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Effect of Varying Level of Nitrogen and Spacing on the Yield of Boro Rice Cv. BRRI Dhan47

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted at the Agronomy Field Laboratory of Bangladesh Agricultural University, Mymensingh, during the period from November 2008 to April 2009 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}, and four spacings, viz. 25 cm × 10 cm, 25 cm × 15 cm, 25 cm × 20 cm, and 25 cm × 25 cm. The experiment was laid out in a randomized, complete block design with three replications. The interaction between different levels of N and spacing significantly influenced most of the studied characters. The highest number of total tillers $hill^{-1}$ (14.67), number of non-effective tillers $hill^{-1}$ (4.80 sterile spikelets $panicle^{-1}$ (20.97), spikelts

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panicle^{-1} (165.55), and straw yield (7.07 t ha^{-1}) were obtained from the interaction of 120 kg N ha^{-1} with 25 cm × 25 cm spacing. The uppermost number of effective tillers hill^{-1} (11.67), grain yield (5.86 t ha^{-1}), biological yield (12.62 t ha^{-1}), and harvest index (46.42%) were obtained from the interaction of 100 kg N ha^{-1} with 25 cm × 15 cm. The control nitrogen with 25 cm × 10 cm spacing and 25 cm × 15 cm spacing gave the worst combined result in most of the cases. Overall, the treatment combination of 100 kg N ha^{-1} with 25 cm × 15 cm spacing gave the best desirable output, hence it should be recommended for field application.

Keywords: Nitrogen; spacing; growth; yield; brri dhan47.

1. INTRODUCTION

The increasing global population, especially in Asia and Africa, has made food security a critical concern. There is an urgent need to produce a larger amount of food using efficient and sustainable agricultural production technologies in order to feed the rapidly growing population [1]. Bangladesh's natural resources face substantial strain due to the country's dense population [2]. Rice, scientifically known as Oryza sativa, holds significant importance as a key dietary staple globally. Based on [3], it is the second most widely utilized commodity worldwide, behind wheat. Agriculture plays a vital role in the economy of Bangladesh, with a primary emphasis on rice cultivation, which covers more than 75% of the cultivable land. The primary agricultural focus revolves around the growth of Boro and T. Aman rice. It accounts for 91.12% of the total cereal production. The documented area for Aus, Aman, and Boro cultivation is 1.16 million hectares, 5.72 million hectares, and 4.81 million hectares, respectively. The yields for these crops are 3 metric tons per hectare, 1.46 metric tons per hectare, and 2.02 metric tons per hectare, respectively [4]. In order to increase rice production, it is crucial to prioritize the development of high yielding varieties (HYV) that have a greater number of productive tillers per unit area. This can be accomplished through the strategic arrangement of plants, the careful use of fertilizers, effective management of water resources, and the implementation of appropriate measures to protect plants from pests and diseases.

Rice depends heavily on nitrogen (N) as a vital component for their growth and productivity. It is necessary in greater amounts than other nutrients, making it the most restrictive factor [5]. Nitrogen has a substantial impact on rice production by playing a vital role in photosynthesis, the accumulation of biomass, efficient tillering, and the generation of spikelets [6]. These mechanisms ultimately lead to a higher grain yield in rice. Nevertheless, an overabundance of nitrogen can result in adverse effects, as it enhances vulnerability to pest infestations and illnesses. [7] indicated that a substantial fraction of the agricultural soils in Bangladesh suffer from nitrogen deficit. Therefore, the use of nitrogen fertilizer is essential for optimizing the productivity of modern rice varieties [8]. Modern rice cultivars with high yields experience a substantial boost in production when nitrogen is applied. Nevertheless, the nitrogen needs of plant types change based on their genetic composition and agronomic traits, which are impacted by various climatic conditions [9]. Nevertheless, an overabundance of nitrogen can lead to the contamination of groundwater, increased production expenses, reduced agricultural output, and harm to the ecosystem [5]. Therefore, implementing a fertilizer recommendation customized for certain crop types could be an effective approach to enhance nitrogen management.

Spacing is a crucial factor in increasing the output of rice crop, among other better agricultural practices. Proper plant spacing is a crucial aspect to consider while transplanting rice. Plant spacing has a significant impact on the production and yield components of rice. Farmers are employing variable plant spacing for Boro rice growth in field conditions. Some individuals employ a narrower spacing between plants, while others opt for a larger gap. Tighter spacing impedes intercultural operations. Ensuring smooth cross-cultural collaboration and effective herbicide application for weed management are important aspects of maintaining optimal spacing in crop production [10]. Optimal planting geometry is essential for maximizing light interception, improving light consumption efficiency, and ensuring even light distribution across the crop canopy. These qualities [11] have an indirect impact on the crop yield. The rice yield is directly influenced by the planting density, which is determined by the distances between rows and individual plants. Furthermore, the grain production may decrease in narrow spacing when compared to ideal spacing because to increased competition for nutrients and moisture [12]. Nevertheless, the efficiency of crop cultivation depends on the exploitation of appropriate and geographically relevant kinds.

Therefore, it is crucial to determine the ideal amount of nitrogen fertilizer and optimum spacing required for a specific variety. Based on the aforementioned information, this study aimed to identify the optimum dose of nitrogen and suitable spacing for BRRI dhand47 variety, in order to promote optimal growth and maximize grain yield.

2. MATERIALS AND METHODS

The research was conducted at the Agronomy Field Laboratory of Bangladesh Agriculture University, located in Mymensingh. The aim was to examine the influence of nitrogen and spacing on the yield of Boro rice cv. BRRI dhan47. The experimental site is situated inside the agro-ecological zone designated as the old Brahmaputra Floodplain (AEZ 9), which is distinguished by its dark gray soil [13]. The experimental region has a sub-tropical climate characterized by significant rainfall from June to September and minimal precipitation for the rest of the year. The experiment consisted of four nitrogen levels, specifically 0, 80, 100, and 120 kg N ha^{-1}, and four distinct spacings, namely 25 cm × 10 cm, 25 cm × 15 cm, 25 cm × 20 cm, and 25 cm × 25 cm, which were employed as treatments. The BRRI dhan47 variety was employed for this study. This variety was developed by the Bangladesh Rice Research Institute through a cross between IR 51511-B-34-B and TCCP 266-2-49-BB-3. BRRI Dhan47, a cultivar of Boro rice, was first introduced in 2007. This specific variety has the capacity to endure salt levels of 12–14 ds/m when in the seedling stage and 6 ds/m for the rest of its life. The BRRI dhan47 cultivar attains maturity 150 days post-transplantation. The plant attains a height of approximately 105 cm. The BRRI dhan47 variety exhibited a mean yield of 6.1 metric tons per hectare. The experiment was carried out utilizing a randomized, complete block design with three replications. Every replication functioned as a separate block within the experiment. The blocks were divided into plots consisting of four units each, and the treatment combinations were randomly assigned. The experiment consisted of a total of 16 plots, with each plot including 48 units. The unit plot had dimensions of 2.0 meters by 2.5 meters, resulting in a total area of 5 square meters. The replications were positioned at intervals of 1 meter, whereas the plots were positioned at intervals of 0.75 meters. The crop in each treatment was farmed using the same management practices. The Agronomy Field Laboratory at Bangladesh Agricultural University, Mymensingh, selected a suitable piece of high terrain for the cultivation of rice seedlings. Afterwards, the sprouted seeds were sown in the nursery beds. We eradicated unwanted vegetation and supplied irrigation as necessary at the seedling nursery. The experimental plot was established promptly after the completion of the final land preparation, following the experimental parameters. Each individual plot was cleared of weeds and stubbles, and then meticulously levelled using a wooden board to ensure complete drainage of water from the puddled field. The experiment entailed the administration of complete quantities of chemical fertilizer, namely triple superphosphate at a dosage of 125 kg per hectare, muriate of potash at a dosage of 100 kg per hectare, and gypsum at a dosage of 55 kg per hectare. The application of these fertilizers occurred during the final stage of land preparation for each individual plot. Urea was applied in equal amounts of 0, 80, 100, and 120 kg N ha^{-1}, divided into two equal halves and applied as top dressing 15 and 45 days after transplanting. The seedlings were uprooted without inflicting any physical harm to the roots. Afterwards, the uprooted juvenile plants were transferred to the main cultivation zone. The many intercultural activities and plant protection measures were implemented as necessary. Before the harvest, a random sample of five hills was chosen from each plot. Each experimental plot was separately harvested after the crops reached full maturity. Data on grain and straw yields were collected by picking the crop plants from the middle 1 m2 zone of each plot. The measurements consist of the plant's height (in centimetre), the overall number of tillers per hill, the number of tillers per hill that contribute to the plant's productivity, the number of tillers per hill that do not contribute to the plant's productivity, the length of the panicle (in centimetre), the total number of grains per panicle, and the number of sterile spikelet's per panicle. Measurements were undertaken as necessary to determine the weight of 1000 grains, grain yield, maximum straw yield, and biological yield (Mtha^{-1}). The aggregate of grain yield and straw yield is together known as biological yields. The biological yield was determined using the 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:

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

2.1 Statistical Analysis

The data acquired underwent examination using the analysis of variance (ANOVA) technique. The mean differences were calculated using Duncan's Multiple Range Test (DMRT) [14] (Gomez and Gomez, 1984) with the use of the STAR (Statistical Tool for Agricultural Research) data processing program, which was designed by the International Rice Research Institute (IRRI) in Los Baños, Philippines.

3. RESULTS AND DISCUSSION

The combined effect of nitrogen and spacing showed significant variation among the studied traits except plant height, panicle length and grains $panicle^{-1}$. The uppermost plant height (101.76 cm), number of non-effective tillers $hill^{-1}$ (4.80), and number of sterile spikelets $panicle^{-1}$ (20.97) was recorded from 120 kg N ha^{-1} with 25 cm × 25 cm spacing combination. But the highest straw yield (7.07 t ha^{-1}) was recorded from 120 kg N ha^{-1} with 25 cm × 25 cm spacing association. On the contrary, the longest panicle (28.39 cm) was obtained from 120 kg N ha^{-1} with spacing of 25 cm × 20 cm combination. However, the highest number of effective tillers $hill^{-1}$ (11.67), maximum number of grains $panicle^{-1}$ (144.57), uppermost grain yield (5.86 t ha^{-1}), top biological yield (12.62 t ha^{-1}) and greater harvest index (46.42%) was produced from 100 kg N ha^{-1} with 25 cm × 15 cm spacing. Besides, 1000-grain weight (26.48) was obtained from 100 kg N ha^{-1} with 25 cm × 25 cm spacing. In most of the cases 0 kg N ha^{-1} with 25 cm × 10 cm spacing and 80 kg N ha^{-1} under 25 cm × 10 cm spacing gave the worst result for the desirable characters (Table 1).

Proper nitrogen application ensures that the rice plants receive the necessary nutrients for robust growth and maximum yield. When combined with appropriate spacing, each plant has adequate access to nutrients, sunlight, and water, leading to optimized growth and higher yields per unit area. Applying the right amount of nitrogen at the right time and in the right manner minimizes nutrient losses through leaching, volatilization, or runoff. Proper spacing ensures that nutrients are efficiently utilized by individual plants, reducing wastage and environmental impact. Adequate spacing between rice plants suppresses weed growth by limiting the available space and resources for weed establishment. Proper nitrogen application encourages rapid rice growth, which can help in shading out weeds, further reducing competition. Optimal spacing allows for efficient water management, facilitating irrigation and drainage practices. Proper nitrogen application influences water uptake and transpiration rates, affecting the overall water requirements of the rice crop. Together, they contribute to improved water use efficiency and better adaptation to varying moisture conditions. Consistent spacing promotes uniformity in plant growth and development, resulting in a more synchronized canopy structure and flowering. Combined with balanced nitrogen application, it helps in achieving uniform maturity and grain filling, essential for quality grain production and ease of harvesting. [15] recorded that application of 138kg N ha^{-1} and 20 cm × 15 cm spacing influence all the growth parameters except t panicle length, weight of 1000 grains and biological yield. [16] stated that the application of 200 kg N ha^{-1} with plant spacing of 25 cm × 15 cm gave the highest grain yield, 1000-grain weight and harvest index. [17] Found that the application of nitrogen with a spacing of 25 cm × 18 cm in rice resulted in the highest tillers $hill^{-1}$ (14.9), 1000-grain weight (28.6g), grain yield (12.6 t ha^{-1}), and straw production (10.3 t ha^{-1}). In a study conducted by [18], it was found that optimal plant spacing is crucial for promoting proper growth of plants, both above and below the ground. This is achieved by effectively utilizing resources such as nitrogen, which is essential for the development of structural and functional proteins, chlorophyll, and nucleic acids. Additionally, maintaining the right plant spacing can increase crop yield by 25-30%. Closer spacing impedes intercultural operations and leads to increased competition among plants for growth resources [19]. Conversely, broader spacing facilitates greater competition between crop plants and weeds. Insufficient usage of growth factors leads to a decrease in plant growth and grain production [20].

From the results discussed above, it can be concluded that *Boro* rice cv. BRRI dhan47 grown under 100 kg N ha^{-1} with 25 cm × 15 cm spacing emerged out as a promising practice in order to get the desired plant growth and grain yield.

Table 1. Effect of interaction between different level of N and spacing on plant characters and yields of Boro rice cv. BRRI dhan47

N level × Spacing	Plant height (cm)	Total tillers hill^{-1} (no.)	Effective tillers hill^{-1} (no.)	Non-effective tillers hill^{-1} (no.)	Panicle length (cm)	Grains panicle^{-1} (no.)	Sterile spikelet's panicle^{-1} (no.)	Total spikelet's panicle^{-1} (no.)	Weight of 1000 grains (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
$N_0 \times S_1$	82.72	6.13h	4.93g	1.20i	20.50	80.32	6.63g	90.28h	25.77	3.03g	4.74ef	7.77f	38.96g
$N_0 \times S_2$	85.64	6.80h	5.67g	1.13i	21.01	92.12	8.16g	94.90gh	26.11	3.31g	4.32f	7.63f	43.38b-d
$N_0 \times S_3$	85.36	8.60g	7.13ef	1.47i	21.02	83.75	13.19ef	100.27g	25.95	3.17g	4.57f	7.74f	40.96ef
$N_0 \times S_4$	84.14	8.07g	5.60g	2.47gh	21.84	83.40	19.61ab	118.06f	26.13	3.30g	5.04e	8.34f	39.56fg
$N_1 \times S_1$	91.04	10.27f	6.93f	3.33de	23.07	126.65	17.34c	143.99de	25.59	4.91de	6.20d	11.10e	44.19b-d
$N_1 \times S_2$	92.76	11.60c-e	9.07cd	2.53gh	22.55	132.21	12.55f	139.59e	26.34	5.52b	6.91ab	12.43ab	44.37b-d
$N_1 \times S_3$	91.63	10.53ef	7.40ef	3.13d-f	23.45	138.71	20.52a	159.23ab	25.86	5.12cd	6.59a-d	11.70b-e	43.76b-d
$N_1 \times S_4$	90.75	12.00cd	8.73d	3.27de	23.17	127.04	20.52a	152.73b-d	26.14	5.09cd	6.55b-d	11.64c-e	43.73b-d
$N_2 \times S_1$	93.64	10.87d-f	8.13de	2.73fg	23.45	127.91	19.41ab	138.12e	26.21	5.08cd	6.36cd	11.44c-e	44.43bc
$N_2 \times S_2$	97.58	13.87a	11.67a	2.20h	23.49	144.57	15.27d	151.57 b-d	25.94	5.86a	6.76a-c	12.62a	46.42a
$N_2 \times S_3$	97.11	13.78a	10.67ab	3.12d-f	23.30	135.20	18.20bc	151.51b-d	26.19	5.35bc	6.52b-d	11.87a-e	45.04ab
$N_2 \times S_4$	96.93	13.62ab	10.80ab	2.82e-g	23.49	133.60	19.67ab	147.95c-e	26.48	5.13cd	6.95ab	12.08a-d	42.47de
$N_3 \times S_1$	95.03	11.80c-e	7.40ef	4.40ab	22.69	118.71	18.27bc	146.17c-e	26.38	4.51f	6.87ab	11.38de	39.67fg
$N_3 \times S_2$	100.22	12.53bc	9.00cd	3.53cd	23.38	132.68	14.79de	148.39c-e	26.11	5.52b	6.67a-d	12.19a-c	45.28ab
$N_3 \times S_3$	99.71	13.93a	9.93bc	4.00bc	28.39	133.31	19.97ab	155.17bc	26.15	5.04cd	6.76a-c	11.80b-e	42.71c-e
$N_3 \times S_4$	101.76	14.67a	9.87bc	4.80a	23.95	131.91	20.97a	165.55a	26.34	4.65ef	7.07a	11.71b-e	38.82g
Level of significance	NS	**	**	**	NS	NS	**	**	NS	*	*	*	**
$S\bar{X}$	1.86	0.40	0.34	0.17	1.18	3.04	0.56	3.24	0.34	0.11	0.15	0.24	0.59
CV (%)	6.47	6.26	7.10	9.94	8.86	5.38	5.90	4.08	2.26	6.07	6.20	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} *S_1 = 25 cm × 10 cm*
N_1 = 80 kg N ha^{-1} *S_2 =25 cm × 15 cm*
N_2 = 100 kg N ha^{-1} *S_3 = 25 cm × 20 cm*
N_3 = 120 kg N ha^{-1} *S_4 = 25 cm × 25 cm*

** Significant at 5% level of probability, ** Significant at 1% level of probability, NS = Not significant*

4. CONCLUSION

Assessment of proper doze of nitrogen and optimum spacing is crucial for rice cultivation not only for proper growth, development and yield but also for getting maximum return. Our study suggested that use of 100 kg N ha^{-1} with 25 cm × 15 cm spacing will be ideal for cultivation of *Boro* rice cv. BRRI dhan47.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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