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Performance of Boro Rice in Response to Different Application Methods of Urea Fertilizer

Ashick Ahmed[1*], Md. Mahbubur Rashid[1], Md. Julfiker Rahman[1], Md. Sirajul Islam[2]

[1]*BRAC Agricultural Research and Development Centre, Joydebpur, Gazipur-1701, Bangladesh*
[2]*Agriculture and Food Security Programme, BRAC, 75, Mohakhali, Dhaka-1212, Bangladesh*

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*Corresponding Author:
E-mail: ashick.ahmed@brac.net

A B S T R A C T

N (nitrogen) is an essential element that is very complex to manage. Adjustment to different application methods of N containing urea can be a crucial option for effective management of N. The experiment was carried out at the BRAC Agricultural Research and Development Centre, Gazipur during 2012/2013 and 2013/2014 growing seasons with the objectives to find out the response of genotypes and different urea fertilizer application methods on growth parameters, yield and yield attributes of Boro rice. The experiment was arranged in split-plot design with three replications having two genotypes viz. (i) V_1 = GSR I Sal Y 1242 and (ii) V_2 = BRRI dhan28 placed in main plot and four urea application methods viz. (i) T_1 = 220 kg ha^{-1} PU at three equal splits (ii) T_2= 2% foliar spray @ 80 kg ha^{-1} (iii) T_3= 75 kg N ha^{-1} USG (2.7 g) and (iv) T_4= LCC based urea @ 67.5 kg ha^{-1} placed in sub plot. Results showed that genotypes had non-significant influence for most of the growth parameters and yield components, whereas urea fertilizer application methods had significant effect on all growth parameters, yield and yield attributes except plant height at 40 DAT and 50% flowering stage. . With different methods of urea application, T_4 achieved significantly the highest value of all growth parameters, yield and yield components with total N content hill^{-1} (3.859%) and harvest index (50.70%) except filled grain panicle^{-1} (82.98) at harvest. Among the interactive treatments, the highest number of tillers m^{-2} (351.66), dry weight hill^{-1} (88.13 g), panicle number m^{-2} (340.83), panicle length (23.33 cm) and grain yield (7.32 t ha^{-1}) was obtained at V_1T_4. So, in aspect of yield and other parameters, V_1T_4 was the best treatment under the present study.

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Introduction

Management of N in farming systems is difficult because of the interactions between soil mineralization potential, soil water availability and the type of crops grown (Hatfield, 2004). Rice (*Oryza sativa* L.) is the main food crop of Bangladesh and it covers about 80% of the total cropped area of the country (AIS, 2008). The area and production of rice in Bangladesh is about 11.35 million hectares and 31.98 million MT, respectively where Boro covers the largest part of about 4.7 million hectares with the production of 18.06 million MT (BBS, 2010). However, the average grain yield in the country is much lower (2.94 t ha^{-1}) (BBS, 2012). Among the various reasons for low yield, judicious fertilizer management is one of them (Yoshida, 1981). The optimum use of N can be achieved by matching N supply with crop demand (Bijay et al., 2002). Farmers generally apply nitrogen fertilizer in fixed time recommended N split schedule (Pillai and Kundu, 1993) in 1:2:1 or 2:1:1 ratio at basal, maximum tillering and panicle initiation stages respectively, without taking into account whether the plants really require N at that time, which may lead to loss or may not be found adequate enough to synchronize nitrogen supply with actual crop nitrogen demand (Ladha et al., 2000). Among the fertilizers, nitrogen is the major essential plant nutrient and key input for rice production and increasing yield in Bangladesh (Hasan et al., 2002). Dastan et al. (2012) reported that N is the most important and essential plant nutrients to increase the crop yield positively.

Prilled urea (PU) is the most commonly used nitrogenous fertilizer for rice cultivation in Bangladesh. The efficiency of nitrogenous fertilizer especially, PU in rice cultivation is about 25-30% and rest 70-75% is lost for many reasons after application (BRRI, 2008). PU is a very fast releasing nitrogenous fertilizer that usually broadcasted in splits, can cause a considerable as ammonia volatilization, de-nitrification, surface run-off and leaching etc (De Datta, 1978). It was observed that Urea Super Granule (USG) can minimize the loss of nitrogen from the soil and hence the affectivity increased up to 20-25% (BRRI, 2008). Placement of USG in the root zone is the most effective method for increasing the nitrogen use efficiency and rice yield (Prasad et al., 1982; Sharma, 1995). Urea can also be supplied to plants through the foliage, facilitating optimal nitrogen management, which minimize nitrogen losses to the environment without affecting yield (Millard and Robinson, 1990). Most plants absorb foliar applied urea rapidly (Wittwer et al., 2002; Nicoulaud and Bloom, 1996) and hydrolyze the urea in the cytosol. Farmer's application of N does not coincide with the critical growth stages and proper amount may not be always maintained. Therefore, to provide an optimum N schedule to the farmers proper monitoring of N is required. N requirements vary among crop varieties (Raut, 2007). Rice leaf colour chart (LCC) can be used for adjustment of N application based on actual plant N status (Balasubramanian et al., 1999). LCC acts as a visual and subjective indicator of crop need for N fertilizer (Wells and Turner, 1984). LCC developed in Japan is used to measure the green color intensity of rice leaves (Furuya, 1987). Need based N application would result in greater agronomic efficiency of N fertilizer than the commonly practiced method (Hussain et al., 2000). However, there is an ample need to find out the relative efficiency of different application methods of N fertilizer on the performance of rice crops (Hasanuzzaman et al., 2009).

Zhang (2007) proposed strategies for developing Green Super Rice (GSR) to meet the challenges in rice production. In 2010, the Ministry of Science and Technology of China launched a mega project to develop GSR as proposed by Zhang (2007). One main aspect of this project is to decrease N fertilizer application in rice production through the genetic development of N-efficient varieties. In light of this aim, the present study was undertaken to observe the response of different methods of application of nitrogenous fertilizer on the performance of popular variety BRRI dhan28 and exotic GSR (Green Super Rice) genotype GSR I Sal Y 1242.

Materials and Methods

Experimental Site

The field experiment was carried out at the BRAC Agricultural Research and Development Centre, Gazipur under the agro-ecological zone of Modhupur Tract, AEZ-28. Geographically the experimental area is located at 23°58/N latitude and 90°23/E longitude at an altitude of 18 m above the sea level. The experimental site belongs to the Grey Terrace Soils under Chhiiata Series containing 19.23%, 78.84% and 1.93% of sand, silt and clay, respectively. The soil layer is 0-20 cm deep; having pH 6.42 (Sorensen, 1909); 1.68% organic matter (Walkley and Black, 1934); 0.086% total N (Yoshida et al., 1976); 15.20 µg g^{-1} soil available P (Olsen et al., 1954); 14.89 µg g^{-1} soil available S (Calcium dihydrogen phosphate extraction method) and 0.116 meq 100 g^{-1} soil exchangeable K (Jackson, 1973). The information regarding rainfall pattern, temperature fluctuations and sunshine hour's data collected from the meteorological station of BRRI, plant physiology division that located near to the experimental site during 2012/2013 and 2013/2014 rice growing seasons, are presented in Figure 1.

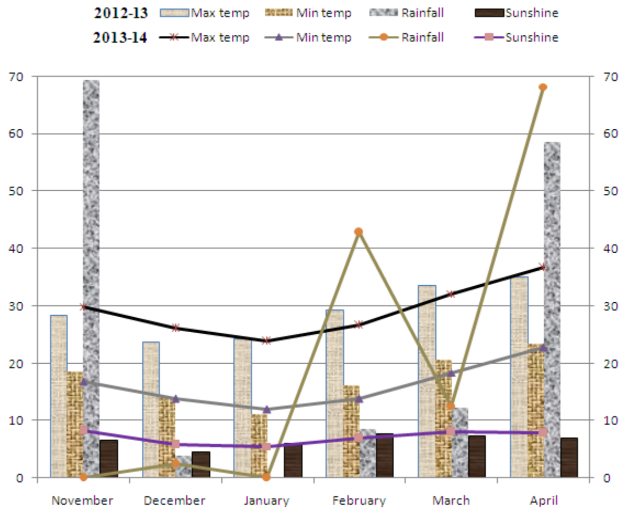

Figure 1 Rainfall, maximum and minimum temperatures and sunshine hours recorded at study area over two years during the crop period

Experimental Design and Procedure

The experiment was conducted with a view to find out the performance of Boro rice in response to different application methods of urea fertilizer during 2012/2013 and 2013/2014 growing seasons. The experiment was arranged in a split-plot design with three replications. The experimental treatments comprised with four urea application methods (T_1= 220 kg ha^{-1} PU at three equal splits, 1/3 at final land preparation + 1/3 at maximum tillering stage + 1/3 at PI (Panicle initiation) stage, T_2= 2% foliar spray @ 80 kg ha^{-1} from 10 DAT at 7 days interval up to flowering, T_3= 75 kg N ha^{-1} USG (2.7 g) at 15 DAT, T_4= LCC based urea @ 67.5 kg ha^{-1} at 21 DAT up to flowering as and when necessary) were used as sub plot and two Boro genotypes V_1 = GSR I Sal Y 1242 (exotic GSR inbred), V_2 =BRRI dhan28 (popular inbred) were used as main plot. Phosphate (P), potash (K), sulphur (S) and zinc (Zn) @ 130, 120, 70, 10 kg ha^{-1} in the form of triple super phosphate (TSP), muriate of potash (MoP), gypsum, and zinc sulphate, respectively were used as basal. Nitrogenous fertilizers were applied as per treatment. The USG weighing 2.7 g size each was placed manually in the root zone at 5-10 cm soil depth at 15 days after transplanting (DAT) in the center of four hills of two adjacent rows @ 1 granule in one spot to supply 75 kg N ha^{-1} as per Adhunik Dhaner Chash (BRRI, 2008). After the establishment of seedlings with proper care in seed bed; 31 days old seedlings were transplanted with two seedlings in each hill, maintaining the spacing with 20 cm × 20 cm on the well puddle plots. Standard crop production management practices for weeding, irrigation, crop protection operations were followed as and when required until the crop was mature.

Measurement of Parameters

Five hills (excluding border hills) from each sub-plot were selected and tagged after transplanting for taking growth parameters data at various stages and then at physiological maturity stage the hills were uprooted, cleaned, and standard data collection procedure maintained for taking yield component's data. Morphological datas were collected for qualitative and quantitative characters at the appropriate growth stage of rice plant following the description for *Oryza sativa* L. (IRRI, 2002). The characters that were evaluated are plant height (cm), number of tillers m^{-2}, dry weight $hill^{-1}$(g), N content (%) $hill^{-1}$, panicles no. m^{-2}, panicle length (cm), filled grains $panicle^{-1}$, unfilled grains $panicle^{-1}$, 1000 grain weight (g), grain yield (ton ha^{-1}) and harvest index (%) were recorded. An area of 5 m^2 was harvested from the centre of each plot and the plants were threshed; cleaned, sun dried, weighted and adjusted at 14% moisture content to estimate the grain yield. The grain moisture content was estimated with a digital moisture meter (GMK 303RS, Korea). The grain and straw yield (at 14% moisture content) on the sun dry weight basis were reported in t ha^{-1}. The randomly selected five plant samples from each sub-plot were separated into different plant components and then oven dry at 80^0c temperature to a constant weight for measuring total dry weight $hill^{-1}$ at different growth stages. Nitrogen content (root, stem, leaf and grain) from three plant samples of each sub-plot were determined by the micro Kjeldahl method (Yoshida et al., 1976). Harvest index (%) was calculated using the following formula: Grain yield/Biological yield × 100.

Statistical Analysis

The recorded data were analyzed statistically using the statistical computer package program MSTAT-C (Russell, 1986) and the mean values separated using least significant differences (LSD) test (Gomez and Gomez, 1984) at 5% level of significance.

Results and Discussion

Effect on Plant Height

Genotypes exerted a significant influence on plant height in 40 DAT and 60 DAT but later on a non-significant response was found in 50% flowering and at harvest (Table 1). Results showed that V_2 had the higher plant height (44.34 and 72.30 cm) compare to V_1 (42.41 and 59.37 cm) at 40 DAT and 60 DAT, respectively. These results also in agreement with Bisne et al. (2006) who stated that plant height significantly differed among different varieties.

Plant height was significantly influenced by different urea fertilizer application methods at 60 DAT and maturity stage, but non-significant at 40 DAT and 50% flowering (Table 1). The tallest plant at 60 DAT (69.14 cm) and at harvest (103.48 cm) was recorded by T_3, which was statistically identical with T_4 at harvest. The significant shortest plant (63.96 and 98.95 cm) and (65.60 and 97.78 cm) was observed in T_1 and T_2 treatment at 60 DAT and at harvest, respectively. The result under the present study was similar with the findings of Rahman (2003), Alam (2002) and Vijaya and Subbaiah (1997). Sathiya and Ramesh (2009) also stated that application of nitrogen in split according to the crop needs based on LCC was the reason for better rice growth parameter.

The interaction effect of genotype and different urea fertilizer application methods significantly influenced the plant height at different growth stages of Boro rice (Table 2). Results indicated that the longest plant (46.17 cm, 76.08 cm, 101.30 cm, and 106.60 cm at 40 DAT, 60 DAT, 50% flowering, and at harvest, respectively) was with V_2T_3. On the other hand, V_2T_2 showed the lowest plant height (93.20 cm and 96.96 cm at 50% flowering and at harvest, respectively) which was statistically similar to V_2T_1 at 50% flowering and at harvest but with V_1T_1 and V_1T_2 only at maturity stage. The results obtained from all other treatments at different growth stages on plant height gave statistically significant results.

Effect on Tillering Pattern

The genotypes had no significant influence on the number of tillers m^{-2} in 40 DAT, 60 DAT, and at 50% flowering, respectively but significant only at harvest (Table 3). Comparing tiller producing capacity of tillers m^{-2} between the two genotypes at harvest, V_1 showed the lower number of tillers m^{-2} (303.12) than V_2 (318.95).

Variation in the number of tillers m^{-2} was statistically significant for different urea fertilizer application methods throughout the growth period of Boro rice (Table 3). The highest number of tillers m^{-2} was recorded by T_3 (290.83 and 349.06 at 40 and 60 DAT, respectively) but later on the highest tillers m^{-2} was recorded from T_4 at 50% flowering and at harvest. Similar results observed by Hasanuzzaman et al. (2009) who reported that deep placement of USG @ 75 kg N ha^{-1} showed the highest number of tillers. This results also in agreement with the findings of Rahman (2003) and Alam (2002). The results obtained from T_2 showed the lowest number of tillers m^{-2} (308.75 and 282.08) which was closely followed by T_1 at 50% flowering and at harvest, respectively.

Table 1 Effect of variety and urea fertilizer application methods on plant height of Boro rice

Treatment	Plant height (cm)			
	40 DAT	60 DAT	At 50% flowering	At harvest
Effect of genotype				
V_1	42.41^b	59.37^b	97.63	100.14
V_2	44.34^a	72.30^a	97.24	101.50
$LSD_{(0.05)}$	1.72	2.78	NS	NS
Effect of different methods of Urea application				
T_1	42.33	63.96^b	96.51	98.95^b
T_2	43.76	65.60^b	96.55	97.78^b
T_3	44.96	69.14^a	99.30	103.48^a
T_4	42.45	64.64^b	97.38	103.06^a
$LSD_{(0.05)}$	NS	3.273	NS	2.987
CV (%)	6.46	3.95	2.46	2.36

Table 2 Combined effect of variety and urea fertilizer application methods on plant height of Boro rice

Treatment	Plant height (cm)			
	40 DAT	60 DAT	At 50% flowering	At harvest
Combined effect of genotype and different methods of Urea application				
V_1T_1	41.90^{ab}	58.43^{c}	97.63^{abc}	99.83^{cd}
V_1T_2	43.03^{ab}	59.25^{c}	99.90^{ab}	98.60^{cd}
V_1T_3	43.77^{ab}	62.19^{c}	97.30^{a-d}	100.36^{bcd}
V_1T_4	40.97^{b}	57.62^{c}	95.70^{bcd}	101.76^{bc}
V_2T_1	42.77^{ab}	69.49^{b}	95.40^{cd}	98.06^{cd}
V_2T_2	44.50^{ab}	71.95^{ab}	93.20^{d}	96.96^{d}
V_2T_3	46.17^{a}	76.08^{a}	101.30^{a}	106.60^{a}
V_2T_4	43.93^{ab}	71.66^{ab}	99.06^{abc}	104.36^{ab}
$LSD_{(0.05)}$	4.983	4.629	4.258	4.225
CV (%)	6.46	3.95	2.46	2.36

Table 3 Effect of variety and urea fertilizer application methods on number of tillers m^{-2} of Boro rice

Treatment	Number of tillers m^{-2}			
	40 DAT	60 DAT	At 50% flowering	At harvest
Effect of genotype				
V_1	234.37	311.46	336.04	303.12^{b}
V_2	262.70	319.74	368.12	318.95^{a}
$LSD_{(0.05)}$	NS	NS	NS	6.46
Effect of different methods of Urea application				
T_1	237.91^{b}	305.31^{ab}	341.25^{bc}	303.75^{bc}
T_2	232.91^{b}	304.69^{ab}	308.75^{c}	282.08^{c}
T_3	290.83^{a}	349.06^{a}	373.75^{ab}	325.83^{ab}
T_4	232.50^{b}	303.33^{b}	384.58^{a}	332.50^{a}
$LSD_{(0.05)}$	24.64	44.86	32.53	25.08
CV (%)	7.88	11.30	7.34	6.41

Table 4 Combined effect of variety and urea fertilizer application methods on number of tillers m^{-2} of Boro rice

Treatment	Number of tillers m^{-2}			
	40 DAT	60 DAT	At 50% flowering	At harvest
Combined effect of genotype and different methods of Urea application				
V_1T_1	223.33^{cd}	294.79^{b}	321.66^{de}	287.50^{cd}
V_1T_2	215.83^{d}	291.04^{b}	311.66^{e}	268.33^{d}
V_1T_3	276.66^{ab}	338.96^{ab}	339.16^{cde}	305.00^{c}
V_1T_4	221.66^{cd}	321.04^{ab}	371.66^{abc}	351.66^{a}
V_2T_1	252.50^{bc}	315.83^{ab}	360.83^{bcd}	320.00^{abc}
V_2T_2	250.00^{bcd}	318.33^{ab}	305.83^{e}	295.83^{cd}
V_2T_3	305.00^{a}	359.17^{a}	408.33^{a}	346.66^{ab}
V_2T_4	243.33^{bcd}	285.62^{b}	397.50^{ab}	313.33^{bc}
$LSD_{(0.05)}$	34.85	63.44	46.01	35.47
CV (%)	7.88	11.30	7.34	6.41

Table 5 Dry weight $hill^{-1}$ of rice as influenced by variety and different urea fertilizer application methods

Treatment	Dry weight $hill^{-1}$ (g)			
	40 DAT	60 DAT	At 50% flowering	At harvest
Effect of genotype				
V_1	40.55	48.76	68.31	84.83
V_2	45.54	53.88	65.00	77.75
$LSD_{(0.05)}$	NS	NS	NS	NS
Effect of different methods of Urea application				
T_1	35.90^{c}	43.51^{b}	59.99^{b}	76.18^{b}
T_2	38.65^{bc}	47.23^{b}	67.42^{a}	80.45^{b}
T_3	47.21^{ab}	55.35^{ab}	67.38^{a}	80.83^{ab}
T_4	50.42^{a}	59.21^{a}	71.82^{a}	87.71^{a}
$LSD_{(0.05)}$	10.940	11.850	7.283	9.900
CV (%)	20.19	18.36	8.69	6.85

The combined effect of genotype and different methods of urea application significantly influenced the number of tillers m^{-2} at different growth stages of the two genotypes of Boro rice (Table 4). Results indicated that the highest number of tillers m^{-2} (305.00, 359.17, and 408.33 at 40 DAT, 60 DAT, and at 50% flowering, respectively) was recorded with V_2T_3 which was closely followed by V_1T_3 at 40 and 60 DAT; with V_1T_4, V_2T_1, and V_2T_2 at 60 DAT but with V_1T_4 and V_2T_4 at 50% flowering stage. V_1T_4 which was closely followed by V_2T_3 and V_2T_1 obtained the highest tillers number m^{-2} (351.66) at harvest. The lowest number of tillers m^{-2} was recorded from V_1T_2 (215.83, 311.66, and 268.33 at 40 DAT, 50% flowering, and at harvest, respectively) which was statistically identical with V_1T_1 at 40 DAT, 50% flowering, and at harvest, respectively; V_1T_4 and V_2T_4 at 40 DAT but closely related with V_2T_2 at 40 DAT, 50% flowering, and at harvest, respectively.

Effect on Dry Weight Hill^{-1}

Non-significant variation was observed in terms of dry weight hill^{-1} for genotypic variation (Table 5).

Different urea fertilizer application methods significantly affect the dry weight hill^{-1} at all growth stages (Table 5). The highest dry weight hill^{-1} was recorded for T_4 (50.42 g, 59.21 g, 71.82 g, and 87.71 g at 40 DAT, 60 DAT, 50% flowering, and at harvest, respectively) which were statistically identical with T_3 at all growth stages but similar with T_2 at 50% flowering. The lowest dry weight hill^{-1} was recorded from T_1 (35.90 g, 43.51 g, 59.99 g, and 76.18 g at 40 DAT, 60 DAT, 50% flowering, and at harvest, respectively) which were closely followed by T_2 at 40 DAT, 60 DAT, and at harvest, respectively. The results under the present study was similar with the findings of Vijaya and Subbaiah (1997) and Jayanthi et al. (2007).

Variation in dry weight hill^{-1} was statistically significant for the combination of genotype and different urea fertilizer application methods (Table 6). V_2T_4 showed the highest dry weight hill^{-1} (54.03 g, 61.87 g, 73.40 g, and 87.30 g at 40 DAT, 60 DAT, 50% flowering, and at harvest, respectively) which was closely followed by V_1T_3, V_1T_4, and V_2T_2 at all growth stages also with V_1T_1 and V_2T_3 except 40 DAT and at harvest, respectively. The results recorded from V_2T_1 showed obtain the lowest dry weight hill^{-1} (33.69 g, 40.56 g, 56.01 g, and 69.60 g at 40 DAT, 60 DAT, 50% flowering, and at harvest, respectively) which was similar with V_1T_2 at 40 DAT and 60 DAT; statistically identical with V_2T_2 at all growth stages as well as with V_1T_1 except at the time of harvest. However, V_1T_3 and V_1T_4 showed similar results at all growth stages.

Effect on N Content (%) Hill^{-1}

Genotypes exerted a significant influence on root N content (%) but non-significant in the case of leaf, stem and grain N content (%). The highest N content in root (0.469%) was obtained from V_1 followed by V_2 i.e. 0.449% N (Table7).

Table 6 Dry weight hill^{-1} of rice as influenced by combined effect of variety and different urea fertilizer application methods

Treatment	Dry weight hill^{-1} (g)			
	40 DAT	60 DAT	At 50% flowering	At harvest
Combined effect of genotype and different methods of Urea application				
V_1T_1	38.11^{bc}	46.25^{ab}	63.98^{ab}	82.76^{ab}
V_1T_2	34.88^{c}	42.22^{b}	68.75^{a}	82.00^{ab}
V_1T_3	42.43^{abc}	50.03^{ab}	70.25^{a}	86.43^{a}
V_1T_4	46.80^{abc}	56.56^{ab}	70.25^{a}	88.13^{a}
V_2T_1	33.69^{c}	40.56^{b}	56.01^{b}	69.60^{c}
V_2T_2	42.43^{abc}	52.24^{ab}	66.08^{ab}	78.90^{abc}
V_2T_3	52.00^{ab}	60.66^{a}	64.51^{ab}	75.23^{bc}
V_2T_4	54.03^{a}	61.87^{a}	73.40^{a}	87.30^{a}
$LSD_{(0.05)}$	15.460	16.760	10.300	7.001
CV (%)	20.19	18.36	8.69	6.85

Table 7 Effect of variety and urea fertilizer application methods on nitrogen content (%) of Boro rice at harvest

Treatment	N content (%)			
	Root	Stem	Leaf	Grain
Effect of genotype				
V_1	0.469^{a}	0.541	1.269	1.207
V_2	0.449^{b}	0.627	1.382	1.254
$LSD_{(0.05)}$	0.01	NS	NS	NS
Effect of different methods of Urea application				
T_1	0.467^{b}	0.607^{ab}	1.397^{a}	1.393^{a}
T_2	0.408^{c}	0.562^{bc}	1.210^{b}	1.182^{b}
T_3	0.407^{c}	0.527^{c}	1.218^{b}	1.160^{b}
T_4	0.555^{a}	0.640^{a}	1.447^{a}	1.187^{b}
$LSD_{(0.05)}$	0.056	0.056	0.112	0.105
CV (%)	9.91	7.98	6.69	6.93

Table 8 Combined effect of variety and urea fertilizer application methods on nitrogen content (%) of Boro rice at harvest

Treatment	N content (%)			
	Root	Stem	Leaf	Grain
Combined effect of genotype and different methods of Urea application				
V_1T_1	0.440^{cd}	0.540^{cde}	1.323^{bcd}	1.387^{ab}
V_1T_2	0.477^{bc}	0.473^{e}	1.120^{e}	1.130^{c}
V_1T_3	0.377^{de}	0.560^{cd}	1.217^{de}	1.137^{c}
V_1T_4	0.583^{a}	0.590^{bc}	1.417^{abc}	1.173^{c}
V_2T_1	0.493^{bc}	0.673^{a}	1.470^{ab}	1.400^{a}
V_2T_2	0.340^{e}	0.650^{ab}	1.300^{cd}	1.243^{bc}
V_2T_3	0.437^{cd}	0.493^{de}	1.220^{de}	1.183^{c}
V_2T_4	0.527^{ab}	0.690^{a}	1.537^{a}	1.190^{c}
$LSD_{(0.05)}$	0.079	0.079	0.159	0.148
CV (%)	9.91	7.98	6.69	6.93

Table 9 Effect of variety and urea fertilizer application methods on yield, yield components and harvest index (%) of Boro rice

Treatment	PN	PL	FGP	UGP	GW	GY	HI
Effect of genotype							
V_1	295.2	22.81	98.88	51.25	19.91^{b}	6.87^{a}	48.59
V_2	306.25	22.79	82.51	44.06	20.48^{a}	6.31^{b}	50.97
$LSD_{(0.05)}$	NS	NS	NS	NS	0.380	0.38	NS
Effect of different methods of Urea application							
T_1	289.58^{b}	22.86^{ab}	94.59^{ab}	45.65^{bc}	19.77^{c}	6.48^{b}	49.51^{ab}
T_2	278.33^{b}	22.69^{ab}	97.23^{a}	42.96^{c}	20.22^{b}	6.21^{c}	48.39^{b}
T_3	319.16^{a}	22.27^{b}	87.98^{ab}	53.05^{a}	20.21^{b}	6.62^{b}	50.53^{a}
T_4	315.83^{a}	23.39^{a}	82.98^{b}	48.97^{ab}	20.57^{a}	7.05^{a}	50.70^{a}
$LSD_{(0.05)}$	22.2	0.97	12.54	5.838	0.221	0.221	1.778
CV (%)	5.87	3.38	10.99	9.74	0.88	2.67	5.93

PN: Panicle number m^{-2}, PL: Panicle length (cm), FGP: Filled grain $panicle^{-1}$, UGP: Unfilled grain $panicle^{-1}$, GW: 1000 grain weight (g), GY: Grain yield (t ha^{-1}), HI: Harvest index (%)

Table 10 Combined effect of variety and urea fertilizer application methods on yield, yield components and harvest index (%) of Boro rice

Treatment	PN	PL	FGP	UGP	GW	GY	HI
Combined effect of genotype and different methods of urea application							
V_1T_1	281.66^{bc}	22.44^{ab}	101.81^{ab}	46.27^{b}	19.61^{e}	6.95^{b}	49.57^{b}
V_1T_2	262.50^{c}	22.88^{ab}	108.36^{a}	50.33^{ab}	19.74^{de}	6.32^{cd}	46.73^{c}
V_1T_3	295.83^{b}	22.61^{ab}	101.27^{ab}	57.42^{a}	20.24^{c}	6.88^{b}	$49.20b^{c}$
V_1T_4	340.83^{a}	23.33^{a}	84.08^{bc}	51.01^{ab}	20.07^{c}	7.32^{a}	48.86^{bc}
V_2T_1	297.50^{b}	23.28^{ab}	87.37^{bc}	45.03^{b}	19.93^{cd}	6.02^{d}	49.46^{b}
V_2T_2	294.16^{b}	22.50^{ab}	86.11^{bc}	35.59^{c}	20.70^{b}	6.09^{cd}	50.05^{ab}
V_2T_3	342.50^{a}	21.94^{b}	74.69^{c}	48.69^{b}	20.21^{c}	6.36^{c}	52.19^{a}
V_2T_4	290.83^{bc}	23.44^{a}	81.88^{c}	46.93^{b}	21.08^{a}	6.77^{b}	52.20^{a}
$LSD_{(0.05)}$	31.4	1.372	17.73	8.257	0.313	0.313	2.514
CV (%)	5.87	3.38	10.99	9.74	0.88	2.67	5.93

PN: Panicle number m^{-2}, PL: Panicle length (cm), FGP: Filled grain $panicle^{-1}$, UGP: Unfilled grain $panicle^{-1}$, GW: 1000 grain weight (g), GY: Grain yield (t ha^{-1}), HI: Harvest index (%)

The N content (%) $hill^{-1}$ varied significantly due to different methods of nitrogen application (Table 7). The highest significant N (%) content in root (0.555%), stem (0.640%), and leaf (1.477%) was found in T_4. The highest N content (%) of grain was measured in T_1 (1.393%) treatment followed by T_4 (1.187%) which was statistically similar to T_2 (1.182%) and T_3 (1.160%) respectively.

The interaction effect of genotype and different methods of urea application showed significance on N content (%) $hill^{-1}$ (Table 8). V_1T_4 showed the highest N content in root (0.583%) which was statistically similar with V_2T_4.The highest concentration of N in stem (0.690%) and leaf (1.537%) was observed in V_2T_4 which were identical to V_2T_1 whereas the lowest content of N was measured 0.473 (%) for stem and 1.120 (%) for leaf in V_1T_2. In case of grain, the highest 1.40 (%) of N content was detected in V_2T_1 which was statistically similar to V_1T_1 (1.387%). The significant lowest amount of N in grain was found in V_1T_2 (1.130%), V_1T_3 (1.137%), V_1T_4 (1.173%) and V_2T_3 (1.183%).

Effect on Yield and Yield Attributes

Genotypic variation had non-significant effect on the panicle no. m^{-2}, panicle length (cm), filled grain panicle^{-1}, unfilled grain panicle^{-1}, and harvest index (%) but significant response on 1000-grain weight (g) and grain yield (t ha^{-1}) (Table 9). Qurashi et al. (2013) also reported non-significant varietal effect on harvest index (%). V_1 obtained statistically lower weight (19.91 g) compare to V_2 (20.48 g) but ultimately gained higher production (6.87 t ha^{-1}) than V_2 (6.31 t ha^{-1}). These results are in agreement with Chowdhury et al. (1993) who reported difference in 1000-grain weight among the varieties.

Different urea fertilizer application methods showed significant influence on yield and yield attributes of Boro rice (Table 9). The highest panicle no. m^{-2} (315.83), panicle length (23.39 cm), unfilled grain panicle^{-1} (48.97), 1000-grain weight (20.57 g), grain yield (7.05 t ha^{-1}), and harvest index (50.70%) were recorded for T_4 which was similar with T_3 for panicle no. m^{-2}, filled grain panicle^{-1}, unfilled grain panicle^{-1}, and harvest index (%). Krishnakumar and Haefele (2013), Kenchaiah et al. (2000) also got similar results for the higher panicle number, lengthier panicle, and grain yield due to LCC based urea application. Alam et al. (2005); Alam et al. (2009); and Baksh et al. (2009) stated that use of LCC for N management has consistently increased grain yield and profit in comparison to the farmers' fertilizer practice in Bangladesh. The lowest panicle no. m^{-2} (278.33), unfilled grain panicle^{-1} (42.96), grain yield (6.21 t ha^{-1}), and harvest index (48.39%) were recorded from T_2, which was similar with T_1 for all yield contributing parameters except 1000-grain weight (19.77 g) and grain yield (6.48 t ha^{-1}).

Combination of genotype and different urea fertilizer application methods significantly influenced the yield and yield contributing characters of Boro rice (Table 10). Combinations of V_1T_4 and V_2T_3; V_1T_4 and V_2T_4; V_2T_3 and V_2T_4 showed the highest panicle no. m^{-2}, panicle length, and harvest index (%), respectively. The highest filled grain panicle^{-1} (108.36), unfilled grain panicle^{-1} (57.42), and 1000-grain weight (21.08) were gained by V_1T_2, V_1T_3, and V_2T_4, respectively. The lowest panicle no. m^{-2} (262.50), filled grain panicle^{-1} (74.69 and 81.88), unfilled grain panicle^{-1} (35.59), 1000-grain weight (19.61 g), and harvest index (46.73%) were recorded for the combinations of V_1T_2; V_2T_3 and V_2T_4; V_2T_2; V_1T_1; V_1T_2, respectively. The combination of V_1T_4 gave the highest grain yield (7.32 t ha^{-1}) whereas V_2T_1 produced the lowest (6.02 t ha^{-1}).

Conclusions

According to the result of the experiment, it can be concluded that the performance of exotic inbred GSR I Sal Y 1242 was better than popular inbred BRRI dhan28 during the Boro season in aspect of yield. Among the different application methods of urea fertilizer, LCC based urea T_4 gave the best result. Therefore, it is suggested to cultivate GSR I Sal Y 1242 with LCC based urea application method which was appeared as a promising practice in Boro rice cultivation. However, study should be conducted more regarding these different methods of urea application in different locations with a different soil types for more intensive knowledge.

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