EFFECT OF DIFFERENT NITROGEN LEVEL ON THE YIELD PERFORMANCE OF AMAN RICE

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Abstract

The increasing food demands from an expanding population necessitate international efforts to extend crop production and guarantee of food security. The rate of N fertilizer application is strongly associated with the soil properties and crop physiology as well as crop yield. A field experiment was conducted at BINA sub-station, Barishal during the period from July 2021 to October 2021 to find out the impact of various nitrogen (N) level such N_0 = 0 kg N ha^{-1}, N_1 = 25 kg N ha^{-1}, N_2 = 50 kg N ha^{-1}, N_3 = 75 kg N ha^{-1}, N_4 = 100 kg N ha^{-1} and N_5=125 kg N ha^{-1}as on growth, yield and yield attributing characters of Binadhan-11. The experiment was laid out in a randomized complete block design with three replications. During harvest, data were collected on different yield contributing characters and yield of aman rice. The data revealed that morphological characters, yield parameters and grain yield showed significantly better for treatment N_3 75 kg N ha^{-1} having yield 4.28 tons ha^{-1} that was increased grain yield twenty one times of control.

Keywords: Nitrogen fertilizer, soil chemical properties, Aman rice

Introduction

Rice (*Oryza sativa* L.) is one of the foremost widespread field crops among different cereals within the world, being cultivated in numerous agroecosystems. Rice is the staple food for world's growing population (FAO, 2004). It ensures the supply of energy for major portion of world's population and ranks second following maize in relation to production (Manjappa and Shailaja, 2014). Globally 503.17 MT rice is produced wherever China produces 29.5% of the all, followed by India (23.8%), Bangladesh (7.0%), Indonesia (6.9%), Vietnam (5.4%), and Thailand (3.7%) (USDA, 2020). Aadditionally, rice is staple food in People's Republic of Bangladesh and accounting for roughly 78 % of the country's total net-cropped areas cultivation (Mamun *et al.*, 2021). In 2019–20 total rice production in Bangladesh was about 36.6 MT within 28.69 million acres of land (BBS, 2020). Recently, Bangladesh positioned the third place worldwide in rice production, behind China and India, with a production volume of 3.6 crore tons (Rahman *et al.*, 2021).

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Fertilizer is now one of the expensive inputs for crop production in Bangladesh. Among the nutrients, nitrogen stands prominent in rice cultivation because rice plant requires huge amount of nitrogen throughout its life cycle for proper growth and development (Leghari *et al.*, 2016). Nitrogen fertilizer is taking part as a key role in rice production and it is needed in great deal (Hossain *et al.*, 2008). Nitrogen highly influences the yield and other yield components. Nitrogen fertilizer also prolongs grain-filling duration that favors accumulation of more photosynthate in the grain and hence, increases grain weight (Yue Kai, *et al.*, 2022). M.S. Islam *et al*., (2020) reported that nitrogen is deficient in almost all the soils of Bangladesh. Therefore, the importance of N fertilizer in increasing rice yield is widely recognized. At present, the farmers of Bangladesh use increased amount of nitrogen fertilizer to get higher yield, but it is also evident that the yield of rice is affected very much if correct dose is not applied (Djaman, *et al*., 2017). So, optimum level of N supply is required to get satisfactory yield. Moreover, Nitrogen is the most significant limiting nutrient in rice production (Primitiva Andrea Mboyerwa *et al*., 2022). Among several factors deficiency of N is currently considered because the main reason of low yield of rice in saline region of Bangladesh (Ghose, 2003). Thus, it is necessary to search out the appropriate rate of nitrogen fertilizer for economical management and higher yield of Aman rice in coastal area of Bangladesh. The present investigation was undertaken to find out the effect of different doses of nitrogen (N) fertilizers on the yield and yield contributing characters of Aman rice in coastal area of Bangladesh.

Materials and Methods

The experiment was conducted in 2021 during Aman season (July-October) at BINA substation, Barishal where Binadhan-11 was used as a planting material, which is BINA developed high yielding submergence tolerance rice variety. The experiment was laid out in randomized completely block design (RCBD) with three replications and plot size was 15 m^2 each.

Seeds were immersed in water in bucket for 24 hours. Then seeds were taken out of water and kept thickly in gunny bags. The seeds started sprouting after 48 hours and were sown after 72 hours. Then the sprouted seeds were sown in the nursery bed. Twenty five days old seedlings were transplanted on 02 August 2021 in rows of 20 cm apart using 15 cm hill spacing and 3 seedlings per hill. Land was fertilized with 110 kg of TSP, 50 kg of MoP and 8 kg of $ZnSO_4$ per hectare, respectively. The entire amount of these fertilizers was applied during final land preparation. Nitrogen fertilizer was applied in the form of urea in three splits. First doses of urea (30%) were applied at 12 days after transplanting (DAT), 2nd split of urea (40%) at 30 DAT and 3rd split of urea (30%) at 40 DAT as per treatment was applied. Virtako @ 75 g ha^{-1} was applied with two split doses of urea to prevent stem borer infestation. For controlling of weeds, hand weeding was done with the help of “Khurpi” after 30 days after transplanting and 50 days after transplanting. Irrigation was applied as per requirement but no major irrigation was applied as aman rice is grown in rainfed condition.

The SPAD-502 Chl meter (Soil Plant Analysis Development, Minolta Camera Co., Ltd., Japan) is generally used for the quick, non-destructive assessment of relative leaf Chl concentration (Gianquinto *et al.* 2004). SPAD value was recorded at 75, 80, 85, 90 and 95 DAS (days after sowing) from five flag leaf of each treatment plot.

After physiological maturity, five destructive sample hills were collected from each individual plot outside the harvested area for recording plant height, number of tillers hill^{-1}, effective tiller hill^{-1}, panicle length, number of grains panicle^{-1}. For grain and straw yield, 1 m^2 area was harvested from the center of the plot. The grain yield was adjusted to 12% moisture content and expressed in ton ha^{-1}. A one-way analysis of variance was conducted using SPSS 25 to explore the impact of different nitrogen doses on yield and yield attributing characters of Binadhan-11. Soil samples were collected from experimental field before transplanting and after harvesting of the rice. The collected samples were air-dried, crushed thoroughly, sieved through a 2-mm sieve and chemical characterization obtained with the assistance of laboratory analysis from Soil Resource Development Institute (SRDI), Barishal.

Results and Discussion

Pre sowing nutrient status of the soil of the experimental site are depicted in Table 1, which indicates the chemical properties of the soil in initial condition. In Table 1 shown that the soil contained 2.10% organic matter, 0.105% Nitrogen and Electrical conductivity was 1.07 dSm^{-1} and pH was 7.3 before setting of the experiment. Moreover this soil contained 40.8 µg g^{-1} soil of Phosphorus; 0.10 meq./100gm soil of Potassium; 9.6 µg g^{-1} soil of Sulphur; 0.24 µg g^{-1} soil of Zinc and 1.47 µg g^{-1} soil of Boron. Before starting of this experiment, soil nutrient condition was high in concentration.

Table 1. Initial soil characteristics of the experimental site

pH	EC (dSm^{-1})	Organic matter (%)	Nitrogen (%)	Phosphorus (Olsen) (µg g^{-1} soil)	Potassium (meq./100gm soil)	Sulphur (µg g^{-1} soil)	Zinc (µg g^{-1} soil)	Boron (µg g^{-1} soil)
7.3	1.07	2.10	0.105	40.8	0.10	9.6	0.24	1.47

After harvesting Binadhan-11 soil nutrient content showed declined significantly among different treatments, which were presented in Table 2. Post-harvest soil pH was 6.23 to 6.36 at different nitrogen level. Organic matter (0.75 to 0.93%), nitrogen (0.07 to 0.08%), phosphorus (6.50 to 8.60 µg g^{-1} soil) and potassium (0.08 to 0.09 meq./100gm soil) content of post-harvest soil were significantly similar at different nitrogen level though the amount was drastically decline from initial soil condition. Rawal *et al.* (2017) reported that extensive rice cultivation can lead to decline of soil fertility and inadequate supply of indigenous essential nutrients specifically P and K and organic matter.

Table 2. Nutrient status of post-harvest soil of the experimental site

Fertilizer dose	pH	Organic Matter (%)	Nitrogen (%)	Phosphorus (Olsen) (µg g^{-1} soil)	Potassium (meq./100gm soil)
N_0	6.36±0.11[a]	0.85±0.32[a]	0.07±0.02[a]	8.60±2.42[a]	0.083±0.01[a]
N_1	6.30±0.10[a]	0.85±0.03[a]	0.07±0.003[a]	6.50±0.45[a]	0.090±0.02[a]
N_2	6.30±0.10[a]	0.93±0.03[a]	0.08 ±0.003[a]	6.83±0.05[a]	0.083±0.01[a]
N_3	6.23±0.15[a]	0.83±0.21[a]	0.07±0.02[a]	7.46±0.72[a]	0.090±0.02[a]
N_4	6.23±0.15[a]	0.75±0.12[a]	0.07±0.01[a]	7.46±0.72[a]	0.083±0.02[a]
N_5	6.30±0.10[a]	0.89±0.31[a]	0.08±0.03[a]	6.96±0.47[a]	0.080±0.02[a]
CV %	0.27	0.48	0.04	3.35	0.03

Note: Significantly different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test. Data is presented as mean ± standard deviation.

The SPAD-502 Chl meter (Soil Plant Analysis Development, Minolta Camera Co., Ltd., Japan) was used for determining Chlorophyll content at different nitrogen level at different duration. Chlorophyll content was increased upto 80 DAS (days after sowing), then gradually decreased from 80 DAS to 95 DAS in all Nitrogen level (Fig. 1). Chlorophyll content at 95 DAS was shown at Figure 2. Maximum cholorophyll content was observed in N_3 treatment that was statistically similar to N_2 and N_5 treatment followed by N_4 treatment. Minimum chlorophyll content was observed in N_1 treatment that was statically similar with control group N_0 (Fig. 2).

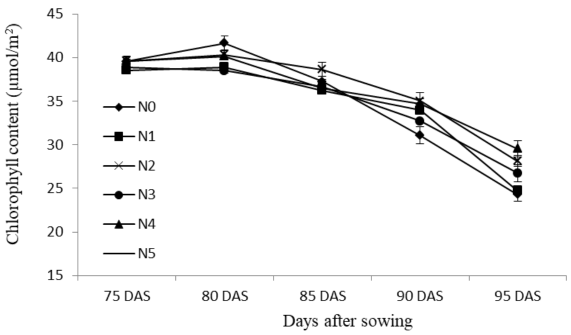

Fig. 1. Chlorophyll content of aman rice flag leaf at different nitrogen level in different growth stages

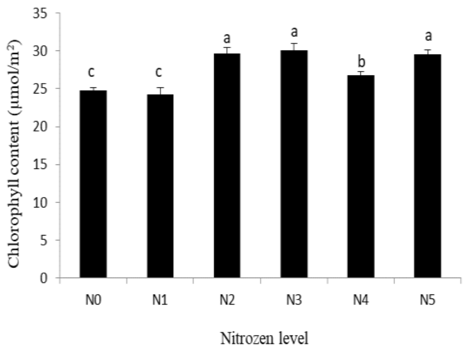

Fig. 2. Chlorophyll content of aman rice flag leaf at different nitrogen level at DAS.

All yield attributing characters showed insignificant difference comparison with nitrogen fertilizer dose N_3 except flag leaf breadth. Maximum plant height was recorded in N_3 treatment (97.45 cm). Number of effective tiller was also observed in N_3 treatment though maximum number of non effective tiller was in control that means N_0 (2.22), similar result also observed in N_1 (2.22) treatment (Table 3). Akter *et al.* (2020) revealed that plant height, effective tiller, flag leaf length, filled grain, unfilled grain and 1000 grain weight were increased with increasing nitrogen doses up to 110 kg N/ha for Binadhan-19 in Aus season.

Table 3. Morphological characters of Binadhan-11 at different nitrogen fertilizer doses

Treatments	Plant height (cm)	No. of effective tillers/hill	No. of non-effective tillers/hill	Flag leaf length (cm)	Flag leaf breadth (cm)
N_0	95.22±3.37	9.67±1.15	2.22±0.51	30.33±1.45	1.28±0.13[ab]
N_1	95.05±5.27	9.33±2.03	2.22±1.07	27.82±1.11	1.18±0.08[ab]
N_2	94.66±1.87	10.22±0.83	1.11±0.76	28.21±2.65	1.15±0.05[b]
N_3	97.45±2.58	11.33±0.87	1.00±0.33	28.00±3.21	1.20±0.06[ab]
N_4	96.45±2.83	11.22±0.19	1.33 ±0.66	27.78±3.94	1.11±0.05[b]
N_5	94.89±2.26	10.56±1.92	1.58±1.61	28.94±3.03	1.53±0.35[a]
CV %	6.50	4.05	2.44	6.50	0.36

Note: Significantly different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test. Data is presented as mean ± standard deviation.

Yield and yield contributing parameters were shown in Table 4. From this table, it was shown that maximum panicle length was observed in N_3 treatment (24.81 cm) and minimum panicle length was observed N_4 treatment though all panicle length of all treatment including control was statistically similar to each other. Maximum number of filled grain was observed in N_3 treatment (425.33). Maximum number of unfilled grain and spikelet per panicle was recorded in N_4 treatment. The highest grain yield was observed in N_3 treatment (4.28 t ha^{-1}) (Table 4) that was statistically different from other treatments, might be due to vigorous and enhanced plant growth and for the continuous synchronize supply of nutrients throughout the growth stages of rice. On the other hand, the lowest yield was found 3.50 tons ha^{-1} for N_1 treatment might be due to the limited supply of nitrogenous fertilizer. A similar finding was also scrutinized by Biwajit *et al.* (2017) that the levels of nitrogen, N_3 (90 kg N/ha) produced significantly higher grain yield which was followed by N_2 (60 kg N/ha) and N_1 (30 kg N/ha). Ying *et al.,* (2008) found that rice yield was significantly increased by N application up to 90 kg per hectare for some indigenous rice varieties. Hossain *et al.*, 2021 reported that the applications of large amounts of N fertiliser by farmers to increase yields of high yielding rice were not justified agronomically and ecologically. That's why N_3=75 kg N ha^{-1} could be useful dose for optimum yield of Binadhan-11 without harming soil and minimizing input cost.

Table 4. Yield and yield contributing characters of Binadhan-11 at different nitrogen fertilizer doses

Treatments	Panicle length (cm)	No. of filled grain/panicle	No. of unfilled grain/panicle	No. of spikelet/panicle	Grain yield (t/ha)
N_0	23.86±1.03	312.67±4.77	53.66±3.77	6.00±3.60	3.53±0.17
N_1	23.54±1.40	370.67 ±3.18	68.00±1.88	6.33±5.13	3.50±0.72
N_2	23.80±0.75	412.67±5.50	61.33±5.50	7.66±1.52	3.75±0.19
N_3	24.81±0.70	425.33 ±5.85	59.66±2.85	8.00±1.00	4.28±0.23
N_4	23.29±0.68	389.00±2.54	73.33±1.54	8.33 ±1.15	3.75±0.25
N_5	23.50±1.16	353.33±4.50	51.33±1.50	8.00±1.00	3.85±0.12
CV %	2.99	10.47	6.40	7.79	1.41

Note: Significantly different at 5% probability level by Tukeys's Honest Significant Difference (THSD) test. Data is presented as mean ± standard deviation.

Grain yield is determined by the combined action of different yield contributing factors like number of panicle, panicle length, filled grain, and 1000 grain weight (Saha *et al.*, 2017). Results of this study showed remarkable influence of different N rates on rice grain yield. Grain yield increasing rate as percent of control that means untreated (N_0) was shown in Figure 3. Maximum grain yield increasing rate was observed in N_3 treatment followed by N_4 treatment due to maximum panicle length and number of filled grain. N_1 treatment shown the lowest grain yield increasing rate followed by N_2 treatment.

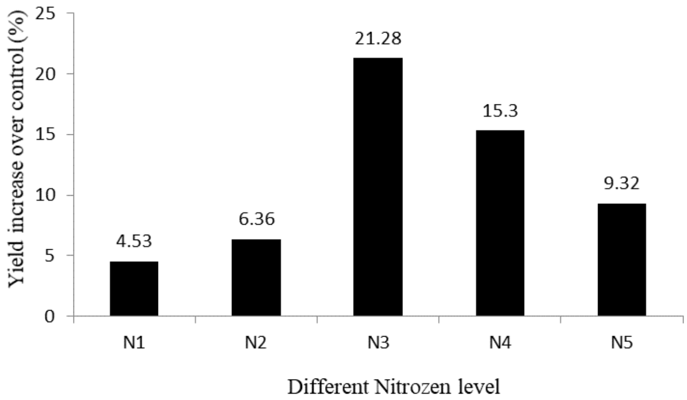

Fig. 3. Yield increase over control at different nitrogen doses of aman rice.

Our results showed that rice yield increased with applied N to a certain level and after that it decreased with the increased N rates. Tayefe *et al.* (2014) and Moro *et al.* (2015) reported quadratic response of grain yield to N fertilization which supports our result. In T. Aman season, the lower increase of rice grain yield with applied N rates compared to N_0 was due to the availability of soil indigenous nutrients. In T. Aman season, due to high rainfall and temperature, the soil indigenous nutrients become more available leading to low response to the applied N. Nitrogen fertilization improved rice vegetative growth in terms of plant height and tiller number leading to increased grain yield. Our results suggest that total N uptake by rice plant increased with increased N rates up to a certain level than it decreased. Yesuf and Balcha (2014) also reported similar findings. Nitrogen use efficiency is largely influenced by grain yield, N fertilizer input and N uptake (Qiao *et al.*, 2012).

Conclusion

In present study, treatment N_3=75 kg N ha^{-1} appeared better dose among the used treatments and produced satisfactory yield whereas N_1=25 kg N ha^{-1} showed more poor performance than other treatments. Therefore, 75 kg N ha^{-1} can be a recommended dose for successful production of Binadhan-11 under the agro climatic conditions of Barishal region. Farmer can apply this nitrogen fertilizer dose dividing three splits with other fertilizers for better yield in low land coastal area in Aman season.

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