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Comparative Study of Nitrogen, Phosphorus and Potassium Fertilizers on Yield and Nutrient Uptake by Rice

M. Uddin, M. M. Rahman, M. A. Hoque and S. Begum
Department of Soil Science, Bangladesh Agricultural University, Mymensingh, Bangladesh

Abstract: The field experiment was conducted in a silt loam soil to compare the effect of N, P and K fertilizers on the yield and nutrient uptake by rice and post-harvest soil properties. Seven treatments were T_0 (control), T_1 (Urea + Triple superphosphate + Muriate of potash), T_2 (Urea + Diammonium phosphate + Muriate of potash), T_3 (Urea + Triple superphosphate + Ash), T_4 (Urea + Single superphosphate + Muriate of potash), T_5 (Urea + Single superphosphate + Ash) and T_6 (Urea + Diammonium phosphate + Ash). Application of fertilizers significantly increased the grain and straw yields of rice. Panicle length, effective tillers hill^{-1} and filled grains panicle^{-1} were also increased significantly due to application of fertilizers but the increase of 1000-grain weight was insignificant. Grain yield was highest with T_3 (Urea + Triple superphosphate + Ash) treatment (5.46 t ha^{-1}) which was followed by T_1 (Urea + Triple superphosphate + Muriate of potash) treatment (5.30 t ha^{-1}), while the lowest was in control. The grain yields were increased by 47.0 to 68.0% over control due to application of fertilizers. The results on straw yield reflected similar trend as in grain yield. Application of fertilizers caused a significant increase during NPKS uptake by rice. The application of fertilizers had a negligible influence on pH, CEC, organic matter, total N, available P, exchangeable K, and available S content of the post-harvest soils compared to their initial status.

Key words: Rice yield, nutrient uptake, N, P and K fertilizers

Introduction

Fertilizers are indispensable for the crop production systems of modern agriculture. Among the factors that affect crop production, fertilizer is the single most important one that plays a crucial role in yield increase, provided other factors are not too limiting. Chemical fertilizers today hold the key to the success of the crop production systems of Bangladesh agriculture, being responsible for about 50% of the total production (BARC, 1997). The yield of several crops including rice is either stagnating or declining in many soils due to intensive cropping and imbalanced use of fertilizers (Bhuiyan, 1995). High yielding crop varieties under intensive cropping will fail to express their full potential unless plant nutrients are supplied in adequate amounts and appropriate proportions. Balanced use of fertilizer nutrients in crops and cropping pattern will act as an insurance against possible nutrient deficiencies which are created by the repeated use of a single fertilizer nutrient. Besides balanced fertilizer, nutrients can play a vital role in sustaining higher yield of crops and cropping patterns as well as in maintaining fertility status of soils on a long basis. In Bangladesh, positive response of crops to fertilizer nutrients has been well demonstrated through numerous experiments conducted during the past three decades. The results of long term trials at BRRI, Gazipur amply demonstrated the need for balanced nutrient use in rice (Panaullah, 1998). In a twelve-year, on station trial with triple rice cropping pattern at BRRI central station, Joydebpur, it was found that the average grain yield of rice was around 4.5 t ha^{-1} yr^{-1} without any added fertilizers, but the yield increase considerably (8.0 t ha^{-1} yr^{-1}) with the application of NPK fertilizers (BARC, 1997). Higher crop yields demand higher amount of readily available forms of plant nutrients. But organic matter can't supply readily available nutrients because of their slow nutrient releasing capacity. So, it should be overcome through the application of chemical fertilizers easily. Considering the above points, the experiment was undertaken to compare the effect of N, P and K fertilizers on the yield and nutrient uptake by rice and post-harvest soil properties.

Materials and Methods

The experiment was conducted at Bangladesh Agricultural University Farm, Mymensingh, Bangladesh during winter season of 2000 to compare the effect of N, P and K fertilizers on the yield and nutrient uptake by rice and post-harvest soil properties. BRRI Dhan 29 used as a test crop in this experiment. The soil of the experimental field was silt loam with pH 6.74, organic mater content 2.63 %, total N 0.14%, available P 15.7 ppm, exchangeable K 0.12 me/100 g soil, available S 22.7 ppm and CEC 24.47 me/100 g soil. The treatments used in the experiment were T_0 = control, T_1 = Urea + Triple superphosphate + Muriate of potash (Urea + TSP + MP), T_2 = Urea + Diammonium phosphate + Muriate of potash (Urea + DAP + MP), T_3 = Urea + Triple superphosphate + Ash (Urea + TSP + Ash), T_4 = Urea + Single superphosphate + Muriate of potash (Urea + SSP + MP), T_5 = Urea + Single superphosphate + Ash (Urea + SSP + Ash) and T_6 = Urea + Diammonium phosphate + Ash (Urea + DAP + Ash). All the treatments contained recommended doses of nitrogen, phosphorus and potassium. Potassium content in straw ash was 10.0%. The treatments were laid out in a randomized complete block design (Gomez and Gomez, 1984). The experimental field was prepared by ploughing and cross ploughing with power tiller and country plough. All kinds of weeds were removed from the field and the land was leveled by laddering. The full dose of TSP, SSP, DAP, MP and Ash were applied one day before transplanting. Urea was applied in three equal splits. The first split of urea was applied as top dressing after 10 days of transplanting. The second split of urea was applied after 30 days of transplanting and the third split of urea after 60 days of transplanting (Panicle initiation stage). Sulphur was used as basal dose to all the experimental plots but sources of S were gypsum and SSP in this experiment. Gypsum was applied to all the experimental plots except for the SSP treated plots where an equivalent amount of S was added from SSP. The full dose of urea was not applied to the DAP treated plots where an equivalent amount of nitrogen was supplied from DAP (20 % N). The seedlings were transplanted in the experimental plots on 12 February 2000. Irrigation was done in the experimental plots as per needed. Weeding was done as and when necessary. The crop was harvested at maturity on 3 June 2000. Ten hills were randomly selected from each plot at maturity to record the yield components. Grain and straw yields were recorded plotwise and were converted into t ha^{-1}. The plant samples were analyzed for N, P, K and S contents and soil samples were also analyzed for pH, organic carbon,

Table 1: Effect of N, P and K fertilizers on growth and yield components of rice (CV. BRRI Dhan 29)

Treatment	Plant height (cm)	Effective tillers hill^{-1} (no)	Panicle length (cm)	Filled grains panicle^{-1} (no)	100-grain weight (g)
T_0(control)	73.4c	8.33b	22.8c	83.4c	19.0
T_1(Urea + TSP + MP)	84.7a	11.9a	24.9ab	101.2a	19.5
T_2(Urea + DAP + MP)	81.4b	10.8a	24.0bc	96.4b	20.0
T_3(Urea + TSP + Ash)	85.1a	12.6a	25.8a	103.0a	20.2
T_4(Urea + SSP + MP)	80.4b	10.9a	23.6bc	93.0b	20.0
T_5(Urea + SSP + Ash)	81.0b	11.0a	24.8ab	97.5b	19.4
T_6(Urea + DAP + Ash)	81.7b	11.2a	24.0bc	95.9b	19.7
SE(m) ±	0.53	0.56	0.64	1.09	N. S
CV(%)	3.15	8.88	3.94	5.75	1.77

N. S = Non significant

In a column, the figures having common letter(s) do not differ significantly at 1% level of probability

Table 2. Effect of N, P and K fertilizers on grain and straw yields of rice

Treatment	Grain yield (t ha^{-1})	% increase over control	Straw yield (t ha^{-1})	% increase over control
T_0(control)	3.25b	-	3.70b	-
T_1(Urea + TSP + MP)	5.30a	63.0	5.46a	47.5
T_2(Urea + DAP + MP)	5.05a	55.3	5.18a	40.0
T_3(Urea + TSP + Ash)	5.46a	68.0	5.52a	49.2
T_4(Urea + SSP + MP)	4.78a	47.0	4.98ab	34.6
T_5(Urea + SSP + Ash)	4.83a	48.6	4.98ab	34.6
T_6(Urea + DAP + Ash)	4.90a	50.7	5.1ab	37.8
SE(m) ±	0.26	-	0.30	-
CV(%)	9.51	-	10.59	-

In a column, the figures having common letter(s) do not differ significantly at 1% level of probability

Table 3. Effect of N, P and K fertilizers on nutrient uptake by rice

Treatment	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})	S uptake (kg ha^{-1})
T_0(control)	46.0d	13.7d	42.2e	6.10c
T_1(Urea + TSP + MP)	76.4b	24.0a	65.0b	10.3ab
T_2(Urea + DAP + MP)	75.5b	21.0bc	65.0b	10.0ab
T_3(Urea + TSP + Ash)	80.5a	25.1a	71.1a	11.2a
T_4(Urea + SSP + MP)	71.1c	19.7c	60.1d	8.80b
T_5(Urea + SSP + Ash)	69.7c	21.6bc	61.4cd	9.00ab
T_6(Urea + DAP + Ash)	69.1c	22.0b	63.0bc	9.10ab
SE(m) ±	0.51	0.45	0.45	0.50
CV(%)	1.28	3.64	1.30	4.41

In a column, the figures having common letter(s) do not differ significantly at 1% level of probability

Table 4. Effect of N, P and K fertilizers on properties of post-harvest soils

Treatment (me/100 g soil)	pH	Organic matter (%)	Total N (%)	Available P (ppm)	Exchangeable K (me/100 g soil)	Available S (ppm)	CEC (me/100 g soil)
T_0(control)	6.62	2.62	0.13	14.7	0.11	22.4	24.5
T_1(Urea + TSP + MP)	6.62	2.60	0.15	16.7	0.12	22.2	25.1
T_2(Urea + DAP + MP)	6.58	2.58	0.14	15.5	0.12	23.4	24.7
T_3(Urea + TSP + Ash)	6.58	2.63	0.15	15.9	0.11	23.7	23.4
T_4(Urea + SSP + MP)	6.61	2.62	0.14	16.5	0.11	24.8	25.6
T_5(Urea + SSP + Ash)	6.71	2.71	0.14	17.0	0.12	23.3	23.4
T_6(Urea + DAP + Ash)	6.51	2.64	0.15	17.3	0.12	22.9	24.3
Initial soil status	6.74	2.63	0.14	15.7	0.12	22.7	24.4

total N, available P, exchangeable K, available S and CEC by using standard procedure (Page ., 1989). Data were analyzed by statistical procedure and mean values were adjudged by the Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

Results and Discussion

Growth and yield components of rice: Application of fertilizers significantly increased the plant height, effective tillers hill^{-1}, panicle length and filled grains panicle^{-1} of rice (Table 1). The tallest plant (85.1 cm) was obtained with T_3 (Urea + TSP + Ash) treatment and the shortest plant (73.4 cm) was found from T_0 (control). The influence of TSP was more compared to DAP or SSP. Singh . (1986) also reported that plant height increased with increasing rates of different fertilizers. The highest number of effective tillers hill^{-1} (12.6) was recorded in T_3 (Urea + TSP + Ash) treatment and the lowest was in control (T_0). It was also noted that Urea, TSP and Ash exerted superior effect in producing effective tillers hill^{-1} and this effect was insignificant with other fertilizer treatments. Zhou . (1998) found that N, P and K nutrition increased the number of effective tillers of the rice plant. Panicle length ranged from 22.8 cm to 25.8 cm. The maximum panicle length of 25.8 cm was recorded in T_3 (Urea + TSP + Ash) treatment which was followed by T_1 (Urea + TSP + MP) treatment. TSP was the superior source in supplying P in producing the panicle length (Table 1). Apostol (1989) also found similar results. The number of filled grains panicle^{-1} ranged from 83.4 to 103.0.

The treatment T_3 (Urea + TSP + Ash) produced the highest number of filled grains panicle^{-1} which was statistically similar with T_1 (Urea + TSP + MP) treatment but statistically superior to all other treatments. It was found that Urea, TSP and Ash were the superior sources to supply NPK in producing higher filled grains panicle^{-1} compared to DAP, SSP and MP fertilizers. Mondal . (1990) observed that the percentage of filled grains of rice was increased with the increasing NPK rat es. Application of fertilizers increased the 1000-grain weight of BRRI Dhan 29 but this increase was insignificant. 1000-grain weight was highest with treatment T_3 (Urea + TSP + Ash) and the lowest was in control. The performance of Urea, TSP and Ash in increasing the 1000-grain weight was superior to that of other fertilizers.

Grain and straw yields: There was a significant effect of different fertilizers on the grain yield of rice. All the treatments increased grain yield considerably over control. The maximum grain yield (5.46 t ha^{-1}) was recorded with T_3 (Urea + TSP + Ash) treatment (Table 2) which was followed by T_1 (Urea + TSP + MP) and the minimum grain yield (3.2 t ha^{-1}) was obtained in control treatment. Application of fertilizers did 47.0 to 68.0% yield increases over control. Grain yield responded better due to application of Urea, TSP and Ash at the recommended doses. Mahabari . (1995) and Singh . (1998) also reported that application of NPK fertilizers increased grain yield of rice. Mondal and Latif (1996) also showed that Ash and sulphur fertilizer increased the grain yield when applied with N fertilizers.

Straw yield was also significantly influenced by different treatments (Table 2). All the treatments increased straw yield compared to the control. Application of Urea, TSP and Ash produced the highest straw yield followed by the application of Urea, TSP and MP. Similar results were obtained by Bhuiya . (1979) who reported that application of N, P and K fertilizers increased the straw yield but the effect of N fertilizer was more pronounced than P and K fertilizers.

Nutrient uptake: Nutrient uptake by rice was significantly influenced by different treatments (Table 3). Nutrient uptake ranged from 46.0 to 80.5 kg N ha^{-1}, 13.7 to 25.1 kg P ha^{-1}, 42.2 to 71.1 kg K ha^{-1} and 6.1 to 11.2 kg S ha^{-1}. The highest NPKS uptake by rice was recorded in T_3 (Urea + TSP + Ash) treatment while the lowest uptake was recorded in the control. Application of Urea + TSP + Ash significantly increased the N, P, K and S uptake by grain and straw as well as the total uptake by BRRI Dhan 29. Phongan (1988) reported that N uptake by rice increased significantly with increasing rates of urea application.

Properties of post-harvest soils : All the treatments resulted a negligible influence on properties of the post-harvest soils such as pH, CEC, organic matter content, total N, available P, exchangeable K, and available S (Table 4). Soil pH value was decreased slightly from the initial value. The values of CEC, organic matter content, total N, available P, exchangeable K, and available S content of the post-harvest soils were remained similar or even declined due to the application of fertilizers. It was observed that organic matter content tended to increase in the soils treated with T_3 (Urea + TSP + Ash), T_5 (Urea + SSP + Ash) and T_6 (Urea + DAP + Ash) while the soils treated with T_1 (Urea + TSP + MP), T_2 (Urea + DAP + MP) and T_4 (Urea + SSP + MP) caused a decreasing effect. The increase of organic matter content might be due to application of Ash. Mian and Eaqub (1980) found that organic carbon content was increased with chemical fertilizer in combination with FYM and green manure but decreased due to chemical fertilizer only.

It may be concluded that the application of N, P and K fertilizers showed significant effects on the yield and yield components of rice (BRRI Dhan 29). The NPKS uptake by rice plants was also increased significantly due to this fertilization. The use of urea, TSP and straw ash was found to be very effective and beneficial for rice cultivation.

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