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Effects of rate and method of urea on the growth and yield of T. Aman rice

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ABSTRACT

An experiment was conducted at Bangladesh Agricultural University, Mymensingh, during T. Aman 2010 with a view to investigate the effect of rate and method of urea application on the yield and yield components of transplanted aman rice cv. BRRI dhan46. The experiment comprises of two methods of urea application and five rates of urea fertilizer. The experiment was laid out in a randomized complete block design with four replications and the data collected on 10 parameters. The results showed that the method of urea application had significant effect on number of total tillers per hill, number of effective tillers per hill, number of grains per panicle, grain yield, straw yield and harvest index. The highest grain yield (4.66 t/ha) was recorded with split application of urea fertilizer. The effect of urea rate had significant influence on most of the plant characters except panicle length and 1000 grains weight. The highest grain yield (5.07 t/ha) was produced in U_1 (140 kg urea/ha). The interaction between rate and method of urea application also significantly influenced most of the parameter studied. The highest grain yield (5.15 t/ha)was recorded with the interaction combination of M_1U_1 (split application of urea @ 140 kg urea/ha).

Key Words: *Oryza sativa L., Urea doses, Application methods and Effects*

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I. Introduction

Rice (*Oryza sativa* L.) is the world's most important food crop being the primary food source for more than one third of the world's population and grown in 79.4% of the total cultivatable land area (FAO, 1988). Global rice production is expected to touch 476 million tons in the year 2011 (FAO, 2011). In Bangladesh, rice dominates the cropping pattern throughout the country as almost 90% population is rice eaters and about 80% of the cropped area is used for rice production, with annual production of 32.3 million metric tons in total acreage of 11.8 million ha. The average yield of rice in Bangladesh is

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4.20 t/ha (Bangladesh Grain and Feed Annual Report, 2011). Among the rice groups grown in the country, transplant aman rice is the most important which covers the largest area of 5.8 million ha with production of 12.6 million metric tons (BBS, 2010). But this yield of rice is much lower than the world average. It is mainly due to lack of potential varieties and management practices. Among different management practices, optimum rate and judicious application method of fertilizer are considered to be the major determinants for maximizing the yield of transplant aman rice.

The fact is that rice plants require more nutrients to produce more yields. Nitrogen is a major essential plant nutrient and a key input for increasing crop yield and urea fertilizer is the major source of nitrogen. Yield increase (70-80%) of field rice could be obtained by the application of urea fertilizer (IFC, 1982). It is required in large amount and has a positive influence on the production of effective tillers/plant, yield and yield attributes but excess urea may cause excessive vegetative growth, prolong the growth duration and delay crop maturity with reduction in grain yield. On the other hand, urea fertilizer has heavy system losses when applied as inorganic sources in puddle field. Large amount of urea fertilizer is losses from the soil through NH_3 volatilization, denitrification, leaching, surface run off, chemical fixation or by immobilization by microbes in wet season. The utilization efficiency of applied urea by the rice plant is very low. So, urea should be applied in proper methods. Urea is generally applied as basal and through top dressing. But it can also be applied through spraying in standing crops.

Inadequate and improper application methods of urea are now considered as one of the major reasons for low yields of rice in Bangladesh. Therefore, urea should be applied in such a way that the minimum is leached or washed away and the maximum is utilized for plant growth and grain production. The application method of urea fertilizer is important aspect in overall nitrogen management in transplanted rice especially for BRRI dhan46 because, this variety is suitable for flood prone areas were fertilizer requirement is higher. So, it is essential to find out the most economically sustainable rate and method of urea application for to minimize the waste of fertilizer use and obtaining maximum yield. On the basis of mentioned above facts, the present study was designed to study the interaction of rate and method of urea application on the yield and yield components of BRRI dhan46.

II. Materials and Methods

The experiment was conducted at the Bangladesh Agricultural University, Mymensingh during aman season starting from July 2010 to December 2010. The two factors experiment included the following treatments: Factor A: different 5 rates of urea fertilizer: viz. U_1 = 140 kg/ha, U_2 = 160 kg/ha, U_3 = 160 kg/ha, U_4 = 200 kg/ha and U_5 = 200 kg/ha and Factor B: different 2 types methods of urea fertilizer application: viz. M_1 = split application (4 times) done at 10 DAT, 30 DAT, 50 DAT and 70 DAT and M_2 = spraying (4 times) done at 10 DAT, 30 DAT, 50 DAT and 70 DAT. The experiment was laid out in a randomized complete block design with four replications. The whole experimental area was divided into four blocks. Each block was divided into 10 unit plots of 4m×2.5m size each. Thus, the total No. of unit plots were 40 (4×10). The distance maintained between two unit plots was 0.75m and between blocks was 1m. The bunds around individual plots were made to control water movement between plots. The treatments were randomly allocated. The land was fertilized with urea as per treatment specification. In addition, Triple super phosphate, Muriate of potash, Gypsum and Zinc sulphate were applied in all plots @ 100, 70, 60 and 10 kg/ha, respectively, during final land preparation.

For each method, urea dose was applied in 4 splits with equal share-10, 30, 50 and 70 days after transplanting during the life cycle of BRRI dhan46. In case of split application, ¼th amount of prilled urea is Broadcast for each time and in case of spray application, ¼th portion of total urea was dissolved in 5L of water and then sprayed on the foliage using hand sprayer at 10, 30 50 and 70 days after transplanting.Three seedlings/hill were transplanted maintaining the spacing of 25cm×15cm. Intensive care was taken during the growing period to ensure adequate growth and development of the crop. Weeding depends on the infestation of weeds in the field. Before split and spray application of urea, the plots were made weed free. No irrigation was given to the plots as there was abundant rainfall during the growing period. Data were collected on plant height (cm), number of total tillers/hill, number of effective tillers/hill, panicle length (cm), number of grains/panicle, weight of 1000 grains (g), grain yield (kg), straw yield (kg), biological yield (kg) and harvest index (%). Data on different parameters were compiled and tabulated in proper form for statistical analysis. “Analysis of

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variance" was done with the help of computer package MSTAT. The mean differences among the treatments were tested with Duncan's Multiple Range Test (Gomez & Gomez, 1984).

III. Results and Discussion

Effects of urea [methods, rates and methods x rates (interaction)] application on the yield and yield components of BRRI dhan46

Plant height (cm)

Methods of urea application did not influence the plant height significantly in aman rice *cv*. BRRI dhan46. However, numerically the taller plants (114.05 cm) were found from split application of urea while the plant height reaches maximum 113.99 cm through spray application (Table 01). Akanda et al. (1986) found that the tallest plants were produced when 80 kg N ha^{-1} was applied in three splits (20 kg at basal, 40 kg at active tillering and 20 at maximum tillering). The plant height of BRRI dhan46 was significantly affected by the rates of urea fertilizer. Plant height ranged from 108.17 to 116.21 cm. The tallest plant (116.21 cm) was found with U_4 (180 kg/ha) while shortest one (108.17 cm) was found when U_5 (220 kg/ha). The shortest plant in U_5 might be the effect of excess uptake of nitrogen from highest dose of nitrogen application resulting lodging of plants which resulted stunted growth of the plant (Table 02). Faraji & Mirlohi (1998) reported that plant height increased with an increase in the rate of N fertilizer application. Sixty, 90, 120 and 150 kg N ha^{-1} were given before transplanting or in 2 or 3 splits while grain yield and panicle number increased with up to 120 kg N ha^{-1} but decreased at 150 kg N ha^{-1}. Plant height of BRRI dhan46 was not significantly influenced by the interaction of methods and rates of urea application. Numerically the highest plant height 117.48 cm was found from M_1U_1 (split of urea @ 140 kg/ha) and the lowest (108.06 cm) from M_2U_5 (spray of urea @ 220 kg/ha) (Table 03). The shortest plant in M_2U_5 might be the effect of excess amount of urea in the soil due to highest dose and simultaneous spray causes failures of equal nitrogen uptake by the plant for proper growth which results stunted growth of the plant.

Number of total tillers per hill

Different methods of urea fertilizer application exhibited significant difference in producing number of total tillers/hill in BRRI dhan46. The higher number of total tillers/hill(14) was obtained when urea fertilizer was applied in 4 equal splits. On the other hand, the lower number of total tillers/hill (13.15) was obtained from spray of urea fertilizer (Table 01). Geethadeviet al.(2000) found that 120 kg N ha^{-1} in the form of urea; 50% of nitrogen was applied as basal rate to all treatments while the remaining 50% was applied in four splits resulted in higher number of tillers. Number of total tillers/hill was significantly influenced by the different rates of urea application. The highest number of tillers/hill (15.19) obtained from U_4 (200 kg/ha) and plants receiving 220 kg/ha (U_4) produced the lowest number of tillers/hill (11.49). This might be the lodging effect of the hills resulting from excess uptake of nitrogen for higher dose (Table 02). Interaction of rates and methods of urea application exhibited significant influence on number of total tillers/hill of transplantedaman rice *cv.* BRRI dhan46 (Table 03). The highest number of total tillers/hill was found from the interaction of M_1U_4 (Split urea @ 200 kg/ha) and the lowest number of total tillers/hill was noticed at M_2U_5 (Spray of urea @ 220 kg/ha). This might be the lodging effect of the hills resulting from excess uptake of nitrogen from higher dose. Idris & Matin (1990) noticed that the maximum tillers $hill^{-1}$ was reduced with 140 kg N ha^{-1} which was statistically similar to these with 60, 80, 100 and 120 kg N ha^{-1}. The minimum tillers $hill^{-1}$ was obtained from the control treatment (0 kg ha^{-1}).

Number of effective tillers per hill

The number of effective tillers/hillwassignificantlyaffected by the methods of urea application (Table 01). The bearing tillers/hillwas highest (10.93) when the crop was fertilized with urea in the 4 equal splits. On the other hand number of effective tillers/hill was found lowest (10.59) when urea was applied in spray method. This indicates that, split method is better than spray method. Islam et al. (1996) reported that number of effective tillers $hill^{-1}$ increased with top dressing of nitrogen. Different rates of urea application exhibited significant difference in producing the number of effective tillers/hill in BRRI dhan46 (Table 02). The highest number of effective tillers/hill (12.16) was found

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with U_4 (200 kg/ha) as U_1 (140 kg/ha) and U_2 (160 kg/ha) statistically followed the same trend as U_4 in terms of total number of effective tillers/hill. The lowest number of effective tillers/hill (8.28) was obtained from U_5 (220 kg/ha). BRRI (1992) stated that productive tillers hill^{-1} was significantly affected by the level of nitrogen. The highest number of productive tillers hill^{-1} was obtained from the highest level of nitrogen (120 kg ha^{-1}). The effect of interaction between rates and methods of urea application was not significantly affected the number of effective tillers/hill (Table 03). Apparently, the highest number of effective tillers/hill (12.42) was given by the treatment combination M_1U_1 (split of urea @ 140 kg/ha) and the lowest number of tillers/hill (8) was produced in M_2U_5 (spray of urea @ 220 kg/ha).

Panicle length (cm)

It was seen that, panicle length was not significantly affected by the method of urea fertilizer application (Table 01). Apparently, the higher panicle length (25.74cm) was observed with split application of urea than spray application. Rao et al. (1996) showed that nitrogen application as 50 kg ha^{-1} at tillering, 25 kg ha^{-1} at panicle initiation and 25 kg at booting stage produce the longest panicle. The panicle length of BRRI dhan46 did not vary due to different rates of urea application (Table 02). However, numerically, the highest panicle length (25.90 cm) was observed with 200 kg/ha (U_4) and the lowest panicle length (24.94 cm) was observed with 180 kg/ha (U_3). Azad et al. (1995) stated that panicle length increased significantly with the increasing level of nitrogen from 0 to 75 kg ha^{-1}. Singh and Singh (1993) observed that panicles m^{-1}, panicle length and grains panicle^{-1} increased due to application of 60 kg N ha^{-1}. The panicle length of BRRI dhan46 did not significantly vary due to interaction effect of rates and methods (Table 03). However, numerically, the highest panicle length (26.25 cm) was obtained from spray of urea @ 140 kg/ha (M_1U_1) and the lowest panicle length (24.93 cm) was observed with spray of urea @ 180 kg/ha (M_2U_3).

Number of grains per panicle

Number of grains/paniclevaried significantly due to the method of urea application in BRRI dhan46 (Table 01). The highest number of grains/panicle (159.29) was found from split urea application where as the number of grains/panicle (143.86) found from spray method is apparently lower than spray method of urea application. Thakur (1991) reported that total spikelets panicle^{-1} was the highest when 40%, 30% and 30% nitrogen was applied as basal, at maximum tillering and panicle initiation stages respectively. Urea rates exerted significant influence on the production of number of grains/panicle in BRRIdhan46 (Table 02). The highest number of grains/panicle (161.85) was found when U_4 (200 kg/ha) was applied in the crop field and it was identical to U_1 (140 kg/ha). Application of U_2 (160 kg/ha) produced the second highest number (157.40) of grains/panicleand it was followed by U_3(180 kg/ha) and U_5 (220 kg/ha). The lowest number of grains/panicle (138.71) was recorded from the application of U_5 (220 kg/ha). Interaction of rates and methods of urea fertilizer exhibited significant influence on the number of grains/panicleof BRRI dhan46 (Table 03) the highest number of grain/panicle (172.91) was observed with the combination of M_1U_4 (split of urea @ 200 kg/ha) which was statistically identical with M_1U_1 (split of urea @ 140 kg/ha). The above two combinations were significantly apart from the others and followed by M_1U_3 (split of urea @ 180 kg/ha), M_2U_2 (spray of urea @ 160 kg/ha) and M_2U_1 (spray of urea @ 140 kg/ha) respectively. The significantly lowest number of grain/panicle (130.71) was observed from the interaction combination of M_2U_5 (split of urea @ 220 kg/ha) which was identical with the combination of M_2U_3 (split of urea @ 180 kg/ha). Chander & Pandy (1996) stated that a significant increase in grains panicle^{-1}, tillers m^{-2} and grain yields was obtained from application of 120 kg N ha^{-1} compared to 60 kg N ha^{-1}.

Weight of 1000 grains (g)

Data presented in Table 01 revealed that the method of urea fertilization did not influence the weight of 1000 grains significantly. Numerically the maximum (24.93g) was obtained from split method and minimum (24.63g) was obtained from spray method. This clearly indicates that split method produced heavier individual grain weight than that of split method of urea application. Ali et al. (1992) reported that 1000 grain weight was the highest when 100 kg N ha^{-1} was applied in three equal splits at basal, 30 and 60 days after transplanting. The rates of urea fertilizer did not influence the weight of 1000 grains significantly. However, numerically the highest weight (25.15 g) and lowest weight (24.51g) of 1000 grains was observed by the rates of U_5 (220 kg/ha) and U_4 (220 kg/ha) respectively (Table 02).

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Sadeque et al. (1990) obtained the maximum 1000 grain weight (24.93) from 50 kg N ha^{-1} than 100 and 200 kg N ha^{-1}. Islam et al. (1990) concluded that there was an increasing trend of 1000 grain weight with an increase in levels of nitrogen up to 80 kg N ha^{-1}. Data presented in the Table 03 showed that, the interaction of rates and methods of urea fertilizer exhibited a significant difference in 1000 grain weight of BRRI dhan46. The highest 1000 grain weight (25.80 g) was observed from the combination of M_1U_5 (split of urea @ 220 kg/ha) and it was statistically identical with the M_1U_1 (split of urea @ 140 kg/ha). The lowest number of 1000 grain weight (23.93 g) was observed with the interaction of M_2U_1 (spray of urea @ 140 kg/ha).

Grain yield (t/ha)

Significant variation in grain yield (t/ha) was observed inaman rice *cv*. BRRI dhan46 due to different fertilization methods of urea application (Table 01). The highest grain yield (4.66 t/ha) was obtained from split application of urea fertilizer whereas same application of urea as spray method produces 4.34 tons grains/ha. The increased yield with split method of urea was contributed by higher number of effective tillers/hill, higher number of grains/panicleand individual grain weight. Ehsanullah et al. (2001) reported that nitrogen as split application at different growth stages significantly affected grain yield. Grain yield of BRRI dhan46 was significantly affected by the rates of urea fertilizer (Table 02). The highest grain yield (5.20 t/ha) was obtained with the rate of U_4 (200 kg/ha) but it was identically followed by U_2 (160 kg/ha) and U_1 (140 kg/ha). The highest yield obtained by the treatments might be due to the contribution of effective tillers/hilland number of grains/panicle. The results revealed that (Table 02), U_1 (140 kg/ha), U_2 (160 kg/ha), and U_4 (220 kg/ha) produced the identical but highest yield. Therefore, 140 kg/ha urea may be suggested to grow BRRI dhan46. The lowest yield (3.13 t/ha) was found from U_5 (220 kg/ha). Hossian et al. (2007) observed that, nitrogen rates have significant effect on yield and yield attributes of transplanted aman rice. The highest grain yield was obtained from the application of 75% of the recommended dose (150 kg urea, i.e. 69 kg N ha^{-1}) of N and the lowest from the control (0 kg ha^{-1}). Significant variation in grain yield (t/ha) was observed in BRRI dhan46 due to the interaction of different rates and methods of urea (Table 03). The highest grain yield (5.42 t/ha) was obtained from the combination of M_1U_4 (Split of urea @ 200 kg/ha) and the lowest grain yield (2.88 t/ha) was obtained from the interaction of M_2U_5 (Spray of urea @ 220 kg/ha).

Straw yield (t/ha)

Methods of urea fertilizer application significantly influenced the straw yield of BRRI dhan46. The highest straw yield (6.24 t/ha) was recorded when urea is applied in split method. Spray method produces 6.12 tons straw/ha which was significantly lower than split method of urea application (Table 01). Moeiniet al.(2006) conducted a 3-year trial from 1999 to 2001 in Karaj, Iran. Treatments included 9 levels of urea application in two methods (foliar application and top dressing). The results indicated that foliar application of urea had a significant effect on yield. Rates of urea application significantly influenced the straw yield of BRRI dhan46 (Table 02). The highest straw yield (6.99 t/ha) was observed by U_4 (200 kg/ha) and the lowest straw yield (5.21 t/ha) was found by U_5 (220 kg/ha). The highest straw yield in U_4 (200 kg/ha) might be the contribution of total number of tillers/hill. The interaction of methods and rates of urea fertilizer showed significant influence on straw yield (t/ha). However, the highest straw yield (6.99 t/ha) was found from the interaction of M_1U_4 (split of urea @ 200 kg/ha) and M_2U_4 (spray of urea @ 200 kg/ha) and they are statistically similar with the combination of M_1U_1 (split of urea @ 140 kg/ha) and M_2U_2 (spray of urea @ 160 kg/ha). Least straw yield (5.04 t/ha) was found from the combination of M_2U_5 (spray of urea @ 220 kg/ha) (Table 03). Sarkar et al. (2001) reported that application of nitrogen increased straw yield significantly up to 120 kg N ha^{-1}. Singh et al. (2000) claimed each incremental dose of nitrogen gave significantly higher straw yield.

Biological yield (t/ha)

Biological yield was not significantly varied due to different methods of urea fertilizer application (Table 01). Apparently, the highest biological yield (10.90 t/ha) was observed with split urea application than spray application method (10.46 t/ha). From Table 02, it is noticed that, biological yield of BRRI dhan46 was influenced significantly by rates of urea fertilizer. The highest biological yield (12.19 t/ha) was obtained from the rate U_4 (200 kg/ha) while the lowest biological yield (8.34 t/ha) was found by U_5 (220 kg/ha) urea rates positively influenced grain yield and straw yield which

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in turn increased the biological yield. From Table 03 it is observed that the biological yield of BRRI dhan 46 was influenced by the interaction of rates and methods of urea fertilizer application. Highest biological yield (12.41 t/ha) was found from the interaction of M_1U_4 (Split of urea @ 200 kg/ha) it was statistically followed by the combination of M_1U_1 (split of urea @ 140 kg/ha) and M_2U_4 (spray of urea @ 200 kg/ha). The interaction combination M_2U_5 (spray of urea @ 220 kg/ha) is responsible for the least biological yield (7.92 t/ha). Mandal & Swamy (2003) found that application of N (120 kg ha^{-1}) as urea in equal splits during transplanting, tillering, panicle initiation and flowering resulted in the highest number of panicles, number of filled grains $panicle^{-1}$, 1000 grain weight, straw yield and harvest index.

Harvest index (%)

Method of urea fertilizer application exhibited significant differences in harvest index (%) of BRRI dhan46 (Table 01). The higher harvest index (42.53%) was observed with split method which was significantly superior to spray method of urea application (41.07%). Urea rates had significant effect on harvest index (Table 02). The highest harvest index (44.79%) was found with the rate U_2 (160 kg/ha) on the other hand, the lowest harvest index (37.28%) was obtained from the rate U_5 (220 kg/ha). Sarkar et al. (2001) obtained the nitrogen responses of a *Japonica* (Yumelvitachi) and an *Indica* (Takanari) rice variety with different nitrogen levels viz. 0, 40, 80 and 20 kg N ha^{-1}. They observed that application of nitrogen increased grain and straw yields significantly but harvest index was not increased significantly. The interaction of rates and methods of urea application for BRRI dhan46 showed significant influence on harvest index (Table 03). Highest Harvest Index (45.99%) was found from M_1U_2 (split of urea @ 160 kg/ha) which was statistically followed with the combination of M_2U_1 (spray of urea @ 140 kg/ha), M_2U_2 (spray of urea @ 160 kg/ha) and M_1U_4 (split of urea @ 200 kg/ha). The least harvest index (36.12%) was observed from the interaction of M_2U_5 (spray @ 220 kg/ha).

IV. Conclusion

It can be concluded that transplanted aman rice *cv.* BRRI dhan46 may be fertilized with the rate of U_1 (urea) @ 140 kg/ha for getting higher yield in the aman season. Method of application is very important particularly in case of nutrient like nitrogen which is essential for different growth stages of the crop. The result discussed in this experiment shows that split method of urea application support higher grain yield (4.66 t/ha) compared with the spray method. So, split method is better than spray method. Among the five rates of urea the result revealed that, U_1 (140 kg/ha), U_2 (160 kg/ha), and U_4 (220 kg/ha) produced the identical but highest grain yield. Therefore, 140 kg urea/ha(U_1) may be suggested to grow BRRI dhan46 because this rate is economically and ecologically sustainable than the others.Interaction of treatment combination M_1U_1 (split of urea @ 140 kg/ha) is revealed significantly better over all the tested treatment. Though in few specific parameter, the interaction combination M_1U_4 (split of urea @ 200 kg/ha) was found to possess significantly higher result but this treatment run with higher level of nitrogen application, effect of such treatment is not altogether stable in all characteristics so, this treatment combination is recommendable for cultivation of aman rice. Fertilizer dose selection and the method of fertilizer application should be experimented for the judicial and optimum use of fertilizer to obtain better result for specific crop under its cultivation environment.

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Table 01. Effect of methods of urea application on the yield and yield components BRRI dhan46

Methods of urea application	Plant height (cm)	No. of total tillers/hill	No. of effective tillers/hill	Panicle length (cm)	No. of grains/panicle	Weight of 1000 grains (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
M_1 (Split)	114.05	14.00	10.93	25.74	159.29	24.93	4.66	6.24	10.90	42.53
M_2 (Spray)	113.99	13.51	10.59	25.47	143.86	24.63	4.34	6.12	10.46	41.07
CV (%)	*4.67*	*6.69*	*5.42*	*4.49*	*2.87*	*3.52*	*4.90*	*5.28*	*4.23*	*3.94*
Level of Significance	*NS*	**	**	*NS*	**	*NS*	**	**	*NS*	**

** = Significant at 1% level of probability, NS = Not significant, M_1 = Split method and M_2 = Spray method

Table 02. Effect of rates of urea application on the yield and yield components BRRI dhan46

Rates of urea (kg/ha)	Plant height (cm)	No. of total tillers/hill	No. of effective tillers/hill	Panicle length (cm)	No. of grains/panicle	Weight of 1000 grains (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
U_1	115.44a	14.49a	12.01a	25.73	160.76a	24.75	5.07a	6.61b	11.68b	43.46ab
U_2	114.28a	14.92a	11.68a	25.72	151.40b	24.73	5.10a	6.30b	11.40b	44.79a
U_3	116.21a	12.69b	9.66b	24.94	145.16c	24.78	4.01b	5.80c	9.81c	40.82c
U_4	115.99a	15.19a	12.16a	25.90	161.85a	24.51	5.20a	6.99a	12.19a	42.65b
U_5	108.17b	11.49c	8.28c	25.72	138.71d	25.15	3.13c	5.21d	8.34d	37.28d
CV (%)	*4.67*	*6.69*	*5.42*	*4.49*	*2.87*	*3.52*	*4.90*	*5.28*	*4.23*	*3.94*
Level of Significance	**	**	**	*NS*	**	*NS*	**	**	**	**

** = Significant at 1% level of probability, NS = Not significant, In a column figures with same letter or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), U_1 = 140 kg/ha, U_2 = 160 kg/ha, U_3 = 180 kg/ha, U_4 = 200 kg/ha and U_5 = 220 kg/ha of urea

Table 03. Effect of interaction between rates and methods of urea application on the yield and yield components BRRI dhan46

Method (M) × Rate (U) of urea fertilizer	Plant height (cm)	No. of total tillers/hill	No. of effective tillers/hill	Panicle length (cm)	No. of grains/panicle	Weight of 1000 grains (g)	Grain yield (t/ha)	Straw yield (t/ha)	Biological yield (t/ha)	Harvest index (%)
M_1U_1	117.48	15.60a	12.42	26.25	169.27a	25.57a	5.15ab	6.86a	12.01ab	42.89b
M_1U_2	112.85	14.58ab	11.94	25.76	148.75cd	24.59ab	5.09ab	6.00cd	11.09c	45.99a
M_1U_3	115.70	12.31cde	9.50	24.95	158.80b	24.38ab	4.26c	5.98cd	10.24d	41.64bc
M_1U_4	115.93	15.62a	12.22	25.62	172.91a	24.33ab	5.42a	6.99a	12.41a	43.69ab
M_1U_5	108.27	11.89de	8.56	26.11	146.72d	25.80a	3.38e	5.38ef	8.76e	38.44de
M_2U_1	113.41	13.38bc	11.59	25.22	152.25bcd	23.93b	5.00b	6.36bc	11.36bc	44.03ab
M_2U_2	115.71	15.26a	11.43	25.69	154.06bc	24.87ab	5.10ab	6.60ab	11.70bc	43.60ab
M_2U_3	116.73	13.07cd	9.82	24.93	131.52e	25.18ab	3.75d	5.63de	9.38e	40.00cd
M_2U_4	116.05	14.77ab	12.09	26.19	150.79cd	24.69ab	4.98b	6.99a	11.96ab	41.61bc
M_2U_5	108.06	11.08e	8.00	25.33	130.71e	24.50ab	2.88f	5.04f	7.92f	36.12e
CV (%)	*4.67*	*6.69*	*5.42*	*4.49*	*2.87*	*3.52*	*4.90*	*5.28*	*4.23*	*3.94*
Level of Significance	*NS*	*	*NS*	*NS*	**	**	*	**	*	*

* = Significant at 5% level of probability, ** = Significant at 1% level of probability, NS = Not significant, In a column figures with same letter(s) or without letter do not differ significantly whereas figures with dissimilar letter differ significantly (as per DMRT), M_1U_1 = Split method x 140 kg/ha, M_1U_2 = Split x 160 kg/ha, M_1U_3 = Split x 180 kg/ha, M_1U_4 = Split x 200 kg/ha, M_1U_5= Split x 220 kg/ha, M_2U_1 = Spray x 140 kg/ha, M_2U_2 = Spray x160 kg/ha, M_2U_3 = Spray x 180 kg/ha, M_2U_4 = Spray x 200 kg/ha and M_2U_5 = Spray x 220 kg/ha urea used and CV (%) = Co efficient of variation

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