__Original Research Article__

Optimization of nitrogen fertilizer dose for the growth and development of BRRI Dhan27

ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh during the period from November 2022 to April 2023 to study the effect of nitrogen and spacing on the yield of Boro rice cv. BRRI dhan47. The experiment consisted of four levels of nitrogen viz. 0, 80, 100, and 120 kg N ha^{-1} The experiment was laid out in a randomized complete block design with three replications. The level of nitrogen significantly influenced all the parameters except the weight of 1000-grain. The tallest plant (99.18 cm), the highest number of total tillers hill--1 (13.23), the maximum number of non-effective tillers hill-1 (4.18), the uppermost panicle length (24.60 cm), the highest number of sterile spikelets panicle-1 (18.50), the top number of total spikelets panicle-1 (153.82) and highest straw yield (6.84 t ha-1) were obtained from 120 kg N ha-1. The greater number of effective tillers hill-1 (10.32), the uppermost number of grains panicle-1 (135.32), the maximum grain yield (5.36 t ha-1), the top biological yield (12.01 t ha-1), and the highest harvest index (44.59%) were recorded from 100 kg N ha^{-1}. The dwarf plant (84.47 cm), the lowest number of total tillers hill-1 (7.40), the minimum number of effective tillers hill-1 (5.83), the bottommost non-effective tillers hill-1 (1.57), the shortest panicle length (21.09), the lowest number of grains panicle-1 (84.90), the minimum number of sterile spikelets panicle-1 (11.90), the fewer total spikelets panicle-1 (100.88), the minimum grain yield (3.20 t ha-1), the least straw yield (4.67 t ha-1) the lowest biological yield (7.87 t ha-1) and the lowest harvest index (40.71%) were obtained from the control treatment (0 kg N ha^{-1}). Based on the findings of the study, it can be suggested that the use of 100 kg N ha-1 would be a promising practice to maximize the grain yield of BRRI dhan47.

Keywords: Nitrogen, Fertilizer, Growth, Yield, BRRI Dhan47

1. INTRODUCTION

Food security is a pressing issue due to the rising global population, particularly in Asia and Africa. There is a pressing requirement to generate a greater quantity of food using efficient and sustainable agricultural production systems in order to nourish the swiftly expanding population [1]. The high population density in Bangladesh exerts significant pressure on the country's natural resources [2].

Rice, scientifically known as Oryza sativa, holds significant importance as a key dietary staple globally. It is the second most widely consumed product worldwide, after wheat. Agriculture plays a significant role in the economy of Bangladesh, with a primary emphasis on rice cultivation, which covers almost 75% of the available land for farming (Rahman et al., 2023). The primary agricultural practice revolves around the growth of Boro and T. Aman rice. It accounts for 91.12% of the total cereal production. [3] reports that the acreage allocated for Aus, Aman, and Boro production are 1.16 million hectares, 5.72 million hectares, and 4.81 million hectares, respectively. The corresponding yields for these crops are 3 t ha-1, 1.46 t ha-1, and 2.02 t ha-1. The present necessity for Bangladesh's agriculture sector is to tackle the increasing demand for food from the growing population [4]. To achieve higher rice yields, it is essential to focus on developing high yielding varieties (HYV) with a greater number of productive tillers per unit area. This can be achieved by optimal spacing, the judicious use of fertilizers, efficient water management, and suitable plant protection measures.

Nitrogen (N) is the most crucial nutrient for the growth and productivity of rice crops (Paul et al., 2021). It is required in larger quantities compared to other nutrients, making it the most limiting factor [5]. Nitrogen (N) significantly affects rice output by playing a crucial role in photosynthesis, biomass buildup, effective tillering, and spikelet development [6]. These processes ultimately contribute to increased grain yield in rice. However, excessive nitrogen can have negative consequences, as it promotes susceptibility to insect attacks and diseases. A significant proportion of the agricultural soils in Bangladesh exhibit nitrogen deficiency, as reported by [7]. Hence, the application of nitrogen fertilizer is crucial for maximizing the production potential of contemporary rice cultivars [8]. Modern rice varieties with high yields exhibit a significant increase in productivity when nitrogen is administered. However, the nitrogen requirements of these varieties vary depending on their genetic makeup and agronomic characteristics, which are influenced by different climatic circumstances [9]. However, an excessive application of nitrogen can result in the polluting of groundwater, higher production costs, decreased crop yield, and environmental damage [5]. Hence, employing a fertilizer suggestion tailored to individual crop varieties could be a viable strategy for improving nitrogen management. Therefore, it is crucial to determine the ideal amount of nitrogen fertilizer required for a specific variety. Based on the aforementioned information, this study aimed to identify the optimum dose of nitrogen for BRRIdhand 47 variety, in order to promote optimal growth and maximize grain yield.

2. Methods and Materials

The experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agriculture University, Mymensingh, during the period from November 2008 to April 2009 with a view to studying the effect of nitrogen on the yield of Boro rice cv. BRRI dhan47. The experimental site belongs to the agro-ecological zone of the old Brahmaputra Floodplain (AEZ 9) with dark gray soil [10]. The experimental area has a sub-tropical climate characterized by heavy rainfall during the months from June to September and scanty rainfall during the rest of the year. The experiment consisted of four levels of nitrogen, viz. 0, 80, 100, and 120 kg N ha-1. We used the BRRI dhan47 variety for this experiment. It was developed by the Bangladesh Rice Research Institute from the cross between IR 51511-B-34-B and TCCP 266-2-49-BB-3. It was released in 2007 as transplant Boro rice and named BRRI Dhan47. This variety can tolerate 12–14 ds/m salinity at the seedling stage and 6 ds/m salinity for the rest of the living period. The cultivar BRRI dhan47 matures within 150 days after transplanting. It attains a plant height of about 105 cm. BRRI dhan47 yielded an average of 6.1 t ha^{-1}. The experiment was laid out in a randomized, complete block design with three replications. Each of the replications represented a block in the experiment. Each block was divided into 4-unit plots, where the treatment combinations were allocated at random. Altogether, there were 12-unit plots in the experiment. The size of a unit plot was 5 m2 (2.0 m × 2.5 m). The distances between replications and between plots were 1 m and 0.75 m, respectively. The crop in each treatment was raised under the same level of management practices. For raising rice seedlings, a piece of high land was selected at the Agronomy Field Laboratory, Bangladesh Agricultural University, Mymensingh. Then the sprouted seeds were sown in the nursery beds on November 22, 2022. Weeds were removed, and irrigation was given in the seedling nursery as and when necessary. Immediately after final land preparation, the layout of the experimental plot was made on January 10, 2009, according to the experimental specification. Weeds and stubbles were cleared off from individual plots, and finally, they were leveled so properly by a wooden plank that no water remained in the puddled field. In the experiment, full doses of chemical fertilizer, viz., triple superphosphate (at 125 kg/ha), muriate of potash (at 100 kg/ha), and gypsum (at 55 kg ha^{-1}), were applied at the time of the final land preparation of individual plots. Urea (at 0, 80, 100, and 120 kg N ha^{-1}) was applied in equal instalments at 15 and 45 days after transplanting as top dressing. The seedlings were uprooted without causing any mechanical injury to the roots. Then the uprooted seedlings were transplanted into the main field. The seedlings were transplanted on January 11, 2023. The different intercultural operations and plant protection measures were done as per need. Five hills were selected randomly from each plot prior to harvesting. The crop of each experimental plot was harvested separately at full maturity on April 30, 2023. From the central 1 m2 area of each plot, the crop plants were harvested to collect data on grain and straw yields. The plant height (cm), the total tillers $hill^{-1}$, the effective tiller number per hill, the non-effective tillers $hill^{-1}$, panicle length (cm), the total grains $panicle^{-1}$, the number of sterile spikelets $panicle^{-1}$, Weight of 1000- grains, grain yield, highest straw yield, and biological yield (t ha^{-1}) were taken when needed. Grain yield and straw yield were altogether considered biological yields. The biological yield was calculated with the following formula: Biological yield (t ha^{-1}) = grain yield (t ha^{-1}) + straw yield (t ha^{-1}). It is the ratio of grain yield to biological yield and was calculated with the following formula:

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Statistical analysis

All the collected data were analysed by following the analysis of variance (ANOVA) technique, and mean differences were adjudged by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) using a STAR (Statistical Tool for Agricultural

Research) data analysis program developed by International Rice Research Institute (IRRI) in Los Baños, Philippine.

3. Results and Discussion

In most cases, the different characters studied in this experiment to determine the effect of various doses of nitrogen on BRRI Dhan47 showed significant variation among them (Table 1 and Figure 1). We observed the tallest plant (99.18 cm) at 120 kg N ha-1, followed by 100 kg N ha-1. We recorded the tallest plant (84.47 cm) in the control treatment. When plants receive an adequate supply of nitrogen, they tend to exhibit lush green foliage and vigorous growth. The additional nitrogen of 120 kg N ha^{-1} likely provided the rice plants with more resources to produce biomass, resulting in taller plants compared to other dozes. However, 100 kg N ha^{-1} yielded the highest number of effective tillers per hill (10.32), followed by 120 kg N ha^{-1}. The control treatment yielded the lowest number of effective tillers (5.83). The specific variety of rice may have received the optimal amount of nitrogen from 100 kg N ha^{-1}. Sometimes, too much nitrogen can actually hinder tillering or lead to excessive vegetative growth without corresponding increases in yield. However, 120 kg N ha^{-1} produced the highest number of non-effective tillers (4.18), while 0 kg N ha-1 produced the lowest number (1.57). Control nitrogen (0 kg N ha^{-1}) had fewer tillers hill-1 and, as a consequence, probably fewer non-productive tillers hill-1. The higher nitrogen application rate (120 kg N ha^{-1}) might have caused excessive vegetative growth, leading to the development of more non-effective tillers compared to the lower nitrogen application rate (100 kg N ha^{-1}). This could be due to a saturation point, where additional nitrogen beyond a certain threshold does not contribute to increased grain production but instead promotes the growth of non-effective tillers. We found the longest panicle (24.60) at 120 kg N ha^{-1}, followed by 100 kg N ha^{-1}, and the shortest at 0 kg N ha^{-1} (21.09). This result agrees with the findings of [11]. Adequate nitrogen levels enhance the plant's ability to take up other essential nutrients, which are crucial for overall plant health and development. This improved nutrient uptake can result in better panicle development and, consequently, longer panicles. Conversely, 100 kg N ha^{-1} yielded the highest number of grains $panicle^{-1}$ (135.32). The control group (0 kg N ha^{-1}) recorded the lowest number of grains $panicle^{-1}$ (84.90). Nitrogen is essential for chlorophyll production, which is crucial for photosynthesis. With higher nitrogen levels, rice plants might have been able to carry out photosynthesis more efficiently, leading to increased carbohydrate production and ultimately more grains per panicle. The maximum number of sterile spikelets panicle^{-1} (18.50) was recorded at 120 kg N ha^{-1}. We found the minimum number of sterile spikelets at 0 kg N ha^{-1} (11.90). We found the highest 1000-grain weight at 120 kg N ha^{-1} (26.25 g). We found the lowest 1000-grain weight at control (25.99), which is identical to 80 kg N ha-1. The results indicated that increasing nitrogen levels increased grain weight. An adequate nitrogen supply is critical for maximizing rice yield potential. While excess nitrogen can cause lodging and environmental problems, the 120 kg N ha^{-1} rate may have been within the optimal range for maximizing both yield and grain quality. We obtained the highest grain yield (5.36 t ha^{-1}) from 100 kg N ha^{-1} and the lowest yield (3.20 t ha^{-1}) from 0 kg N ha^{-1}. Because the plants got more nitrogen, they may have produced more grains, each weighing 1000 grains, having the longest panicle length, and having the most effective tillers per hill. This may explain why the grain yield went up from 100 kg N ha^{-1}. Conversely, at 120 kg N ha^{-1}, we observed the highest straw yield (6.84 t ha^{-1}). The control treatment produced the lowest straw yield (4.67 t ha-1). Sarker et al. (2001) found a similar result. 100 kg N ha^{-1} (12.00 t ha^{-1}), followed by 120 kg N ha^{-1} (11.77 t ha^{-1}). Table 1 shows that 0 kg N ha^{-1} yielded the lowest biological yield (7.87 t ha1). Nitrogen is a crucial nutrient for plant growth and plays a significant role in various physiological processes, including photosynthesis, protein synthesis, and overall plant metabolism. When the nitrogen supply is optimal, it enhances the plant's ability to produce chlorophyll, which is essential for capturing sunlight and converting it into energy through photosynthesis. This, in turn, leads to increased biomass production and, ultimately, a higher grain yield. The experimental results revealed that 100 kg N ha^{-1} yielded the highest harvest index (44.59%), followed by 80 kg N ha^{-1} (44.01%), and 0 kg N ha^{-1} yielded the lowest harvest index (40.71%). With the increase in nitrogen from 0 kg N ha^{-}1 to 100 kg N ha^{-1}, grain yield increased. Increased levels of nitrogen significantly influenced grain and straw yields, thereby increasing the harvest index, as stated by [12, 13]. The study's findings suggest that using 100 kg N ha$_{-1}$ could be a promising practice to maximize the grain yield of BRRI dhan47.

Table 1. Effect of different levels of N on growth and yield characters of *Boro* rice cv. BRRI dhan47

Level of N	Plant height (cm)	Panicle length (cm)	Total spikelet's panicle^{-1} (no.)	Weight of 1000 grains (g)	Biological yield (t ha^{-1})	Harvest index (%)
N_0	84.47d	21.09b	100.88c	25.99	7.87b	40.71c
N_1	91.54c	23.06a	148.88b	25.99	11.72a	44.01a
N_2	96.32b	23.43a	147.29b	26.21	12.01a	44.59a
N_3	99.18a	24.60a	153.82a	26.25	11.77a	41.62b
Level of significance	**	**	**	NS	**	**
S $\bar{x}$	0.93	0.59	1.62	0.17	0.12	0.29
CV (%)	6.47	8.86	4.08	2.26	5.77	3.38

In a column, the figures with similar letter (s) do not differ significantly whereas the figures with dissimilar letter (s) differ significantly (as per DMRT).

N_0 = 0 kg N ha^{-1}
N_1 = 80 kg N ha^{-1}
N_2 = 100 kg N ha^{-1}
N_3 = 120 kg N ha^{-1}

** Significant at 1% level of probability

NS = Not significant

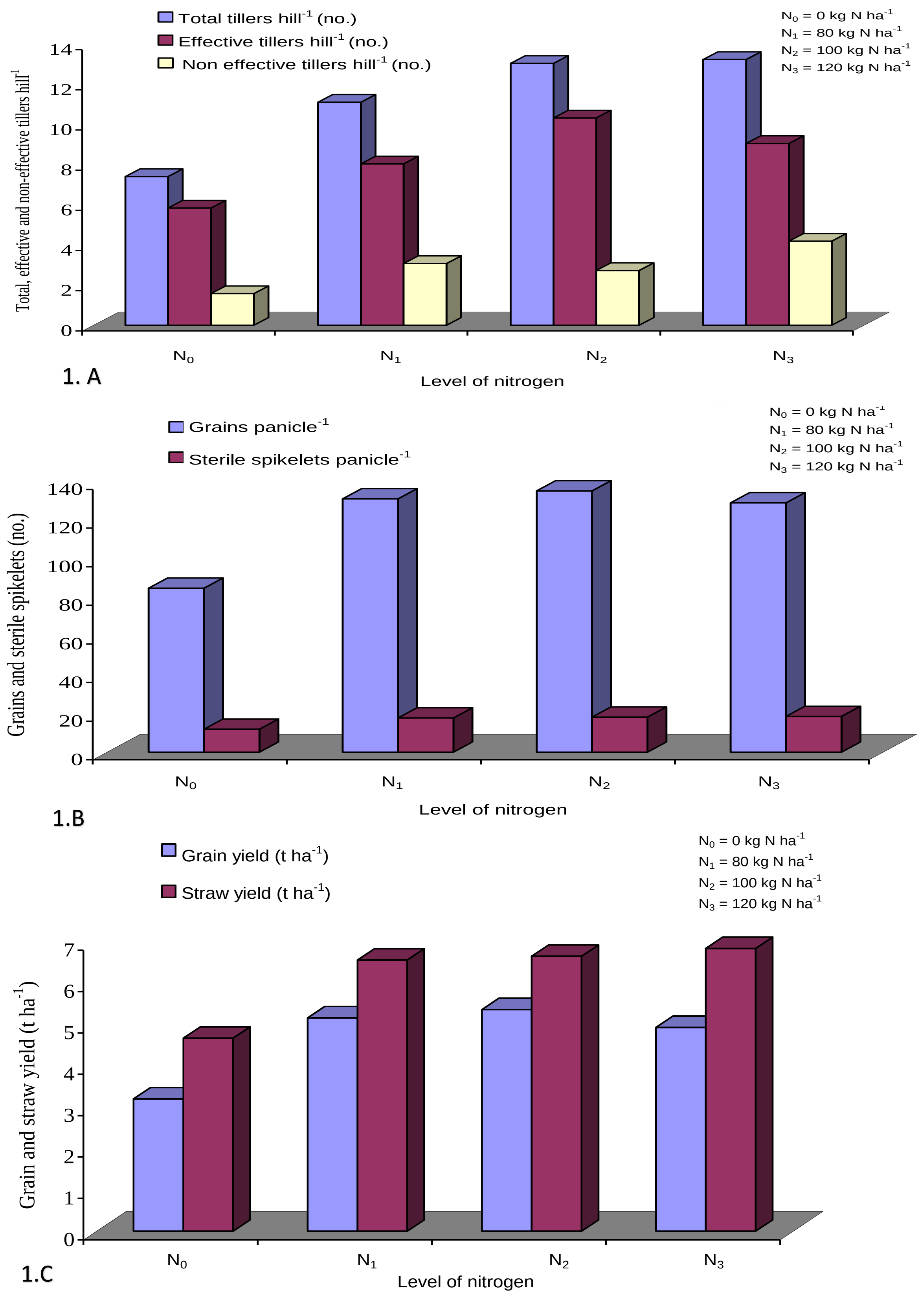

Fig.1.Effect of different level of nitrogen on tiller number, grains panicle^{-1}, sterile spikelet's panicle^{-1}, grain and straw yield

REFERENCES

1. Islam SM, Gaihre YK, Islam MR, Ahmed MN, Akter M, Singh U, Sander BO. Mitigating greenhouse gas emissions from irrigated rice cultivation through improved fertilizer and water management. Journal of Environmental Management. 2022 Apr 1;307:114520.
2. Bari A, Promi RJ, Shumsun N, Hasan K, Hosen M, Demir C, Barutçular C, Islam MS. Response of Sulphur and Boron on Growth, Yield Traits and Yield of Boro Rice (BRRI dhan28) at High Ganges River Floodplain of Bangladesh. ISPEC Journal of Agricultural Sciences. 2023 Mar 26;7(1):158-72.
3. BBS (Bangladesh Bureau of Statistics) 2022: Yearbook of Agricultural Statistics of Bangladesh, Government of Bangladesh, Dhaka.
4. Rahman MT, Sarker UK, Kabiraj MS, Jha S, Rashid MH, Paul SK. Response of Boro Rice (cv. BRRI dhan89) Yield to Foliar Application of Micronutrients. Journal of Agroforestry and Environment. 2023;16(2):153-9.
5. Djaman K, Mel VC, Diop L, Sow A, El-Namaky R, Manneh B, Saito K, Futakuchi K, Irmak S. Effects of alternate wetting and drying irrigation regime and nitrogen fertilizer on yield and nitrogen use efficiency of irrigated rice in the Sahel. Water. 2018 May 31;10(6):711.
6. Ju J, Yamamoto Y, Wang Y, Shan Y, Dong G, Yoshida T, Miyazaki A. Genotypic differences in grain yield, and nitrogen absorption and utilization in recombinant inbred lines of rice under hydroponic culture. Soil Science & Plant Nutrition. 2006 Jun;52(3):321-30.
7. Saha PK, Islam SM, Akter M, Zaman SK. Nitrogen response behaviour of developed promising lines of T. Aman rice. 2012.
8. Chamely SG, Islam N, Hoshain S, Rabbani MG, Kader MA, Salam MA. Effect of variety and nitrogen rate on the yield performance of boro rice. Progressive Agriculture. 2015 Aug 12;26(1):6-14.
9. Rahman MH, Ali MH, Ali MM, Khatun MM. Effect of different level of nitrogen on growth and yield of transplant aman rice cv BRRI dhan32.2007.
10. FAO U. Land Resources Appraisal of Bangladesh for Agricultural Development Report No. 2. Agro-ecological Regions of Bangladesh. United Nations Development Programme and Food and Agricultural Organization., Rome., Italy. 1988:212-21.
11. Idris M, Matin MA. Response of four exotic strains of aman rice to urea. Bangladesh J. Agril. Sci. 1990;17(2):271-5.
12. Haque MA, Razzaque AH, Haque AN, Ullah MA. Effect of plant spacing and nitrogen on yield of transplant aman rice var. BRRI dhan52. Journal of Bioscience and Agriculture Research. 2015;4(02):52-9.
13. Khanda CM, Dixit L. Effect of zinc and nitrogen fertilization on yield and, nutrient uptake of summer rice (Oryza sativu). Indian Journal of Agronomy. 1996;41(3):41-43.