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Effects of NPKS on Yield and Nutrition of BRRI dhan49

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ABSTRACT

Nitrogen (N), phosphorus (P), potassium (K) and sulphur (S) strongly influence rice plant nutrition. Present experiment was conducted at the Bangladesh Rice Research Institute (BRRI) farm, Gazipur in a permanent layout in wet season of 2014. Objectives of the research were to study the effects of NPKS on grain yield, plant nutrition, requirement of NPKS to produce one ton grain and to estimate the indigenous nutrient supply of the soil. BRRI dhan49 was tested with NPKS (complete), PKS (-N), NKS (-P), NPS (-K) and NPK (-S) fertilizer packages. The NPKS were applied @ 100-7-80-3 kg ha^{-1}. Omission of each nutrient from the complete treatments significantly reduced grain and straw yields of BRRI dhan49. The highest yield reduction was recorded because of N omission followed by K. Nutrient concentration in grain and straw as well as nutrient uptakes were significantly affected by major plant nutrients. Nutrient uptake was directly related to the biomass production. About 87% of total K uptake remained in straw and thus a good K source for rice cultivation. Nitrogen, P, K, S and Zn required to produce one ton rice were 20.88, 5.04, 18.77, 2.08 and 0.07 kg, respectively. The indigenous N, P, K and S supply capacity of this soil was 37, 13, 41 and 6 kg ha^{-1}, respectively.

Key words: Rice, nutrient uptake, indigenous nutrient, straw

INTRODUCTION

Rice production in Bangladesh needs to be increased to feed 215.4 million people in 2050 (Kabir *et al.*, 2015). This can be done in two ways: expanding the rice growing area and increasing productivity, or both (Hasan *et al.*, 2015). Crop productivity can be increased by supplying nutrients as per crop requirement or soil fertility management (Islam *et al.*, 2016a) in different seasons. Among the seasons, wet season rice required less irrigation and fertilizer and farmers can be benefited by cultivating rice in this season.

Nitrogen, P, K and S affect rice production and its physiological activity. Efficient use of N is an important complementary strategy for improving rice yield and reducing cost of production (Islam *et al.*, 2016b). Phosphorus is intimately associated with all energy involved life processes and a vital constituent of every living cell. This element tends to be concentrated in the seed and stimulates early root formation and growth of the plant. Without adequate supply of P plant cannot reach its maximum yield. Since in many soils, much of the available P is derived through the mineralization of organic matter, the repeated addition of P fertilizer appears to be the only satisfactory way of supplying plant needs for this nutrient (Ali *et al.*, 2004). Potassium is luxuriously absorbed by plants. Modern high-yielding rice varieties remove much higher amount of K than P or even N from the soil (Islam *et al.*, 2015; Islam and Muttaleb, 2016; Islam *et al.*, 2016c; Miah *et al.*, 2008). It increases crop yields by accelerating photosynthesis, controlling stomata opening, efficient utilization of N and promoting the transport of assimilates. Sulphur deficiency is the cause of reduced plant height, reduced number of tillers, fewer and shorter panicles, reduced number of spikelets per panicle (Dobermann and Fairhurst, 2000). Problem of S deficiency in soil can be aggravated with the use of excess P fertilizer (Ali *et al.*, 2004).

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Among 30 agro ecological zones (AEZ), AEZs 28 (Madhupur Tract) is low in overall fertility status (FRG, 2012). Before fertilizer recommendation, it is necessary to determine the nutrient supply capacity of a soil, nutrient requirement and fertilizer recovery efficiency of a variety. Keeping these points in mind a field experiment was conducted in transplanted Aman (T. Aman) 2014 season (wet season) to study the effects of NPKS on grain yield, rice plant nutrition, requirement of NPKS to produce one ton grain and to estimate the indigenous nutrient supply of the soil.

MATERIALS AND METHODS

Soil, crop, experimental design and treatments
An experiment was conducted in the research field of BRRI farm, Gazipur in a permanent layout first designed in Boro 1985. Initial soil of the experimental field was clay loam in texture having pH, 5.70, 1.14% organic carbon, 0.08% total N, 9.80 ppm available P, 70 mg kg^{-1} exchangeable K, 9.00 ppm available S and 3.30 ppm available Zn. In T. Aman 2014, BRRI dhan49 was tested with five fertilizer treatments: NPKS (complete), PKS (-N), NKS (-P), NPS (-K) and NPK (-S). NPKS @ 100-7-80-3 kg ha^{-1}. Dates of sowing and transplanting were 15 June 2014 and 21 July 2014, respectively. The experimental design was randomized complete block with three replications. One-third of N as urea and the whole amount of P as triple super phosphate, K as muriate of potash and S as gypsum were applied at the final land preparation. The remaining two-third N was applied in two equal installments at 25-30 days after transplanting (DAT) and seven days before panicle initiation stage (PI stage). Two rice seedlings (36-day-old) were transplanted at 20 × 20 cm spacing under irrigated condition. Appropriate cultural and management practices including plant protection measures were followed during growing season. All plots were surrounded by 30 cm soil levees to avoid contamination between plots.

Data collection and analysis
Grain yield. The crops were harvested at maturity from 2.5 × 2 m area at 15 cm above ground level for grain yield calculation. Grain yields were recorded at 14% moisture content and calculated as follows:

$$\textit{Grain yield } (t\ ha^{-1}) = \frac{GW \times 10 \times (100-M)}{A \times 86}$$

Where, GW = Grain weight in kg, M = % moisture of grain, A = Area of sample in m^2

Straw yield. Straw yields were recorded from 16-hill sample harvested at the ground level from four corners and dry matter yield was calculated as:

$$\textit{Grain yield } (t\ ha^{-1}) = \frac{ODW \times FWT \times 10}{A \times FWS}$$

Where, ODW = Oven dry weight of sub-sample in g, FWT = Total fresh weight of harvested sample in g, FWS = Sub-sample fresh weight in g, A = Area of sample in m^2

Plant nutrient composition
Total nitrogen. Total N was determined following Micro Kjeldahl method (Steam distillation method). Total N uptake was determined by the following formulae:

$$\text{Nitrogen uptake by grain (kg ha}^{-1}\text{)} = \frac{\text{\% N in grain} \times \text{grain yeild (kg ha}^{-1}\text{)}}{100}$$

$$\text{Nitrogen uptake by straw (kg ha}^{-1}\text{)} = \frac{\text{\% N in straw} \times \text{straw yeild (kg ha}^{-1}\text{)}}{100}$$

Other nutrient uptake was determined similarly with respective nutrient concentration in grain and straw.

Phosphorus, K, S and Zn
Both straw and grain samples were digested using HNO_3-$HClO_4$ (5:2) di acid mixture. Phosphorus and S were determined colorimetrically with spectrophotometer (Model: V-630, Jasco). Potassium was determined by flame photometer (Model:

410, Sherwood) and Zn by atomic absorption spectrophotometer (Model: 170-30, HITACHI).

Estimation of indigenous nutrient supply

Indigenous N supply = Total N uptake (kg ha^{-1}) in N omission plots (with full supply of P, K and S)

Indigenous P supply = Total P uptake (kg ha^{-1}) in P omission plots (with full dose of N, K and S)

Indigenous K supply = Total K uptake (kg ha^{-1}) in K omission plots (with full dose of N, P and S)

Indigenous S supply = Total S uptake (kg ha^{-1}) in S omission plots (with full dose of N, P and K)

Statistical analysis

All data were analyzed statistically using CropStat software version 7.2.

RESULTS AND DISCUSSION

Grain yield

The highest grain yield of 4.90 t ha^{-1} was recorded with complete fertilizer (Table 1). Omission of N, P, K and S from complete fertilization significantly reduced grain yield by 1.94, 1.25, 1.34 and 0.94 t ha^{-1} respectively. Omission of K and N gave significantly lower grain yield than S and P omission plots. This finding was similar with the observations of Miah *et al.* (2004).

Straw yield

Omission of S produced the highest straw yield of 7.14 t ha^{-1} (Table 1) which was statistically identical with complete fertilization (6.79 t ha^{-1}) and P omission plot (6.47 t ha^{-1}). Omission of N produced the lowest straw yield followed by K omission. Omissions of N, P, K from complete fertilization reduced straw yield by 1.89, 0.32 and 0.74 t ha^{-1}, respectively.

Table 1. Effect of major nutrient elements on yield of T. Aman rice (var. BRRI dhan49), BRRI, Gazipur 2014.

Treatment	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
NPKS	4.90	6.79
-N	2.96	4.90
-P	3.65	6.47
-K	3.56	6.05
-S	3.96	7.14
$LSD_{(0.05)}$	0.40	0.68
CV (%)	6.8	7.0

The higher grain yield with NPKS fertilizer might be due to the contribution of these nutrients to yield contributing characters of rice plant (Dubey *et al.*, 2012). Potassium application helps to produce large amount of starch due to K-mediated carbohydrate metabolism (Islam *et al.*, 2015). Sulphur application also helps to protein synthesis in rice grain and increases the grain weight, which is reflected in grain yield of rice (Singh and Singh, 2002).

Nitrogen nutrition

Different major plant nutrient elements significantly affected the N content, uptake and N required per ton rice production (Table 2). Grain N content varied from 0.68% in N omission plot to 1.17% in K omission plot. Complete fertilization had the 1.16% N content in grains, which decreased to 0.68, 0.85 and 1.02% due to N, P and S omissions, respectively. Straw N content varied from 0.35% in N omission plot to 0.70% in P omission plot. Complete fertilization had the straw N content of 0.67%, which decreased to 0.35, 0.52 and 0.64% due to N, K and S omissions, respectively. Increase of grain N under K omission might be due to the same ionic radius of NH_4^+ and K^+ ions. In the absence of K^+ ions plants absorb more NH_4^+ ions. However, P omission slightly increased the straw N content of BRRI dhan49, which indicated the restriction of N translocation to the grain due to the lack of metabolic energy.

Grain N uptake varied from 20.13 kg ha^{-1} in N omission plot to 56.84 kg ha^{-1} in NPKS treated plot. Omissions of N, P, K and S from complete fertilization significantly reduced N uptake by 36.71, 25.81, 15.19 and 16.45 kg ha^{-1}, respectively. Straw N uptake varied from 17.15 kg ha^{-1} in N omission plot to 45.70 kg ha^{-1} in S omission plot. Nitrogen uptake significantly decreased due to N and K omissions. Total N uptake varied from 37.28 kg ha^{-1} in N omission plot to 102.33 kg ha^{-1} in complete treatment. Omissions of N, P, K and S from complete fertilization significantly

Table 2. Effect of major nutrient elements on N nutrition of T. Aman rice (var. BRRI dhan49), BRRI, Gazipur, 2014.

Treatment	N content (%)		N uptake (kg ha^{-1})			N req.
	Grain	Straw	Grain	Straw	Total	(kg t^{-1})
NPKS	1.16	0.67	56.84	45.49	102.33	20.88
-N	0.68	0.35	20.13	17.15	37.28	12.59
-P	0.85	0.70	31.03	45.29	76.32	20.91
-K	1.17	0.52	41.65	31.46	73.11	20.54
-S	1.02	0.64	40.39	45.70	86.09	21.74
$LSD_{(0.05)}$	0.10	0.14	7.2	5.8	8.2	1.15
CV (%)	5.7	6.5	7.6	5.5	4.5	9.2

reduced total N uptake by 65.05, 26.01, 29.22 and 16.24 kg ha^{-1}, respectively.

N required producing one ton rice grain varied from 12.59 kg t^{-1} in N omission plot to 21.79 kg t^{-1} in S omission plot. In complete fertilization, N required to produce one ton rice was 20.88 kg that decreased to 12.59, 20.91 and 20.54 kg due to N, P and K omissions, respectively.

These results demonstrate the importance of N nutrition for lowland rice yield. Application of K in combination with N has synergistic influence in uptake, translocation and use of nutrients for assimilation in growth and development of final grain yield and its contributing attributes (Bukhsh *et al.*, 2012).

Phosphorus nutrition

Grain P content varied from 0.22% in P omission plot to 0.34% in S omission plot (Table 3). Complete fertilization had the grain P content of 0.33%, which decreased to 0.22%, and 0.32% due to P and K omissions, respectively. Phosphorus omission significantly decreased grain P content of BRRI dhan49. Complete fertilization had 0.12% straw P content, which significantly decreased to 0.09%, and 0.07% due to N and P omissions, respectively. Rice grown on a P deficient soil would not only give a poor grain yield but also would have low grain P content (BRRI, 2017; Saleque *et al.*, 1998). Low P content in seeds would delay root growth and ultimately crop establishment especially under low soil P conditions.

Grain P uptake varied from 8.33 kg ha^{-1} in P omission plot to 16.02 kg ha^{-1} in complete fertilization. Omissions of N, P, K and S significantly reduced grain P uptake by 6.01, 7.69, 4.5 and 2.36 kg ha^{-1}, respectively. Complete fertilization had straw P uptake of 8.37 kg ha^{-1}, which decreased to 4.18, 4.26 and 7.70 kg ha^{-1} due to N, P and K omissions, respectively. Total P uptake varied from 12.59 kg ha^{-1} in P omissions plot to 24.39 kg ha^{-1} in complete fertilized plot (Table 3). Omissions of N, P, K and S from complete fertilization significantly reduced total P uptake by 10.2, 11.8, 5.17 and 1.24 kg ha^{-1}, respectively.

P required for one ton rice grain yield varied from 3.36 kg t^{-1} in P omission plot to 5.83 kg t^{-1} in S omission plot (Table 3). In complete fertilization, P requirement was 5.04 kg, which decreased to 4.75 kg and 3.36 kg due to N and P and omissions, respectively. Phosphorus omission plot showed significantly the lowest P requirement.

Potassium nutrition

Different major plant nutrient elements significantly affected the straw K content, uptake and K requirement of BRRI dhan49 (Table 4). However, grain K content was not affected by different major plant nutrients. Straw K content varied from 0.88% in K omission plot to 1.97% in N omission plot. Complete fertilization had the straw K content of 1.58%, which decreased to 0.88% and 1.07 due to K and S omission, respectively. However, N omission slightly increased straw K content of BRRI dhan49. Potassium content was above critical limit except K omission plot. This result established

Table 3. Effect of major nutrient elements on P nutrition of T. Aman rice (var. BRRI dhan49), BRRI, Gazipur, 2014.

Treatment	P content (%)		P uptake (kg ha^{-1})			P req.
	Grain	Straw	Grain	Straw	Total	(kg t^{-1})
NPKS	0.33	0.12	16.02	8.37	24.39	5.04
-N	0.33	0.09	10.01	4.18	14.19	4.75
-P	0.22	0.07	8.33	4.26	12.59	3.36
-K	0.32	0.13	11.52	7.70	19.22	5.34
-S	0.34	0.13	13.66	9.48	23.15	5.83
LSD $_{(0.05)}$	0.04	0.03	1.46	2.68	2.78	1.26
CV (%)	7.1	17.0	6.5	20.9	7.9	13.7

Table 4. Effect of major nutrient elements on K nutrition of T. Aman rice (var. BRRI dhan49), BRRI, Gazipur, 2014.

Treatment	K content (%)		K uptake (kg ha^{-1})			K req.
	Grain	Straw	Grain	Straw	Total	(kg t^{-1})
NPKS	0.30	1.58	14.33	76.86	91.19	18.77
-N	0.29	1.97	8.73	59.06	67.79	22.66
-P	0.25	1.67	9.32	62.58	71.90	19.21
-K	0.26	0.88	9.46	31.72	41.17	11.43
-S	0.30	1.07	12.03	42.87	54.89	13.66
LSD $_{(0.05)}$	NS	0.20	2.03	5.93	7.42	2.18
CV (%)	7.6	7.4	10.0	5.8	6.0	6.8

the importance of K in rice plant nutrition. Increase in K concentration in rice plant with higher K rates might be due to higher uptake of K by plants. Similar results were reported by Hong and Huo (2004).

Grain K uptake varied from 8.73 kg ha^{-1} in N omission plot to 14.33 kg ha^{-1} in complete fertilization (Table 4). Omissions of N, P, K and S from complete fertilization significantly reduced K uptake in grain by 5.6, 5.01, 4.87 and 2.3 kg ha^{-1}, respectively. Straw K uptake varied from 31.72 kg ha^{-1} in K omission plot to 76.86 kg ha^{-1} in complete fertilization. Omissions of N, P, K and S from complete fertilization significantly reduced K uptake by 17.8 kg ha^{-1}, 14.28 kg ha^{-1}, 45.14 and 33.99 kg ha^{-1}, respectively. Total K uptake varied from 41.17 kg ha^{-1} in K omission plot to 91.19 kg ha^{-1} in complete fertilization. Omissions of N, P, K and S from complete fertilization significantly reduced total K uptake by 23.4, 19.29, 50.02 and 36.3 kg ha^{-1}, respectively. Potassium omission significantly decreased total K uptake of BRRI dhan49. More K uptake might be due to satisfactory availability of applied K. Bahmaniar and Ranjbar (2007) elucidated that K uptake in shoot and grain was significantly affected by cultivar and K treatment interaction.

K required producing one ton rice grain varied from 11.43 kg t^{-1} in K omission plot to 22.66 kg t^{-1} in N omission plot. In complete fertilization K required to produce one ton rice was 18.77 kg, which decreased to 19.21, 11.43 and 13.66 kg due to P, K and S omission, respectively. The K omission plot showed significantly the lowest K requirement to produce one ton of rice. Nitrogen omission showed the highest K requirement to produce one ton of rice in BRRI dhan49.

Potassium distribution

Distribution of K in rice grain varied from 12.96% in P omission plot to 23.00% in K omission plot (Table 5). Potassium omission slightly increased K percentage, but P omission

Table 5. Effect of major nutrient elements on K distribution and N:K ratio in straw of T. Aman rice (var. BRRI dhan49), BRRI, Gazipur, 2014.

Treatment	K distribution (%)		N:K ratio in straw
	Grain	Straw	
NPKS	15.70	84.30	0.42
-N	22.88	87.12	0.18
-P	12.96	87.04	0.42
-K	23.00	77.00	0.59
-S	21.89	78.11	0.60
$LSD_{(0.05)}$	2.48	2.48	0.20
CV (%)	1.6	7.6	12.0

slightly decreased its percentage in grain of T. Aman rice (BRRI dhan49). Percentage of K in straw varied from 77.0% in K omission plot to 87.12% in N omission plot. Complete fertilization had 84.30% straw K, which decreased to 77.0%, and 78.11% due to K and S omission, respectively. However N and P omission significantly increased the percentage of K in straw of BRRI dhan49.

The higher percentage of K in rice straw compared to grain has been widely reported (Fageria *et al.*, 2010; Islam *et al.*, 2016c). Fageria *et al.* (2010) reported 5.5 times higher straw K uptake than rice grain K uptake. Hence, incorporation of rice straw in the soil after harvest of this crop may contribute significantly to maintaining K status of rice soil.

N:K ratio in straw

The N:K ratio in straw varied from 0.18 in N omission plot to 0.60 in S omission plot (Table 5). Over all N:K ratio of BRRI dhan49 seems to low for proper growth and development. Ravichandran and Sriramachandrasekharan (2011) reported that the N:K ratio in rice straw should be between 1.0 and 0.71 (1:1 to 1:1.4) for optimum growth of the plant. In this study the N:K ratio was lower than the reported range indicating the insufficient dose of N applied. So, it is very much essential to maintain proper N:K ratio in rice straw for optimum rice plant growth. Nitrogen and potassium should be applied in suitable ratio for optimum yield.

Sulphur nutrition

Different major nutrient elements significantly affected straw S content and uptake by BRRI dhan49. However, grain S content was not affected by different major plant nutrients (Table 6). Grain S uptake varied from 1.80 kg ha^{-1} in N omission plot to 3.42 kg ha^{-1} in complete fertilized plot. Complete fertilization had the highest grain S uptake of 3.42 kg ha^{-1}. Omissions of N, P, K and S from complete fertilization significantly reduced S uptake by 1.62, 0.43, 0.89 and 1.29 kg ha^{-1}, respectively. Straw S uptake varied from 3.69 kg ha^{-1} in N omission plot to 6.70 kg ha^{-1} in complete fertilization plot. Complete fertilization had the highest straw S uptake of 6.70 kg ha^{-1}. Omission of N, P, K and S from complete treatment significantly reduced S uptake by 3.01, 1.63, 1.34 and 2.5 kg ha^{-1}, respectively. These results corroborates well with the findings of Islam *et al.* (1997). They reported that application of S significantly increased S uptake in rice. Total S uptake varied from 5.49 kg ha^{-1} in N omission plot to 10.12 kg ha^{-1} in complete fertilization. Omissions of N, P, K and S from complete treatment significantly reduced total S uptake by 4.63, 2.06, 2.22 and 3.78 kg ha^{-1}, respectively. Sulphur required to produce one ton rice grain was not affected by different major plant nutrients.

Zinc nutrition

Different major plant nutrient elements significantly affected Zn content in straw and Zn uptake (Table 7). However, Zn content in grain and Zn requirement was not affected by different major plant nutrients. Straw Zn content varied from 24.18 ppm in N omission plot to 36.57 ppm in NPKS treated plot. Omission of N, P, K and S had statistically similar straw Zn content.

Grain Zn uptake varied from 0.06 kg ha^{-1} in N omission plot to 0.10 kg ha^{-1} in complete fertilization. Complete fertilization had the highest grain Zn uptake, which decreased to 0.06, 0.08, 0.08 and 0.08 kg ha^{-1} due to N, P, K and S omission, respectively. Omission of P, K and S had statistically similar Zn uptake. Straw Zn uptake varied from 0.11 kg ha^{-1} in

Table 6. Effect of major nutrient elements on S nutrition of T. Aman rice (var. BRRI dhan49), BRRI, Gazipur, 2014.

Treatment	S content (%)		S uptake (kg ha^{-1})			S req.
	Grain	Straw	Grain	Straw	Total	(kg t^{-1})
NPKS	0.07	0.10	3.42	6.70	10.12	2.08
-N	0.06	0.08	1.80	3.69	5.49	1.83
-P	0.08	0.08	2.99	5.07	8.06	2.16
-K	0.07	0.09	2.53	5.36	7.90	2.19
-S	0.05	0.06	2.13	4.20	6.34	1.58
$LSD_{(0.05)}$	NS	0.02	1.01	1.32	1.97	NS
CV (%)	18.2	12.1	20.9	14.0	13.8	14.9

Table 7. Effect of major nutrient elements on zinc (Zn) nutrition of T. Aman rice (var. BRRI dhan49), BRRI, Gazipur, 2014.

Treatment	Zn content (ppm)		Zn uptake (kg ha^{-1})			Zn req.
	Grain	Straw	Grain	Straw	Total	(kg t^{-1})
NPKS	21.02	36.57	0.10	0.25	0.35	0.07
-N	19.10	24.18	0.06	0.11	0.17	0.06
-P	20.15	29.18	0.08	0.19	0.26	0.07
-K	21.90	28.16	0.08	0.17	0.25	0.07
-S	21.10	27.27	0.08	0.19	0.28	0.07
$LSD_{(0.05)}$	NS	7.07	0.02	0.05	0.05	NS
CV (%)	10.5	12.9	13.5	13.7	10.0	11.3

N omission plot to 0.25 kg ha^{-1} in complete fertilized plot. Omissions of N, P, K and S from complete fertilization significantly reduced Zn uptake by 0.14, 0.06, 0.08 and 0.06 kg ha^{-1}, respectively. Total Zn uptake varied from 0.17 kg ha^{-1} in N omission plot to 0.35 kg ha^{-1} in complete fertilized plot. Complete fertilization had the highest total Zn uptake of 0.35 kg ha^{-1}. Omission of N, P, K and S from complete fertilization significantly reduced total Zn uptake by 0.18, 0.09, 0.1 and 0.07 kg ha^{-1}, respectively.

Nutrient supply capacity and recovery efficiency of soil

Calculated indigenous nutrient supply capacities of soil were NPKS @ 37.28, 12.59, 41.17 and 6.34 kg ha^{-1} to the T. Aman rice crop.

Nitrogen recovery varied from 35.83 to 65.05%. The highest N recovery was observed in complete fertilization and the lowest was in K omission plot (Table 8). Phosphorus recovery varied from 22.86 to 168.57%. Like N, P recovery also the highest in complete fertilization. The lowest P recovery was in N omission treatment. Recovery of applied K ranged from 17.15 to 62.53% being the highest in complete fertilization. Sulphur recovery ranged from -28.33 to 126.00% being the highest again in complete fertilization.

Nitrogen use efficiency in wetland rice is only 30-50%. However, Fageria and Baligar (2005) found nitrogen recovery efficiency for lowland rice less than 50%. In the present

Table 8. Recovery efficiency of applied nutrients for T. Aman rice (var. BRRI dhan49) in Grey Terrace soil, BRRI, Gazipur 2014.

Treatment	Recovery efficiency (%)			
	N	P	K	S
NPKS	65.05	168.57	62.53	126.00
-N	-	22.86	33.28	-28.33
-P	39.04	-	38.41	57.33
-K	35.83	94.71	-	52.00
-S	48.81	150.86	17.15	-

study, higher N recovery is due to lower rate of N application. The recovery efficiency of P throughout the world is not more than 20% of applied P (Qureshi *et al.*, 2012). In this study very high recovery of P was recorded. This might be due to lower P dose and higher availability of soil native P and residual effect of P applied in the previous crop. Yulin Liao *et al.* (2010) reported that the average value of K recovery efficiency for the three K fertilizer treatments (112.5, 150 and 187.5 kg K_2O ha^{-1}) in the reddish-yellow paddy soil was 35.0% for early rice and 51.8% for late rice; while the comparative figures for the purple calcareous clayey soil were 27.1% for early rice and 42.6% for late rice. While in this study 62.53% K recovery was recorded with NPKS fertilization.

CONCLUSION

Major plant nutrients significantly affected the yield, nutrient concentration and uptake of T. Aman rice (BRRI dhan49). Major portion of absorbed K remain in rice straw. So, rice straw should be recycled in the field for K source. The indigenous N, P, K and S supply capacity of this soil was 37, 13, 41 and 6 kg ha^{-1}, respectively. A good recovery of applied nutrients was also observed in this soil.

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