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Soil and foliar application of nitrogen for Boro rice (BRRIdhan 29)

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Abstract

An experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during Boro season of 2008 with a view to examining the effect of soil and foliar application of urea on the yield and nutrient uptake of BRRIdhan 29 and to evaluate whether urea foliar application (FA) could replace its soil application (SA) in the rice cultivation. The experiment was laid out in a randomized complete block design (RCBD) with eight treatments, each treatment replicated thrice. The treatments were: T_1 (control), T_2 (282 kg urea ha^{-1} SA), T_3 (1% urea solution FA), T_4 (2% urea solution FA), T_5 (3% urea solution FA), T_6 (94 kg urea ha^{-1} SA + 1% urea solution FA), T_7 (94 kg urea ha^{-1} SA + 2% urea solution FA) and T_8 (94 kg urea ha^{-1} SA + 3% urea solution FA). The results showed that soil and foliar application of nitrogen significantly influenced the growth and yield of crop. The treatment T_2 (282 kg urea ha^{-1}) produced the highest grain yield (5.34 t ha^{-1}). The T_6 (94 kg urea ha^{-1} + 1% urea solution FA) produced the highest straw yield (6.58 t ha^{-1}) of the crop. The lowest grain yield (3.20 t ha^{-1}) and the lowest straw yield (4.19 t ha^{-1}) were recorded with T_1 (control). Economic analysis showed that treatment T_2 gave the highest marginal benefit cost ratio (7.65) while the lowest value (2.71) was observed with T_5 treatment. The overall results demonstrated that soil application of 282 kg urea ha^{-1} was the best treatment for obtaining higher grain yield, higher nitrogen content of rice and higher marginal benefit cost ratio, and soil application is better than foliar application of urea.

Keywords: Urea, Nitrogen, Foliar application, Soil application

Introduction

Nitrogen is one of the major plant nutrients required for plant growth. For maximizing yield of rice, nitrogenous fertilizer is the kingpin in rice farming. It is essential for the synthesis of protein, which is the constituent of protoplasm and chloroplasts. It is a constituent of numerous important compounds found in living cells, including amino acid, protein (enzymes), nucleic acid and chlorophyll (Traore and Maranville, 1999). This element is the most essential element in determining the yield potential of intensified agriculture system (Mae, 1997). But nitrogen use efficiency is very low and the recovery of N in wetland rice seldom exceeds 40% (De Datta and Buresh, 1989). Many factors determine the fertilizer efficiency for rice crop during cultivation such as soil, cultivar, season, environment, planting time, water management, weed control, cropping pattern, source, form, rate, time of application and method of application (De Datta, 1978). In many cases aerial spray of nutrients is preferred and gives quicker and better results than the soil application (Jamal *et al*., 2006). Recently foliar application of nutrients has become an important practice in the production of crops while application of fertilizers to the soil remains the basic method of feeding the majority of the crop plants. In this aspect, the present study was, therefore, undertaken to see the effect of soil and foliar application of urea on BRRIdhan 29.

Materials and Methods

The experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University, Mymensingh during Boro season of 2009 with a view to evaluating the effect of foliar and soil application of urea-N on the yield and nutrient uptake of BRRIdhan 29. The soil belongs to the Sonatala soil series under the AEZ of Old Brahmaputra Floodplain. The soil was silty loam in texture having pH 6.8, organic matter content 1.82%, total N 0.096%, available P 8.0 ppm, exchangeable K 0.12 me/100 g soil and available S 13.0 ppm. The experiment was laid out in a randomized complete block design (RCBD) with eight treatments and three replications. The treatments combinations were: T_1 (control), T_2 (282 kg urea ha^{-1} SA), T_3 (1% urea solution FA), T_4 (2% urea solution FA), T_5 (3% urea solution FA), T_6 (94 kg urea ha^{-1} SA + 1% urea solution FA), T_7 (94 kg urea ha^{-1} SA + 2% urea solution FA), T_8 (94 kg urea ha^{-1} SA + 3% urea solution FA) where as SA means soil application and FA means foliar application. The amounts of urea applied were: 0, 282, 100, 200, 300, 169, 244, 319 kg ha^{-1}, respectively. The total number of unit plots was 24 and the size of unit plot was 4m × 2.5m. Full doses of P, K and S were applied to soil as basal @ 26, 60 and 10 kg ha^{-1}, respectively, during final land preparation. In T_2, urea @ 282 kg ha^{-1} was applied in 3 equal splits at 10, 30 and 55 DAT. For T_3, T_4 and T_5 treatments, foliar urea was applied at 10 days after transplanting for the 1st time, then at 15-day intervals for the 2nd, 3rd and 4th times. For T_6, T_7 and T_8 treatments, 94 kg urea was applied after 10 DAT, followed by three sprays at 15-day intervals. In each case of foliar spray, 2.5 L of urea solution was applied in 10 m^2 plot (2500 L ha^{-1}). Forty days old seedlings were transplanted in the experimental plots with three seedlings hill^{-1} with plant spacing of 15 cm × 20 cm. Intercultural operations were done whenever required. At maturity, the crop was harvested. Grain yield was recorded on 14% moisture basis and straw yield on sun-dry basis. The grain and straw samples were analyzed for nitrogen concentration. The nitrogen uptake was calculated from the N concentration and yield data. All the data were statistically analyzed by F-test and the mean differences were adjudged by Duncan's Multiple Range Test (DMRT).

Results and Discussion

The yield contributing characters such as plant height, panicle length, number of effective tillers hill^{-1} and number of grains panicle^{-1} of BRRIdhan 29 responded significantly to the treatments (Table 1). The tallest plant (79.0cm) was observed in treatment T_6 (94 kg urea ha^{-1} SA + 1% urea FA) which was statistically similar to all other treatments except T_1 and T_3. The shortest plant (65.6 cm) was recorded with T_1 (control) treatment. The maximum number of effective tillers hill^{-1} (12.7) was found in T_8 (94 kg urea ha^{-1} SA + 3% urea FA) which was statistically identical to the treatments T_2, T_5 and T_7 with the values of 12.1, 11.3, 11.1, respectively. The lowest number of tillers hill^{-1} (6.9) was found in T_1 (control). The panicle length varied from 20.6 cm to 24.7 cm due to different treatments. The largest panicle was observed in T_2 (282 kg urea ha^{-1} SA). The shortest panicle was obtained in T_1 (control) treatment. The number of grains panicle^{-1} varied significantly from 88.3 to 141.5. The highest number of grains panicle^{-1} was found in T_6 (94 kg urea ha^{-1} SA + 1% urea solution FA) and the lowest number in T_1 (control). Chopra and Chopra (2004) reported that nitrogen had significantly effects on yield attributes such as plant height, panicle plant^{-1} and 1000-seed weight with increasing levels of N up to 120 kg N ha^{-1} in rice.

Table 1. Effects of soil and foliar application of urea on the yield contributing characters of BRRIdhan 29

Treatment	Plant height (cm)	No. of effective tillers hill^{-1}	Panicle length (cm)	No. of grains panicle^{-1}	1000- grain weight (g)
T_1 (Control)	65.6 c	6.9 d	20.6 c	88.3 c	21.7
T_2 (282 kg urea ha^{-1} SA)	78.4 ab	12.1 a	24.7 a	134.4 a	22.20
T_3 (1% urea solution FA)	73.3 b	8.8 c	22.6 b	110.6 ab	22.1
T_4 (2% urea solution FA)	75.2 ab	10.0 bc	24.10 a	137.1 a	22.0
T_5 (3% urea solution FA)	76.5 ab	11.3 ab	23.5 ab	127.2 ab	22.3
T_6 (94 kg urea ha^{-1} SA + 1% urea solution FA)	79.0 a	10.0 bc	24.1 a	141.5 a	21.8
T_7 (94 kg urea ha^{-1} SA + 2% urea solution FA)	77.5 ab	11.1 ab	23.8 ab	123.8 ab	22.1
T_8 (94 kg urea ha^{-1} SA + 3% urea solution FA)	78.5 ab	12.7 a	24.1 ab	133.9 a	21.4

Figures in a column having common letter(s) do not differ significantly at 5% level of significance.

Soil and foliar application of urea showed significant influence on grain yield of BRRIdhan 29 (Table 2). The highest grain yield (5.34 t ha^{-1}) was recorded in T_2 (282 kg urea ha^{-1} SA) and the lowest yield (3.20 t ha^{-1}) in T_1 (control). Treatments T_4 and T_7 gave statistically similar yield but identical to T_2. The grain yields due to different treatments may be ranked in the order of $T_2 > T_7 > T_4 > T_6 > T_8 > T_5 > T_3 > T_1$.Duhan and Singh (2002) showed that the yield and uptake were always higher with 120kg ha^{-1} than the lower rate of N. Chopra and Chopra (2000) reported that application of either 80 or 120 kg N ha^{-1} improved the entire yield attributes compared with control. Results on grain yield reveal that application of 1% urea solution alone (46 kg N ha^{-1}) is not enough to produce good yield (4.09), while with 94 kg urea soil application (112.24 kg N ha^{-1}) the performance was better but still the yield were lower than that obtained with soil application alone (T_2). The reason might be a lower level of N for a successful plant growth. On the other hand, 3% urea alone also showed poor performance compared to soil application of urea (T_2) and even with 2% urea solution (T_4 and T_7). The reason might be a higher level of N for successful plant growth which causes negative effect. However, 2% urea solution (92 kg N ha^{-1}) gave a statistically comparable yield with soil application of 130 kg N ha^{-1}. When it is applied alone (T_4) 38 kg N (82 kg urea) could be saved while when with soil application of 94 kg urea (T_7) then 17 kg N (38 kg urea) could be saved. These two treatments could be alternative of soil application.

Table 2. Effects of soil and foliar application of urea on the grain and straw yield of BRRIdhan 29

Treatments	Grain yield		Straw yield	
	t ha^{-1}	% increase over control	t ha^{-1}	% increase over control
T_1 (Control)	3.20 e	-	4.19 c	-
T_2 (282 kg urea ha^{-1} SA)	5.34 a	66.9	6.44 a	53.7
T_3 (1% urea solution FA)	4.09 d	27.8	5.41 b	29.1
T_4 (2% urea solution FA)	5.04 ab	57.5	6.12 ab	46.1
T_5 (3% urea solution FA)	4.38 cd	36.9	6.06 ab	44.6
T_6 (94 kg urea ha^{-1} SA + 1% urea solution FA)	4.77 bc	49.06	6.58 a	57
T_7 (94 kg urea ha^{-1} SA + 2% urea solution FA)	5.18 ab	61.9	6.34 a	51.3
T_8 (94 kg urea ha^{-1} SA + 3% urea solution FA)	4.63 bcd	44.68	6.47 a	54.4

Figures in a column having common letter(s) do not differ significantly at 5% level of significance.

The grain N content varied from 0.97 to 1.17%. The grain content was the highest in T_5 (3% urea FA). The control treatment (T_1) recorded the lowest grain N content. The N content in straw varied significantly due to different treatments. The straw N content ranged from 0.57 to 0.78%, with the highest value observed in T_7 (94 kg urea ha^{-1} SA + 2% urea FA) and the lowest N content in T_1 (control). The N uptake by grain and straw of BRRIdhan 29 was significantly influenced by the different treatment combinations. The total uptake of N by grain and straw varied from 55.00 kg ha^{-1} to 109.77 kg ha^{-1}. The highest total N uptake was observed in T_2 (282 kg urea ha^{-1} SA) and the lowest N uptake in T_1 (control). Prasad *et al.* (2007) reported that N at 120 kg ha^{-1} resulted in higher N uptake compared to lower N levels.

Table 3. Effects of soil and foliar application of urea on nitrogen concentration and uptake of BRRIdhan 29

Treatments	N concentration (%)		N uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total
T_1 (Control)	0.97	0.57 c	31.19 c	23.84 d	55.00 c
T_2 (282 Kg urea ha^{-1} SA)	1.14	0.75 a	61.01 a	48.74 a	109.76 a
T_3 (1% urea solution FA)	1.03	0.67 b	42.47 b	36.69 c	79.16 b
T_4 (2% urea solution FA)	1.00	0.77 a	50.74 ab	47.17 a	97.93 a
T_5 (3% urea solution FA)	1.17	0.73 ab	51.39 ab	44.42 ab	95.80 a
T_6 (94 kg urea ha^{-1} SA + 1% urea solution FA)	1.14	0.61 c	54.81 a	40.01 bc	94.83 a
T_7 (94 kg urea ha^{-1} SA + 2% urea solution FA)	1.10	0.78 a	57.23 a	49.69 a	106.93 a
T_8 (94 kg urea ha^{-1} SA + 3% urea solution FA)	1.09	0.72 ab	50.72 ab	46.84 a	97.56 a

Figures in a column having common letter(s) do not differ significantly at 5% level of significance.

The economic performance of different treatments was evaluated through economic analysis. The analysis showed that the highest gross return (Tk 81790) was obtained from T_2 and the lowest one (Tk 49923) was from T_1 treatment. The analysis also showed that the highest variable cost was obtained in T_5 (Tk 5200) and the lowest one in treatment T_3 (Tk 2800). Marginal gross margin also varied due to different treatments. The highest marginal gross margin was obtained (Tk 28183) from T_2 treatment and the lowest one (Tk 11234) was obtained from T_3 treatment. The highest and lowest marginal benefit cost ratio was recorded from the treatment T_2 (7.65) and T_5 (2.71), respectively. Sudhakar *et al.* (2001) found that there was a significant increase grain yield, straw yield, net return and B:C ratio with each increment of nitrogen application up to 125 kg ha^{-1}.

The overall results indicate that T_2 treatment (282 kg urea ha^{-1}) gave the highest yield. Treatments T_4 and T_7 gave a statistically comparable yield with treatment T_2. These two treatments could be alternative of soil application. But in these two treatments, total variable cost is higher (Tk 4000 and Tk 4228, respectively) than that in T_2 treatment (Tk 3684). On the other hand, marginal benefit cost ratio was the highest in T_2 treatment (7.65). From the above discussion it can be stated that treatment T_2 is the best in terms of obtaining higher grain yield and from the economic point of view, and soil application is not replaceable by foliar application.

Table 4. Economic analysis of BRRIdhan 29 production

Treatment	Gross return (Tk ha^{-1})	TVC (Tk ha^{-1})	Gross margin (Tk ha^{-1})	Marginal gross margin (Tk ha^{-1})	MBCR
T_1 (Control)	49923	-	49923	-	-
T_2 (282 Kg urea ha^{-1} SA)	81790	3684	78106	28183	7.65
T_3 (1% urea solution FA)	63957	2800	61157	11234	4.01
T_4 (2% urea solution FA)	77310	4000	73310	23387	5.84
T_5 (3% urea solution FA)	69225	5200	64025	14102	2.71
T_6 (94 kg urea ha^{-1} SA + 1% urea solution FA)	75335	3328	72007	22084	6.63
T_7 (94 kg urea ha^{-1} SA + 2% urea solution FA)	79595	4228	75367	25444	6.01
T_8 (94 kg urea ha^{-1} SA + 3% urea solution FA)	73352	5128	68224	18301	3.56

TVC: Total variable cost
MBCR: Marginal benefit cost ratio

Conclusion

The application of 282 kg urea ha^{-1} is the best treatment in terms of both obtaining higher grain yield and economic performance. The results of the study also indicate that soil application is better than foliar application. However, further investigation is necessary to draw a definite conclusion.

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