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MORPHO-PHYSIOLOGICAL AND YIELD ATTRIBUTES OF BORO RICE VARIETIES AS INFLUENCED BY DIFFERENT NITROGEN SOURCES

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ABSTRACT

The present study was carried out at the Research Field of Sher-e-Bangla Agricultural University (SAU), Dhaka during Boro season, 2021-2022 to discover the best nitrogen source for enhancing Boro rice grain production. The experiment consisted of two factors: A) Three varieties: BRRI dhan29 (V_1), BRRI dhan58 (V_2), and Heera (V_3). B) Four nitrogen sources: no nitrogen (T_1), BRRI-recommended prilled urea (T_2), recommended dose of mixed NPK (T_3), and BARC-recommended USG (T_4). The experiment was laid out in split plot design with three replications where main plot was for nitrogen source and subplot was for variety. USG treatment resulted in the highest grain production (8.6 t/ha) and the lowest percentage of spikelet sterility of any nitrogen source tested. Except for harvest index, all of the examined characteristics differed considerably between types. This is mostly due to BRRI dhan29 having the maximum number of full grains (98.8/panicale) and a significantly lower degree of spikelet sterility (7.3%). Among the interaction effects, the combination of the USG application with BRRI dhan29 showed the greatest performance in terms of delivering the maximum grain production (9.3 t/ha) by significantly reducing spikelet sterility.

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INTRODUCTION

Bangladesh is self-sufficient in rice (Mainuddin *et al.*, 2015; Timsina *et al.,* 2018), which is the staple food, with an average per capita consumption of 134 kg per annum, compared to the world average of 57 kg per annum (Mottaleb *et al.,* 2016). It is the most dominant crop and generates a major share of farmers' income and employment (Sarker *et al.*, 2012; Alam *et al.*, 2016). Rice is the predominant crop in the three main crop-growing seasons in Bangladesh; Aus rice is grown during March to June, Aman rice during June/July to October/November and irrigated Boro rice during November to April/May (the Rabi season popularly known as Boro season). Both Aus and Aman rice are mainly rainfed or only occasionally irrigated. The Rabi season has very little rainfall and hence the Boro rice is fully irrigated. Boro rice is cultivated in waterlogged, low-lying or medium lands .The average yield of rice has increased linearly over the past four decades (Mainuddin *et al.*, 2015). Total production of rice has increased from 11.6 million tons in 1977 to 34 million tons (almost 3 fold) in 2016 while the population during this period increased from 76 million to 168 million (2.2 fold) (BBS, 2018; Mainuddin *et al.*, 2014).Currently, 61% of the total cropped area in the Rabi season is under Boro cultivation which contributes 55% to total rice production (BBS, 2018). Rice yield can be increased in many ways such as developing new high yielding varieties or adopting proper agronomic management to the existing varieties.

Proper fertilization is an important management practice to increase rice yield. Proper fertilization can markedly increase the yield and improve the quality of rice (Yoshida, 1981). Nitrogenous fertilizer has immense effect on rice yield throughout the positive influence on the production of effective tillers (BRRI, 1990). Nitrogen is an essential macronutrient for plant function and is a key component of amino acids, which form the building blocks of plant proteins and enzymes. Proteins make up the structural materials of all living matters and enzymes facilitate the vast array of biochemical reactions within a plant. Nitrogen not only enhances the yield of rice but also reduces the spikelet sterility. Nitrogen is required in adequate amount at early, at mid tillering and panicle initiation stage for better grain development (Ahmed *et al.*, 2005; Iqbal, 2011). The soil nitrogen status of Bangladesh is also very low due to warm climate as well as extensive cultivation practices without addition of manures. The nitrogen efficiency, especially of urea fertilizer, is very low in rice cultivation. Nitrogen losses ranged from 2.82-5.07% in rice field (Wani *et al.*, 1999). The use of USG and Mixed fertilizer has often been advocated to minimize nitrogen losses because organic manures act as a great source of plant nutrients, especially of N, P, K and S, and also prevents leaching loss of the nutrients. USG @ 120 kg N ha-1 was the best in producing the yield and yield attributes of rice (Wani *et al.*, 1999). Prilled urea also plays a vital role in improving physical, chemical and biological properties of the soil and ultimately enhances crop production. Application of heavy nitrogen increases tillering as well as spikelet number per plant thus reduces the number of engorged pollen grains per anther and leading into increased spikelet sterility (Gunawardena *et al.*, 2003). Considering the above facts this study was undertaken to investigate the influence of different nitrogen sources on morphophysiological and yield attributes of boro rice varieties.

MATERIALS AND METHODOLOGY

The experiment was conducted in the experimental field of Department of Agricultural Botany, SAU during Boro season, and conducted during July 2021 to May 2022.

Plant materials

High yielding variety BRR1 dhan29 and BRRI dhan58 and Hybrid Heera. The grains of BRRI dhan29 and BRRI dhan58 are medium-slender with light- golden husks. Heera was introduced by Supreme Seed Company Ltd. from China. The grains grains of Heera are medium, thick with light golden husks.

Experimental site

Seeds of afore-mentioned cultivars/varieties were collected from Rice Research Institute (BRRI) and SAU Germplasm, respectively. The field experiment was carried out during July, 2021 to May, 2022. The experiment conducted at Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh.

Soil and climate

The soil of the experimental field belongs to the Joydebpur series of shallow red terrace loamy soil. The experimental area was under sub-tropical zone.

Experimental design

The experiment was laid out in split plot design with three replications where main plot was for nitrogen source and subplot was for variety. A total of 36 unit plots were used for this experiment. The size of the unit plot was 4 m x 2.5 m with a space between replications 1.0m and unit plots 0.50m.

Treatments

Two different factors were used as follows-

Factor a) Varieties: V_1 = BRR1 dhan29, V_2 = BRRI dhan58 and V_3 = Heera.

Factor b) Treatments: Nitrogen sources

T_1 = No nitrogen	T_3 = recommended dose of mixed NPK
T_2 = BRRI recommended dose of prilled urea	T_4 = BARC recommended dose of USG

Fertilization

Except in the T_1 treatment plot, TSP, MP, gypsum, and zinc sulphate were treated at rates of 148-178-100-15 kg ha^{-1}, respectively (BRRI, 2013). Urea rates for T_2 treatment plots were 260 kg ha^{-1} for inbred rice and 325 kg ha^{-1} for hybrid rice. At the final land preparation of individual plots, a full dosage of TSP, MP, gypsum, zinc sulphate, and cow dung (10 t ha^{-1}) was administered as a basal dose. Urea was administered to the T_2 treatment plot in three equal splits on 15, 30, and 55 DAT for BRRI dhan29 and BRRI dhan58, respectively, and on 0, 21, and 42 DAT for hybrid varieties.

Uprooting of seedlings

Seedlings of 40 for BRRI dhan29 and BRRI dhan58, both 30 days old hybrid types, were carefully plucked from nursery beds.

Transplanting

On the well-puddled experimental plots, seedlings were transplanted. For BRRI dhan29 and BRRI dhan58, the spacing was 25cmX15cm, while for hybrid types, the spacing was 20cmX15cm. $Hill^{-1}$ received two seedlings for BRRI dhan29 and BRRI dhan58, as well as one seedling for hybrid varieties.

Other intercultural operation

After one week of transplanting, several hills' seedlings perished and were replaced by gap filling with seedlings from the same source. Manual weeding was performed three times at 16 DAT, 31 DAT, and 56 DAT, followed by the first, second, and third urea top dressings. From transplanting until the maximum tillering stage, irrigation was done by alternate soaking and drying. A thin layer of water (2-3 cm) was retained on the plots from panicle initiation (PI) until hard dough stage. During the ripening stage, water was withdrawn from the plots. Plants were infested to some extent with rice stem borer and leaf hopper, which were successfully controlled by using Diazinon three times and Ripcord once.

Data collection

Data were collected on the following parameters: Ten plants were sampled from each plot.

Grains $panicle^{-1}$ (no.)

Presence of any kernel in the spikelet was considered as grain and total number of filled grain on each panicle was counted.

Unfilled grains $panicle^{-1}$ (no.)

Spikelet having no food material inside was considered as unfilled spikelet i.e sterile spikelet and the number of such spikelet present in each panicle was recorded

The percentage of sterility was calculated by following formula

Sterility (%) = (Number of sterile spikelet per panicle ÷number of total spikelet per panicle) X 100

From the sample hills, each panicle was divided into three equal parts by eye estimation. The apical, middle and lower parts were termed as top, middle and bottom portion of panicle, respectively. Percentage of sterility for each portion was calculated using following formulae:

a. Sterility at top portion (%) = (Number of sterile spikelet at top portion of a panicle ÷ number of total spikelet of a whole panicle) X 100
b. Sterility at mid portion (%) = (Number of sterile spikelet at mid portion of a panicle ÷ number of total spikelet of a whole panicle) X 100
c. Sterility at bottom portion (%) = (Number of sterile spikelet at bottom portion of a panicle ÷ number of total spikelet of a whole panicle) X 100

1000-grain weight: One thousand clean dried (at 14% moisture level) grains from the seed stock of each plot were counted separately and weighed.

Grain and straw yield: Grain and straw obtained from the central $4m^2$ areas of each plot were sun dried, cleaned, weighed separately and finally converted into t/ha. Grains yield were measured by adjusting moisture level at 14%.

Biological yield: Grain yield and straw yield were together regarded as biological yield i.e., Biological yield (t/ha) = Grain yield (t/ha) + Straw yield (t/ha)

Harvest index: It was calculated with the following formula: Harvest Index (%) = (Grain yield ÷ Biological yield) x 100

RESULTS AND DISCUSSIONS

Number of Effective tillers hill^{-1}

Significant variation was found for number of effective tiller among the nitrogen sources, varieties and those combinations. The highest number of the effective tiller was found for T_4 (15.8/hill), V_1 (14.3/hill) and V_1T_4 (16.9/hill) whereas lowest from T_1 (9.3/hill), V_3 (12.2/hill) and T_1V_3 (8.6/hill) (Table 1). Increasing levels of nitrogen increased the number of effective tillers (Hari *et al.,* 2000). These findings collaborate with these reported by Bhowmick and Nayak (2000) who stated that effective tillers/hill was varied with variety.

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

The number of non-effective tiller was varied significantly for nitrogen sources and combinations but not varied due to the variation of variety. The maximum number of non-effective tiller was found for T_1 (1.5/hill) and T_1V_3 (1.6/ hill) while minimum for T_4 (0.6/hill) and T_4V_1 (0.7/hill) (Table 1).

Number of filled grains panicle^{-1}

Nitrogen sources, varieties and combinations showed significant variation on production of filled grains. Maximum number of filled grain was for the T_4 (102.1/panicle), V_1 (98.8/panicle) and T_4V_1 (115.1/panicle) whereas minimum for T_1 (69.5/panicle), V_3 (84.8/panicle) and T_1V_3 (73.4/panicle) (Table 1).

Number of unfilled grains panicle^{-1}

Nitrogen sources, varieties and combinations of these treatments had significant influence on unfilled grains panicle (Table 1). Lowest number of unfilled grain was obtained from T_4 (6.7/panicle), V_1 (7.5/panicle) and T_4V_1 (5.5/panicle) while highest T_1 (14.5/panicle), V_3 (13.7/panicle) and T_1V_3 (19.2/ panicle) (Table 1). The interaction result showed that interaction of BRRI dhan29 with all the nitrogen doses produced higher number of unfilled grains/panicle (ranged 5.0-19.7). The result was supported by BRRI (2006) that no nitrogen produced the highest number of unfilled grains/panicle in boro season.

1000 seed weight (gm)

The weight of 1000 grains was significantly influenced by the different nitrogen sources, varieties and interaction of these treatments (Table 1). The highest 1000-grains weight found for T_4 (22.7 g), V_3 (22.5 g) and T_4V_3 (23.8 g) whereas lowest for T_1 (21.5 g), V_1 (20.8 g) and T_4V_3 (20.4g) (Table 1). The result fairly agreed with the findings of (Mohaddesi *et al.,* 2011).

Table 1. Effect of nitrogen sources, varieties and combination of these two treatments on yield contributing characteristics of rice

Treatment	Number of tillers $hill^{-1}$		Number of grains $panicle^{-1}$		1000 seed weight(gm)
	Effective	Non-effective	Filled	Unfilled	
Varieties					
V_1	14.3a	1.2a	98.8a	7.5d	20.8c
V_2	13.6b	1.1a	86.3b	12.8b	22.1b
V_3	12.2c	1.2a	84.8bc	13.7a	22.5b
Nitrogen sources					
T_1	9.3c	1.5a	69.5c	14.5a	21.5d
T_2	13.9b	1.3b	89.6b	11.6b	21.9c
T_3	14.2b	1.2b	90.8b	10.8b	22.3b
T_4	15.8a	0.6c	102.1a	6.7c	22.7a
Combinations					
V_1 T_1	9.9i	1.4bc	74.9f	8.9ef	20.4g
V_1 T_2	15c-e	1.4bc	102.1bc	14.3c	20.8fg
V_1 T_3	15.2b-d	1.3cd	103.2b	7.5fg	20.9fg
V_1 T_4	16.9a	0.7e	115.1a	5.5h	20.9fg
V_2 T_1	9.6ij	1.5b	66.7gh	16.7b	21.4e-g
V_2 T_2	14.1d-g	1.2d	87.8e	14.4c	22.2c-e
V_2 T_3	14.5d-e	1.2d	89.3de	12.2d	22.2c-e
V_2 T_4	16abc	0.7e	101.5bc	7.9ef	22.5b-d
V_3 T_1	8.6j	1.6b	73.4fg	19.2a	21.8d-f
V_3 T_2	12.8h	1.3cd	85.4e	8ef	21.7d-f
V_3 T_3	13.2gh	1.3cd	85.1e	7.8e-g	22.8b-d
V_3 T_4	14.2d-g	0.6e	95.1cd	14cd	23.8a
CV%	4.3	7.9	4.6	9.8	2.5

Values in column having different letter are significantly different and same letter are not significantly different at 0.05 level of probability by DMRT. Here, V_1 = BRRI dhan29, V_2 = BRRI dhan58, V_3 = Heera, and T_1 =Control, T_2 =Prilled Urea, T_3 = Mixed Urea, T_4 = USG

Spikelet sterility (%) of panicle

Total Spikelet Sterility

Nitrogen source, varieties and those combinations exerted significant variation on spikelet sterility (%) (Table 2). Result showed that sources of nitrogen reduced the spikelet sterility significantly. The spikelet sterility was lowest for T_4 (5.0%), V_1 (7.31%) and T_4V_1 (4.1%) while highest for T_1 (14.9%), V_3 (11.7%) and T_1V_3 (18.1%) (Table 2). USG, mixed NPK and prilled urea reduced the sterility over control treatment.

Sterility (%) at the top, middle and bottom portion of panicle

Nitrogen sources, varieties and those combinations showed significant variation for producing the percentage of spikelet sterility at top, middle and bottom portion of panicle (Table 2). In most of the cases, the highest sterility was found at bottom portion and lowest at top portion of panicle whereas middle portion of panicle showed intermediate level of sterility. USG has lowest spikelet sterility in all portions. Highest spikelet sterility was found for Heera for all potions (except bottom portion). Hybrid varieties BRRI dhan29 and BRRI dhan58 showed the lower level of spikelet sterility than inbred varieties BRRI dhan29 and BRRI dhan58. The highest sterility was found at bottom portion and lowest at top portion of panicle for all the combined treatments (Table 2).

Table 2. Effect of nitrogen sources, varieties and those combinations on spikelet sterility of boro rice

Treatment	Spikelet Sterility (%) of panicle at			
	Total	**Top portion**	**Middle portion**	**Bottom portion**
Varieties				
V_1	7.3d	1.8c	2.7c	2.9c
V_2	9.7c	2.1b	3.3b	4.3b
V_3	11.1b	3a	3.8a	4.3b
Nitrogen sources				
T_1	14.9a	3.4a	5.1a	6.3a
T_2	10.3b	2.3b	3.7b	4.3b
T_3	9.6c	2.1b	3.2c	4.2b
T_4	5d	1.3c	1.2d	2.6c
Combinations				
V_1 T_1	10f	2.3de	3.8e	4.1e
V_1 T_2	7.8h	1.7fg	3.3f	2.9f
V_1 T_3	7.1i	1.6g	2.5h	2.9f
V_1 T_4	4.1k	1.6g	1.2i	1.8h
V_2 T_1	14.7c	3.4b	5.1c	6.1c
V_2 T_2	9.6fg	2.1ef	3.2f	4.4e
V_2 T_3	9.4g	1.8fg	3.3f	4.1e
V_2 T_4	4.9jk	1.2h	1.4i	2.4g
V_3 T_1	17a	5.1a	6a	8.3a
V_3 T_2	11.8d	3b	4.1d	5.4d
V_3 T_3	10.6e	2.7c	4de	5.4d
V_3 T_4	4.9jk	1.2h	1.4i	2.4g
CV%	8.5	8.4	11.9	9.4

Values in column having different letter are significantly different and same letter are not significantly different at 0.05 level of probability by DMRT. Here, V_1 = BRRI dhan29, V_2 = BRRI dhan58, V_3 = Heera, and T_1 =Control, T_2 =Prilled Urea, T_3 = Mixed Urea, T_4 = USG

Yield characters (t ha^{-1})

Grain yield

The maximum grain yield obtained for T_4 (8.7 t/ha), V_1 (8.2 t/ha) and T_4V_1 (9.3 t/ha). On the other hand, lowest grain yield was for T_1 (6.1 t/ha), V_3 (6.8 t/ha) and T_1V_3 (5.9 t/ha) (Table 3). Improvement of yield component such as number of effective tillers/hill and number of grains/panicle in these treatments ultimately resulted in high yield of grains. BRRI dhan29 showed its superiority in producing highest grain yield which was 17.0%, 10.2% and 7.9% higher than BRRI dhan58 and Heera.

Straw yield

Straw yield varied significantly with the different nitrogen sources, varieties and combination (Table 3). Straw yield was highest for T_1 (9.7 t/ha), V_3 (8.9 t/ha) and T_3V_1 (9.9 t/ha) while lowest for T_1 (6.2 t/ha), V_2 (7.7 t/ha) and T_1V_2 (5.8 t/ha) (Table 4). Elbadry et al. (2004) observed similar view on straw yield due to nitrogen application the differences in straw yield among the varieties might be attributed to the genetic makeup of the varieties. Patel (2004) reported variable straw yield among the varieties.

Biological yield

Biological yield differed significantly due to the different sources of nitrogen, varieties and those combinations. T_3 produced the highest biological yield (18.3 t/ha) and lowest was recorded from T_0 (12.3 t/ha) (Table 3). The result agreed with the findings of Ahmed et al. (2005) who observed the significant effect of nitrogen on biological yield of rice. Biological yield was ranges from 14.6 - 17.1 t/ha (Table 3). The highest and lowest biological yield was obtained from BRRI dhan29 and BRRI dhan58, respectively. The results showed that the interaction between T_4V_1 gave the highest biological yield (19.3 t/ha) and lowest from T_1V_3 (12.3 t/ha) (Table 4).

Harvest Index

No significant difference was observed for harvest index due to varietal differences but harvest index varied due to the variation of the treatments and combination of the nitrogen sources and varieties. Maximum harvest index was found for T_4 (49.3%), V_1 (48.6%) and T_4V_1 (50.3%) while lowest for T_1 (47.1%), V_3 (47.2%) and T_1V_3 (43.7%) (Table 3).

Table 3. Effect of nitrogen sources, varieties and those combinations on yield and harvest index of boro rice

Treatment	Yield(t ha^{-1})			Harvest Index (%)
	Grain	**Straw**	**Biological**	
Varieties				
V_1	8.2a	8.9a	17.1a	48.6NS
V_2	6.8c	7.7b	14.6c	47.2NS
V_3	7.6b	8b	15.6b	48.2NS
Nitrogen sources				
T_1	6.1d	6.2d	12.3d	47.1c
T_2	7.1c	7.9c	15.1c	47.3bc
T_3	8.2b	8.6b	16.8b	48.8ab
T_4	8.6a	9.7a	18.3a	49.3a
Combinations				
V_1 T_1	6.6fg	6.8fg	13.4fg	48.4ab
V_1 T_2	8.1b-d	9.3ab	17.4b-d	46.6a-c
V_1 T_3	8.9ab	9.4ab	18.3a-c	48.7ab
V_1 T_4	9.3a	9.9a	19.3a	50.3a
V_2 T_1	5.9g	5.8h	11.7h	43.7c
V_2 T_2	6.6fg	7.6ef	14.1ef	46.5bc
V_2 T_3	7.4d-f	7.9de	15.2ef	48.3ab
V_2 T_4	7.5c-e	9.6	17.2cd	49ab
V_3 T_1	5.9g	6.3gh	12.3gh	48.2ab
V_3 T_2	7.2ef	7.5ef	14.6ef	49ab
V_3 T_3	8.2bc	8.7bc	16.9d	48.7ab
V_3 T_4	9ab	9.7a	18.7ab	48.4ab
CV%	7.7	8.8	7.7	10.9

Values in column having different letter are significantly different and same letter are not significantly different at 0.05 level of probability by DMRT. NS: Non-significant. Here, V_1 = BRRI dhan29, V_2 = BRRI dhan58, V_3 = Heera, and T_1 =Control, T_2 =Prilled Urea, T_3 = Mixed Urea, T_4 = USG

CONCLUSION

The current study's findings advise employing USG, BRRI dhan29, and those therapy combinations. Both nitrogen source USG and BRRI dhan29 variety outperform resulting in the highest yield. The study also reveals that hybrid varieties outperform inbred variants in terms of producing more viable rice spikelets.

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COMPETING INTERESTS

There are no competing interests in this research article.

Authors' contributions

This work was carried out by PAB. Author PAB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript, managed the literature searches, read and approved the final manuscript.

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