Grains pan^{-1} = number of grains $panicle^{-1}$, WTS = weight of 1000 seeds, CV = coefficient of variation; HI = harvest index

Table 2. Effect of level of nitrogen on the performance of transplant *aman* rice

N level (N)	PH (cm)	Tot. tillers $hill^{-1}$	Eff. tillers $hill^{-1}$	Grains pan^{-1}	WTS (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	HI (%)
Control (no N)	97.22	7.68c*	7.03c	89.10b	22.29	2.92c	4.13c	40.77c
50% of RD	103.98	9.77b	9.07b	107.20a	21.46	3.90b	4.78bc	44.75b
100% of RD	108	11.21a	10.59a	108.70a	22.87	4.77a	5.62a	45.21ab
125% of RD	110.23	11.32a	10.54a	108.41a	22.92	4.99a	5.40ab	48.11a
150% of RD	105.93	10.67a	9.93ab	111.20a	22.92	4.63a	5.52ab	45.39ab
Level of sig.	NS	0.01	0.01	0.01	NS	0.01	0.01	0.01
CV (%)	13.43	9.85	11.36	4.3	10.61	18.63	17.3	7.69

In a column, figures having common letter(s) do not differ significantly; RD = recommended dose (150 kg N ha^{-1}), PH = plant height, Tot. tiller $hill^{-1}$ = number of total tillers $hill^{-1}$, Eff. tillers $hill^{-1}$ = number of effective tillers $hill^{-1}$, Grains pan^{-1} = number of grains $panicle^{-1}$, WTS = weight of 1000 seeds, CV = coefficient of variation; HI = harvest index

was influenced significantly due to variety as it is mostly governed by their heredity.

The heaviest 1000-grain weight (24.02 g) was obtained from BRRI dhan71 (Table 1). Roy et al. (2014) found differences in 1000-grain weight due to varietal variation. Mou et al. (2017), Afroz et al. (2019) and Salam et al. (2020) found variation in 1000-grain weight among the cultivars used. They opined that the variation in 1000-grain weight among the cultivars might be due to the genetic constituents of the cultivars. Statistically identical highest grain yield (4.99 and 4.77 t ha^{-1}, respectively) were obtained from BRRI dhan71 and BRRI dahn66 cultivars due to the highest number of effective tillers $hill^{-1}$, highest number of grains $panicle^{-1}$ and heaviest 1000-grain weight in these cultivars (Table 1). Similar research findings were also reported by IRRI (2017) who observed highest grain yield in BRRI dhan71 and BRRI dhan66 among the four rice cultivars (Binadhan-7, BRRI dhan56, BRRI dhan66 and BRRI dhan71). In the present study, BRRI dhan71 and BRRI dhan66 produced the highest grain yield because of their drought tolerance in reproductive stage. From the recorded meteorological data for the study period (not shown here), it was observed that the rainfall of the study area during late September to early October decreased gradually which ultimately created moisture stress for rice plant particularly for BRRI dhan49 variety which is a drought sensitive variety. These findings corroborate the findings of IRRI (2017) and IRRI (2018) who also found the lowest grain yield of drought sensitive rice cultivar Biandhan-7 in Kathalia, Modhupur tract due to severe drought in reproductive stage of rice plant. BRRI dhan56 gave the highest straw yield (5.43 t ha^{-1}) which was statistically identical to BRRI dhan66 and BRRI dhan71 and the lowest straw yield (4.41 t ha^{-1}) was obtained from the rice cultivar BRRI dhan49. Variation in straw yield was also reported by Akando (2017) and Gawali et al. (2015) and this was might be due to genetic heredity of the cultivars. The highest harvest index (47.47%) was recorded from the rice cultivar BRRI dhan66 (Table 1). Differences in harvest index due to varietal effect was also reported by Sultana et al. (2012). The check variety indicated the lowest value for most of the yield attributing characters and yield (Table 1).

Table 3. Interaction effect of cultivar and level of nitrogen on the performance of transplant *aman* rice

N level (N)	PH (cm)	Tot. tillers hill^{-1}	Eff. tillers hill^{-1}	Grains pan^{-1}	WTS (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	HI (%)
V1N0	99.47	6.98i*	6.30h	85.88d	18.97c	2.14e	4.00def	34.72
V1N1	100.13	8.33f-i	7.74fgh	102.40c	13.76d	2.28e	4.14c-f	35.69
V1N2	101	9.20d-h	8.54d-g	104.81bc	19.42bc	3.26de	5.13a-f	39.15
V1N3	106.67	9.80b-f	9.10b-f	104.20bc	19.59abc	3.86bcd	4.30c-f	47.5
V1N4	105	9.40c-g	8.67c-g	105.22bc	19.66abc	3.15	4.48b-f	40.77
V2N0	104.4	7.83ghi	7.10fgh	90.33d	23.22abc	2.88de	4.23c-f	40.82
V2N1	103.8	10.93a-d	10.23a-d	106.82abc	24.19a	4.93abc	5.81abc	45.77
V2N2	108.4	11.59ab	11.10ab	109.30abc	24.19a	5.06ab	5.58a-d	47.64
V2N3	115.73	12.34a	11.33a	111.30ab	24.03ab	5.33ab	5.71a-d	48.07
V2N4	104.27	10.63a-e	9.94a-e	112.50ab	24.27a	5.23ab	5.83abc	48.12
V3N0	77.33	8.40f-i	7.97e-h	93.00d	23.33abc	3.31de	3.84ef	43.88
V3N1	106.06	10.85a-d	10.19a-d	109.20abc	23.66ab	4.87abc	5.35a-f	48.77
V3N2	114.53	12.33a	11.68a	111.50ab	23.63ab	5.63a	6.15ab	47.35
V3N3	105.6	11.62ab	10.92ab	108.82abc	24.01ab	5.45a	5.76abc	49.41
V3N4	107.53	11.16abc	10.43a-d	115.20a	23.78ab	5.10ab	5.55a-e	47.93
V4N0	107.66	7.50hi	6.73gh	87.17d	23.63ab	3.34de	5.55a-e	43.67
V4N1	105.93	8.97e-h	8.12e-h	110.50abc	24.23a	3.52cde	4.44b-f	48.78
V4N2	108.07	11.72ab	11.04ab	109.20abc	24.22a	5.13ab	3.81f	46.69
V4N3	112.93	11.53ab	10.82ab	109.21abc	24.07ab	5.30ab	5.60a-d	47.44
V4N4	106.93	11.50ab	10.69abc	112.00ab	23.96ab	5.05ab	5.83abc	44.75
Level of sig.	NS	0.05	0.05	0.05	0.05	0.05	0.05	NS
CV (%)	13.43	9.85	11.36	4.3	10.61	18.63	17.3	7.69

In a column, figures having common letter(s) do not differ significantly; V1= BRRI dhan49, V2=BRRI dhan56, V3=BRRI dhan66, V4=BRRI dhan71 N0= No nitrogen (control), N1= 50% of RD of N, N2= 100% of RD of N, N3= 125% of RD of N, N4= 150% of RD of N; RD = recommended dose (150 kg N ha^{-1}), PH = plant height, Tot. tiller hill^{-1} = number of total tillers hill^{-1}, Eff. tillers hill^{-1} = number of effective tillers hill^{-1}, Grains pan^{-1} = number of grains panicle^{-1}, WTS = weight of 1000 seeds, CV = coefficient of variation; HI = harvest index

3.2 Effect of N level on yield parameters and yield of transplant *aman* rice

Nitrogen application significantly influenced yield contributing characters (except plant height and 1000-grain weight) and yield significantly (Table 2). But numerically the tallest plant was found 110.23 cm in 125% of RD and the shortest one was found 97.22 cm from the control treatment. This might be due to the less utilization of N in vegetative growth purposes than in reproductive purposes by the drought tolerant varieties. The result of the experiment reveals that the highest number of total tillers hill^{-1} (11.32) was obtained from 185 kg (125% of RD) N ha^{-1} (Table 2). Salam et al. (2020) also recorded a positive effect of nitrogen management on number of total tillers hill^{-1}. The highest number of effective tillers hill^{-1} (10.59) was obtained from 150 kg (100% of RD) N ha^{-1}. Similar result also supported by Ahmed et al. (2005) who opined that number of effective tillers hill^{-1} increased with the better response to nitrogen. The improvement in the formation of effective tillers with nitrogen management might be due to availability of higher amount of nitrogen that enhanced effective tillering. The maximum number of grains panicle^{-1} (111.20) was obtained from 185 kg (125% of RD) N ha^{-1}. Rahman et al. (2007) reported variation in number of grains panicle^{-1} due to different nitrogen management practices. The highest grain yield (4.99 t ha^{-1}) was obtained from 185 kg (125% of RD) N ha^{-1} (Table 2). There was a trend to increase grain yield with the increase of nitrogen levels up to 185 kg (125% of RD) N ha^{-1} and after that grain yield decreased with increasing nitrogen rate. It reveals that excess N rates did not give extra benefit regarding to grain yield which was also reported by Shome et al. (2019). The highest straw yield (5.62 t ha^{-1}) was obtained from 150 kg (100% of RD) N ha^{-1}. Chamely et al. (2015) and Islam et al. (2022) also observed variation in grain and straw yields due to different nitrogen rates. The highest harvest index (48.11 %) was obtained from 185 kg (125% of RD) N ha^{-1}. Sarker et al. (2015) found that effect of nitrogen exerted significant variation on harvest index of rice. The control treatment resulted in the lowest value for the yield attributing characters and yield of rice (Table 2).

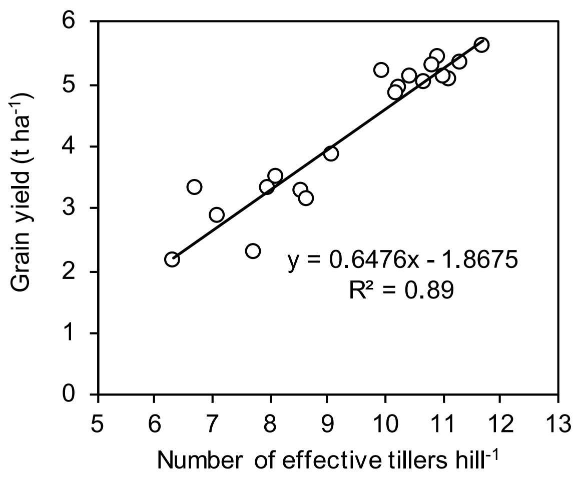

Figure 1. Correlation between grain yield and number of effective tillers hill^{-1}

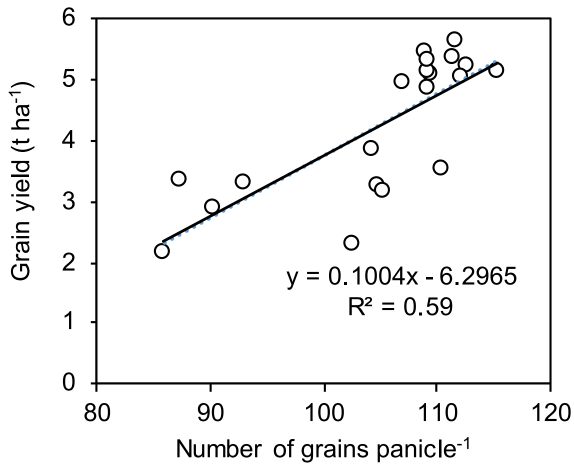

Figure 2. Correlation between grain yield and number of grains panicle^{-1}

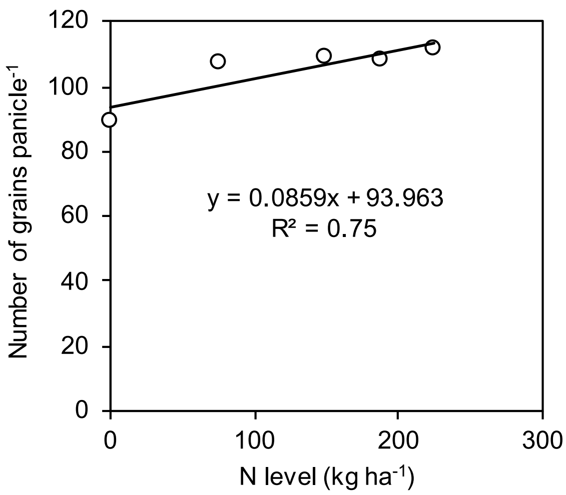

Figure 3. Correlation between N level and number of grains panicle^{-1}

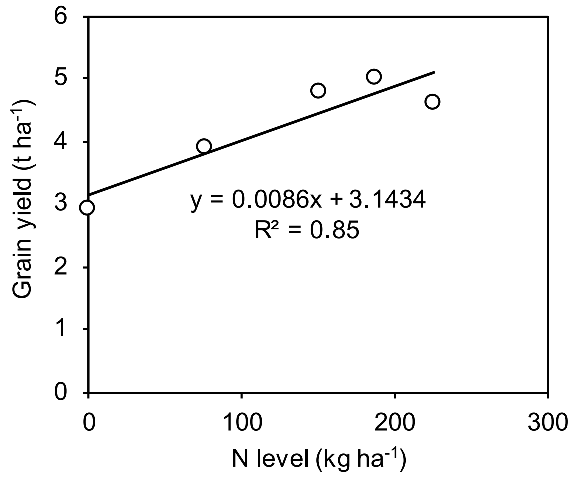

Figure 4. Correlation between N level and grain yield

3.3 Effect of interaction on yield parameters and yield of transplant *aman* rice

Interaction effect of cultivars and different levels of nitrogen showed significant variation in relation to yield attributes and yield (Table 3). Total and effective tillers hill^{-1}, grains panicle^{-1}, 1000-grain weight, grain and straw yields were found significant, but plant height and harvest index were not. The highest number of total tillers hill^{-1} (12.34) was obtained from BRRI dhan56 fertilized with 185 kg (125% of RD) N ha^{-1} and the highest number of effective tillers hill^{-1} (11.68) was obtained from BRRI dhan66 received 150 kg (100% of RD) N ha^{-1} (Table 3). Jisan et al. (2016) also observed that interaction of variety and level of N showed significant effect on number of total and effective tillers hill^{-1}. Haque and Haque (2016) narrated that the number of effective tillers contributes more to enhance productivity of rice plant than total number of tillers. The highest number of grains panicle^{-1} (115.20) was recorded from BRRI dhan66 with 150% RD of nitrogen which was statistically similar with BRRI dhan66 with 100% RD of nitrogen (Table 3). BRRI dhan56 coupled with 150% RD of N produced the heaviest 1000-grain weight (24.27 g). Similar result was also documented by Shome et al. (2019). The highest grain yield t ha^{-1} (5.63) and straw yield t ha^{-1} (6.15) were achieved by BRRI dhan66 with 150 kg (100% of RD) N ha^{-1}. Chamely et al. (2015) disclosed that number of grains panicle^{-1}, grain yield and straw yield of rice were significantly affected by the interaction of variety and level of nitrogen (Table 3). This result corroborates the findings of Hossain et al. (2018). All the yield and yield attributing characters were found lowest in BRRI dhan49 with control treatment (Table 3).

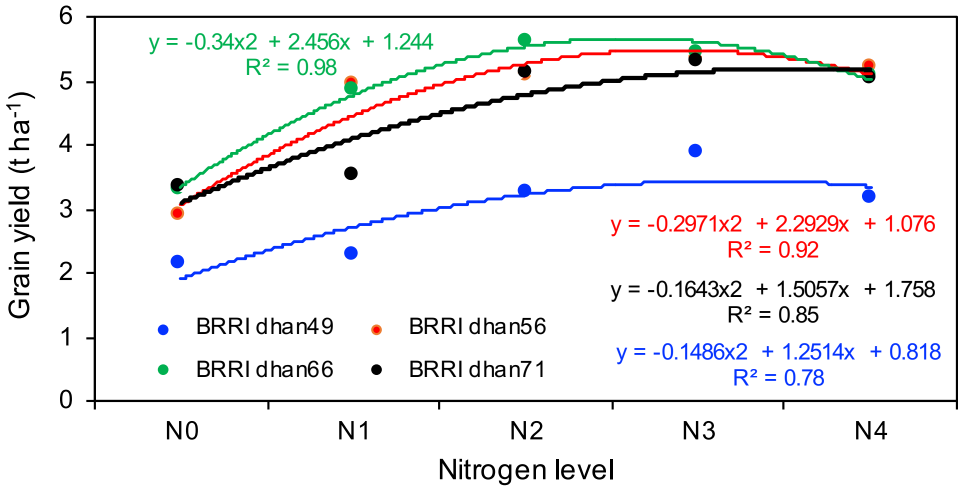

Figure 5. Yield response of different rice varieties to applied nitrogen levels. N0= No nitrogen (control), N1= 50% of RD of N, N2= 100% of RD of N, N3= 125% of RD of N, N4= 150% of RD of N [RD (Recommended dose) = 150 kg N ha^{-1}

3.4 Relationship between grain yield and yield attributing traits

To assess the relationship between grain yield and yield attributing traits simple correlation coefficient was worked out. The positive correlation between grain yield and yield attributing traits like number of effective tillers hill^{-1} and number of grains panicle^{-1} was observed. Number of effective tillers hill^{-1} is an important character responsible for higher yield. Experimental result reveals that the grain yield showed very strong positive correlation (R^2 = 0.89) with number of effective tillers hill^{-1} (Fig. 1). This means an increase in number of effective tillers hill^{-1} resulted in the corresponding increase in the grain yield of *aman* rice varieties. Sarker et al. (2017) and Paudel et al. (2021) also reported significant positive correlation between number of effective tillers hill^{-1} and grain yield. Relationship between number of grains panicle^{-1} and grain yield has been shown Fig. 2. Grain yield showed positive correlation (R^2 = 0.59) with number of grains panicle^{-1}. This means an increase in number of grains panicle^{-1} will result in corresponding increase in grain yield of *aman* rice varieties. Adhikari et al. (2020) also reported positive correlation between grain yield and number of grains panicle^{-1}.

3.5 Correlation study between N level and yield parameters and yield

A simple correlation coefficient was calculated to establish the relationship between the N level and the number of grains in panicle^{-1}. According to experimental findings, the number of grains panicle^{-1} exhibited a favorable association (R^2 = 0.75) with nitrogen level (Fig. 3). This indicates that for the *aman* rice cultivars, a rise in nitrogen level led to a comparable increase in the number of grains panicle^{-1}. The availability of N to plants throughout the active tillering and panicle development stages was improved by increased N treatment, which may have led to more productive tillers and grains. The linear association between N level and grain yield for all tested genotypes is clearly depicted in Fig. 4. Grain yield showed positive correlation (R^2 = 0.85) with N level. According to the coefficient of determination (R^2), the difference in N levels may explain for 85% of the yield differences between the tested cultivars. The increase in grain yield by the increasing N uptake in the present study may be attributed to either the effect of N on source (i.e., production of photo-assimilate or sink size) (Mahajan et al., 2010).

3.6 Yield response of different rice varieties to applied N levels

The quadratic equation provides the best explanation for how four *aman* rice cultivars respond to nitrogen levels in terms of yield (Fig. 5). The test analysis indicated that more than 78%, 85%, 92% and 98% of the variation in crop performance (grain yield) occurred due to different nitrogen rates in BRRI dhan49, BRRI dhan71, BRRI dhan56 and BRRI dhna66, respectively. The estimated coefficients of the polynomial regression models showed significant variation. The optimum doses of N calculated from this response curve for BRRI dhan49 and BRRI dhan66 were 100% RD of N and for BRRI dhan56 and BRRI dhan71 were 150% RD of N, respectively. Saha et al. (2020) also reported significant variation in estimated coefficients of the polynomial regression models for different *aman* rice varieties.

4 Conclusion

Based on the result of the present study, it may be concluded that drought tolerant rice cultivar BRRI dhan66 could be grown successfully for obtaining maximum yield with 100% recommended dose of nitrogen (150 kg ha^{-1}) in combination with recommended rates of TSP, MoP and gypsum fertilizer to ensure optimum requirement of nutrients for commercial rice cultivation.

Conflict of Interest

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

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