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Effect of elevated nitrogen levels on the growth and yield performance of late T. *aman* rice cultivars

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ABSTRACT

Rice requires plenty of fertilizer to grow and yield properly. But poor management of nitrogenous fertilizer is one of the main obstacles to enhancing the production of late T. aman rice in Bangladesh. To overcome such conditions, an investigation was conducted at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, from July to December 2020 to evaluate the impact of cultivars as well as nitrogen on the growth and grain performance of late T. aman rice. The research conducted at RCBD with five nitrogen levels: 0 kg N ha^{-1}, 35 kg N ha^{-1}, 42 kg N ha^{-1}, 49 kg N ha^{-1} and 56 kg N ha^{-1} on three cultivars (BR22, BR23 and BRRI dhan46). Fertilizers were treated per plot by recommendations and every treatment of the study was repeated three times. Results showed that cultivars and nitrogen levels substantially impacted the growth and grain output of late T. aman rice. The maximum number of total tillers (14.66), effective tillers (13.66) and seed output (5.94 t h^{-1}) were recorded at BR23. The maximum effective tiller (13.33), panicle length (26.00 cm), grain panicle^{-1} (14.66), as well as seed output (5.93 t ha^{-1}) were recorded in 42 kg nitrogen. The maximum seed output (5.93 t ha^{-1}) was recorded at the coupling with BR23 with 42 kg nitrogen and the least (3.36 t ha^{-1}) was recorded in treatment combining BR22 with 0 kg nitrogen. The current study found that applying 42 kg of nitrogen is the optimum level for enhancing BR23 growth as well as production.

***Key Words**: Nitrogen level, T. aman, Growth, Yield and Nitrogen fertilizer*

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I. Introduction

Rice is the main dietary item of the people of Asia and many other countries worldwide and is inextricably linked to its heritage, ceremonies and rites. Bangladesh is the third-largest producer in the world, including the fastest expanding (FAO, 2022). In Bangladesh, there are three separate rice growing seasons i.e., *aus, aman* and *boro*. *Aman* produces 1.49 billion tons over 56.2 million hectares throughout these seasons (BBS, 2021). In 2050, when Bangladesh will have a population of 215.4

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million, 44.6 MT of cleaned paddy would be needed. Enhancing heritable variation, diminishing yield gaps and reducing the adopting gap are three primary strategies that could be used to reach this goal (Kabir et al., 2015). Choosing suitable cultivars, planting in the suitable technique and adding adequate concentration of plant nutrient components could play a crucial role in rice output and domestic earnings.

N management is another crucial aspect that affects the establishment, development, output attributes and yields of late T. *aman* rice. Among the most vital nutrient components, N is the primary essential macronutrient for rice crop advancement and output, and it is needed in more significant quantities than other supplements (Djaman et al., 2018). N affects crop output by influencing photosynthesis, biomass building, efficient tillering and spikelet development (Yoshida et al., 2006). Increasing the N usage efficacy and reducing the output difference of latest varieties, the proper nitrogen level and schedule of applications are essential (Hossain et al., 1992). Most agricultural lands in Bangladesh are insufficient in nitrogen (Saha et al., 2012; Sarkar et al., 2016). As a result, nitrogen application is required in the latest cultivars concerning maximizing output abilities (Chamely et al., 2015). Rahman et al. (2007) also found that high-yielding modern rice cultivars benefit more from nitrogen fertilizer, but the amount of N they require changes depending on their genetic make-up and agronomic characteristics in various environmental situations. Besides, Surplus N usage can result in groundwater contamination, enhanced operating costs, reduced gain yield and ecological degradation (Djaman et al., 2018). Hence, using appropriate nitrogen doses in T. *aman* rice is crucial.

On the other hand, Bangladesh faces a flood during *aman* growing season. To prevent flood conditions, producing late T. *aman* rice is crucial for farmers. Therefore, cultivar-based N fertilizer suggestions may be a better practice for boosting rice production. Therefore, a recent investigation was undertaken to evaluate the impact of elevated N on the growth and yield of late T. *aman* rice cultivars.

II. Materials and Methods

Location of experiment

An investigation was carried out at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh, from July to December 2020 to investigate the influence of elevated nitrogen on growth, output attributes and seed output of late T. *aman* rice. The study site was located at 24.75° N latitude and 90.50° E longitude and 18 m above sea level. The experimental site belongs to the Old Brahmaputra Floodplain (AEZ-9). The area is covered with a huge expanse of Brahmaputra sediment deposited prior to the rivers' 200-year migration into their current Jamuna channel (UNDP and FAO. 1988). The experimental soil was made up of non-calcareous dark gray floodplain soils. The pH of the soil was 6.5 and it had a silty-loam texture, was medium-high and included Twenty percent sand, Sixty seven percent silt and Thirteen percent clay. The land's bulk density is 1.35 g cm^{-3} and its OM content is only 1.96% (Islam et al., 2017). From April to September, the area saw hot temperatures, high humidity levels, much rain and sporadic gusts of wind; from October to March, it received little rain and moderately cool temperatures.

Experiment design and treatment

Five levels of nitrogen viz. no nitrogen (N_0), 35 kg ha^{-1} (N_{35}), 42 kg ha^{-1} (N_{42}), 49 kg ha^{-1} (N_{49}) and 56 kg ha^{-1} (N_{56}) and three late T. *aman* rice cultivars viz. BR22, BR23 and BRRI dhan46 were employed during this investigation. The investigation was designed according to a completely randomized block design (RCBD) with 3 trials. The nitrogen was treated in 3 separate applications, each at the end stages of land cultivation, tillering and panicle initiation, respectively. Phosphorus, potassium and sulfur were applied in the field as basal doses. Following 7 days after the transplant, the gaps were filled and all agronomic management was carried out as per requirement. The doses of P-K-S *aman* rice were Ten, Fifty and Ten kg ha^{-1}. 20 m^2 consisted of a single plot. Thirty days of seedlings were replanted on five of September and harvested on fourteen of December.

Data and plant specimen collection

Five hill $plot^{-1}$ were used to assess the height of the plant (at its peak of the tallest panicle on the individual hill to the topsoil level). The number of total tillers (TT), number of effective tiller $hill^{-1}$ (ETH), panicle length (PL), grains $panicle^{-1}$ (GP) and thousand grain weight (TGW) at the maturity. Grain yield (GY), straw yield (SY), biological yield (BY), as well as harvest index (HI), were calculated

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from 1 m² area of individual plots. GY was calibrated to Fourteen percent moisture content (MC) using the following equation below.

$$MC\ (\%) = \frac{WF - WO}{WF} \times 100$$

$$YA = \frac{WF\ \times (100 - \%MC)}{100 - 14} \times 100$$

Here,
MC% = Moisture content (%), WF= Fresh weight (g), WO = Oven dry weight (g); and YA = corrected yield at 14% MC

Harvest index (HI) was calculated with the equation below

$$HI\% = \frac{Grain\ yield}{Biological\ yield} \times 100$$

Statistical analysis
Average values were calculated and analyzed for ANOVA. Mean values were compared by DMRT (Gomez and Gomez. 1984).

III. Results and Discussion

Plant height
Cultivars, different levels of N and their interaction substantially influenced plant height (Table 01, Table 02 and Table 03). The maximum plant height (128.86 cm) was found at BR22, whereas the least (113.93 cm) plants were produced in BRRI dhan46. Genetic factors could influence plant height differences. Jahan et al. (2014) reported that variation occurs from variety to variety. Regarding N level, the highest PH (122.66 cm) recorded in N_{42} was substantially equal to N_{35}, N_{49} and N_{56}. Similar reports were found by Islam et al. (2009) and Hasanuzzaman et al. (2009). BR22 the maximum plant height (128.86 cm) in combination with $N_{42,}$ whereas the lowest one in N_{49} coupling with BRRI dhan46. The function of nitrogen enhancing rice growth, internode elongation, photosynthesis and digestion and assimilation production may cause better plant height with nitrogen administration. Mahjoobeh et al. (2013) noted that using N significantly enhanced rice's plant height.

Numbers of tillers
Number of total tiller and number of effective tiller hill^{-1} had no effect on the cultivar (Table 01). N level had a significant influence on number of effective tiller hill^{-1} except for total tiller (Table 02). The greatest number of effective tiller hill^{-1} (13.33) was found from the treatment of N_{35} (11.0), which was identically similar to N_{49} (10.66) and N56 (10.33). The interaction between various levels of N and cultivars had a substantial impact on total tiller as well as effective tiller hill^{-1} (Table 02 and Table 03). The highest number of total tiller (14.66) was recorded in BR23 with N_{42}, whereas BR23 with N_{49} ranked second (TT: 13) which was numerically equal to BR22 with N_{42} and BRRI dhan46 with N_{42}. In the matter of number of effective tiller hill^{-1}, the maximum result (13.33) was recorded in BR23 with N_{42} followed by BR22 with N_{42} (12.0), which is substantially identical to BRRI dhan46 (11.66). The lowest total tiller and number of effective tiller hill^{-1} were recorded in all three studied varieties with 0 kg N. Jahan et al. (2014), Ahmed et al. (2010) and Ahmed et al. (2005) noted equivalent findings.

Table 01. Influence of cultivars on the produce attributes and grain output of late T. *aman* rice

Cultivars	Plant height (cm)	Total tiller hill^{-1}	Effective tiller hill^{-1}	Panile length (cm)	Grain panicle^{-1}	Thousand grain weight (g)	Grain yield (t ha^{-1})	Sraw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
BR22	128.86a	13.66	12.00	25.63	115.33b	24.66	5.84a	6.18ab	12.02a	48.58
BR23	122.66b	14.66	13.33	26.00	117.33b	25.20	5.93a	6.60a	12.53a	47.22
BRRI dhan46	113.93c	13.00	13.00	25.93	140.66a	25.33	4.94b	5.76b	10.70b	46.15
F-test	**	**	NS	NS	**	NS	**	*	**	NS

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Panicle length

Panicle length is the significant yield attributing character in rice. PL was substantially affected by various rates of N (Table 02). The longest panicle length (26.00 cm) was recorded in N_{42} followed by N_{35} treatment. Interaction between cultivars with N levels had a substantial effect on panicle length. The longest panicle length was observed in BR23, with 42 kg N ha^{-1}. Nitrogen helps in contributing panicle formation by enhancing cell division during reproductive stages. The increment of panicle length with different levels of nitrogen was also reported by Jahan et al. (2022), Jahan et al. (2014) and Gewaily et al. (2018).

Table 02. Effect of nitrogen levels on the yield attributes and yield of late T. *aman* rice

Nitrogen treatment	Plant height (cm)	Total tiller hill^{-1}	Effective tiller hill^{-1}	Panicle length (cm)	Grain panicle^{-1}	Thousand grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
N_0	110.10b	11.00	8.33c	22.43c	106.00c	24.86bc	3.96d	4.88d	8.83e	44.79d
N_{35}	121.93a	13.00	11.00b	24.43b	123.00b	25.13ab	5.49b	6.46ab	11.95b	45.94c
N_{42}	122.66a	14.66	13.33a	26.00a	140.66a	25.33a	5.93a	6.20bc	12.13a	48.87a
N_{49}	121.26a	12.66	10.66b	24.10b	122.33b	24.76c	5.31bc	6.05c	11.36d	46.73b
N_{56}	120.83a	12.00	10.33b	24.10b	121.33b	24.93bc	5.09c	6.60a	11.69c	45.53e
F-test	**	NS	**	**	*	*	**	**	**	**

In a column, similar letter (s) are not significantly different, whereas dissimilar letters are significantly different as per DMRT

Grain panicle^{-1}

The cultivars, nitrogen level and their interaction had a substantial impact on grain panicle^{-1} (Table 01, Table 02 and Table 03). BRRI dha46 produced the highest grain panicle^{-1} (140.66), whereas the BR22 recorded the lowest (115.33). Nitrogen level N_{42} produced the highest grain panicle^{-1} (140.66), whereas the lowest grain panicle^{-1} (106.00) was noted in the 0 kg N ha^{-1}. In the combination, BR23 produced the highest grain panicle^{-1} (140.66) when applied 42 kg ha^{-1} N whereas BR22 with 0 kg nitrogen yielded the least. Nitrogen fertilizer is crucial for sink and source development (Masclaus-Daubresse et al., 2010). In addition, mono-nutritional components provide other nutrients and heritable makeup, determining the yield attributes in rice (Jahan et al., 2022; Yesuf and Belcha, 2014).

Grain and straw yield

Grain yield was calculated at an integrated workout of various grain attributes such as the number of panicles, panicle length, grain panicle^{-1} and thousand seed weight (Saha et al., 2017). This research revealed the substantial effect of nitrogen level on grain yield (Table 02). The maximum grain yield (5.93 t ha^{-1}) was observed at BR23, whereas the least (4.94 t ha^{-1}) was observed in BRRI dhan46. Application 42 kg nitrogen gave the highest yield (5.93 t ha^{-1}) as well as the least (3.96 t ha^{-1}) recorded in the 0 kg N ha^{-1}. Figure 01 demonstrates the correlation between N levels to grain output, having a positive correlation supported by Moro et al. (2015). In the case of interaction, the BR23 couple with 42 kg N ha^{-1} provided the maximum grain yield (5.93 t ha^{-1}), BR22 with the 0 kg N ha^{-1} produced the least (3.36 t ha^{-1}) (Table 03). Grain output accelerated to nitrogen up to a specific point, then declines of enhanced levels of N (Kongpun et al., 2021; Jahan et al., 2022). Overall the best N fertilizing levels that maximize output notably varied among rice cultivars and growing seasons, showing that rice cultivars and environmental parameters should be considered. Regarding plant height and tiller number, nitrogen fertilizer enhanced rice vegetative growth, increasing the straw production of BR23 during the period of late T. *aman* production. Straw yield was greatly influenced by cultivar, nitrogen level and their interaction. BR23 produces the maximum straw yield (6.60 t ha^{-1}) and the least straw yield (5.76 t ha^{-1}) recorded in BRRI dhan46. Application 56 kg nitrogen provided the maximum straw yield (6.60 t ha^{-1}), whereas the lowest was found at 0 kg N ha^{-1}. Jahan et al. (2022), Adhikari et al. (2018), Hussain et al. (2016), Siddique et al. (2014), Jahan et al. (2014) and Ahmed et al. (2005) found similar results that are in corroborated with our experiment.

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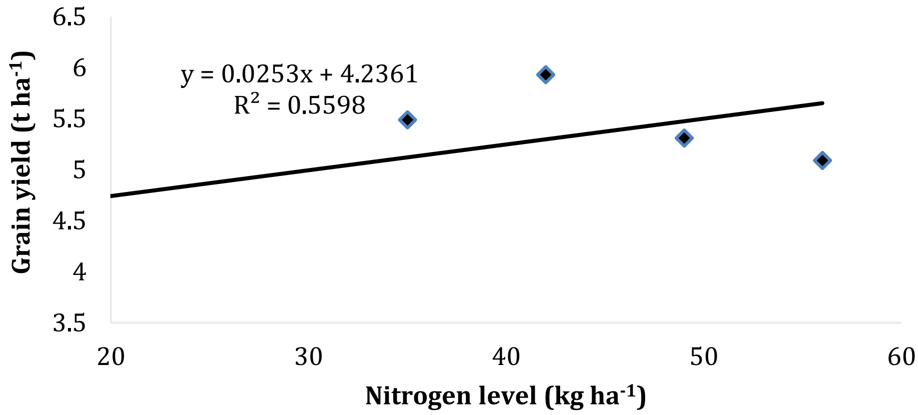

Figure 01. Response of grain yield to different levels of nitrogen

Biological yield and Harvest index

The effect of variety, nitrogen and among combination substantially impacted biological yield and harvest index (HI) (Table 01, Table 02 and Table 03). BR23 produced the highest biological yield (12.53 t ha^{-1}), which was numerically identical to BR22 (12.02 t ha^{-1}). The impact of N on biological yield ranges from 8.83 t ha^{-1} to 12.13 t ha^{-1}. The highest biological yield (12.13 t ha^{-1}) was found at N_{42} followed by N_{35} (11.95 t ha^{-1}). The studied cultivars with 0 kg N ha^{-1} produce the least biological yield (8.24 t ha^{-1}). The influence of N levels and their interaction with cultivars substantially affect the harvest index. BR22 with 42 kg N ha^{-1} was found maximum harvest index (48.87%) while the least was recorded (40.46%) was noted in 0 kg N ha^{-1}. Rony et al. (2019), Jahan et al. (2014), Ahmed et al. (2010) and Ghose (2003) reported similar results.

Table 03. Influence of interaction between cultivars and nitrogen levels in late T. *aman* rice

Interaction Cultivar nitrogen level	Plant height (cm)	Total tiller hill^{-1}	Effective tiller hill^{-1}	Panicle length (cm)	Grain panicle^{-1}	Thousand grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
$V_1 \times N_0$	116.20d	10.66e	8.33f	23.23c	102.00h	23.40g	3.36h	4.88ef	8.24c	40.76d
$V_1 \times N_{35}$	121.93bc	13.00abcd	11.00bcd	24.43b	104.33h	24.10f	5.49bc	6.07bc	11.56a	47.49b
$V_1 \times N_{42}$	128.86a	12.00ab	12.00ab	25.63a	106.00gh	24.86bcd	5.84ab	6.00bc	11.84a	49.33a
$V_1 \times N_{49}$	121.26bc	12.66a-e	10.66bcd	24.26b	109.66fg	23.16g	5.31cd	5.40de	10.71b	49.59a
$V_1 \times N_{56}$	120.83bc	12.00bcde	10.33cd	24.10b	114.33def	24.23f	5.09de	6.18abc	11.27a	45.16c
$V_2 \times N_0$	114.16d	12.00bcde	8.66ef	23.23c	123.66b	25.13abc	3.80g	4.41g	7.94c	47.82b
$V_2 \times N_{35}$	121.00bc	14.00ab	11.33bcd	24.13b	115.33de	24.66de	5.79ab	6.46ab	12.25a	47.27b
$V_2 \times N_{42}$	122.66b	14.66a	13.33a	26.00a	140.66a	25.20ab	5.93a	6.20abc	12.13a	48.88
$V_2 \times N_{49}$	120.83bc	13.00abcd	10.66bcd	24.16b	110.33efg	25.33a	5.49bc	6.05bc	11.54b	47.56b
$V_2 \times N_{56}$	120.30c	12.66a-e	10.00de	24.03b	112.66def	23.53g	5.08de	6.60a	11.69b	43.49de
$V_3 \times N_0$	101.10g	11.00de	8.33f	22.43d	122.33bc	24.26ef	3.96g	4.71g	8.67c	45.64cd
$V_3 \times N_{35}$	111.13e	12.00bcde	10.00de	24.20b	104.33h	24.76cd	4.83ef	5.76cd	10.59a	45.59c
$V_3 \times N_{42}$	113.93d	13.00abcd	11.66bc	25.93a	117.33cd	23.26g	4.94def	5.3ef	10.26a	48.13a
$V_3 \times N_{49}$	108.76	12.00bcde	10.33cd	24.10b	111.66ef	24.03f	4.73ef	5.25ef	9.98b	47.41b
$V_3 \times N_{60}$	110.16	11.66cde	10.00de	24.06b	121.33bc	24.93a-d	4.53f	5.49f	10.07a	45.47c
CV%	1.17	10.21	8.10	1.09	8.97	1.01	4.54	5.19	7.09	9.06
Level of significant	**	*	**	**	**	**	**	**	*	**

In a column, similar letter (s) are not significantly different whereas dissimilar letters are significantly different as per DMRT

V_1= BR22, V_2= BR23, V_3= BRRI dhan46, N_0= control, N_{35}= 35 kg ha^{-1} (RN), N_{42}= 42 kg ha^{-1} (20% higher than RN), N_{49}= 49 kg ha^{-1} (40 % higher than RN), N_{56}= 56 kg ha^{-1} (60 % higher than RN).

IV. Conclusion

Nitrogen dosages influenced development, yield, as well as grain output attributing parameters of late T. *aman* verities. The investigation's findings revealed that all the growth, produce and produce attributes gradually increased of increment of N level up to 42 kg nitrogen after that decline. BR23 was

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the best cultivar compared to others and 42 kg ha^{-1} N performed superior among N levels. Besides, 35 kg, 42 kg, and 49 kg nitrogen showed substantially similar results. Our investigation suggests that the requirement of N fertilizer for rice crops may be based on cultivars to enhance rice yield and reduce surplus chemical fertilizer use.

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