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ENHANCEMENT OF THE GROWTH AND YIELD OF RICE BY SPLIT APPLICATION OF PHOSPHORUS, POTASSIUM AND SULPHUR FERTILIZERS

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ABSTRACT

Dey BR, Rahman MM, Hoque MA (2014) Enhancement of the growth and yield of rice by split application of phosphorus, potassium and sulphur fertilizers. *J. Soil Nature* 7(1), 7-12.

A field experiment was conducted to investigate the effects of single and split applications of P, K and S fertilizers on the growth and yield of rice (cv. BRRI dhan29). Eight treatment combinations consisting of P, K and S fertilizers applied at different growth stages of rice crop. Split application of P, K and S fertilizers resulted significant increase in plant height, effective tillers, panicle length, filled grains and 1000-grain weight as well as grain and straw yields of rice. The highest grain (6.20 t/ha) and straw (7.75 t/ha) yields were produced by application of urea super granule (USG) at transplanting + 50% PKS at transplanting + 50% PKS at maximum tillering stage. PKS uptake by crop significantly increased due to the split application of fertilizers. Therefore, split application of P, K and S fertilizers along with USG exerted a beneficial effect on yield contributing characters, resulting in higher grain and straw yields of BRRI dhan29 in comparison to single application of those fertilizers during transplanting. The present study suggests that split application of PKS fertilizers along with USG-N might be recommended for profitable rice production in Bangladesh agriculture.

Key words: *phosphorus; potassium; sulphur; split application; rice growth*

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the major food crops in the world. In Bangladesh, rice covers about 80% of total cropped area producing 32.3 million tons of rice (AIS 2011). But the yield of rice in Bangladesh is low (3.43 t/ha) compared to other major rice producing countries of the world such as Australia, Korean Republic, Japan and Spain with rice yield 10.11, 5.72, 5.65 and 7.30 t/ha, respectively (FAO 2009).

Soil is the principal supplier of plant nutrients. Nitrogen, phosphorus, potassium and sulphur are major essential nutrient elements and play vital roles in crop growth and development. The role of nitrogenous fertilizer in increasing rice yield has widely been recognized. Phosphorus promotes plant root formation and development. Potassium is linked with plant physiology either directly or indirectly like photosynthesis, fats, carbohydrates, enzymes, etc. Sulphur helps chlorophyll formation and is an essential constituent of many proteins, enzymes and certain volatile compounds (Sharma 2007).

Farmers of Bangladesh generally apply urea fertilizer in splits, and still then the N use efficiency is very low (30-35%) in rice cultivation (IFDC 2007). Phosphorus, potassium and sulphur fertilizers are applied at a time during final land preparation. Although these fertilizers are readily available, they are slowly converted into unavailable forms. During the early growth stages, plants utilize the readily available forms of P, K and S but in the later growth stages there is a high possibility that plant suffers deficiency of those nutrients. Besides, luxurious vegetative growth due to excess supply of N might induce hidden hunger of other nutrients and split application of these nutrients could improve crop growth and yield (Sarmah and Baruah, 1997; Sengar *et al.* 2000; Kalita *et al.* 2002; Saha *et al.* 2008). Application of PKS in two equal splits at tillering and panicle initiation stages can favorably influence the yield and uptake of nutrients (Haque *et al.* 2001; Taher *et al.* 2002; Kumer *et al.* 2004; Saha *et al*. 2008). Therefore, the present study was undertaken to evaluate the effects of single and split application of PKS fertilizers on the growth and yield of rice as well as on the nutrient content and uptake by rice.

MATERIALS AND METHODS

The field experiment was carried out at the Soil Science Field laboratory of Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh during the boro (winter) season of 2011.

Soil physicochemical properties

Soils were collected from the Soil Science Field Laboratory, BAU and analyzed for some physicochemical properties. Characteristically, the soil was silt loam having pH 6.48, total N 0.15%, available P 12.80 ppm, exchangeable K 0.11 me/100g soil, available S 11.50 ppm and organic carbon 1.16%.

Plant materials and treatments

BRRI dhan29, a modern variety of rice, was used as test crop. Thirty-day-old healthy seedlings were transplanted in the experimental plots. Eight treatment combinations were used in the experiments.

T_0: Control (No fertilizer application)
T_1: 100% PKS at transplanting
T_2: 100% PK at transplanting + 50% S at transplanting + 50% S at maximum tillering

T_3: 100% PS at transplanting + 50% K at transplanting + 50% K at maximum tillering
T_4: 100% KS at transplanting + 50% P at transplanting + 50% P at maximum tillering
T_5: 50% PKS at transplanting + 50% PKS at maximum tillering
T_6: 25% N from cowdung at final ploughing + 75% N from urea (25% at transplanting + 25% at maximum tillering + 25% at panicle initiation stage)
T_7: 100% USG and 50% PKS at transplanting + 50% PKS at maximum tillering
In treatments T_1-T_5, 100% N was applied as prilled urea.
The amounts of N, P, K and S required for each plot were calculated as per their rates of application. Fertilizers were applied in splits according to the treatments. The experiment was laid out in a randomized complete block design with three replications.

Management practices, crop harvesting and data recording

Fertilization and other management practices were performed as and when required. The crops were harvested at full maturity. Grain and straw yields and plant parameters were recorded.

Chemical analysis of plant and soil samples

Plant and soil samples were analyzed at the Soil Science Laboratory, BAU. The P, K and S content in plant and soil were determined following standard methods.

Statistical analysis

Data were statistically analyzed by analysis of variance using MSTAT-C. The significance of differences between mean values was compared by Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Growth and yield components of rice

Results in Table 1 shows that growth and yield components of rice significantly responded to P, K and S fertilizers applied in splits at different growth stages. All the treatments showed significant increases in growth and yield contributing characters when compared to control treatment. Results reveal that the maximum plant height, effective tillers/hill, panicle length, filled grains/panicle and 1000-grain weight of BRRI dhan29 were recorded in the treatment T_7 where P, K and S were applied in splits along with 100% N as USG. Results also indicated that split application of P, K and S fertilizers resulted in an increase in yield contributing characters of BRRI dhan29 compared to single application of those fertilizers at transplanting stage (T_1). Similar to our results, several authors have demonstrated that split application of fertilizers P, K and S increased the growth and yield components of crops including rice. Sarmah and Baruah (1997) and Sengar *et al.* (2000) reported that split application of P, K and S increased vegetative growth of rice. Similar results were also observed by Kalita *et al.* (2002) and Saha *et al*. (2008).

Grain and straw yields of rice

Significant increases in grain and straw yields of BRRI dhan29 were observed in response to split application of PKS fertilizers (Table 2). All the treatments where fertilizers were applied either single or in split significantly produced higher grain and straw yields over control (Table 2). The highest grain yield of 6.20 t/ha was obtained in the treatment T_7 while the lowest grain yield of 3.79 t/ha was observed in the control treatment (T_0). The treatments could be ranked in order of T_7 (6.20 t/ha) > T_1 (5.67 t/ha) > T_5 (5.60 t/ha) > T_4 (5.47 t/ha) > T_2 (4.74 t/ha) >T_6 (4.67 t/ha) > T_3 (4.53 t/ha) >T_0 (control) in respect of grain yields. The straw yield due to the different treatments ranged from 4.73 to 7.75 t/ha. The highest straw yield of 7.75 t/ha (63.8% increase over control) was obtained from T_7 treatment (where 100% N from USG and 50% PKS at transplanting + 50% PKS at maximum tillering). The lowest straw yield of 4.73 t/ha was recorded in the control treatment. In terms of straw yield, the treatments could be ranked in the order of T_7 (7.75 t/ha) >T_1 (7.08 t/ha) >T_5 (7.00 t/ha) >T_4 (6.84 t/ha) >T_2 (5.93 t/ha) > T_6 (5.84 t/ha) >T_3 (5.66 t/ha) >T_0 (4.73 t/ha). Saha *et al*. (2008) and Kalita *et al*. (2002) reported that application of P in two splits increased plant height, effective tiller production, and grain and straw yields. Haque *et al.* (2001) and Taher *et al.* (2002) reported that phosphatic fertilizer in two splits increased grain and straw yields significantly. Similarly, Ghosh *et al.* (1995) and Saha *et al.* (2008) have demonstrated that split application of P and K increased growth and yield of rice significantly.

Table 1. Effects of single and split application of P, K and S fertilizers on growth and yield components of BRRI dhan29

Treatments	Plant height (cm)	No. of effective tillers/hill	Panicle length (cm)	No. of filled grains/panicle	No. of unfilled grains/panicle	1000-grain weight (g)
T_0	64.2b	9.2c	20.3d	78.0d	23.4a	20.1c
T_1	73.1ab	11.3b	21.7c	86.0bc	19.8ab	21.3ab
T_2	79.6a	13.1a	24.2ab	90.3ab	19.0b	22.1a
T_3	80.2a	10.6bc	23.8ab	90.0ab	20.9ab	20.8bc
T_4	80.6a	11.2b	24.3ab	90.7ab	17.3b	20.5bc
T_5	77.7a	10.3bc	23.8ab	88.3ab	16.9b	20.8bc
T_6	74.5ab	11.1b	23.0bc	82.0cd	17.7b	20.7bc
T_7	82.8a	13.2a	24.8a	92.3a	12.3c	22.2a
SE ±	1.68	0.31	0.45	1.73	0.98	0.22
CV (%)	2.20	2.79	1.94	1.99	5.31	1.04

Same letter(s) in a column do not differ significantly at 5% level of significance. SE (±) = Standard Error of Means, CV (%) = Co-efficient of Variance

T_0:Control (no fertilizer application); T_1:100% PKS at transplanting; T_2:100% PK at transplanting + 50% S at transplanting + 50% S at maximum tillering; T_3:100% PS at transplanting + 50% K at transplanting + 50% K at maximum tillering; T_4:100% KS at transplanting + 50% P at transplanting + 50% P at maximum tillering; T_5:50% PKS at transplanting + 50% PKS at maximum tillering; T_6: 25% N from cowdung at final ploughing + 75% N from urea (25% at transplanting + 25% at maximum tillering + 25% at panicle initiation stage); T_7:100% USG and 50% PKS at transplanting + 50% PKS at maximum tillering

Table 2. Effects of single and split application of P, K and S fertilizers on grain and straw yields of BRRI dhan29

Treatment	Grain yield		Straw yield	
	Yield (t/ha)	% yield increase over control	Yield (t/ha)	% yield increase over control
T_0	3.79d	-	4.73d	-
T_1	5.67b	49.6	7.08b	49.7
T_2	4.74c	25.1	5.93c	25.4
T_3	4.53c	19.5	5.66c	19.7
T_4	5.47b	44.3	6.84b	44.6
T_5	5.60b	47.8	7.00b	48.0
T_6	4.67c	23.2	5.84c	23.5
T_7	6.20a	63.6	7.75a	63.8
SE (±)	0.16	-	0.34	-
CV (%)	3.17	-	2.06	-

Same letter(s) in a column do not differ significantly at 5% level of significance. SE (±) = Standard Error of Means, CV (%) = Co-efficient of Variance

T_0:Control (no fertilizer application); T_1:100% PKS at transplanting; T_2:100% PK at transplanting + 50% S at transplanting + 50% S at maximum tillering; T_3:100% PS at transplanting + 50% K at transplanting + 50% K at maximum tillering; T_4:100% KS at transplanting + 50% P at transplanting + 50% P at maximum tillering; T_5:50% PKS at transplanting + 50% PKS at maximum tillering; T_6: 25% N from cowdung at final ploughing + 75% N from urea (25% at transplanting + 25% at maximum tillering + 25% at panicle initiation stage); T_7:100% USG and 50% PKS at transplanting + 50% PKS at maximum tillering

Nutrient contents and uptake by rice grain and straw

We measured the nutrient contents in grain and straw samples of rice whether spilt application of PKS fertilizers affected P, K and S contents. Thereafter, PKS uptake by grain and straw was calculated.

Phosphorus content and uptake by grain and straw

Phosphorus contents in rice grain and straw of BRRI dhan29 increased significantly due to the split application of PKS fertilizers (Table 3). The P content in rice grain ranged from 0.15% to 0.27% and the highest P content (0.27%) was observed in the treatment T_2. The lowest value of P content (0.15%) in rice grain was recorded in the T_6 treatment. Results also show that P content in rice grain was higher than that in rice straw.

There was a significant variation in P uptake by BRRI dhan29 due to the split application of PKS fertilizers. The highest P uptake by rice grain as well as by straw was found in treatment T_7 (100% N from USG and 50% PKS at transplanting + 50% PKS at maximum tillering). All the treatments showed significantly higher P uptake by rice grain over control. Raju (1999) reported that application of labeled P in 2-splits increased P uptake in grain

and straw over the application at transplanting and also showed that translocation of P to grain from the soil was higher than from fertilizer.

Table 3. Effect of single and split application of P, K and S fertilizers on P contents and uptake by BRRI dhan29

Treatment	P content (%)		P uptake (kg/ha)		
	Grain	Straw	Grain	Straw	Total
T_0	0.16b	0.05ef	6.06e	2.36c	8.43d
T_1	0.22a	0.07bcd	12.47b	4.96b	17.43b
T_2	0.27a	0.05def	12.80b	2.96c	15.76c
T_3	0.23a	0.08abc	10.42cd	4.53b	14.95c
T_4	0.21a	0.06cde	11.48bc	4.10b	15.60c
T_5	0.17b	0.09a	9.52d	6.30a	15.82c
T_6	0.15b	0.04f	7.00e	2.33c	9.34d
T_7	0.24a	0.09a	14.88a	6.98a	21.85a
SE (±)	0.007	0.004	0.575	0.558	1.034
CV (%)	3.39	4.99	5.43	7.52	5.74

Same letter(s) in a column do not differ significantly at 5% level of significance. SE (±) = Standard Error of Means, CV (%) = Co-efficient of Variance

T_0:Control (no fertilizer application); T_1:100% PKS at transplanting; T_2:100% PK at transplanting + 50% S at transplanting + 50% S at maximum tillering; T_3:100% PS at transplanting + 50% K at transplanting + 50% K at maximum tillering; T_4:100% KS at transplanting + 50% P at transplanting + 50% P at maximum tillering; T_5:50% PKS at transplanting + 50% PKS at maximum tillering; T_6: 25% N from cowdung at final ploughing + 75% N from urea (25% at transplanting + 25% at maximum tillering + 25% at panicle initiation stage); T_7:100% USG and 50% PKS at transplanting + 50% PKS at maximum tillering

Potassium content and uptake by grain and straw

Potassium contents in rice grain varied from 1.31 to 1.88% (Table 4). The maximum K content in rice grain (1.88%) was recorded from treatment T_1. The lowest value of K content (1.31%) in rice grain was observed in the T_6 treatment which was statistically similar to the treatments T_3 and T_0. The highest straw K content (1.77%) was recorded in treatment T_7 while the lowest (1.06%) was in the treatment T_2.

The potassium uptake by BRRI dhan29 was also influenced significantly due to the split application of PKS fertilizers. The maximum K uptake by both rice grain (106.6 kg/ha) and straw (137.2 kg/ha) was observed in the treatment T_7 due to the application of 100% N from USG and 50% PKS at transplanting + 50% PKS at maximum tillering. Kumer *et al.* (2004) showed a higher K uptake by rice due to the split application of N, P and K fertilizers. Improvement of K content in boro rice associated with increased P contents as reported by Singh *et al.* (2006).

Table 4. Effect of single and split application of P, K and S fertilizers on K contents and uptake by BRRI dhan29

Treatment	K content (%)		K uptake (kg/ha)		
	Grain	Straw	Grain	Straw	Total
T_0	1.57b	1.23c	59.50e	58.18d	117.7d
T_1	1.88a	1.65ab	106.6a	116.8b	223.4b
T_2	1.87a	1.06c	88.64c	62.86d	151.5c
T_3	1.58b	1.53b	71.57d	86.60c	158.2c
T_4	1.80a	1.65ab	98.46b	112.8b	211.3b
T_5	1.74a	1.59ab	97.44b	111.3b	208.7b
T_6	1.31c	1.60ab	61.18e	93.44c	154.6c
T_7	1.72ab	1.77a	106.6a	137.2a	243.8a
SE (±)	0.045	0.052	4.102	9.198	12.38
CV (%)	2.67	3.45	4.75	5.93	5.13

Same letter(s) in a column do not differ significantly at 5% level of significance. SE (±) = Standard Error of Means, CV (%) = Co-efficient of Variance

T_0:Control (no fertilizer application); T_1:100% PKS at transplanting; T_2:100% PK at transplanting + 50% S at transplanting + 50% S at maximum tillering; T_3:100% PS at transplanting + 50% K at transplanting + 50% K at maximum tillering; T_4:100% KS at transplanting + 50% P at transplanting + 50% P at maximum tillering; T_5:50% PKS at transplanting + 50% PKS at maximum tillering; T_6:25% N from cowdung at final ploughing + 75% N from urea (25% at transplanting + 25% at maximum tillering + 25% at panicle initiation stage); T_7:100% USG and 50% PKS at transplanting + 50% PKS at maximum tillering

Sulphur content and uptake by grain and straw

Sulphur content in rice grain was significantly influenced due to the split application of PKS fertilizers. The S contents in rice grain ranged from 0.12 to 0.20% (Table 5). The highest S content was observed in the treatment T_3 (100% PS and 50% K at transplanting + 50% K at maximum tillering) which was statistically similar to the treatments T_1, T_4, T_5 and T_7. The lowest S content in grain was recorded in the treatment T_6. The S content in rice straw varied from 0.14% to 0.19%. The highest value of 0.19% S was found in the treatment T_7 whereas the lowest value was in T_6 treatment.

Sulphur uptake by BRRI dhan29 significantly increased due to the application of PKS fertilizers at different growth stages. The highest S uptake (10.77 kg/ha) by grain and straw (14.72 kg/ha) was recorded in the treatments T_1 (100% PKS at transplanting) and T_7 (100% N from USG and 50% PKS at transplanting + 50% PKS at maximum tillering), respectively. The highest total S uptake was observed in the treatment T_7. Miller (1999) reported that the S content in rice grain improved by split application of PKS fertilizers. Hasaan and Olson (1996) observed that gypsum fertilizer increased S content in rice straw compared to application of other fertilizers.

Table 5. Effect of single and split application of P, K and S fertilizers on S contents and uptake by BRRI dhan29

Treatment	S content (%)		S uptake (kg/ha)		
	Grain	Straw	Grain	Straw	Total
T_0	0.16bc	0.15b	6.06cd	7.09d	13.16e
T_1	0.19a	0.17a	10.77a	12.04b	22.81b
T_2	0.15c	0.18a	7.11c	10.67bc	17.78d
T_3	0.20a	0.18a	9.06b	10.18c	19.25cd
T_4	0.17ab	0.17a	9.30b	11.62bc	20.93c
T_5	0.19a	0.18a	10.64a	12.60b	23.24b
T_6	0.12d	0.14b	5.60d	8.18d	13.78e
T_7	0.17ab	0.19a	10.54a	14.72a	25.26a
SE (±)	0.006	0.004	0.454	0.856	1.24
CV (%)	3.20	2.55	5.09	4.84	4.65

Same letter(s) in a column do not differ significantly at 5% level of significance. SE (±) = Standard Error of Means, CV (%) = Co-efficient of Variance

T_0:Control (no fertilizer application); T_1:100% PKS at transplanting; T_2:100% PK at transplanting + 50% S at transplanting + 50% S at maximum tillering; T_3:100% PS at transplanting + 50% K at transplanting + 50% K at maximum tillering; T_4:100% KS at transplanting + 50% P at transplanting + 50% P at maximum tillering; T_5:50% PKS at transplanting + 50% PKS at maximum tillering; T_6: 25% N from cowdung at final ploughing + 75% N from urea (25% at transplanting + 25% at maximum tillering + 25% at panicle initiation stage); T_7:100% USG and 50% PKS at transplanting + 50% PKS at maximum tillering.

CONCLUSION

The overall results from the present study showed that split application of P, K and S fertilizers along with USG was more beneficial for yield contributing characters, yield and nutrient uptake by rice in comparison to single application of those fertilizers at transplanting stage. However, further investigation is needed to confirm these findings.

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