International Journal of Scientific Research in Multidisciplinary Studies
Vol.10, Issue.7, pp.107-114, July 2024
E-ISSN: 2454-9312 P-ISSN: 2454-6143
Available online at: www.isroset.org

Research Article

Performance of Different Types and Doses of Urea on the Growth and Yield of Boro Rice

Most. Nahida Umme Tamim[1], Bitopi Biswas[2], M. Robiul Islam[3*]

[1,2,3]Dept. of Agronomy and Agricultural Extension, University of Rajshahi, Bangladesh

*Corresponding Author: mrislam@ru.ac.bd

Received: 25/May/2024; **Accepted**: 27/Jun/2024; **Published**: 31/Jul/2024

Abstract— The experiment was conducted at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, Rajshahi University, from December 2021 to April 2022. It aimed to investigate the impact of various types and doses of urea on the growth and yield of boro rice. The study involved three boro rice varieties: BRRI dhan28 (V_1), BRRI dhan29 (V_2), and BRRI dhan58 (V_3) (Factor A), and three different urea dosages: 75% of the recommended dose of prilled urea (PU) (T_1), 100% of the recommended dose of PU (T_2), and 75% of the recommended dose of urea super granules (USG) (T_3) (Factor B). The experiment was conducted using a split-plot design with three replications. The experimental results shows that, BRRI dhan58 demonstrated superior performance across various parameters, including plant height (86.05 cm), total tillers hill^{-1} (18.70), panicle length (23.00 cm), 1000-grain weight (22.47 g), grain yield (6.11 t ha^{-1}), straw yield (7.12 t ha^{-1}), and biological yield (13.22 t ha^{-1}). Concerning urea dosages, T_3 (75% of the recommended dose of USG) resulted in the highest values for plant height (86.66 cm), total tillers hill^{-1} (19.04), panicle length (22.93 cm), 1000-grain weight (22.28 g), grain yield (6.30 t ha^{-1}), straw yield (7.13 t ha^{-1}), and biological yield (23.43 t ha^{-1}), with V_2 demonstrating the maximum harvest index (46.25). The combined treatment of BRRI dhan58 and 75% of the recommended dose of USG yielded the most favorable overall result, highlighting the importance of considering both cultivar selection and urea dosage in optimizing boro rice production in experimental areas or areas with similar ecologies.

Keywords— Boro rice; Urea types; Urea super granules (USG); Growth parameters; Yield components of rice

1. Introduction

Agriculture is a crucial sector that underpins livelihoods, generates employment, and drives economic growth [1]. Rice (*Oryza sativa* L.) is not only a staple food for a significant portion of the global population, particularly in Asia, but it also holds immense agricultural and socio-economic importance in Bangladesh [2]. The country benefits from favorable conditions for rice cultivation year-round. However, its yield per unit area falls behind that of leading global rice-producing countries. Rice dominates the cereal crops grown in Bangladesh, covering 80% of the country's cropped area, making it crucial for the nation's food security. Despite this, Bangladesh faces an annual food grain deficit of about 39.04 million metric tons. Increasing the rice yield per unit area could significantly reduce this deficit.

Bangladesh has three distinct rice-growing seasons: aus, aman, and boro. Boro rice production of Bangladesh is crucial for the country's self-sufficiency in rice production. To enhance rice yields, strategies such as developing high-yielding varieties, implementing effective management practices, and proper fertilization are essential. Optimizing nutrient management practices is crucial for maximizing the productivity and sustainability of rice cultivation systems in Bangladesh [3].

Among the various nutrients required for rice growth, nitrogen (N) is considered a primary determinant of yield and quality. Urea, a common nitrogen fertilizer, is widely used in rice production due to its affordability and high nitrogen content. However, the efficiency of urea application can vary depending on factors such as timing, dosage, and the specific cultivar being cultivated. For better grain development, adequate N is required at the early, mid-tillering, and panicle initiation stages [4]. Although urea is the primary nitrogen source for rice in the agriculture of Bangladesh, the efficiency of N fertilizer, particularly urea, is very low in rice. In the pursuit of enhancing boro rice productivity, researchers and agronomists have continuously explored different urea types and application strategies to optimize nutrient uptake, improve growth parameters, and increase grain yield. Understanding the performance of different urea types and doses on boro rice cultivars is imperative for devising precision nutrient management strategies that are both economically viable and environmentally sustainable.

Prilled urea (PU) and urea super granules (USG) differ in their physical characteristics and nutrient release mechanisms. Prilled urea typically releases nitrogen more rapidly upon application, which may lead to potential nitrogen losses through volatilization, especially in flooded rice fields [5]. On the other hand, urea super granules are designed to release nitrogen gradually, providing a more sustained nutrient supply to rice plants over time [6]. Studies have shown that urea super granules can improve nitrogen use efficiency and reduce nutrient losses compared to prilled urea, resulting in better agronomic performance, including increased grain yield and nitrogen uptake by rice plants [7].

Prilled urea (PU) is the most commonly used nitrogen fertilizer for rice cultivation in Bangladesh. However, its efficiency in rice culture is only 25-30%, with the remaining 70-75% being lost due to various factors [7]. In contrast, urea super granules (USG) can enhance nitrogen absorption, improve soil health, and save 30% more nitrogen compared to PU, leading to increased rice yields [7]. The controlled-release properties of USG allow for a more efficient utilization of nitrogen by rice plants, as they better align with the crop's growth stages and nutrient requirements. This synchronization reduces nitrogen losses and improves nutrient uptake efficiency, particularly in environments susceptible to leaching or volatilization. While prilled urea is readily available and cost-effective, it often requires split applications or additional management practices to minimize nitrogen losses and maximize nutrient use efficiency, especially in high rainfall or waterlogged conditions.

However, the successful adoption and integration of USG into rice farming systems necessitate careful consideration of local conditions, farmer preferences, and economic feasibility. These factors are crucial to ensure optimal outcomes and promote sustainable agricultural practices [8].

Therefore, the objective was to systematically evaluate and compare the effects of various types (prilled urea and urea super granules) and doses of urea fertilizers on the growth and yield parameters of boro rice cultivars. The study also aims to compare the effectiveness of USG over prilled urea, for boro rice production.

2. Experimental Procedure

Plant Materials and Growth Condition

The study took place from December 2021 to April 2022, at the Agronomy Field Laboratory, Department of Agronomy and Agricultural Extension, University of Rajshahi, Bangladesh, to evaluate the effectiveness of urea super granules (USG) versus prilled urea on boro rice performance. The experimental site located at 24°22’36” N latitude and 88°38’27” E longitude, the site is part of Agro-Ecological Zone-11, characterized by a subtropical climate and prone to flooding. Soil analysis showed 0.4 g kg^{-1} organic carbon, 0.7 g kg^{-1} nitrogen, 1.8 ppm potassium, 7.5% calcium, and minimal phosphorus, with a pH of 7.6 and electrical conductivity of 0.04 mS/cm. The area experiences distinct seasonal variations: high temperatures and moderate rainfall during the kharif season (April to September) and lower temperatures during the rabi season (October to March), with fluctuating monthly rainfall, temperatures, and humidity. (Figure -1)

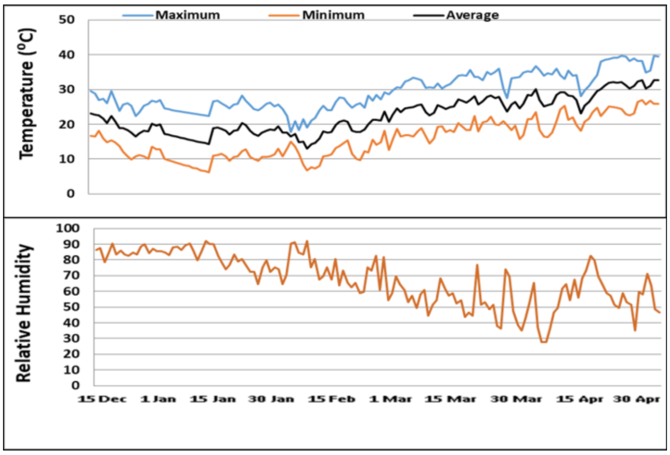

Figure-1: Monthly air temperature and relative humidity pattern during the study period (December 2021 to April 2022)

Three rice varieties were used: BRRI dhan28 (V_1), BRRI dhan29 (V_2), and BRRI dhan58 (V_3), known for their drought and cold tolerance. BRRI dhan28 matures in 145 days, yielding 6.0 tons/ha; BRRI dhan29 matures in 155-160 days, yielding 7.5 tons/ha; BRRI dhan58 matures in 150-155 days, yielding 7.0-7.5 tons/ha. The fertilizers used were: Treatment 1 (T_1) with 75% of the recommended dose of prilled urea (PU), Treatment 2 (T_2) with 100% recommended dose of PU (200 kg ha^{-1}), and Treatment 3 (T_3) with 75% recommended dose of urea super granules (USG). Prilled urea (PU) was applied in three equal splits: at basal, pre-tillering, and pre-anthesis stages. Urea Super Granules (USG) were applied through deep placement in the middle of four hills, once at the pre-tillering stage. The size of the USG was customized according to experimental requirements.

Experimental Design and Data Collection

The experiment followed a two-factor split-plot design with three replications. The main plot included three rice varieties, and the subplots incorporated three fertilizer regimes. Each unit plot was 20 m², totaling 27 plots. Plots were prepared for transplantation on December 13, 2021, with uniform spacing of 25 cm × 15 cm and each hill receiving two seedlings for all varieties. Fertilizers, including triple super phosphate (TSP), muriate of potash (MoP), gypsum, and zinc sulfate, were applied at rates of 130, 120, 70, and 5 kg ha^{-1}, respectively, as a basal dose during final land preparation, with urea applied as per treatment specifications. During growth, various parameters like plant height, number of tillers, and SPAD value were recorded. At maturity, yield components and yield parameters were measured.

Statistical Analysis

Data were analyzed using ANOVA, and mean differences were determined with DMRT, utilizing the SPSS statistical software package

3. Results and Discussion

Data on various yield attributes and yield were statistically analyzed, and the results were presented in Table 1–4.

Plant height

The plant height of rice varied significantly among the rice varieties at 20 and 100 days after transplanting (DAT). At 20 DAT, the tallest plants (23.42 cm) were observed in V_3 (BARI dhan58), followed by a slight reduction (5.59%) in V_2 (BRRI dhan29) and a significant decrease (12.43%) in V_1 (BRRI dhan28). This trend continued at subsequent observation points. For instance, at 40 DAT, the tallest plants (37.00 cm) were in V_3, while the shortest (35.21 cm) were in V_1. Similarly, at 60 DAT, V_2 exhibited taller plants (62.82 cm) compared to V_1 (62.40 cm). At 80 DAT, the tallest plants (79.50 cm) were again in V_3, with the shortest (79.41 cm) in V_1. Finally, at 100 DAT, V_3 had the maximum plant height (86.05 cm), significantly taller than V_2 and V_1 (Table 1).

The plant height of rice was significantly influenced by the application of different levels of nitrogen fertilizer at all observation points (20 DAT, 40 DAT, 60 DAT, 80 DAT, and 100 DAT). At 20 DAT, the tallest plants (24.03 cm) were observed in T_3 (75% of the recommended dose of urea as USG), followed by a slight reduction (4.62%) in T_2 (100% of the recommended dose as PU), and a significant decrease (20.60%) in T_1 (75% of the recommended farmers' dose as PU). This trend persisted at 100 DAT, where the plant height of T_3 (86.66 cm) was 3.73% higher than T_2 and 10.79% higher than T_1 (Table 1).

The interaction between rice varieties and different levels of nitrogen fertilizer significantly affected the plant height of rice at all observation points, except 20 and 100 DAT. For example, at 20 DAT, the tallest plants (25.71 cm) were in V_3T_3, while the shortest (18.42 cm) were in V_1T_1. Similarly, at 40 DAT, the tallest plants (39.06 cm) were in V_3T_3, while the shortest (33.36 cm) were in V_1T_1. This pattern continued at subsequent observation points, with V_3T_3 consistently exhibiting the tallest plants and V_1T_1 the shortest. For instance, at 100 DAT, the interaction of V_3T_3 (91.00 cm) was 19.75% higher than that of V_2T_1 (73.02 cm) (Table 1).

SPAD value

The SPAD values of rice did not differ significantly among the different varieties in all observations. At 40 DAT, the highest SPAD value (49.32) was observed in V_2, while the lowest (43.26) was recorded in V_1. At 60 DAT, the SPAD value of V_2 (48.81) was 11.10% higher than that of V_1 (43.39) (Table 1). The SPAD values of rice varied significantly based on the levels of nitrogen fertilizer application. At 40 DAT, the highest SPAD value (50.60) was recorded in T_3. However, this decreased slightly by 2.89% in T_2 and significantly by 21.96% in T_1. At 60 DAT, the highest SPAD value (48.46) was observed in T_2, while the lowest (41.74) was recorded in T_1 (Table 1).

Table 1: Varietal differences, nitrogen fertilization, and their interactions on the growth parameters of Boro rice

Variety	Plant height					SPAD value	
	20 DAT	40 DAT	60 DAT	80 DAT	100 DAT	40 DAT	60 DAT
V_1	20.51±0.85b	35.21±0.97	62.40±0.61	79.41±1.51	80.23±1.37b	43.26±2.22	43.39±1.39
V_2	22.11±1.00ab	35.54±1.07	62.82±0.74	76.51±1.97	81.11±2.42b	46.62±2.00	45.24±1.21
V_3	23.42±1.09a	37.00±1.26	62.6±0.85	79.50±1.86	86.05±1.97a	49.32±1.88	48.81±1.76
Treatment							
T_1	19.08±0.65b	33.43±0.50b	61.18±0.55b	75.46±1.54b	77.31±1.62a	39.49±1.2b	41.74±1.27
T_2	22.92±0.83a	36.58±1.10ab	62.83±0.79ab	78.54±1.712ab	83.43±1.520b	49.14±1.175a	47.23±1.23
T_3	24.03±0.80a	37.74±1.08a	63.82±0.55a	81.84±1.68a	86.66±1.87b	50.60±1.27a	48.46±1.42
Interaction							
V_1T_1	18.42±1.31d	33.36±0.91	61.09±0.65	77.80±2.37	78.13±2.45bc	35.44±2.36d	39.71±2.74d
V_1T_2	20.88±1.30bcd	35.71±1.81	62.87±1.23	78.19±2.91	79.5±2.56bc	46.54±1.91ab	45.07±1.69bcd
V_1T_3	22.22±1.24abcd	36.57±2.12	63.26±1.07	82.26±2.66	83.08±1.89ab	47.8±1.88ab	45.39±1.61bcd
V_2T_1	18.96±1.22d	33.49±1.17	61.58±1.32	75.02±3.11	73.2±1.72c	39.94±2.68cd	41.84±1.81cd
V_2T_2	22.2±1.28abc	35.54±0.83	62.86±1.50	75.44±3.68	84.22±2.35ab	49.3±1.99ab	46.72±1.66abc
V_2T_3	24.17±1.10ab	37.61±2.70	64.01±1.08	79.07±4.31	85.9±3.71ab	50.611±1.70a	47.14±1.65abc
V_3T_1	19.87±1.18cd	33.44±0.87	60.87±1.11	73.544±2.91	80.60±2.85bc	43.07±2.00bc	43.66±2.14bcd
V_3T_2	24.69±1.15ab	38.49±2.81	62.76±1.92	81.98±1.55	86.55±1.66ab	51.5±1.67a	49.91±2.57ab
V_3T_3	25.71±1.37a	39.06±0.86	64.18±1.02	82.99±1.98	91±2.91a	53.4±2.27a	52.84±1.95a
CV (%)	9.76	8.41	3.47	6.49	5.32	7.74	7.63

In a column, means followed by dissimilar letter(s) differed significantly as per DMRT; V_1=BRRI dhan28; V_2=BRRI dhan29; V_3=BRRI dhan58; T_1=75% of the farmer recommended doses of prilled urea; T_2=100% of the recommended dose of prilled urea; T_3=75% of the recommended dose of urea super granules; CV(%)=Co-efficient of variation; DAT=Days after transplanting.

Table 2: Varietal differences, nitrogen fertilizations, and their interactions on the yield contributing parameters of Boro rice

Variety	Total number of tiller hill^{-1}				Effective tiller hill^{-1}	Non-Effective tiller hill^{-1}
	20DAT	40 DAT	60 DAT	80 DAT		

V_1	2.26±0.09c	6.07±0.30b	11.22±0.45b	16.63±0.57b	14.37±0.48c	2.26±0.15a
V_2	2.67±0.16b	6.63±0.31ab	12.18±0.54ab	17.19±0.50b	15.44±0.56b	1.74±0.24b
V_3	3.04±0.19a	7.07±0.36a	12.70±0.50a	18.70±0.77a	17.37±0.95a	1.56±0.25b
Treatment						
T_1	2.15±0.059c	5.85±0.26b	10.85±0.46b	15.52±0.33c	13.48±0.34b	2.15±0.18a
T_2	2.74±0.16b	6.85±0.31a	12.18±0.46a	17.96±0.45b	16.56±0.66b	1.41±0.25b
T_3	3.07±0.16a	7.07±0.33a	13.07±0.38a	19.04±0.57a	17.15±0.72a	2±0.21a
Interaction						
V_1T_1	2±0.00f	5.56±0.49c	10.11±0.68c	14.89±0.48e	12.89±0.49d	2.00±0.20ab
V_1T_2	2.22±0.11ef	6.34±0.58abc	11.33±0.58abc	16.78±0.49cde	14.56±0.68cd	2.22±0.22ab
V_1T_3	2.55±0.11cd	6.34±0.58abc	12.22±0.68abc	18.22±0.78bc	15.67±0.38bc	2.56±0.29a
V_2T_1	2.11±0.11ef	5.89±0.48bc	10.67±0.88bc	15.55±0.68e	13.56±0.68d	2.00±0.51ab
V_2T_2	2.78±0.11c	6.89±0.48abc	12.53±0.68abc	17.89±0.49bcd	16.78±0.59ab	1.11±0.29c
V_2T_3	3.11±0.11b	7.11±0.49abc	13.33±0.58a	18.11±0.49bc	16±0.39bc	2.11±0.11ab
V_3T_1	2.33±0.00de	6.11±0.49abc	11.78±0.78abc	16.11±0.49de	14±0.58cd	2.45±0.11a
V_3T_2	3.22±0.11b	7.33±0.58ab	12.67±1.07ab	19.22±0.68ab	18.33±0.88ab	0.89±0.29c
V_3T_3	3.56±0.11a	7.78±0.48a	13.67±0.58a	20.77±0.87a	19.77±0.78a	1.33±0.19bc
CV (%)	6.42	13.64	10.65	6.14	8.6	25.43

In a column, means followed by dissimilar letter(s) differed significantly as per DMRT; V_1=BRRI dhan28; V_2=BRRI dhan29; V_3=BRRI dhan58; T_1=75% of the farmer recommended doses of prilled urea; T_2=100% of the recommended dose of prilled urea; T_3=75% of the recommended dose of urea super granules; CV(%)=Co-efficient of variation; DAT=Days after transplanting.

Total number of tillers hill^{-1}

This section presents a summary of the findings and contributions regarding the total number of tillers per hill of rice, which exhibited significant variation among the different varieties in all observations. At 20 days after transplanting (DAT), the highest number of tillers hill^{-1} (3.04) was recorded in V_3, showing a significant reduction of 25.66% and 12.17% compared to V_2 and V_1, respectively. At 40 DAT, V_3 maintained the highest number of tillers hill^{-1} (7.07), which experienced a slight reduction of 6.22% in V_2 and a significant reduction of 14.14% in V_1. Subsequently, at 60 DAT, V_3 exhibited the highest number of tillers hill^{-1} per hill (12.70), with a marginal reduction of 4.09% in V_2, while experiencing a significant decrease of 11.65% in V_1. At 80 DAT, V_3 displayed the maximum number of tillers hill^{-1} (18.70), which saw a significant reduction of 8.07% and 11.07% in V_1 and V_2, respectively (Table 2).

The total number of tillers hill^{-1}of rice differed significantly due to the application of different levels of nitrogen fertilizer in all observations. At 20 DAT, the highest plant number of tillers hill^{-1}(3.07) was observed in T_3, which was reduced significantly by 10.75 and 29.97% in $T_2$and T_1, respectively. At 40 DAT, the highest number of tillers hill^{-1} (7.07) was observed in T_3, which was reduced slightly by 3.11% in T_2, but significantly by 17.26% in T_1. At 60 DAT, the highest number of tillers hill^{-1} (13.07) was observed in T_3, which was reduced slightly by 6.81% in T_2, but significantly by 16.99% in T_1. At 80 DAT, the highest number of tillers hill^{-1}(19.04) was observed with T_3, which was reduced significantly by 5.67 and 18.49% in $T_2$and T_1, respectively (Table 2).

The total number of tillers hill^{-1} of rice differs significantly due to the interaction between rice varieties and different levels of nitrogen fertilizer at all observations (20, 40, 60 and 80 DAT). At 20 DAT, the highest number of tillers hill^{-1} (3.56) was observed in V_3T_3 and the lowest (2.00) was in V_1T_1. At 40 DAT, the highest number of tillers hill^{-1} (7.78) was observed in V_3T_3 and the lowest (5.56) with V_1T_1. At 60DAT, the highest number of tillers hill^{-1}(13.67) was observed in V_3T_3 and the lowest (10.11) was in V_1T_1. At 80 DAT, the highest number of tillers hill^{-1}(20.77) was found in V_3T_3, and the lowest number of tillers hill^{-1} (14.89) was in V_1T_1 (Table 2).

Number of non-effective tillers hill^{-1}

The highest non-effective tillers hill^{-1} (2.26) was recorded in V_1, which was reduced significantly by 23.01 and 30.97% in V_2 and V_3, respectively (Table 2). Rice varieties differed significantly in non-effective tiller because of the application of different levels of nitrogen fertilizer. The highest non-effective tiller hill^{-1} (2.15) was seen in T_1, which was 6.98% and 34.41% higher than T_3, and T_2, respectively (Table 2). The non-effective tiller of rice differs significantly due to the interaction between rice varieties and different levels of nitrogen fertilizer and the highest non-effective tiller (2.56) was viewed in combination with V_1T_3 and the lowest (1.11) was in V_2T_2 (Table 2).

Panicle length

The panicle length of rice differed significantly among the different varieties. The highest panicle length (23.00 cm) was found in V_3, which was reduced slightly by 7.30% in V_2, but significantly by 13.35% in V_1 (Table 3). The panicle length of rice varied significantly for nitrogen fertilizer and T_3 showed the highest panicle length (22.93 cm) (Table 3). The panicle length of rice differs significantly due to the interaction between rice varieties and different levels of nitrogen fertilizer in all observations. The highest panicle length (24.63 cm) was noticed in V_3T_3 and the lowest (18.09 cm) was in V_1T_1 (Table 3).

1000 grain weight

The 1000-grain weight (g) of rice varied significantly across different varieties. The highest recorded 1000-grain weight

(22.47 g) was observed in V_3, which decreased by only 3.92% and 4.45% in V_2 and V_1, respectively (Table 3). In T_3, the highest 1000-grain weight (22.28 g) was noted, which was 2.11% higher than T_2 and 3.82% higher than T_1 (Table 3). The combined variety and treatment V_3T_3 recorded the highest 1000-grain weight (22.87 g), while V_1T_1 had the lowest (21.07 g) (Table 3).

Grain yield

The grain yield (t ha^{-1}) of rice varied significantly among different varieties. The highest grain yield (6.11 t ha^{-1}) was observed in V_3, which decreased slightly by 5.89% in V_2 and significantly by 12.60% in V_1 (Table 3). Variations in nitrogen fertilizer levels also had a significant impact on rice grain yield. The highest grain yield (6.30 t ha^{-1}) was recorded in T_3, which decreased slightly by 5.08% in T_2 and significantly by 21.75% in T_1 (Table 3). The interaction between rice varieties and nitrogen fertilizer levels significantly influenced the grain yield of rice in all observations. The highest grain yield (6.77 t ha^{-1}) was observed in V_3T_3, while the lowest (4.60 t ha^{-1}) was in V_1T_1 (Table 3).

Straw yield

The straw yield (t ha^{-1}) of rice exhibited significant variation among the rice varieties. The highest straw yield (7.12 t ha^{-1}) was achieved in V_3, showing a slight decrease of 7.02% in V_2 and a significant decrease of 12.92% in V_1 (Table 3). Regarding nitrogen fertilizer levels, the highest straw yield (7.13 t ha^{-1}) was recorded in T_3, with a slight reduction of 2.52% in T_2 and a significant decrease of 17.95% in T_1 (Table 3). The interaction between rice varieties and nitrogen fertilizer levels had a notable impact on the straw yield of rice across all observations. The highest straw yield (7.61 t ha^{-1}) occurred in V_3T_3, while the lowest (5.51 t ha^{-1}) was observed in V_1T_1 (Table 3).

Biological yield

Significant variations were observed in the biological yield (t ha^{-1}) of rice among different varieties. The highest biological yield (13.22 t ha^{-1}) was observed in V_3, showing a slight reduction of 6.42% in V_2 and a significant decrease of 12.70% in V_1 (Table 3). Variations in nitrogen fertilizer application resulted in significant differences in the biological yield of rice across all observations. The highest biological yield (13.43 t ha^{-1}) was recorded in T_3, with a minor reduction of 3.72% in T_2 and a notable decrease of 19.73% in T_1 (Table 3). The interaction between rice varieties and different nitrogen fertilizer levels had a significant impact on the biological yield of rice across all observations. The highest biological yield (14.38 t ha^{-1}) was observed in V_3T_3, while the lowest (10.11 t ha^{-1}) was noted in V_1T_1 (Table 3).

Table 3: Varietal differences, nitrogen fertilizations, and their interactions on the yield components and yield of Boro rice

Variety	Panicle length (cm)	1000 grain weight (g)	Grain yield (t ha-1)	Straw Yield (t ha-1)	Biological Yield (t ha-1)	Harvest Index (%)
V1	19.93±0.73b	21.47±0.27b	5.34±0.27b	6.20±0.24b	11.54±0.51b	46.16±0.36
V2	21.32±0.80ab	21.59±0.17b	5.75±0.25ab	6.62±0.23ab	12.37±0.48ab	46.42±0.31
V3	23.00±0.90a	22.47±0.17a	6.11±0.26a	7.12±0.31a	13.22±0.56a	46.19±0.44
Treatment						
T1	19.20±0.65b	21.43±0.28	4.93±0.21b	5.85±0.18b	10.78±0.39b	45.63±0.32a
T2	22.13±0.80a	21.81±0.21	5.98±0.18a	6.95±0.23a	12.93±0.40a	46.25±0.33ab
T3	22.93±0.74a	22.28±0.19	6.30±0.20a	7.13±0.23a	13.43±0.42a	46.19±0.32a
Interaction						
V1T1	18.09±1.14c	21.07±0.66	4.60±0.48d	5.51±0.37d	10.11±0.84e	45.31±0.94ab
V1T2	20.54±1.18bc	21.27±0.27	5.52±0.30bcd	6.36±0.33bcd	11.88±0.63bcde	46.44±0.20ab
V1T3	21.17±1.02abc	22.07±0.29	5.9±0.30abc	6.72±0.30abc	12.63±0.60abcd	46.72±0.19ab
V2T1	19.42±1.31bc	21.17±0.38	4.92±0.33cd	5.91±0.32cd	10.83±0.65de	45.38±0.33ab
V2T2	21.56±1.10abc	21.7±0.15	6.13±0.24ab	6.89±0.28abc	13.02±0.51abc	47.07±0.42a
V2T3	22.99±1.19ab	21.9±0.21	6.22±0.25ab	7.061±0.28ab	13.28±0.53abc	46.82±0.07ab
V3T1	20.1±1.012bc	22.07±0.29	5.26±0.25bcd	6.13±0.28bcd	11.39±0.52cde	46.21±0.08ab
V3T2	24.28±1.13a	22.47±0.24	6.28±0.26ab	7.60±0.25a	13.89±0.50ab	45.23±0.48b
V3T3	24.63±1.02a	22.87±0.20	6.77±0.33a	7.61±0.51a	14.38±0.80a	47.14±1.07a
CV (%)	9.11	2.62	9.44	8.65	8.84	2.02

In a column, means followed by dissimilar letter(s) differed significantly as per DMRT; V_1=BRRI dhan28; V_2=BRRI dhan29; V_3=BRRI dhan58; T_1=75% of the farmer recommended doses of prilled urea; T_2=100% of the recommended dose of prilled urea; T_3=75% of the recommended dose of urea super granules; CV(%)=Co-efficient of variation; DAT=Days after transplanting.

Harvest index

The rice varieties exhibited significant variation in harvest index. V_2 showed the highest index at 46.42, while V_1 had the lowest at 46.16 (Table 3). Among the treatments, T_2 had the highest harvest index at 46.25, which decreased marginally by 0.13% in T_3 and significantly by 1.21% in T_1 (Table 3). The interaction between rice varieties and nitrogen fertilizer levels also significantly influenced harvest index across all observations. The highest index of 47.14 was recorded for

V_3T_2, whereas the lowest, 45.23, was observed for V_1T_1 (Table 3).

Correlation Between Different Growth and Yield Parameters of Boro Rice

Correlation analysis was performed between the key crop parameters like height, tiller hill-1, adjusted grain yield, straw yield, panicle length, and thousand-grain weight which is presented in Table 4. Grain yield was positively correlated with, plant height (0.915**), SPAD value at 40 DAT (0.974**), SPAD at 60 DAT (0.957**), number of total tiller hill^{-1} (0.957**), number of the effective tiller (0.905**), panicle length (0.954**), thousand-grain weight (0.471*), and negatively correlated with the number of non-effective tiller (-0.359).

Table No. 4: Correlation matrix among major crop characters, yield and yield contributing characters of rice varieties at harvest

Correlations

	Plant height	SPAD (40DAT)	SPAD (60 DAT)	Number of tiller	No. Effective tiller	Penial Length	1000 Grain weight	Grain yield	Straw yield	Biological yield	Harvest index
Plant height	1	.876**	.914**	.904**	.861**	.912**	.522**	.915**	.907**	.921**	.392*
SPAD (40DAT)		1	.939**	.942**	.887**	.940**	.465*	.974**	.953**	.974**	.484*
SPAD (60 DAT)			1	.951**	.916**	.972**	.469*	.957**	.958**	.968**	.408*
Number of tiller				1	.947**	.939**	.566**	.957**	.954**	.966**	.405*
No. Effective tiller					1	.895**	.571**	.905**	.903**	.913**	.377
Penial Length						1	.473*	.954**	.975**	.975**	.343
1000 Grain weight							1	.471*	.504**	.493**	.093
Grain yield								1	.958**	.989**	.549**
Straw yield									1	.990**	.288
Biological yield										1	.420*
Harvest index											1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

4. Discussion

The study looked at the impact of several boro rice cultivars and urea dosages on various growth and yield characteristics. Notably, the results showed substantial differences in plant height, SPAD values, total tillers per hill, number of non-effective tillers per hill, panicle length, 1000-grain weight, grain yield, straw yield, biological yield, and harvest index among rice types and urea dosages.

Variations in plant height between rice types and urea dosages highlight the impact of genetics and nitrogen availability on plant growth (SPAD values). For example, BRRI dhan58 consistently produced taller plants than BRRI dhan28 and BRRI dhan29, indicating genetic superiority in height attainment (Table 1). Furthermore, urea dosages had a substantial impact on plant height, with greater doses resulting in taller plants, demonstrating the importance of nitrogen fertilizer in stimulating vegetative growth [9].

SPAD readings, which indicate leaf chlorophyll content and nitrogen status, fluctuated between rice cultivars and urea dosages. While rice types had no significant effect on SPAD values, nitrogen fertilizer treatment had a substantial impact, with urea super granules (T_3) consistently producing greater SPAD values than prilled urea dosages (T_1, T_2). This shows that urea super granules may provide a more consistent nitrogen supply, resulting in optimal leaf nitrogen levels and photosynthetic activity throughout the growth cycle [10].

Total tillers hill^{-1}, a key factor in rice productivity, varied dramatically across rice cultivars and urea dosages. BRRI dhan58 had consistently greater tiller counts than BRRI dhan28 and BRRI dhan29, showing a genetic tendency for prolific tillering [11]. Nitrogen fertilizer treatment also played an important influence, with higher doses leading in more tillers, demonstrating nitrogen's stimulatory effect on tiller initiation and development. The number of total tillers increased for application of USG rather than prilled urea[12].

The presence of ineffective tillers, however minimal, shows inefficiencies in tiller utilization and resource allocation within the plant. The observed decrease in non-effective tillers with greater urea dosages indicates enhanced nitrogen consumption efficiency, as excess nitrogen availability may contribute to the production of non-functional tillers.

The study on panicle length, an indicator of reproductive development in rice, revealed significant differences between rice cultivars and urea dosages. BRRI dhan58 consistently produced longer panicles than other varieties, highlighting its genetic superiority in reproductive traits. Additionally, nitrogen fertilizer influenced panicle length, with urea super granules (T_3) resulting in longer panicles compared to prilled urea dosages (T_1 and T_2). This underscores the importance of nitrogen availability for panicle growth. The number of panicles increased with higher nitrogen rates, and the number of panicles per plant rose with increased NPK rates [13]. The 1000-grain weight, an important indicator of rice yield, differed significantly between rice cultivars and urea dosages. BRRI dhan58 typically yielded bigger grains than other kinds, indicating genetic superiority in grain filling and development. Nitrogen fertilization had no remarkable impact on 1000-grain weight. The level of nitrogen didn't influence the weight of 1000-grain weight [14].

Grain yield, straw yield, biological yield, and harvest index, all important yield components, varied significantly between rice types and urea doses. BRRI dhan58 significantly outperformed other varieties in terms of grain production, straw yield, biological yield, and harvest index, demonstrating its genetic superiority in yield potential and resource utilization. Nitrogen fertilizer had a substantial impact on yield parameters, with greater urea dosages leading in enhanced grain yield, straw yield, and biological output, demonstrating the relevance of nitrogen availability in increasing overall crop productivity and resource partitioning [15].

Correlation study shows substantial correlations between crop metrics, highlighting the interdependence of growth and yield processes in rice. Positive relationships between grain output and metrics such as plant height, SPAD values, total tillers per hill, panicle length, and 1000-grain weight demonstrated the significance of these characteristics in determining overall productivity. Negative relationships between grain yield and non-effective tillers indicate that non-functional tillers reduce yield potential. They revealed low correlation (r=0.1355) between rice height and tiller number. Very low correlation (r=0.079) between height and grain yield also founded [16].

5. Conclusion and Future Scope

The findings highlight the importance of genetic variables and nitrogen management strategies in improving rice performance. Nitrogen sources affected all parameters, and all rice varieties showed significant effects on growth and yield contributing characters. Significant differences were found among rice varieties, with V_3 (BRRI dhan58) showing the best overall performance compared to V_2 (BRRI dhan29) and V_1 (BRRI dhan28). Additionally, T_3 or 75% of the recommended dose of USG showed better performance compared to T_2 (100% of the recommended dose of prilled urea) and T_1 (75% of the recommended dose of prilled urea), with the highest values observed in T_3 for plant height, tillers hill^{-1}, panicle length, grain yield, straw yield and biological yield. There was an interaction between rice varieties and nitrogen fertilization, with the combination of V_3T_3 (BRRI dhan58 and 75% of the farmer's recommended dose of urea as USG) showing superior growth and grain yield, straw yield, and biological yield. In conclusion, urea was found to be more efficient when applied in the form of USG, and BRRI dhan58 was identified as the best-performing Boro rice variety in the experimental area.

The studies should explore additional rice varieties, integrate precision farming techniques, additionally, informing policy measures to support efficient nitrogen practices and high-yielding rice varieties can enhance productivity and sustainability. These efforts will build on current findings, contributing to more sustainable and effective rice production systems.

Conflict of Interest

Authors declare that they do not have any conflict of interest.

Authors' Contributions

Author-1 reviewed the literature and conceived the study. Author-2 prepared the first draft and conducted the data analysis. Author-3 was involved in protocol development and revised the final draft of the manuscript.

References

[1] M.O. Ale, A. S. Oluwalami,"Digital Agriculture, Agricultural Mechanization and Food Security in Nigeria, "*International Journal of Scientific Research in Computer Science and Engineering*, Vol.**12**, Issue.**3**, pp.**14-20, 2024** https://doi.org/10.26438/ijsrcse/v12i3.1420

[2] N. Hashim, M. M. Ali, M. R. Mahadi, A. F. Abdullah, A. Wayayok, M. S. M. Kassim, A. Jamaluddin, "Smart Farming for Sustainable Rice Production: An Insight into Application, Challenge, and Future Prospect," *Rice Science*, Vol. **31,** Issue**, 1** pp**.47-61, 2024.** https://doi.org/10.1016/j.rsci.2023.08.004

[3] M. Mainuddin, M. M. Alam, M. Maniruzzaman, M. J. Kabir, M. A. Mojid, M. M. Hasan, M. T. Islam, "Yield, profitability, and prospects of irrigated Boro rice cultivation in the North-West region of Bangladesh," *PloS one*, Vol.**16**, Issue, **4**, **e0250897, 2021**. https://doi.org/10.1371/journal.pone.0250897

[4] H. U. Rehman, I. Ali, F. Ali, M. I. Awan, A. Wakeel, M. Farooq, Hussain, M, "Nitrogen management strategies to improve crop performance, recovery efficiency and their relationship with physiological indices in dry direct-seeded rice," *International Journal of Plant Production*, ,Vol.**17**, Issue **2**, pp.**297-308**, **2023**. https://doi.org/10.1007/s42106-023-00239-2

[5] S. Swify, R. Mažeika, J. Baltrusaitis, D. Drapanauskaitė, and K. Barčauskaitė, "Modified urea fertilizers and their effects on improving nitrogen use efficiency (NUE)," *Sustainability,* Vol.**16**, Issue **1,** pp.**188, 2023**. https://doi.org/10.3390/su16010188

[6] P. Cui, X. Sheng, Z. Chen, Q. Ning, H. Zhang, H. Lu, and H. Zhang, "Optimizing One-Time Nitrogen Fertilization for Rice Production Using Controlled-Release Urea and Urease Inhibitors," *Agronomy*, Vol.**14**, Issue **1**, pp.**67, 2023**. https://doi.org/10.3390/agronomy14010067

[7] M. M. Huq, I. Jahan, M. A. Hoque, M. R. Islam, "Enhancing Yield and Nitrogen Utilization of Boro Rice with Urea Super Granules," *Asian Journal of Research in Crop Science*, Vol.**9**, Issue **2**, pp.**119-127, 2024**. https://doi.org/10.9734/ajrcs/2024/v9i2272

[8] S. S. Swain, T. K. Khura, P. K. Sahoo, K. A. Chobhe, N. Al-Ansari, H. L. Kushwaha, N. L. Kushwaha, K. C. Panda, S. D. Lande, C. Singh, "Proportional impact prediction model of coating material on nitrate leaching of slow-release Urea Super Granules (USG) using machine learning and RSM technique," *Scientific Reports*, Vol.**14**, Issue **1**, pp.**3053, 2024**. https://doi.org/10.1038/s41598-024-53410-8

[9] Owahida Afifa. "Growth and Yield of Boro Rice as Affected by Application Method and Source of Nitrogen Fertilizer," MS. Thesis, Dept. Agronomy, Sher-e- Bangla Agricultural Univ., Dhaka, Bangladesh, 2020.

[10] R. Liu, Y. Wang, Y. Hong, F. Wang, X. Mao, J. Yi, "Controlled-release urea application and optimized nitrogen applied strategy reduced nitrogen leaching and maintained grain yield of paddy fields in Northwest China," *Frontiers in Plant Science*, Vol.**14**, pp.**1033506, 2023**. https://doi.org/10.3389/fpls.2023.1033506

[11] C. Gyawali, B. Chaulagain, S. Kaduwal, P. Gyawaly, P. Paneru, N. Khatri, P. Pantha, "Performance of Promising Rice Genotypes as Affected by Different Nitrogen Levels in Central Terai of Nepal," *Agronomy Journal of Nepal,* Vol.**7**, pp.**111-120**, **2023**. https://doi.org/10.3126/ajn.v7i1.62165

[12] P. A. Bithy, "Morpho-physiological and yield attributes of boro rice varieties as influenced by different nitrogen sources," *Research in Agriculture Livestock and Fisheries*, Vol.**10**, Issue **2**, pp.**175-182, 2023**. https://doi.org/10.3329/ralf.v10i2.68776

[13] A. Bahuguna, D. K. Singh, A. Kumar, K. Garg, P. Verma, S. Patel, S. Sudarshan, "Agronomic evaluation of rice (Oryza sativa)

genotypes under varying fertility levels," *The Indian Journal of Agricultural Sciences,* Vol.**93**, Issue **11**, pp.**1258-1261, 2023**. https://doi.org/10.56093/ijas.v93i11.141416

[14] P. A. Bithy,"Morpho-physiological and yield attributes of boro rice varieties as influenced by different nitrogen sources," *Research in Agriculture Livestock and Fisheries,* Vol.**10**, Issue **2**, pp.**175-182, 2023**. https://doi.org/10.3329/ralf.v10i2.68776

[15] M. R. Yadav, S. Kumar, M. K. Lal, D. Kumar, R. Kumar, R. K. Yadav, S. Kumar, "Mechanistic understanding of leakage and consequences and recent technological advances in improving nitrogen use efficiency in cereals," *Agronomy,* Vol.**13**, Issue **2**, pp.**527**, **2023**. https://doi.org/10.3390/agronomy13020527

[16] M. Mahato, B. Gautam, R. Kunwar, D. Joshi, "Effect of different date of sowing and nitrogen level on production of direct seeded rice," *American Journal of Food Science and Nutrition,* Vol.**6**, Issue.**1**, pp.**1-5, 2019**.

AUTHORS PROFILE

Most: Nahida Umme Tamim is an undergraduate student (4th year) at the Department of Agronomy and Agricultural Extension, Faculty of Agriculture, University of Rajshahi, Bangladesh. She is currently working as a research assistant at Farming System Engineering Laboratory, Department of Agronomy and Agricultural Extension, Faculty of Agriculture, University of Rajshahi, Bangladesh, since 2022.

Bitopi Biswas She earned her B.Sc.Ag. in 2014 and her MS in Agronomy in 2017. Currently, she is pursuing her Ph.D. in Agronomy in the Department of Agronomy and Agricultural Extension at the University of Rajshahi, Bangladesh. Since 2021, she has been working as an Assistant Professor in the Department of Agriculture at Udayan College of Bioscience and Technology, Rajshahi. She has been a member of the Krishibid Institute Bangladesh since 2014 and is a life member of the Society of Agronomy. She has published more than seven research papers in reputable international journals, including those indexed by Thomson Reuters (SCI & Web of Science), and has presented at conferences including IEEE. Her primary research focus is on Agronomy. She has four years of teaching experience and eight years of research experience.

Dr. M. Robiul Islam earned his B.Sc. (1998) and M.Sc. (1999) degrees from the Department of Botany, University of Rajshahi, Bangladesh. He joined the Department of Agronomy and Agricultural Extension at the University of Rajshahi, Rajshahi, Bangladesh, as a lecturer in 2004. He obtained his Ph.D. in Agronomy from China Agricultural University, P.R. China, in 2011. Dr. Islam completed two years of postdoctoral research (2013-2015) at Universiti Putra Malaysia. Since 2018, he has been serving as a Professor in the Department of Agronomy and Agricultural Extension at the University of Rajshahi. He is a life member of the Bangladesh Society of Agronomy. Dr. Islam has published more than 75 research papers in reputed international journals, including those indexed by Thomson Reuters (SCI & Web of Science), and has presented at conferences such as IEEE, with his work also available online. His primary research interests lie in agronomy and precision farming. Dr. Islam has 20 years of teaching and research experience.

