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EFFECT OF TRIPLE SUPER PHOSPHATE ON NUTRIENT UPTAKE IN RICE (*Oryza sativa* L.) AND SOIL NUTRIENTS STATUS OF *HAOR* AREA

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Abstract

The experiment was conducted at Bilpar village under the Saidergaon union of Chatok upazila of Sunamganj district from November 2016 to May 2017 to find out the effects of TSP fertilizer on the nutrient uptakes in boro rice and soil properties in *haor* areas. Two factors experiment- varieties: BRRI dhan29 and BRRI dhan58 and six TSP fertilizer levels: F_1- 85 kg TSP ha^{-1} (Farmers' practice), F_2- 142 kg TSP ha^{-1}, F_3- 127 kg TSP ha^{-1}, F_4- 112 kg TSP ha^{-1} (BARC recommended dose), F_5- 97 kg TSP ha^{-1}, F_6- 82 kg TSP ha^{-1} were included in the experiment, which laid out in a randomized complete block design (RCBD) with three replications. The grain, and straw nutrients (NPKS) were analyzed using standard methods. Initial and post-harvest soil analyses were done for pH, organic matter, total nitrogen, available P, exchangeable K and available S. Between two rice varieties, BRRI dhan58 showed higher nutrient content and uptake in comparison compared to BRRI dhan29. TSP fertilizer significantly influenced nutrient concentration in grain and straw as well as nutrient uptakes. BARC recommended TSP fertilizer (TSP-112 kg ha^{-1}) helps to uptake nutrients (P) superiorly in grain and straw. The soil analyses showed that the nutrient contents in post-harvest soils were higher compared to the initial soil. The application of TSP fertilizer along with Urea, MoP and Gypsum increased total N, available P, K, and S contents in post-harvest soil. The result revealed that cultivation of BRRI dhan58 with 112 kg TSP ha^{-1} (BARC recommended dose) was the best option for rice production and maintaining soil fertility.

Keywords: TSP, Rice, Soil fertility, Nutrient uptake.

Introduction

Rice is the main food crop in terms of area and production and contributes to Bangladesh's national economic development. About 51.88 % of people are engaged in agriculture (BBS, 2018). The increasing land use intensity without adequate and balanced use of chemical fertilizers and organic manures have caused severe soil fertility deterioration as well as stagnating or even declining crop productivity. Most haor farmers are unaware of the balanced fertilizer dose, leading to further nutrient mining. There is an excellent opportunity to increase rice productivity through yield gap minimization with balanced fertilizer application as well as bridging between researchers-managed fertilizer plots and farmers' managed plots for farmers' awareness growth (Ladha *et al.,* 2003). N, P, K and S affect rice production and its physiological activity. P is an essential macro-nutrient for plant growth and development. Despite a high level of total P content in most agricultural soils, only 0.1 % of it exists in soluble form for plant uptake (Richardson and Simpson, 2011). Rice grown on a P-deficient soil would not only give a poor grain yield but also have low grain P content (BRRI, 2017). The efficient use of P is an important complementary strategy for improving rice yield. P may be fixed on exchange sites or formation of insoluble compounds (Leytem and Mikkelsen, 2005) as carbonate, appetite and hydroxyl and flour appetite and causes low availability. However, almost 75-90 % of applied chemical P fertilizers are rapidly immobilized by forming complex with Al^{3+} or Fe^{3+} in acidic soils or with Ca^{2+} in calcareous soils (Islam and Hossain, 2012), resulting in a shortage of available P for plant nutrition (Merbach *et al.*, 2010). Therefore P fertilization seemed highly crucial to gear up the productivity of several arable crops, including rice (Niamatullah *et al*., 2011, Khan *et al*., 2012). P application to rice increased P accumulation but did not consistently increase rice yields because flooding decreased soil P sorption and increased P diffusion in *haor* areas. 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). The experiment aimed to investigate the relation between nutrient uptake and soil fertility due to TSP fertilizer application in two modern boro rice varieties.

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Materials and Methods

The experiment was carried out at the Bilpar village of Sadergaon union of Chatok Upazila, Sunamganj from November 2016 to May 2017. The experimental site lies between 24º55" and 25º0" North latitudes and between 91º40" and 91º45" East longitude. The area's soil are silty clay loams and clay loams on the higher parts and grey clays in the wet basins that dry out seasonally and have a pH 4.5. Two factors experiment included two rice varieties viz. BRRI dhan29 and BRRI dhan58 and six viz. F_1- 85 kg TSP ha^{-1} (Farmers' practice), F_2- 142 kg TSP ha^{-1}, F_3- 127 kg TSP ha^{-1}, F_4- 112 kg TSP ha^{-1} (BARC recommended dose), F_5- 97 kg TSP ha^{-1} and F_6- 82 kg TSP ha^{-1}], where Farmers' practice (FP) (180-85-82 kg ha^{-1} of Urea-TSP-MoP) and BARC Recommendation rate (300-127-75 kg ha^{-1} of Urea-MoP-$CaS0_4$). The experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. Thirty five days old seedlings were transplanted on January 2017 and maintained a spacing of 20 cm × 15 cm. Rice was harvested at maturity on May 2017. NPKS concentrations in grain and straw were measured, and soil analyses were also done following the standard methods. The statistical data analysis was done using a computer package (MSTAT). The significant differences among means in each character were adjudged through Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results

Showed data in Table 1 indicated that the grain and straw of BRRI dhan 58 had higher N concentration than BRRI dhan 29. The highest grain N concentration (1.213 %) was found due to the application of 112 kg TSP ha^{-1} and the lowest (0.915 %) at Farmers' practice. Straw N concentrations varied from 0.535-0.670 % and followed a similar pattern of grain. BRRI dhan 58 with application of 112 kg TSP ha^{-1} resulted in the highest N in straw (0.703 %), whereas the lowest N content (0.556 %) was recorded in BRRI dhan 29 with Farmers' practice.

Grains of BRRI dhan 58 showed higher N uptake (102.53 kg ha^{-1}) in comparison to BRRI dhan 29 (83.83 kg ha^{-1}), and straws of the two varieties also followed a similar pattern (Table 1). The N uptake in grains ranged from 81.36 to 103.6 kg ha^{-1} and in straw, varied from 39.58 to 58.82 kg ha^{-1} due to the application of different levels of TSP. Straw showed a similarity as like grain. BRRI dhan58 uptakes the highest N of 65.72 kg ha^{-1} due to application of 112 kg TSP ha^{-1} in straw.

BRRI dhan 58 showed higher total N uptake (159.06 kg ha^{-1}) than BRRI dhan29 (126.79 kg ha^{-1}). The highest total N uptake (162.4 kg ha^{-1}) was found in F_4, and the lowest total N uptake (120.7 kg ha^{-1}) was in Farmers' practice (F_1). The highest total N uptake (183.2 kg ha^{-1}) was observed in V_2F_4, and the lowest (109.8 kg ha^{-1}) was observed in V_1F_1.

BRRI dhan58 showed a higher P concentration in grain and straw than BRRI dhan 29 (Table 2). The highest P concentration in grain (0.320 %) and straw (0.233 %) were found due to the application of 142 kg TSP ha^{-1}. The lowest was noted in the Farmers' practice. The highest (0.330 %) and the lowest (0.170 %) P concentrations in grain were recorded in V_2F_4 and V_2F_1, respectively. The highest (0.270 %) and the lowest (0.110 %) P concentrations in straw were recorded in V_2F_2 and V_1F_1, respectively.

BRRI dhan 58 showed higher grain P uptake (102.53 kg ha^{-1}) compared to BRRI dhan 29 (83.83 kg ha^{-1}), and straw showed a similar pattern. The P uptake in grain ranged from 12.83 to 22.81 kg ha^{-1}, and in straw varied from 9.270 to 19.86 kg ha^{-1}. BRRI dhan 58 uptake the highest P of 25.24 kg ha^{-1} due to the application of 142 kg TSP ha^{-1} in grain and the lowest 10.54 kg ha^{-1} in BRRI dhan 29 for 82 kg TSP ha^{-1} application. Straw also showed similar results.

Table 1. Effect of variety, TSP fertilizer rates, and their interactions on yield, N concentrations, and uptakes in grain and straw.

Treatment	Grain yield[1] (t ha^{-1})	Straw yield[1] (t ha^{-1})	N concentration (%)		N uptake (kg ha^{-1})		
			Grain	Straw	Grain	Straw	Total (grain+straw)
Variety							
V_1	7.27b	10.02b	1.119b	0.58b	83.83	42.85b	126.79b
V_2	8.92a	11.80a	1.123a	0.63a	102.53	56.53a	159.06a
LS	**	**	*	*	*	*	*
P							
F_1	7.40c	10.30b	0.91b	0.53c	81.13c	39.58e	120.7c
F_2	8.30ab	11.20ab	1.17a	0.65ab	93.65ac	54.83b	148.5b
F_3	8.30ab	11.10ab	1.14a	0.64ab	95.18ab	53.65b	148.8b
F_4	8.80a	11.90a	1.21a	0.67a	103.6a	58.82a	162.4a
F_5	7.90bc	10.60b	1.14a	0.61b	96.66ab	48.57c	145.2b
F_6	7.80bc	10.60b	1.13a	0.55c	88.85bc	43.06d	131.9c
$S_{\bar{x}}$	0.17	0.27	0.028	0.012	3.77	2.92	2.82
LS	**	**	**	**	**	**	**
Variety × P							
V_1 F_1	6.00	8.600f	1.08	0.51d	74.91	34.88f	109.8h
V_1 F_2	7.70	10.40cde	1.20	0.66ab	87.74	50.66d	138.4def
V_1 F_3	7.40	10.30cde	1.14	0.58bcd	82.22	43.54e	125.8fg
V_1 F_4	7.80	11.30abc	1.23	0.66ab	89.77	51.92cd	141.7de
V_1 F_5	6.90	10.10de	1.14	0.58bcd	85.20	40.84e	126.0g
V_1 F_6	6.90	9.400ef	1.11	0.52d	83.12	35.96f	119.1gh
V_2 F_1	7.60	11.10bcd	1.08	0.55d	87.35	44.27e	131.6efg
V_2 F_2	9.20	12.00ab	1.19	0.68a	99.54	63.76a	158.5c
V_2 F_3	9.10	12.00ab	1.17	0.64abc	108.13	59.00b	171.9ab
V_2 F_4	9.70	12.40a	1.20	0.70a	117.47	65.72a	183.2a
V_2 F_5	8.80	11.90ab	1.12	0.64abc	108.11	56.31bc	164.4bc
V_2 F_6	8.70	11.90ab	1.09	0.57cd	94.57	50.15d	144.7d
$S_{\bar{x}}$	-	0.38	-	0.018	-	1.115	3.99
LS	NS	*	NS	**	NS	**	*

In the column, the figure(s) having a similar letter(s) do not differ significantly, whereas dissimilar letter(s) differ significantly. *=Significant at 5 % level of probability, **=Significant at 1 % level of probability, NS= Not significant, LS= Level of significance, V_1= BRRIdhan29, V_2= BRRIdhan58. F_1- 85 kg TSP ha^{-1} (Farmers' practice), F_2- 142 kg TSP ha^{-1}, F_3- 127 kg TSP ha^{-1}, F_4- 112 kg TSP ha^{-1} (BARC recommended dose), F_5- 97 kg TSP ha^{-1}, F_6- 82 kg TSP ha^{-1}. [NB: [1] Data published in AJAAR journal; 10 (2)]

Variety significantly affected total P uptake in two rice varieties (Table 2). BRRI dhan 58 uptakes higher total P (49.53 kg ha^{-1}) than BRRI dhan 29 (39.79 kg ha^{-1}). The highest total P uptake (42.67 kg ha^{-1}) was found in F_2, and the lowest total P uptake (22.10 kg ha^{-1}) was observed in Farmers' practice (F_1). The highest total P uptake (48.11 kg ha^{-1}) was observed in BRRI dhan 58 × 142 kg TSP ha^{-1} (V_2F_2), which was statistically identical to V_2F_4, and the lowest (19.42 kg ha^{-1}) was observed in V_1F_1.

Table 2. Effect of variety TSP fertilizer rates and their interactions on P concentrations and uptakes in grain and straw.

Treatment	P concentration (%)		P uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total (grain+straw)
Variety					
V_1	0.23b	0.16b	15.35b	12.02b	39.09b
V_2	0.26a	0.21a	19.79a	19.09a	49.53a
LS	*	*	*	*	*
P					
F_1	0.20d	0.16bc	12.83c	9.27d	22.1d
F_2	0.32a	0.23a	22.81a	19.86a	42.67a
F_3	0.28b	0.21ab	20.42a	17.69ab	38.11b
F_4	0.27b	0.21ab	20.59a	18.01a	38.6b
F_5	0.23c	0.18ab	15.59b	15.15b	30.74c
F_6	0.21d	0.11c	13.20bc	12.46c	25.66d
$S_{\bar{x}}$	0.004	0.012	0.101	0.641	0.645
LS	**	**	**	**	**
Variety × P					
V_1 F_1	0.17i	0.11e	11.89gh	7.530f	19.42f
V_1 F_2	0.25b	0.19c	20.39bc	14.96d	35.35c
V_1 F_3	0.24de	0.18c	16.37def	13.91d	30.28d
V_1 F_4	0.30d	0.19c	18.60cd	15.05d	33.65d
V_1 F_5	0.23ef	0.15d	14.33efg	10.93e	25.26e
V_1 F_6	0.21gh	0.14d	10.54h	9.760ef	20.3f
V_2 F_1	0.21h	0.12e	13.77fg	11.01e	24.78e
V_2 F_2	0.32ab	0.27a	25.24a	22.87ab	48.11a
V_2 F_3	0.28c	0.23b	24.48a	21.47bc	45.95b
V_2 F_4	0.33a	0.23b	22.57ab	24.67a	47.24a
V_2 F_5	0.23efg	0.22b	16.84de	19.37c	36.21c
V_2 F_6	0.22fgh	0.19c	15.86def	15.16d	31.02d
$S_{\bar{x}}$	0.005	0.005	0.912	0.9077	0.912
LS	*	*	*	*	*

In a column, the figure(s) having a similar letter(s) do not differ significantly, whereas dissimilar letter(s) differ significantly. *=Significant at 5% level of probability, **=Significant at 1% level of probability, NS= Not significant, LS= Level of significance, V_1= BRRI dhan 29, V_2= BRRI dhan 58. F_1- 85 kg TSP ha^{-1} (Farmers' practice), F_2- 142 kg TSP ha^{-1}, F_3- 127 kg TSP ha^{-1}, F_4- 112 kg TSP ha^{-1} (BARC recommended rate), F_5- 97 kg TSP ha^{-1}, F_6- 82 kg TSP ha^{-1}.

Varieties had a significant effect on K concentration in straw (Table 3), where straw of BRRI dhan58 contained higher K (0.634 %) than BRRI dhan 29 (0.589 %). The highest K concentration (0.368 %) in grain was found due to the application of 112 kg TSP ha$^{-1,}$ and the lowest (0.270 %) was noted in the Farmers' practice.

Grains of BRRI dhan 58 showed higher K uptake (27.00 kg ha^{-1}) compared to BRRI dhan 29 (24.43 kg ha^{-1}), and straw also followed a similar pattern. The highest K uptake in grain (32.11 kg ha^{-1}) and straw (95.75 kg ha^{-1}) was observed in F_4 (TSP-112 kg ha^{-1}), and the lowest was in Farmers' practice.

Variety had a significant effect on the total K uptake of two rice varieties (Table 3). BRRI dhan 58 uptake higher total K (90.99 kg ha^{-1}) than BRRI dhan 29 (99.83 kg ha^{-1}). The highest total K uptake (127.9 kg ha^{-1}) was found in $F_{2,}$ and the lowest (67.38 kg ha^{-1}) was obtained in Farmers' practice.

Table 3. Effect of variety, TSP fertilizer rates, and their interactions on K concentrations and uptakes in grain and straw.

Treatment	K concentration (%)		K uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total (grain+straw)
Variety					
V_1	0.29	0.59b	24.43b	66.56b	90.99b
V_2	0.33	0.63a	27.00a	72.83a	99.83a
LS	NS	*	**	*	**
P					
F_1	0.27b	0.41c	20.01c	47.37c	67.38d
F_2	0.32ab	0.80a	26.32b	85.04a	96.28c
F_3	0.32ab	0.62b	26.52b	70.90b	111.6b
F_4	0.36a	0.85a	32.11a	95.75a	127.9a
F_5	0.31ab	0.60b	25.42b	69.97b	96.32c
F_6	0.30b	0.44c	23.94b	47.37c	73.11c
$S_{\bar{x}}$	0.012	0.028	0.95	2.92	2.975d
LS	**	**	**	**	**
Variety × P					
V_1 F_1	0.28	0.30	19.93g	41.44	61.37
V_1 F_2	0.35	0.76	27.41bcde	82.33	109.7
V_1 F_3	0.33	0.62	24.24efg	68.19	92.43
V_1 F_4	0.39	0.86	30.82ab	93.50	124.3
V_1 F_5	0.33	0.59	22.85fg	67.60	90.45
V_1 F_6	0.30	0.45	21.36fg	46.33	67.69
V_2 F_1	0.25	0.41	20.09g	52.01	72.10
V_2 F_2	0.32	0.84	29.49abc	87.75	112.2
V_2 F_3	0.31	0.62	28.81bcd	74.20	103.0
V_2 F_4	0.34	0.85	33.39a	98.00	131.4
V_2 F_5	0.28	0.61	25.22cdef	71.73	96.95
V_2 F_6	0.28	0.51	25.03def	53.30	78.33
$S_{\bar{x}}$	-	-	1.35	-	-
LS	NS	NS	*	NS	NS

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Grains of BRRI dhan 58 showed higher S concentration (0.132 %) compared to BRRI dhan29 (0.125 %). Application of different levels of TSP and the interactions among variety and TSP levels didn't vary S concentrations significantly (Table 4).

Grain and straw of BRRI dhan58 showed higher S uptake (11.78 kg ha^{-1}) and (13.88 kg ha^{-1}), respectively, compared to BRRI dhan29. Different levels of TSP fertilizer significantly differed in S uptake in grain and straw (Table 4). The highest S uptake in grain (12.46 kg ha^{-1}) and in straw (15.04 kg ha^{-1}) was observed in F_4 (TSP-142 kg ha^{-1}), and the lowest was in Farmers' practice. Interactions influenced grains' S uptake significantly, where BRRI dhan58 uptake the highest S of 14.16 kg ha^{-1} with 142 kg TSP ha^{-1}.

Varieties showed a significant effect on total S uptakes in two varieties (Table 4). BRRI dhan58 uptake higher total S (21.46 kg ha^{-1}) over BRRI dhan29 (25.66 kg ha^{-1}). The highest total S uptake (27.89 kg ha^{-1}) was found in F_4, and the lowest total S uptake (19.59 kg ha^{-1}) was obtained in Farmers' practice (F_1).

Table 4. Effect of variety, TSP fertilizer rates, and their interactions on S concentrations and uptakes in grain and straw.

Treatment	S concentration (%)		S uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total (grain+straw)
Variety					
V_1	0.12b	0.12	9.06b	12.40b	21.46b
V_2	0.13a	0.12	11.78a	13.88a	25.66a
LS	**	NS	*	*	*
P					
F_1	0.11	0.11	9.77b	11.04c	19.59c
F_2	0.12	0.13	12.46a	14.29ab	25.18ab
F_3	0.11	0.13	10.89ab	12.71abc	22.49bc
F_4	0.13	0.14	12.46a	15.42a	27.89a
F_5	0.12	0.13	10.51ab	13.27abc	23.78bc
F_6	0.11	0.11	10.35ab	12.11bc	22.46bc
$S_{\bar{x}}$	-	-	0.541	0.745	0.98
LS	NS	NS	**	**	**
Variety × P					
V_1 F_1	0.10	0.11	7.80f	9.55	17.35
V_1 F_2	0.13	0.13	9.92def	12.77	22.69
V_1 F_3	0.12	0.13	9.12def	11.92	20.60
V_1 F_4	0.14	0.13	10.70bcde	15.48	26.20
V_1 F_5	0.12	0.11	8.68ef	13.16	21.28
V_1 F_6	0.11	0.11	8.12f	11.52	20.64
V_2 F_1	0.11	0.10	9.28def	12.54	21.82
V_2 F_2	0.12	0.13	12.89ab	15.81	27.67
V_2 F_3	0.12	0.13	11.86abc	13.51	24.38
V_2 F_4	0.13	0.15	14.19a	15.37	29.56
V_2 F_5	0.11	0.14	11.59bcd	13.38	26.27
V_2 F_6	0.11	0.12	10.87bcde	12.69	24.28
$S_{\bar{x}}$	-	-	0.765	-	-
LS	NS	NS	*	NS	NS

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The pH of the post-harvest soils ranged from 4.3 to 4.5. All the treatments caused a slightly decreasing effect in the pH value of the post-harvest soils compared to the initial soil. The organic matter status of the initial soil was 2.69 %. The organic matter contents of the post-harvest soils varied from 2.62 to 2.68 %. The results revealed that rice cultivation with chemical fertilizers tended to increase the total N content of post-harvest soil due to BARC recommended dose of urea fertilizer. The available P content of initial soils was 3.77 ppm. Application of increasing amount of TSP increased the P level of post-harvest soil. The exchangeable K content of the initial soil was 0.12 meq 100 g^{-1} soil. The highest exchangeable K content (0.15 meq 100 g^{-1}) was found in the soil receiving treatment F_2 and F_3. The lowest exchangeable K content (0.10 meq 100 g^{-1} soils) was observed in treatment F_1 (Farmers' practice). The different treatments affected the available S contents of the post-harvest soils (Table 5).

Table 5. Nutrients status of initial and post-harvest soil of the experimental field.

Interactions (V × F)	pH	OM (%)	Total N (%)	Available P (ppm)	Exchangeable K (meq/100g)	Available S (ppm)
$V_1 F_1$	4.48	2.68	0.14	3.14	0.11	24.95
$V_1 F_2$	4.34	2.63	0.15	6.85	0.15	35.33
$V_1 F_3$	4.45	2.67	0.15	5.15	0.13	37.45
$V_1 F_4$	4.37	2.67	0.15	4.22	0.14	39.91
$V_1 F_5$	4.34	2.67	0.15	4.17	0.12	35.62
$V_1 F_6$	4.30	2.68	0.15	3.96	0.12	31.01
$V_2 F_1$	4.50	2.67	0.13	3.21	0.10	24.33
$V_2 F_2$	4.46	2.62	0.15	4.84	0.15	34.03
$V_2 F_3$	4.30	2.62	0.15	4.65	0.15	36.47
$V_2 F_4$	4.30	2.65	0.14	4.79	0.14	36.79
$V_2 F_5$	4.41	2.65	0.15	4.57	0.13	30.23
$V_2 F_6$	4.46	2.66	0.15	4.00	0.12	28.29
Initial	4.50	2.69	0.14	3.77	0.12	25.16

Discussion

Variety had significant effects on NPS concentrations of grain and NPK concentrations of straw for applied nutrients and significant relationships for uptake of all said nutrients. TSP fertilizer levels significantly affected NPK concentrations and uptake in grain and straw. Application of 112 kg TSP ha^{-1} showed the highest concentrations and nutrient uptake and the lowest for F_1 treatment. The highest NPKS concentrations were found due to the application of fertilizers treatment @ 80:40:40 kg ha^{-1} of N: P_2O_5: K_2O (Dash *et al.,* 2015). Different combinations of varieties and six TSP fertilizer levels significantly affected N, P and S concentrations in grain and P and S concentrations in straw. Interactions showed significant uptakes of P, K, S in grain, N, P uptake of straw, and total N and P uptake. BRRI dhan29 and BRRI dhan58 performed best with F_4 (112 kg TSP ha^{-1}). Masni *et al.* (2019) showed that the highest uptake of total N was recorded with the application of 180 kg N ha^{-1}, 105 kg P ha^{-1}, and 120 kg K ha^{-1}. Rehim *et al.* (2014) observed that the highest P concentration and uptake in Paddy was obtained by application of P @ 120 kg ha^{-1}. The total above-ground P uptake differed significantly when P levels increased. This might be because when more water-soluble P was applied, the available P content in the soil increased (Gupta *et al.* 1992). Masni *et al.* (2019) revealed that the total above-ground K uptake differs significantly when NPK levels increase. Panaullah *et al*. (2006) reported that most K uptake was in straw compared to grain. Sultana (2007) showed that the highest N, P, K, S uptake in grain, straw, and total uptake were recorded in the recommended fertilizers treatment (100 kg N ha^{-1} + 20 kg P ha^{-1} + 40 kg K ha^{-1} + 20 kg S ha^{-1}) which was significantly different from all other treatments. The pH value was observed to decrease from the initial value. Swarup and Singh (1994) reported that the application of fertilizers decreased the soil pH. The highest and the lowest organic matter content was recorded in F_1 (Farmers' practice) and F_4 (BARC recommended TSP fertilizer), respectively. The chemical fertilizers decreased the organic matter content in the soil. Similar results were also found by Razzaque (1996), Hoque (1999), and Azim (1999). The total N, available P, exchangeable K, and available S of the post-harvest soils remained close to the initial value or even declined/increased due to the application of different treatments used in the experiment. Rabikowsha *et al.* (1993) reported that adding NPK fertilizers decreased soil's total N content. Bhuiyan and Saha (1992) found that available soil P content increased substantially due to the application of P fertilizer in each crop. Abedin Mian (1991) found an increased trend in available S status due to S combined with NPK fertilization in Sonatola silt loam soil of BAU farms.

Conclusions

Results of the experiment revealed that the variety BRRI dhan58 and BARC recommendation guide-based fertilizer (F_4-112 kg ha^{-1}), along with other fertilizers, would be suitable for getting the highest production with maintaining soil fertility under the Sadergaon union of Chatok upazila of Sunamganj district (AEZ-21).

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