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Effects of reduced rates of fertilizers on N, P, K, S, and Zn contents and uptakes in BRRI dhan29

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ABSTRACT

An experiment was carried out at the Soil Science field laboratory of Bangladesh Agricultural University, Mymensingh during Boro season of 2014 to study the effects of reduced rates of fertilizers on N, P, K, S and Zn contents and uptakes in BRRI dhan29 rice. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The treatments were categorized as T_1: control, T_2: Recommended Fertilizer Dose (RFD), T_3: 60% of RFD, T_4: 70% of RFD, T_5: 80% of RFD, T_6: 90% of RFD, T_7: 110% of RFD. The recommended fertilizer doses applied for the experiment were 100 kg N ha^{-1}, 15 kg P ha^{-1}, 50 kg K ha^{-1}, 15 kg S ha^{-1} and 1.5 kg Zn ha^{-1}. Nitrogen, phosphorus, potassium, sulphur and zinc were supplied from urea, TSP, MoP, gypsum and zinc sulphate respectively. The full doses of TSP, MoP, gypsum and zinc sulphate were applied as basal dose during final land preparation while urea was applied in three equal splits. The grain and straw yields of BRRI dhan29 were significantly affected due to different treatments. The highest grain yield of 5.12 t ha^{-1} was observed in T_5 which was statistically identical to those recorded in the treatments T_2, T_6 and T_7. The maximum traits of nutrient content by grain and straw and uptake by grain, straw and total had also higher in T_5. Effective tillers $hill^{-1}$, filled grains $panicle^{-1}$, unfilled grains $panicle^{-1}$ and 1000-grains weight were also higher in T_5. However, plant height and panicle length were higher in T_5 which considered better than RFD and other treatments. The result obtained clearly indicated that to increase the crop yield 80% of RFD may be practiced instead of 100% RFD for higher grain yield from BRRI dhan29.

Key words: BRRI dhan29, fertilizers, N, P, K, S, and Zn contents, uptakes.

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INTRODUCTION

Bangladesh is mainly an agro based country. Rice (*Oryza sativa* L.) is the world's single most important food crop, being the primary food source for more than one third of the world's population, and grown in 11% of the world's cultivated area (Khush, 1993). In Bangladesh majority of food grains come from rice. About 80% of cropped area of this country is used for rice production, with annual production of 43729000 metric tons (IRRI, 2006) in total acreage of 1, 10, 59.000 ha. The average yield of rice in Bangladesh is 3.90 t ha^{-1} (BRRI, 2007). Nitrogen, phosphorus and potassium are the primary macronutrients and can play key roles to increase the production of rice to a great extent. Among the plant nutrients, nitrogen is one that deserves special attention because of its large requirement by crop and instability in soil. Nitrogen has a positive influence on growth, yield and yield components of rice process of photosynthesis, N-fixation, flowering, fruiting and maturation. Phosphorus is widely deficient in Bangladesh soils. Potassium is one of the primary nutrient elements for plant. Potassium is necessary for several basic physiological functions, such as the synthesis of protein and starch, normal cell division and growth (Ram, et al. 1999). Its deficiency may greatly reduce crop yield. However, nutrient deficiencies can be corrected by the judicial application of chemical fertilizers. Continuous application of chemical fertilizers accelerates the depletion of soil organic matter and impairs physical and chemical properties of soil in addition to micronutrient deficiencies. Now it is true that use of fertilizers stands as a major factor for environmental pollution. Large scale use of chemical fertilizers has created a potential health hazard, has reduced microbial population and

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earthworm activities, affecting soil health and has reduced utility of water bodies for men, animals and fishes (Bhuiyan et al. 1999). In addition, chemical fertilizers are always expensive inputs for crop production, especially in a developing country like Bangladesh. Chemical fertilizers are likely to be even more costly in near future. The actual recommended rates of N, P, K, S and Zn not only maintain soil health for sustainable agriculture but also save part of the cost of crop production. In addition, global environmental pollution can be reduced by application of reduced rates of fertilizers. Considering the above points, the present study was undertaken to evaluate the effects of reduced rates of N, P, K, S and Zn on the yield and yield contributing characters of BRRI dhan29 and to find out the effects of reduced rates of N, P, K, S and Zn on the nutrient content and uptake by BRRI dhan29.

MATERIALS AND METHOD

Study area

The experiment was carried out at the Soil Science field laboratory of Bangladesh Agricultural University, Mymensingh during Boro season of 2014. The experimental area belongs to sub-tropical climate and is characterized by high temperature and moderately high rainfall during Kharif season (April to September) and low temperature in Rabi season (October to March).

Treatments

There were seven treatments such as T_1: control, T_2: Recommended Fertilizer Dose (RFD), T_3: 60% of RFD, T_4: 70% of RFD, T_5: 80% of RFD, T_6: 90% of RFD, T_7: 110% of RFD. Recommended Fertilizer Dose (RFD) = 100 kg N ha^{-1}, 15 kg P ha^{-1}, 50 kg K ha^{-1}, 15 kg S ha^{-1} and 1.5 kg Zn ha^{-1}. The sources of N, P, K, S and Zn nutrients were urea, TSP, MoP, gypsum and zinc sulphate, respectively.

Test crop

The recommended high yielding variety BRRI dhan29 was used as a test crop. This variety was released by the Bangladesh Rice Research Institute (BRRI), Joydebpur, Gazipur in 2008 after regional and zonal trials and evaluation. During boro season insect and disease invasion is very low and it is resistant to blast disease. The life cycle of this variety ranges from 145 to 155 days (BRRI, 2008). The seedlings were collected from Soil Science Field Farm, Bangladesh Agricultural University, Mymensingh.

Experimental design

The experiment was laid out in a randomized complete block design (RCBD) with three replications of each treatment. Each replication is represented by a block. Each block was divided into seven unit plots for the selected treatment. There were 21 (7 x 3) unit plots and each unit plot size was 2.5 m x 4 m. The spacing between blocks was 1m and between plots was 0.5 m. The treatments were randomly distributed to unit plots in each block.

Land preparation

Land preparation was started on 10 January, 2014. The land was prepared by ploughing and cross ploughing with a power tiller. For raising the seedling, a previously prepared puddle land was selected for the seedling nursery. The sprouted seeds were broadcast on the prepared seedling nursery. Seeds were sown as uniformly as possible. Fourty day old seedlings were transplanted in the experimental plots on 23 January 2014. A distance of 20 cm from row to row and 20 cm from plant to plant was maintained. Three seedlings were used in each hill. The full dose of triple super phosphate (TSP), murite of potash (MoP), gypsum and zinc sulphate were applied at the time of final land preparation. The first split of urea was applied after 20 days of transplanting and second split of urea was applied after 40 days of transplanting at maximum tillering stage and third installment after 60 days of transplanting i.e. at panicle initiation stage. Intercultural operations were done for ensuring and maintaining the normal growth of the crop like irrigation, weeding, insect and pest controls.

Data collection

The crop was harvested at maturity on 03 May, 2014. After harvest, rice plants of three replicated treatments were bundled separately and carried to the laboratory and separated the grains from

panicles. The separated grains and straw were dried in the sun for 4 days. The sun dried weight of grain and straw plot^{-1} were taken (moisture up to 14%) and kept in brown paper bags for analysis of each treatment. From the 10 randomly selected hills plant height, number of tillers hill-^{1}, panicle length, filled and unfilled grains panicle^{-1}, 1000-grain weight, grain and straw were recorded.

Data analysis

The analysis of variance for crop parameters and also for nutrient contents and nutrient uptake by grain and straw were done following the principles of F statistics. The mean results with significant F-value were compared by the Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Nitrogen content

There was a significant effect of different reduced treatments on N concentration of both grain and straw of BRRI dhan29 (Table 1). Nitrogen content in grain varied from 1.08 to 1.18%. The treatment T_2 resulted the maximum N content in grain (1.18%) which was statistically similar to those recorded in the treatments T_3, T_4, T_5, T_6, and T_7 with values of 1.14, 1.15, 1.15, 1.15, 1.15 and 1.17 N, respectively. The minimum content of N (1.08%) was recorded in the control (T_1). The highest N uptake by straw was observed in T_2 and the lowest N uptake by straw was recorded in T_1 (control). The highest N content value (0.68%) was found in T_2 which was statistically close to T_5, T_6 and T_7 with the values of 0.61%, 0.65%, and 0.67% respectively.

Nitrogen uptake

The variations in nitrogen uptake due to the effect of reduced rate of various fertilizers are presented in table 1. The results indicated that the N uptake by grain and straw of BRRI dhan29 was significantly affected which varied from 33.048 to 60.77 kg ha^{-1}. The lowest N uptake (33.048 kg ha^{-1}) by grain was observed in the control. The highest N uptake (60.77 kg ha^{-1}) by grain was recorded in T_2 which was statistically similar to T_5, T_6 and T_7 with the uptake values of 58.65 and 58.88 and 60.021 kg ha^{-1} respectively.

In straw, the N uptake ranged from 18.396 to 43.792 kg ha^{-1}. The lowest N uptake (18.396 kg ha^{-1}) by straw was recorded in T_1 (control). The highest N uptake (43.792 kg ha^{-1}) by straw was observed in T_2 which was statistically similar to T_5, T_6 and T_7 with the N uptake values of 38.37, 41.34 and 42.88 kg ha^{-1}, respectively.

The uptake of total N due to different treatments ranged from 51.444 to 104.562 kg ha^{-1} (Table 1). The lowest total uptake of N (51.444 kg ha^{-1}) was noted in T_1 (control). The highest total N uptake (104.562 kg ha^{-1}) was recorded in T_2 which was statistically similar to T_5, T_6 and T_7 with the total N uptake values of 97.019 and 100.22, and 102.901 kg ha^{-1} respectively.

Phosphorus content

Data presented in table 2 indicated that phosphorus (P) content in both grain and straw of BRRI dhan29 was significant by the effect of different treatments of fertilizer reduced under this study. The P content in grain ranged from 0.152 to 0.202%. The highest P value (0.202%) was recorded in T_2 that statistically similar to T_5, T_6 and T_7 with values of 0.198, 0.200, 0.198. The lowest P value (0.152%) was noted in T_1. The P content in straw varied from 0.156 to 0.210% with highest P value (0.210%) was in T_2 and lowest P value (0.156%) in T_1 which was statistically similar to T_3 and T_4 (0.166 and 0.172, respectively). The results indicated that recommended fertilizer dose in grain and straw had pronounced effect on P content. Similar results were also obtained by Kadu et al. (1991).

Phosphorus uptake

The P uptake was significant in both grain and straw of BRRI dhan29 due to the effect of various fertilizer reduced treatments in the experiment (Table 2). The ranges of P uptake in grain were 4.65 to 10.40 kg ha^{-1}. The maximum P uptake (10.40 kg ha^{-1}) by grain was recorded in T_2 which was statistically similar to those recorded in the treatments T_5, T_6 and T_7 with the P content values of 10.098, 10.24 and 10.15 kg ha^{-1} respectively. The minimum P uptake (4.65 kg ha^{-1}) by grain was observed in T_1 which was significantly different from other treatments.

Table 1
Effects of reduced rates of fertilizers on N content and uptake by BRRI dhan29.

Treatments	N content (%)		N uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total
T_1: Control	1.08 b	0.42 d	33.048 d	18.396 c	51.444 c
T_2 : (RFD)	1.18 a	0.68 a	60.77 a	43.792 a	104.562 a
T_3: 60% of RFD	1.14 a	0.49 c	53.58 c	24.598 b	78.178 b
T_4: 70% of RFD	1.15 a	0.58 b	57.20 b	29.16 b	84.36 b
T_5:80% of RFD	1.15 a	0.61 ab	58.65 ab	38.37 a	97.019 a
T_6: 90% of RFD	1.15 a	0.65 ab	58.88 ab	41.34 a	100.22 a
T_7: 110% of RFD	1.17 a	0.67 a	60.021 a	42.88 a	102.901 a
SE(±)	0.01	0.04	3.70	3.79	7.19

Figures in a column having common letters do not differ significantly at 5% level of significance.
RFD = Recommended fertilizer dose
SE = Standard error of means

Table 2
Effects of reduced rates of fertilizers on P content and uptake by BRRI dhan29.

Treatments	P content (%)		P uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total
T_1: Control	0.152 d	0.156 c	4.65 d	6.83 d	11.48 d
T_2 : (RFD)	0.202 a	0.210 a	10.40 a	13.52 a	23.92 a
T_3: 60% of RFD	0.185 c	0.166 b	8.69 c	8.03 c	16.72 c
T_4: 70% of RFD	0.190 b	0.172 b	9.12 b	9.28 b	18.4 b
T_5:80% of RFD	0.198 a	0.182 ab	10.098 a	11.44 ab	21.53 ab
T_6: 90% of RFD	0.200 a	0.186 a	10.24 a	11.82 a	22.06 a
T_7: 110% of RFD	0.198 a	0.190 a	10.15 a	12.16 a	22.31 a
SE(±)	0.01	0.01	0.77	0.92	1.63

Figures in a column having common letters do not differ significantly at 5% level of significance
RFD = Recommended fertilizer dose
SE = Standard error of means

Table 3
Effects of reduced rates of fertilizers on K content and uptake by BRRI dhan29.

Treatments	K content (%)		K uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total
T_1: Control	0.142 d	0.672 c	4.345 d	29.433 c	33.778 c
T_2 : (RFD)	0.240 a	0.752 a	12.36 a	48.43 a	62.59 a
T_3: 60% of RFD	0.205 c	0.712 b	9.635 c	35.742 b	45.377 b
T_4: 70% of RFD	0.215 b	0.725 b	10.32 b	39.15 b	49.47 b
T_5:80% of RFD	0.225 ab	0.730 ab	11.475 ab	45.917 a	57.392 a
T_6: 90% of RFD	0.235 a	0.732 ab	12.032 a	46.555 a	58.587 a
T_7: 110% of RFD	0.237 a	0.734 ab	12.158 a	46.976 a	59.134 a
SE(±)	0.01	0.01	1.07	2.70	3.83

Figures in a column having common letters do not differ significantly at 5% level of significance
RFD = Recommended fertilizer dose; SE = Standard error of mean

Table 4
Effects of reduced rates of fertilizers on S content and uptake by BRRI dhan29.

Treatments	S content (%)		S uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total
T_1: Control	0.100 c	0.075 c	3.06 c	3.28 d	6.34 c
T_2 : (RFD)	0.143 a	0.101 a	7.364 a	6.50 a	13.864 a
T_3: 60% of RFD	0.110 c	0.085 b	5.17 b	4.267 c	9.437 b
T_4: 70% of RFD	0.123 b	0.090 b	5.28 b	4.86 b	10.14 b
T_5:80% of RFD	0.126 ab	0.095 a	6.426 ab	5.98 ab	12.406 a
T_6: 90% of RFD	0.127 ab	0.097 a	6.502 ab	6.17 a	12.672 a
T_7: 110% of RFD	0.127 ab	0.096 a	6.515 ab	6.14 a	12.655 a
SE(±)	0.005	0.003	0.53	0.46	0.98

Figures in a column having common letters do not differ significantly at 5% level of significance
RFD = Recommended fertilizer dose; SE = Standard error of means.

In case of straw, the P uptake varied from 6.83 to 13.52 kg ha^{-1} (Table 2). The highest P uptake (13.52 kg ha^{-1}) was recorded in T_2 which was statistically similar to those recorded in T_5 and T_6. The lowest P uptake (6.83 kg ha^{-1}) was found in T_1 which was significantly different from other treatments. The total P uptake by grain and straw was also affected significantly by the different treatments (Table 2). The total P uptake by BRRI dhan29 varied from 11.48 to 23.92 kg ha^{-1}. The highest total P uptake (23.92 kg ha^{-1}) was recorded in T_2 which was statistically close T_6 and T_7. The lowest value of total P uptake (11.48 kg ha^{-1}) was noted in T_1 which was statistically different from other treatments.

Potassium content

Potassium (K) content in both grain and straw was affected significantly by different fertilizer reduced treatments in this study (Table 3). It appears that the K content in grain varied from 0.142 to 0.240%. The highest K content (0.240%) was found in T_2 which was statistically similar to those recorded in the treatments T_6 and T_7 with the K content values of 0.235 and 0.237 respectively. The lowest K content (0.142%) was recorded in T_1 which was statistically different with other treatments.

The K content in straw had also significant as result of different fertilizer reduced treatments (Table 3). It was found that the K content varied from 0.672 to 0.752%. The highest K content in straw (0.752%) was found in T_2 which was statistically close to those recorded in the treatments T_5, T_6 and T_7 with values of 0.730, 0.732 and 0.734% respectively. The lowest K content (0.672%) was observed in T_1 which was statistically different with other treatments.

Potassium Uptake

Potassium uptake by BRRI dhan29 in both grain and straw was significantly influenced by various treatments of reduced fertilizer (Table 3). The K uptake by grain varied from 4.345 to 12.36 kg ha^{-1}. The highest K uptake (12.36 kg ha^{-1}) by grain was noted in T_2 which was statistically similar to T_6 and T_7 with the K uptake values of 12.032 and 12.158 kg ha^{-1} respectively. The lowest uptake values of K (4.345 kg ha-^{1}) by grain were obtained in T_1.

In straw, uptake values of K ranged from 29.433 to 48.43 kg ha^{-1} (Table 3). The highest K uptake value of 48.43 kg ha^{-1} was observed in T_2 which was statistically similar to those recorded in T_5, T_6 and T_7 with the K uptake values of 45.917, 46.555 and 46.976 kg ha^{-1} respectively. The lowest K uptake (29.433 kg ha^{-1}) by straw was obtained in T_1. These result revealed that the K uptake by rice straw was much higher than that of K uptake by rice grain. The total K uptake by BRRI dhan29 was also significantly influenced by different fertilizer reduced treatments (Table 3). The total K uptake ranged from 33.778 to 62.59 kg ha^{-1}. The highest total K uptake (62.59 kg ha^{-1}) was observed in T_2 which was statistically similar to those recorded in T_5, T_6 and T_7 with the total uptake values of 57.392, 58.587 and 59.134 kg ha^{-1} respectively. The lowest total K uptake (33.778 kg ha^{-1}) was obtained in T_1 which was statistically different from other fertilizer reduced treatments. The present study revealed that

80% of RFD had pronounced effect on K content in both grain and straw which is in agreement with the findings of Sachdev et al. (1983).

Sulphur content

Results in the table 4 indicated that sulphur (S) content in both grain and the straw of BRRI dhan29 was significantly influenced by the different treatments used in the experiment. S content in grain ranged from 0.100 to 0.143%. The maximum S content (0.143%) in grain was found in T_2 which was statistically close to those recorded in the treatments T_5, T_6 and T_7 with the S content values of 0.126, 0.127 and 0.127. The lowest S content (0.100%) was recorded in T_1.

In case of straw, S content varied from 0.075 to 0.101%. The highest S content (0.101%) was recorded in T_2 which was statistically close to T_5, T_6 and T_7 with the S content values of 0.095, 0.097 and 0.096%. The lowest S content (0.075%) was found in T_1. It indicates that the smaller reduction of the fertilizers from the recommended fertilizer dose did not affect significantly in S content.

Sulphur uptake

Sulphur uptake by rice grain and straw as well as total uptake were significantly affected due to the different fertilizers reduced treatments (Table 4). The S uptake in grain varied from 3.06 to 7.364 kg ha^{-1}. The highest S uptake by grain (7.364 kg ha^{-1}) was obtained in T_2 and the lowest S uptake (3.06 kg ha^{-1}) by grain was observed in T_1 which were statistically different from other treatments.

In straw, S uptake ranged from 3.28 to 6.50 kg ha^{-1} (Table 4). The maximum S uptake (6.50 kg ha^{-1}) was observed in the treatment T_2 and the minimum S uptake (3.28 kg ha^{-1}) by straw was recorded in T_1 which were also statistically different from all other treatments. The total S uptake ranged from 6.34 to 13.864 kg ha^{-1}. The maximum total S uptake (13.864 kg ha^{-1}) was recorded in T_2 which was statistically similar to T_5, T_6 and T_7 with the total uptake values of 12.406, 12.672 and 12.655 kg ha^{-1} respectively. The lowest total S uptake (6.34 kg ha^{-1}) was observed in T_1 which was also statistically different from all other treatments. Sakal (1997) reported that concentration of S in grain and straw and its corresponding uptake increased with increasing rates of sulphur.

CONCLUSION

From the entire observation, it is distinct that the yield obtained from treatment T_2 (Recommended Fertilizer Dose), T_5 (80% of RFD) and T_6 (90% of RFD) is statistically similar. The treatment T_2 is recommended dose for the cultivation of BRRI dhan29 which provide the higher yield. But there is no significant yield difference among T_2, T_5, and T_6. T_2 treatment is comprised of 100% of RFD whereas, the treatment T_5 and T_6 are comprised of 80% and 90% of RFD respectively. So it is worth using 10% and 20% excess fertilizer which ultimately increases the cost of production. The present study suggest that the treatment comprises 80% RFD can be used to get highest yield from BRRI dhan29.

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