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INFLUENCE OF SUPPLEMENTAL PHOSPHORUS ON THE CHANGES IN PHOSPHORUS FRACTIONS OF RICE GROWING SOIL UNDER ACIDIC CONDITION

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ABSTRACT

Islam MS, Hossain AKMM, Bari AKMA, Mondal AB, Siddiqui MNA (2019) Influence of supplemental phosphorus on the changes in phosphorus fractions of rice growing soil under acidic condition. *Int. J. Sustain. Crop Prod.* 14(1), 37-43.

A study on pot experiment were conducted from December, 2014 to May, 2015 in the net house of the Department of Soil Science, Hajee Mohammad Danesh Science and Technology University, Dinajpur to evaluate the effect of supplemental phosphorus on the changes in phosphorus fractions of rice growing soil under acidic condition and its effect on rice (BRRI dhan28). Two soil samples were collected from different places of two Agro-Ecological Zones (AEZs) of Bangladesh. The two places are Hajee Mohammad Danesh Science and Technology University (HSTU) farm (Old Himalayan Piedmont Plain) and Farmer's field Kushdha (North Eastern Barind Tract). There were two treatments in this experiment e.g. control and P amendment (200 mg kg^{-1}). The treatments were replicated thrice. The texture of HSTU farm and Kushdaha soils were sandy loam and silty clay, respectively. The range of pH and organic matter content were 4.22 to 5.01 and 1.45 to 1.76%, respectively. The initial status of labile P, Fe/Al-P and Ca/Mg-P of the different soils were 5.53 to 14.94, 48.40 to 86.50 and 59.65 to 51.45 mg Kg^{-1}, respectively. Due to cropping, a remarkable depletion was found in post-harvest soils in non-treated pots and the depleted amount ranged from 13.65 to 28.73, 1.46 to 8.33 and 0.63 to 2.87% for labile P, Fe/Al-P and Ca/Mg-P, respectively over the initial status. In treated pots, the depletion of labile P, Fe/Al-P and Ca/Mg-P varied from 1.96 to 4.10, 0.95 to 5.01 and 0.35 to 1.97 mg Kg^{-1}, respectively. The percent use efficiency of labile P, Fe/Al-P and Ca/Mg-P in treated pots were 61.57 to 745.45, 28.19 to 92.40 and 10.17 to 42.27%, respectively. Application of P increased the dry matter yield of rice in all the selected soils. The contribution of Fe/Al-P on P uptake was higher in acid soils and Ca/Mg-P in nearly neutral soils.

Key words: *supplemental phosphorus, phosphorus fractions, rice, acidic condition*

INTRODUCTION

In Bangladesh continuous growing of HYV rice and injudicious fertilizer management, most of the soils are getting exhausted. This is resulting in problems of P, K, and S deficiency in soils along with inherited N deficiency (Ali *et al*. 1997; Saleque *et al*. 1998a; Saleque *et al*. 1998b; Saleque *et al*. 2004). With increasing demand of agricultural production and as the peak in global production will occur in the next decades, phosphorus (P) is receiving more attention as a non-renewable resource (Cordell *et al.* 2009). Phosphorus (P) is an essential element for plant growth (Dobermann and Fairhurst, 2000). It is very important in the early vegetative growth stages (Slaton *et al.* 2002). It is important to rice plants because it promotes tillering, root development, early flowering, and ripening.

Only 15–30% of applied fertilizer P is taken up by crops in the year of its application (Syers *et al.* 2008). So, proper management of soils has become a prime necessity for sustained P fertility and yield of crops. The knowledge of soil P fractions is important as it will assist us in assessing the fertility status and fate of Phosphorus (P) from different P fractions in different acidic soils for economically rice crop production in Bangladesh (Bilkis 2002; Hountin *et al.* 2000). The present study was therefore conducted;

1. to evaluate the effects of applied P on the dry matter yield of rice.
2. to see the changes of P fractions from different acidic soils due to uptake by plant.

MATERIALS AND METHODS

The pot experiment was conducted in the net house of the Department of Soil Science, HSTU, Dinajpur to assess the contribution of these P forms on rice (BRRI dhan28). The detailed description of materials and method employed during the course of these investigations are presented in this chapter. A pot experiment was set in the net house of Department of Soil Science of HSTU, Dinajpur. The net house belonged to the same environment of HSTU farm (Agro-Ecological Zone 1). Bulk volumes of two soil is collected at a depth of 0-15 cm. The place is Hajee Mohammad Danesh Science and Technology University (HSTU) farm (Old Himalayan Piedmont Plain, AEZ-1) and Farmer's field Kushdaha (North Eastern Barind Tract, AEZ-27).

Morphological Characteristics of the soils: Soil sample was collected from two different places of two Agro-ecological Zones (AEZs) of Bangladesh. The morphological characteristics of the selected soils are presented in the Table 1.

Table 1. Morphological Characteristics of the soils

Name of the areas	Sampling site	Land type	General soil type	Agro-Ecological Zones(AEZs) with AEZ number	Flood level	Drainage
Kushdaha	Kushdaha, Nawabgonj, Dinajpur	Medium high land	Deep Red Brown Terrace soil	North Eastern Barind Tract AEZ no.: 27	Above flood level	Moderate
HSTU farm	HSTU farm, Dinajpur	High land	Non-calcareous Alluvium	Old-Himalayan Piedmont Plain AEZ no.: 1	Above flood level	Well drained

HSTU farm = Hajee Mohammad Danesh Science and Technology University farm, Farmers field = Kushdaha

Initial and post-harvest Soil analysis: Initial and postharvest soil samples were analyzed for both physical and chemical properties such as soil texture, soil pH, electrical conductivity (EC), organic matter (OM), total N, available P, exchangeable K and available S following standard methods and procedure. The initial results are presented in the Table 2.

Textural class: Particle size analysis of soil was done by hydrometer method (Black 1965) and the textural class was determined by plotting the values for % sand, % silt and % clay in the Marshall's triangular coordinates following the USDA system.

Soil pH: Soil pH was determined using glass electrode pH meter in soil: water suspension of 1:2.5 (Jackson 1962).

Electrical Conductivity (EC): EC of soil samples was determined by an EC meter using soil water suspension of 1:5 (Page *et al.* 1982).

Organic carbon and organic matter: Organic carbon was determined by wet oxidation method as described by Walkley and Black (1934) and the organic matter content was calculated by multiplying the obtained organic carbon with the van Bemmelen factor of 1.73 (Piper 1995).

Total nitrogen: One gram of oven dry soil was taken in a micro-kjeldahl flask. Then, 1.1 g catalyst mixture (K_2SO_4: $CuSO_4$. $5H_20$: Se = 100: 10: 1), 2m1 30% H_2O_2 and 5 ml H_2SO_4 were added to it. The flask was swirled and allowed to stand for about 10 minutes. Heating was slowly raised to 380^0C and continued until digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. The digest was used for nitrogen determination. After completion of digestion, 35% NaOH was added with the digest for distillation. The evolved ammonia was trapped into 4% H_3BO_3 solution with 5 drops of mixed indicator of bromocressol green ($C_{21}H_{14}O_5Br_4S$) and methyl red ($C_{10}H_{10}N_3O_3$) solution. Finally the distillate was titrated with standard 0.01 N H_2SO_4 until the color changed from green to pink.

Available phosphorous: Available soil phosphorus was extracted with 0.5 M $NaHCO_3$ at a pH of 8.5. The Phosphorous in the extract was then determined by $SnC1_2$ reduction method. The intensity of blue color of phosphomolybdate complex was measured with the help of a spectrophotometer at 660 nm. The P concentration in samples was determined by plotting the % intensity in a P standard curve (Olsen *et al.* 1954; Olsen and Sommers, 1982).

Available potassium: Available K was extracted with 1.0 N NH_4OAc (pH 7) and K was determined from the extract by flame photometer (Black 1965) and calibrated with a standard K curve.

Available sulfur: Available sulfur in soil was determined by extracting the soil samples with 0.15 % $CaC1_2$ solution. The S content in the extract was determined turbidimetrically and the intensity of turbid was measured by spectrophotometer at 420 nm wavelengths (Page *et al.* 1989).

Table 2. Physical and chemical properties of the soils

A. Physical properties

Name of the soils	Texture			
	Sand %	Silt %	Clay %	Textural Class
Kushdaha	16	40	44	Silty clay
HSTU farm	52	28	20	Sandy loam

B. Chemical properties

Name of the soils	pH	EC (μs cm^{-1})	OM (%)	N (%)	P (ppm)	K (ppm)	S (ppm)
Kushdaha	4.22	89.0	1.76	0.10	5.57	31.20	2.38
HSTU farm	5.01	140.6	1.45	0.084	14.92	27.30	1.87

Pot preparation: An amount of 1 kg of each test soil was taken in earthen pots in three replicates. Polythene papers were placed at the bottom of the pots to seal the small holes. Then the soils were saturated with water. The pots were kept at this condition for one day to allow the soils to settle in the pots properly. On the following day more water was added to make the pots ready for rice transplanting.

Treatments: There were two treatment combinations in this experiment e.g. control and recommended dose of P (25 kg P ha^{-1}) (FRG 2012). The experiment was replicated thrice with CRD. N, P, S and Zn were applied as basal dose.

Transplanting of seedlings: The rice variety used for the experiment was BRRI dhan28. Thirty five day old seedlings were uprooted carefully from the seedbed in the morning of 31 January, 2014 and transplanted in the pots on the same day. Three healthy seedlings/hill/pot were transplanted in the pots.

Intercultural operations: Full doses of chemical fertilizers *viz*. TSP (25 kg P ha^{-1}), MoP (100 kg K ha^{-1}), gypsum (20 kg S ha^{-1}), zinc oxide (2 kg Zn ha^{-1}) were added to soils (FRG 2012). Urea was applied in three equal splits at 0, 20, 45 days after transplanting (DAT) where the dose of urea for each split was 45 kg N ha^{-1}. Water was supplied into the pots every day to maintain 1 cm height on soil surface. All intercultural operations were performed as and when it was necessary. The rice plants of each pot were harvested at 80 DAT. They were cleaned by distilled water and air dried in the laboratory.

Preparation of soil and plant samples: Soil and plant samples were collected from each of the pots at the time of harvesting the crop and prepare the sample in standard methods and procedure for analyzing.

Fractionation of soil Phosphorus

Labile P: Labile P was extracted from 2g air-dried soil sample by shaking 2 hours with 20ml 1 M NH_4Cl solution at pH 7.0 following the method of Jackson (1973). The extracted phosphorous was determined by developing blue color using $SnCl_2$ and measuring the intensity of color colorimetrically at 660 nm wave length.

Fe/Al-P: Fe/Al-P was extracted from 2g air-dried soil sample by shaking 17 hours with 20 ml 0.1N NaOH solution following the method of Jackson (1973). The extracted phosphorous was determined by developing blue color using $SnCl_2$ and measuring the intensity of color colorimetrically at 660 nm wave length. The labile P was subtracted from the results obtained with NaOH to get Fe/Al-P.

Ca/Mg-P: Ca/Mg-P was extracted from 2 g air dried soil sample by shaking 24 hours with 20 ml 0.5 M HCl solution following the method given by Jackson (1973). The extracted P was determined by developing blue color using $Sncl_2$ and measuring the intensity of color colorimetrically at 660 nm wave length. The labile P was subtracted from the results obtained with HCl to get Fe/Al-P.

The rice plants of each pot were harvested at 70 DAT. They were cleaned by distilled water and air dried in the laboratory.

Preparation of soil samples: Soil samples were collected from each of the pots at the time of harvesting the crop. After collection, the soils were made free from plant roots and air dried. Then soils were prepared for analysis following the stated methods.

Preparation of plant samples: The air dried plant samples (straw) were dried in an oven at 65^0C for about 48 hours. They were ground in a grinding machine and stored in paper bags. The straw samples were analyzed for determination of P.

Digestion of samples with $HN0_3$-$HCl0_4$: A sub- sample of plant samples weighing 0.5 g was transferred into a dry clean digestion vessel. Ten ml of diacid mixture (HNO_3:$HClO_4$=5:1) was added to it. After leaving for a while, the vessels were heated at a temperature slowly raised to 200^0C. Heating was momentarily stopped when the dense white fumes of $HClO_4$ occurred. The contents of the flask were boiled until they become sufficiently clear and colorless. This digest was used for estimating P.

Determination of P in

The concentration of P in the digest was determined by similar method as described in case of soil analysis.

Statistical analysis: This experiment followed by Complete Randomize Design(CRD). The analysis of variance (ANOVA) for dry matter yield of the crop was done following the F-test. Mean comparisons of the treatments were made by the Duncan's Multiple Range Test, DMRT (Gomez and Gomez, 1984) with CRD.

RESULTS

In order to assess the changes in different forms of P in non-treated and treated soils. Results obtained from the pot experiment are presented here.

Labile P: Results showed a remarkable depletion of Labile P in non-treated pots of all soils (Table 3). In initial soils, the status was 5.53 to 14.94 mg kg^{-1} soils which decreased to 3.54 to 12.52 mg kg^{-1} in post-harvest soils. This showed a decrease of 1.60 to 2.42 mg P kg^{-1} over the initial status. The highest amount of P was taken up by the crops from HSTU farm soil and lowest in Kushdaha soils. About 29% of Labile P was taken up by the crop from Kushdaha soil which was the highest and 16% in HSTU soils.

Table 3. Changes in labile P (mg kg^{-1}) in rice soils as influenced by the additional P application

P (kg ha^{-1})	Soils	Initial			Post-harvest			Amount used			% used
0	Kushdaha			SE		±	SE		±	SE	
		5.53*	±	0.0450	3.94		0.0510	1.60		0.0670	28.73
	HSTU farm	14.94	±	0.0435	12.52	±	0.0514	2.42	±	0.0620	16.22
25	Kushdaha	5.57	±	0.0530	3.89	±	0.0640	1.96	±	0.0620	700.00
	HSTU farm	14.92	±	0.0520	11.37	±	0.0635	4.10	±	0.0615	745.45

*indicate means value ± SE of three (?) observations

Like the non-treated pots, a remarkable depletion of Labile P was also found in post-harvest soils. The depleted amount ranged from 3.57 to 11.37 mg kg^{-1} soils. This indicates that the amount of Labile P taken up by plants was much higher than the added amount (1.96-4.10 mg kg^{-1}) in both the soils. The highest amount of Labile P was taken up from the HSTU farm soil (4.10 mg kg^{-1}). The percent use efficiency of added P also showed wide variation across the soils. The highest and the lowest values were found in HSTU farm (745.45%) and Kushdaha (700.00%) soils respectively.

Fe/Al-P: The Fe/Al-P of non-treated pots of all soils also decreased over the initial status but it was not as remarkable as was in case of Labile P (Table 4). The decreased amount of Fe/Al-P varied from 2.28 to 4.03 mg kg^{-1} across the soils. The amount of Fe/Al-P taken up from Kushdaha (4.03 mg kg^{-1}) is higher than HSTU. The percent use of Kushdaha is higher than HSTU soil. The percent use of Fe/Al-P was the lowest in HSTU (2.64%) and the highest in Kushdaha soil (8.33%).

Table 4. Changes in Fe/Al-P in non-treated soils due to cropping (mg kg^{-1})

P (kg ha^{-1})	Soils	Initial			Post-harvest			Amount used			% used
0	Kushdaha			SE		±	SE		±	SE	
		48.36	±	0.0490	44.33		0.0544	4.03		0.0510	8.33
	HSTU farm	86.42	±	0.0475	84.15	±	0.0525	2.27	±	0.0523	2.64
25	Kushdaha	48.36	±	0.0433	51.89	±	0.0510	5.01	±	0.0635	58.67
	HSTU farm	86.42	±	0.0419	87.80	±	0.0529	3.75	±	0.0654	73.10

Appropriate statistical analysis should be given with test of significance

In P treated pot a remarkable depletion of Fe/Al-P was obtained ranging from 3.75 to 5.01 mg kg^{-1} over pre-transplant concentration. As a consequence of plant uptake, the status of the post-harvest soil ranged from 51.89 to 87.80 mg kg^{-1} soils. The highest and the lowest values in the post-harvest soils were in HSTU farm soil and Kushdaha soil respectively. The used amount was highest in Kushdaha soil followed by HSTU. However, the percent use efficiency of added P was highest in HSTU soil (73.10%) although it's used amount was lower in Kushdaha soil. This was followed by HSTU farm soil and then Kushdaha soil. In HSTU soil, the percent use efficiency (73.10%) and the used amount (3.75 mg kg^{-1}) both showed the lowest value.

Ca/Mg-P: A depletion of Ca/Mg-P in non-treated pots of all soils was found over the initial status but it was not as remarkable as was in case of labile and Fe/Al-P (Table 5). In initial soil, the status was 10.59 to 14.75 mg kg^{-1} soil which decreased to 10.32 to 14.62 mg kg^{-1} in post-harvest soils. The depleted amount of Ca/Mg-P varied from 0.13 to 0.27 mg kg^{-1} over the initial status. The highest amount of Ca/Mg-P was taken up by the crops from Kushdaha soil and lowest in HSTU farm soil. The lowest amount was taken up from HSTU farm soil (0.13 mg kg^{-1}). The percent use varied from 0.88 to 2.55% where Kushdaha soil showed the highest value.

Table 5. Changes in Ca/Mg-P in non-treated soils due to cropping (mg kg^{-1})

P (kg ha^{-1})	Soils	Initial			Post-harvest			Amount used			% used
0	Kushdaha			SE			SE			SE	
		10.59	±	0.0631	10.32	±	0.0521	0.27	±	0.0533	2.55
	HSTU farm	14.75	±	0.071	14.62	±	0.0432	0.13	±	0.0522	0.88
25	Kushdaha	10.59	±	0.0681	12.45	±	0.0551	0.58	±	0.0582	23.77
	HSTU farm	14.75	±	0.0621	19.17	±	0.0511	1.06	±	0.063	19.34

Appropriate statistical analysis should be given with test of significance

In P treated pots, a remarkable depletion of Ca/Mg-P was obtained ranging from 0.58 to 1.06 mg kg^{-1} over pre-transplant concentration. As a result of plant uptake, the status of post-harvest soil ranged from 12.45 to 19.17 mg kg^{-1} soil. The highest and the lowest values in post-harvest soils were in HSTU and Kushdaha soils respectively. The percent use efficiency of added P and was highest in Kushdaha soil (42.27%) than HSTU soils.

Dry matter Yield: The dry matter yields of BRRI dhan28 in non-treated pots were varied significantly ranging from 3.54 to 5.48 g pot^{-1} in different soils under study (Table 6). The highest dry matter yield was found in HSTU soil followed by Kushdaha. A remarkable increased amount of dry matter yields were found in treated pots over the non-treated amount (Table 6). A significant variation was found among the yields ranging from 3.67 to 5.48g pot^{-1}. The highest amount was found in HSTU farm soil (5.48g pot^{-1}). It was statistically similar to Kushdaha soil. The soil effects on the dry matter yield showed the highest value in HSTU soil (4.51g pot^{-1}) (Table 6). This was followed by Kushdaha soils which were statistically different. The average dry matter yield of treated pots (4.75g pot^{-1}) was significantly higher than non-treated pots (3.67g pot^{-1}) (Table 6).

Table 6. Effects of P on dry matter yield (g pot^{-1}) of rice plants in different soils

Soil type effects		
1. Kushdaha	4.405 AB	
2. HSTU farm	4.510 A	
LSD value	0.1832	
F test	***	
SE	0.0337	
Treatment effects		
1. Non-treated	3.103 B	
2. Treated	4.747 A	
LSD value	0.09793	
F test	***	
SE	0.0630	
Interaction (soil types & treatments) effects		
Soils	**Non-treated**	**Treated**
1. Kushdaha	3.67 C	5.14 BC
2. HSTU farm	3.54 CD	5.48 A
LSD value = 0.2591		
F test = ***		
SE = 0.0892		
CV = 3.93 %		

Concentration of P in plants

The P concentration in the plants in non-treated pots varied significantly ranging from 1131.69 mg kg^{-1} to 1235.22 mg kg^{-1} (Table 7). The highest amount of P concentration was found in Kushdaha soil followed by HSTU farm (1131.69 mg kg^{-1}) soils. A increased amount of P concentration was found in the plants in treated pots over the non-treated amount (Table 7). The results of P concentration in treated pots varied from 1245.93 mg kg^{-1} to 1288.77 mg kg^{-1} (Table 7). The highest amount was found in Kushdaha soil followed by HSTU farm (1245.93 mg kg^{-1}) respectively.

Table 7. Effects of P on P concentration in rice plants taken up from different soils

Soils	P concentration (mg kg^{-1})					
	Non-treated			Treated		
Kushdaha			SE			SE
	1235.22	±	0.0788	1288.77	±	0.0650
HSTU farm	1131.69	±	0.0758	1245.93	±	0.0670

Appropriate statistical analysis should be given with test of significance

P uptake by plants: A wide variation was observed on P uptake by plants grown in non-treated pots ranging from 1.78 to 4.74 mg pot^{-1} (Table 8). The highest amount of P was taken up from by Kushdaha (4.53 mg pot^{-1}) and then HSTU farm (4.01 mg pot^{-1}) soils. A significant increase in P uptake by plants was found in treated pots over the non-treated pots (Table 8). A slight variation was observed among the soils on P uptake ranging from 6.62 to 6.83 mg pot^{-1} (Table 8). The highest amount was found in HSTU farm soil followed by Kushdaha (6.62 mg pot^{-1}) soils.

Table 8. Effects of P on P uptake by rice plants from different soils

Soils	P uptake by plants (mg pot^{-1})					
	Non-treated			Treated		
Kushdaha			SE			SE
	4.53	±	0.0651	6.62	±	0.0581
HSTU farm	4.01	±	0.0635	6.83	±	0.0595

Appropriate statistical analysis should be given with test of significance

DISCUSSION

A considerable depletion of P was found in P treated and non-treated pots due to cropping. The depleted amount varied considerably across the soils. The used amount of different forms of P in general was higher in P treated pots than in non-treated pots. The use efficiency of labile P was the highest in all soils followed by Fe/Al-P and then Ca/Mg-P. In most of the cases, the labile P use efficiency in treated pots was more than 100%. This indicates that the amount of added P transformation to labile P was not sufficient for the crop. As a consequence, the native labile P was also used both soils. A considerable amount of Fe/Al-P was also taken up by the crops but the amount was much lower than the added P. This indicates that some amount of transformed Fe/Al-P remained unused in soils. The highest amount of Fe/Al-P was used from HSTU farm soil. The use efficiencies of Kushdaha soil was lower from previous soils. Water logging of soils during rice cultivation increase the available P due to reduction of Fe & Al oxides and due to release of P adsorbed or occluded by them. In general, more Fe/Al-P was used from much more acidic soils than slight acidic soils under study. Among the acidic soils highest percent use efficiency was found in HSTU farm soil (73.10%) and then Kushdaha soil (58.60%). However, higher amount of Ca/Mg-P was used from Kushdaha much higher than HSTU farm soils. Application of P increased the dry matter yield of rice irrespective of soils. In general, the P effects were more significant in acidic soils such as HSTU farm and then Kushdaha soils. The dry matter yields of BRRI dhan28 in non-treated pots varied considerably ranging from 3.54 to 3.67 g pot^{-1} in different soils under study (Table 6). The dry matter yield was highest in Kushdaha followed by HSTU farm soils. A remarkable increased amount of dry matter yields were found in treated pots over the non-treated amount (Table 6). A significant variation was found among the yields ranging from 3.54 to 5.48 g pot^{-1}. The yield of Kushdaha soil was next to HSTU but they were statistically similar. A significant variation was observed in P concentration of the plants in non-treated pots ranging from 1131.69 mg kg^{-1} to 1235.22 mg kg^{-1} (Table 7). The highest amount of P concentration was found in Kushdaha soil next in HSTU. In treated pots, the P concentration of the plants increased where the highest and the lowest values were found in Kushdaha (1288.77 mg kg^{-1}) and HSTU (1245.93 mg kg^{-1}) soils respectively. The results of the values of P taken up by plants in non-treated pots varied from 4.01 to 4.53 mg pot^{-1} (Table 8). The values of HSTU soil lower than Kushdaha the soils. The P uptake significantly increased in the treated pots varied from 6.62 mg pot^{-1} to 6.83 mg pot^{-1} (Table 8). The highest amount was found in HSTU farm soil followed by Kushdaha (6.62 mg pot^{-1}) soil.

CONCLUSION

A conclusion may be interpreted from the results obtained from the pot experiment on P management effects on P fertility and yield of rice which is as follows,

1. The dry matter yield and P uptake by rice were increased due to application of P into soils.
2. The uptake efficiency of the labile P was the highest followed by Fe/Al-P and then Ca/Mg-P in highly acidic soils.

REFERENCES

Ali MM, Shahid SM, Kubota D, Masunage T, Wakatsuki T (1997) Soil degradation during the period 1967-1995 in Bangladesh. II. Selection chemical characters. Soil Science and Plant Nutrition 43, 879-890.

Bilkis S (2002) Fractionation of phosphorus in soils amended with organic and in organic fertilizers. MS thesis, Department of Soil Science, Bangladesh Agricultural University, Mymensingh.

Black CA (1965) Methods of Soil Analysis. Part I & II. American Society of Agronomy, Madision, Wisconsin, USA.

Cordell D, Drangert JO, White S (2009) The story of phosphorus: global food security and food for thought. Global Environmental Change. 19, 292-305.

Dobermann A, Fairhurst T (2000) Rice Nutrient Disorders & Nutrient Management. IRRI, Philippines, PPI, U.S.A., and PPIC, Canada. pp. 3-4.

FRG (2012) Fertilizer Recommendation Guide. Bangladesh Agril. Res. Council, Farmgate, Dhaka-1215.

Gomez KA, Gomez AK (1984) Statistical Procedures of Agricultural Research. 2nd edition John Wiley and Sons, New York. pp. 207-215.

Hountin JA, Karam A, Couillard D, Cescas MP (2000) Use of the fractionation procedure to assess the potential for a P movement in a soil profile after 14 years of liquid pig manure fertilizer. Agriculture, Ecosystem and Environment. 78(1), 77-84.

Jackson ML (1962) Soil Chemical Analysis. Constable and Co. Ltd. London.

Jackson ML (1973) Soil Chemical Analysis. Pretice Hall of India. Pvt. Ltd., New Delhi.

Olsen SR, Cole CV, Watanabe FS, Dean LA (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. United States Department of Agriculture Circle. pp. 939.

Olsen SR, Sommers LE (1982) Phisphorus. In: Methods of soil Analysis Part 2. Chemical and microbiological properties. American Society of Agronomy, Madison, Wisconsin, USA. pp. 76-82.

Page AL, Miller RH, Keeney DR (1982) Methods of Soil Analysis part 2, 2nd edition. American Society of Agronomy, Madison, Wisconsin, USA. pp. 105-116.

Page AL, Miller RH, Keeney DR (1989) Methods of Soil Analysis part 2, 2nd edition. American Society of Agronomy, Madison, Wisconsin, USA. pp. 245-256.

Piper CS (1995) Soil and Plant Analysis. Adelaide University. Hassel Press Australia. pp. 421-453.

Saleque MA, Abedin MJ, Panaullah GM, Bhuiyan NI (1998a) Yield and phosphorus efficiency of some lowland rice varieties at different levels of soil-available phosphorus. Commun. Soil Science and Plant Analysis 29, 2905-2916.

Saleque MA, Naher UA, Islam A, Pathan ABMBU, Hossain ATMS, Meisner CA (2004) Inorganic and organic phosphorus fertilizer effects on the phosphorus fractionation in wetland rice soils. *Soil Science Society of America Journal* 68(5), 1635-1644.

Saleque MA, Saha PK, Panaullah GM, Bhuiyan NI (1998b) Response of wetland rice to potassium in farmers field of the Barind tract of Bangladesh. *Journal of Plant Nutrition* 21, 39-47.

Slaton NA, Wilson CE, Norman RJ, Ntamatungiro S, Frizzell DL (2002) Rice response to phosphorus fertilizer application rate and timing on alkaline soils in Arkansas. *Journal of Agronomy*. 94, 1393-1399.

Syers JK, Johnston AE, Curtin D (2008) Efficiency of soil and fertilizer phosphorus use. Reconciling changing concepts of soil phosphorus behavior with agronomic information. FAO Fertilizer and Plant Nutrition Bulletin no. 18. Rome, Italy: FAO.

Walkey A, Black IA (1934) An examination of degtiareff method for determining soils organic matter and a proposed modification of the chromic acid titration method. Soil Science. 37 29-38.