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Effect of Different Doses of Urea on the Yield of Boro Rice Varieties in Haor Areas of Bangladesh

Mahmudul Karim[1], Md. Abul Kashem[1], Azmul Huda[1], Md. Abdul Aziz[1] and Bani Krishna Goswami[1*]

[1]Department of Soil Science, Faculty of Agriculture, Sylhet Agricultural University, Sylhet - 3100, Bangladesh.

Authors' contributions

This work was carried out in collaboration among all authors. Authors MK and MAK designed the study and carried out the research. Author BKG wrote the protocol, wrote the first draft, reviewed and re-wrote the manuscript. Authors MAK and MAA managed the analyses of the study. Author MAA managed the literature searches. Author AH performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was carried out at Sunamganj district during November 2016 to May 2017 to observed the effect of urea fertilizer on the yield of boro rice varieties in *haor* areas of Bangladesh. Two factors experiment viz. Varieties BRRI dhan29 and BRRI dhan58; and six urea fertilizer levels including: 340 (F_1), 320 (F_2), 300 (F_3), 280 (F_4), 260 (F_5), and 165 kg ha^{-1} (F_6) [Farmer's practice (FP)] were used. In case of F_1-F_5, the MoP-TSP-$CaSO_4$-$ZnSO_4$ as 127-112-75-11 kg ha^{-1} were used while Farmers' practice (FP) was done with only 82 kg ha^{-1} TSP. The experiment was laid out in two factors randomized complete block design (RCBD) with three farmers' replications. Data were collected on growth, yield and yield contributing characters of boro rice. Plant height varied at harvest stage in relation to variety and fertilizer. The tillers production $hill^{-1}$ varied at harvest in case of variety and urea application. Higher plant height was found in BRRI dhan58 (93.9 cm) in comparison to BRRI dhan29 (90.3 cm). Plant height was also influenced due to urea fertilizers application. The higher tillers $hill^{-1}$ (15.9), effective tillers $hill^{-1}$ (12.3) and longer panicle length (21.1

**Corresponding author: E-mail: banisau93@gmail.com, gopalkrishna@gmail.com;*

cm) were produced by BRRI dhan58 at harvest compared to BRRI dhan29. The longest panicle (21.4 cm) was produced in the treatment F_3 (300 kg urea ha^{-1}). Higher number of sterile spikelets panicle^{-1} (58.5) and 1000-grain weight (23.2 g) was produced by BRRI dhan58. Higher number of grains panicle^{-1} (137.5) was produced by BRRI dhan29. The highest grain yield (6.7 t ha^{-1}) and straw yield (7.91 t ha^{-1}) were obtained in the treatment F_3 (300 kg urea ha^{-1}). The experimental soil analyses showed that the nutrient contents in post-harvest soils were higher compared to initial soil due to balanced fertilizer application. It is concluded that 300 kg urea ha^{-1} promoted highest grain yield.

Keywords: Fertilizer; Hoar; varieties; boro season.

1. INTRODUCTION

Rice contributes one-half of the agricultural GDP and one-sixth of the national income in Bangladesh. In Bangladesh, area covered by rice was 11.39 million hectares with the production of 35.05 million metric tons [1]. Bangladesh ranks as fourth largest producer country in the world through increasing yield of rice. Boro rice (winter rice) varieties as BRRI dhan28, BRRI dhan29, BRRI dhan58 and BRRI dhan59 are the major high yielding varieties generally cultivated in *haor* areas with coverage of more than 80% area which grown as monocrop boro rice. Nitrogen fertilizers play an important role in the cultivation of rice. Excessive and improper usage of nitrogen fertilizer causes problems on human and environment [2]. But Nitrogen deserves special concern because of its large requirement by crop and instability in soil then other plant nutrients. Nitrogen fertilizer has a good role on growth characters, yield and yield contributing components of rice through the process of photosynthesis, flowering to fruiting and maturity period [3]. Nitrogen fertilizers has significant effect for boosting rice yields also recognized widely, particularly after the development of modern varieties. Nitrogen nutrient acts as a major part of protoplasm, protein and chlorophyll. It also plays a remarkable role in increasing cell size which in turn increases yield [4]. For better grain development it is required to use adequate amount of nitrogen at early, at mid-tillering and at panicle initiation stage [5]. Excess or low nitrogenous fertilizer addresses some physiological problems which are prolonging growing period, lodging of plants, delayed in maturity, diseases and insect-pests susceptibility and ultimately reduces grain yield [6]. Efficient fertilizer management compared to farmers practice gave higher yield with high BCR [7]. Lower dose of nitrogen application seriously hampered plant growth and drastically reduces the yield. It is also major concern that improper use of nitrogenous fertilizer, instead of giving yield advantage, may reduce the same. Many researchers have reported that significant response of rice to nitrogen in different soils in Bangladesh [8,9,10]. So we should give importance about the application of optimum rate of nitrogenous fertilizer application for highest growth and expected yield of Boro rice. The experiment was aimed to see the effect of application of different doses of urea on the growth and yield of two boro rice varieties as well as soil nutrient status.

2. MATERIALS AND METHODS

The experiment was conducted at farmers' field Habibpur village of *Nollah haor* of Jagannathpur Upazila in Sunamganj district during November 2016 to May 2017 under Sylhet Basin (AEZ 21). The climatic scenario of the district is warmer in the summer season and cooler in the winter season. The two factor experiment consists of two boro varieties viz. BRRI dhan29 and BRRI dhan58 and six urea fertilizer levels were 340 (F_1), 320 (F_2), 300 (F_3) [BARC Recommended dose], 280 (F_4), 260 (F_5) and 165 kg ha^{-1} (F_6) [Farmer's practice dose (FP)]. In case of F_1-F_5, Triple Super Phosphate (TSP)- Murate of Potash (MoP)-$CaS0_4$-$ZnS0_4$ as 112-127-75-11 kg ha^{-1} were used while Farmers' practice (F_6) was treated with 82 kg ha^{-1} TSP. Experiment was laid out in a randomized complete block design (RCBD) with three replications. The size of each plot was 5 m × 4 m. Thirty five days aged seedlings were transplanted. The experimental field was ploughed and prepared on 04-05 January, 2017 with the help of a power tiller. The experimental layout was made on 05 January 2017. After final land preparation, according to treatments full amount of triple super phosphate, murate of potash, gypsum and zinc sulphate was applied at final land preparation. Urea (N) was applied in three equal splits i.e., at 15 DAT, again at 30 DAT (active tillering stage) and rest at 45 DAT (before panicle initiation stage). Rice seedlings were transplanted on 07 January 2017. Intercultural operations have been done as when

necessary. BRRI dhan58 and BRRI dhan29 were harvested on 29 April and 8 May 2017, respectively. Data on growth yield and yield contributing characters were collected to record the agronomic characters. The grain and straw yields data were recorded from 1 m^2 area. The initial soil samples and post-harvest soil samples were collected from 0-15 cm soil depth and then air dried and then analyzed for different nutrients [36].

2.1 Statistical Analyses

All recorded data were compiled and tabulated for statistical analysis. Analysis and Duncan's Multiple Range Test were done with the help of computer package, MSTAT-C.

3. RESULTS AND DISCUSSION

3.1 Plant Height

Plant height at 45, 60, 75 DAT and at harvest differed between the varieties (Table 1). Higher plants (93.90 cm) were recorded in BRRI dhan58 compared to BRRI dhan29 (90.30 cm). It was supported by Goswami et al. (2019) [11]. Al-Amin (2016) [12] also found the taller plant in BRRI dhan58, which was higher than BRRI dhan29. Urea fertilizer influenced plant height at 60 days after transplanting (DAT) and at harvest (Table 1). The longest plant (73.40 cm) was recorded at 60 DAT due to application of 280 kg urea ha^{-1} while the shortest plant (70.00 cm) was produced for farmers practice treatment (165 kg urea ha^{-1}). 320 kg urea ha^{-1} gave the tallest plant (93.7 cm) at harvest, which was statistically at par with 340, 300 and 280 kg urea ha^{-1}. The shortest plant (89.80 cm) was recorded due to farmers practice (165 kg urea ha^{-1}). Similar result was also observed by Mazumder et al., (2019) [13] and reported that nitrogen fertilization had a tendency to increase plant height as nitrogen involves in cell division and cell elongation of plants. Increase in plant height due to N fertilizers is probably for enhanced availability of nitrogen which enhanced more leaf area which results in higher photo assimilates and thereby resulted in more dry matter accumulation (INDIRA CHATURVED, 2005) [14]. It is supported by Sultana et al. (2015) [15] and Mizan et al. (2010) [16]. Plant height did not differ due to interaction effect of variety and urea (Table 1).

3.2 Number of Tillers $Hill^{-1}$

At harvest, BRRI dhan58 produced higher number of total tillers $hill^{-1}$ (15.9) in comparison to BRRI dhan29 (13.1). The results supported by Goswami et al. (2019) [11] and Sarker (2012) [17].

Urea fertilizers application influenced the number of total tillers $hill^{-1}$ at 75 DAT (Table 2). 300 kg urea ha^{-1} produced the highest number of total tillers $hill^{-1}$ (24.7) whereas the lowest number of tillers $hill^{-1}$ (20.5) was found at farmers' practice (165 kg urea ha^{-1}). Khatun et al. (2015) [18] reported that about 89% of the variations in tillering pattern occurred due to different N rates. Karim et al. 2019 [19] reported that the crop received from 120 kg N ha-1 produced higher number (12.8) of tillers and the lowest level of applied nitrogen produced lower number (9.6) of tillers per hill. According to Yoshida et al. (1972) [20], as the amount of N absorbed by the crop increases, there is chance of increase in the number of tillers per square meter. But the number of total tillers production $hill^{-1}$ becomes gradually declined after 75 DAT. Meena et al. (2003) [21] also observed that application of N as 125 kg N ha^{-1} increased total number of tillers and dry matter accumulation. The interaction effect of variety and different doses of urea showed insignificant variations.

3.3 Yield and Yield Contributing Characters

Yield contributing characters viz. effective tillers $hill^{-1}$, non-effective tillers $hill^{-1}$, panicle length, grains $panicle^{-1}$, sterile spikelets $panicle^{-1}$ and grain yield differed between the varieties (Table 3). Longer panicle length was observed in BRRI dhan58 (21.10 cm) in comparison to BRRI dhan29 (19.80 cm). It was supported by Goswami et al. [11]. Shamsuddin et al. (1998) [22] observed that the panicle length differed among the varieties of nine different cultivars. BRRI dhan29 produced higher grain yield (6.4 t ha^{-1}) over BRRI dhan58 (4.9 t ha^{-1}). Urea fertilizer application influenced grain yield and yield contributing characters viz. total spikelets $hill^{-1}$, grains $panicle^{-1}$, 1000 grains weight (Table 3). Numbers of spikelets per panicle and filled grains per panicle of individual plants declined under decreased nitrogen application according to Liu et al. 2019 [23]. The highest number of effective tillers $hill^{-1}$ (13.40) was observed due to application of 300 kg urea ha^{-1} and the lowest (10.10) due to farmers' practice. Puteh and Mondal, 2014 [24] showed that the highest number of effective tillers $hill^{-1}$ was observed in application of N @120 kg ha^{-1}.

Table 1. Effect of variety, different doses of urea and interaction effect of variety and different doses of urea on plant height of boro rice in the Haor areas, Bangladesh

Treatment		Plant height (cm)				
		30 DAT	45 DAT	60 DAT	75 DAT	At harvest
Variety						
BRRI dhan29		38.50	48.80b	66.70b	87.90b	90.30b
BRRI dhan58		37.90	56.10a	77.80a	91.90a	93.90a
LS		NS	**	**	**	**
Urea (kg ha^{-1})						
340		39.90	54.00	71.50ab	90.20	93.30ab
320		39.30	53.80	72.50a	90.20	93.70a
300		39.00	54.60	73.20a	91.90	93.30ab
280		38.80	52.20	73.40a	89.80	91.90abc
260		37.40	52.40	72.90a	89.10	90.80bc
165		35.60	50.90	70.00b	88.30	89.80c
$S_{\bar{x}}$		-	-	0.72	-	0.89
LS		NS	NS	*	NS	*
Variety × urea (kg ha^{-1})						
BRRI dhan29	340	38.50	49.90	66.60	87.40	90.40
	320	39.30	51.70	67.40	87.40	91.10
	300	38.90	49.60	67.90	89.80	91.40
	280	39.10	50.20	66.60	87.70	90.90
	260	38.20	49.50	67.30	87.50	89.40
	165	37.20	47.90	64 .30	87.30	88.50
BRRI dhan58	340	39.80	58.10	76.50	92.90	96.10
	320	39.30	55.80	77.70	92.80	96.40
	300	39.10	59.50	78.80	94.00	95.10
	280	38.50	54.20	80.20	91.90	92.80
	260	36.50	55.20	78.50	90.80	92.30
	165	34.00	53.80	75.70	89.20	91.00
LS		NS	NS	NS	NS	NS
CV%		6.70	6.24	2.45	2.97	2.28

*$S_{\bar{x}}$ = Standard error of the mean, CV = Coefficient of variation, * = Significant at 5% level of probability, NS = Non significant, LS = Level of significance. DAT = Days after transplanting*

Singh and Shivay (2003) [25] showed that the increasing nitrogen fertilizer increased the effective tillers hill^{-1}. Application of 300 kg urea ha^{-1} produced the highest number of grains panicle^{-1} (147.50) and the lowest grains panicle^{-1} (111.80) was found at farmers' practice. Sultana et al. (2015) [15] reported that 90 kg N ha^{-1} application gave the highest number of grains panicle^{-1} (142) and the lowest grains panicle^{-1} (104) was obtained from the control. This result also supported by Khatun et al. (2015) [18] and Mizan et al. (2010) [16]. Grain weight is a genetically controlled trait, which is greatly influenced by environment during the process of grain filling (Chaturvedi, 2005) [14]. Results pertaining to 1000-grains weight in all the treatments differed from one another (Table 3). The highest 1000-grain weight (24.5 g) was obtained from the plots fertilized by 300 kg urea and the lowest 1000–grain weight (22.1 g) was produced by 165 kg urea ha^{-1} (farmers' practice). According to Yuseftaber et al. 2012 [26] the highest 1000-grain weight was 26.92 g obtained at 300 kg N ha^{-1}. Kausar et al. (1993) [27] also reported similar result. This result was supported also by Salem et al. (2011) [28]. From the Table 3 it was obvious that the yield data revealed positive response to N fertilizer treatments. The highest yield of grain (6.7 t ha^{-1}) was obtained from F_3 treatment (300 kg urea ha^{-1}). The lowest grain yield (4.7 t ha^{-1}) was recorded due to farmers' practice. Karim et al. 2019 [19] showed that the highest yield (4.43 t ha-1) was found at 60 kg N ha^{-1} and the lowest yield (2.96 t ha-1) was

recorded from the conrol. Puteh and Mondal, 2014 [24] explained that 120 kg N ha^{-1} resulted the highest grain yield and the lowest grain yield was recorded in 80 kg N ha^{-1} due to fewer effective tillers $hill^{-1}$. Rahman et al. (2012) [29] also reported that increasing N levels increased the grain yield of rice and application 150 kg N ha^{-1} gave the highest yield. It was found that application of N fertilizers improves various crop parameters like more productive tillers (Wilhelm 1998) [30], 1000–grain weight (Kirrilov et al. 1989) [31] and grain yield (Singh and Uttam 1992) [32]. These results are consistent with many workers (Hirzel et al., 2011 [33]; Shekara et al., 2011 [34]) who reported that grain yield increased with increasing N rate up to certain level followed by decline or no significant increased. Effect of interaction of variety and fertilizers on yield and yield contributing characters was insignificant (Table 3).

3.4 Nutrients Status of Initial and Post-harvest Soil

Initial and post-harvest soils were analyzed to observe the pre and post-harvest nutrients status in soil (Table 4). The pH value of initial soil was 4.8 and organic matter status was 2.8%. Soil analysis showed that organic matter status and soil pH was lower in post-harvest soil than the initial sample. Due to residual effect of fertilizer the pH values were decreased in post-harvest soil. The total N, available P, exchangeable K and available S values of the initial soil was 0.15%, 4.10, 0.18 and 26. The total N, available P, exchangeable K and available S values were higher in post-harvest soil than initial soil sample (Table 4). Soils of the area are grey, silty clay loams in the higher parts that dry out seasonally and grey clays in the wet basins. Soil reaction of this study area is mainly slightly acidic [35].

Table 2. Effect of variety, different doses of urea and interaction effect of variety and different doses of urea on total tillers $hill^{-1}$ (no.) of Boro rice in the Haor areas, Bangladesh

Treatment		Total tillers $hill^{-1}$ (no.)				
		30 DAT	45 DAT	60 DAT	75 DAT	At harvest
Variety						
BRRI dhan29		11.10	14.50	19.00	22.40	13.10b
BRRI dhan58		11.30	14.30	19.80	23.00	15.90a
LS		LS	NS	NS	NS	**
Urea (kg ha^{-1})						
340		11.20	15.20	19.40	23.80ab	14.10
320		11.60	14.80	20.10	24.30a	14.40
300		12.20	15.20	20.60	24.70a	15.70
280		11.20	13.70	19.90	21.80abc	14.90
260		10.50	13.90	19.20	21.00bc	14.40
165		10.40	13.60	17.50	20.50c	13.40
$S_{\bar{x}}$		-	-	0.72	-	0.89
LS		NS	NS	NS	**	NS
Variety × urea (kg ha^{-1})						
BRRI dhan29	340	10.80	15.00	19.00	23.90	12.00
	320	11.30	15.00	19.60	23.80	14.20
	300	11.90	15.20	20.10	24.10	14.80
	280	11.10	13.90	19.50	21.50	11.40
	260	11.10	14.30	18.40	20.90	14.90
	165	10.40	13.70	17.60	20.10	10.90
BRRI dhan58	340	11.70	15.30	19.80	23.70	16.10
	320	11.80	14.70	20.60	24.70	17.90
	300	12.50	15.30	21.10	25.40	16.60
	280	11.40	13.60	20.30	22.10	15.50
	260	9.90	13.50	19.90	21.10	13.80
	165	10.50	13.40	17.30	20.90	15.70
LS		NS	NS	NS	NS	NS
CV%		8.78	8.97	8.54	7.48	8.12

*$S_{\bar{x}}$ = Standard error of the mean, CV = Coefficient of variation, LS = Level of significance; NS = Non-significant; ** = Significant at 1% level of probability. DAT = Days after transplanting*

Table 3. Effects of variety, different doses of urea and interaction effect of variety and different doses of urea on the yield and yield contributing characters of boro rice

Treatment	Effective tillers hill^{-1} (no.)	Non-Effective tillers hill^{-1} (no.)	Panicle length (cm)	Total spikelets hill^{-1}	Grains panicle^{-1} (no.)	Sterile spikelets panicle^{-1} (no.)	1000 grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
Varieties									
BRRI dhan29	10.50b	2.50b	19.80b	177.30	137.50a	39.80b	22.90	6.40a	7.98
BRRI dhan58	12.30a	3.60a	21.10a	176.90	118.40b	58.50a	23.20	4.90b	7.42
LS	**	*	**	NS	**	**	NS	**	NS
Urea (kg ha^{-1})									
340	10.80	3.30	21.00	191.20ab	133.00ab	58.20	23.30ab	5.40abc	7.84
320	11.70	2.70	20.30	179.50abc	129.90abc	49.50	22.50b	6.40ab	7.77
300	13.40	2.50	21.40	196.50a	147.50a	49.00	24.50a	6.70a	7.91
280	10.90	3.30	20.00	168.00bc	120.00bc	48.00	23.50ab	5.60abc	7.77
260	11.70	2.70	20.40	170.30bc	125.50bc	45.30	22.30b	5.10bc	7.84
165	10.10	4.00	19.60	157.10c	111.80c	44.90	22.10b	4.70c	7.21
$S_{\bar{x}}$	-	-	-	7.76	4.58	-	0.42	0.31	-
LS	NS	NS	NS	*	*	NS	**	**	NS
Variety × urea (kg ha^{-1})									
BRRI dhan29	340 10.00	2.00	19.90	190.00	148.40	41.70	23.10	6.40	7.84
	320 9.50	1.40	19.30	186.30	141.60	44.70	22.70	6.80	7.63
	300 12.30	2.70	21.40	207.70	160.90	46.70	24.10	6.90	8.54
	280 10.50	2.30	18.90	162.70	122.30	40.30	23.70	6.70	7.98
	260 11.90	3.10	19.70	165.70	133.30	33.00	22.30	6.00	8.05
	165 9.10	3.70	19.30	151.70	118.70	32.50	21.30	5.50	7.91
BRRI dhan58	340 11.50	4.60	22.10	192.30	117.70	74.70	23.50	4.30	7.84
	320 13.80	4.10	21.30	172.70	118.30	54.30	22.80	5.90	7.84
	300 14.40	2.20	21.30	185.30	134.00	51.30	24.90	6.60	7.56
	280 11.10	4.40	20.30	173.30	117.70	55.70	23.40	4.20	7.07
	260 11.40	4.30	21.00	175.00	117.60	57.30	22.40	4.30	7.63
	165 11.40	2.30	20.70	162.70	105.00	57.70	22.10	3.90	5.88
LS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	8.83	16.30	4.72	7.74	8.77	11.71	4.43	10.49	10.81

$S_{\bar{x}}$ = Standard error of the mean, CV = Coefficient of variation, LS = Level of significance; NS = Non-significant;
** = Significant at 5% level of probability, ** = Significant at 1% level of probability. DAT = Days after transplanting*

Table 4. Nutrients status of initial and post-harvest soil of rice experimental field

Variety × Urea (kg ha^{-1})		pH	Total-N%	Organic matter%	Available P (ppm)	Exchangeable K (meq/100g)	Available S (ppm)
BRRI dhan29	340	4.5	0.19	2.6	5.3	0.27	30
	320	4.3	0.22	2.7	5.2	0.33	32
	300	4.4	0.19	2.0	5.8	0.25	29
	280	4.4	0.22	2.5	5.2	0.33	31
	260	4.3	0.23	2.7	5.3	0.30	34
	165	4.4	0.15	2.7	5.1	0.28	28
BRRI dhan58	340	4.3	0.19	2.5	5.2	0.34	31
	320	4.5	0.23	2.7	5.5	0.33	33
	300	4.3	0.24	2.4	5.8	0.28	30
	280	4.5	0.23	2.0	5.9	0.32	29
	260	4.4	0.21	2.1	5.6	0.30	32
	165	4.2	0.20	2.2	5.3	0.29	30
Initial soil		4.8	0.15	2.8	4.10	0.18	26

4. CONCLUSION

Results revealed that 300 kg N ha^{-1} along with BARC recommended other fertilizers (BARC recommended TSP, MoP, Gypsum) may be used to obtain the highest grain yield of boro rice cv. BRRI dhan29 and BRRI dhan58. From two varieties BRRI dhan29 produced higher grain yield. So, it could be concluded that the variety BRRI dhan29 with 300 kg urea ha^{-1} produced the highest grain yield which is suggested in the similar extrapolation areas.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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