Indian Journal of Agricultural Sciences **78** (10): 877–80, October 2008

Influence of combined application of farmyard manure and Udaipur rock phosphate on availability and transformation of phosphorus in Typic Ustochrept under rice (*Oryza sativa*) – wheat (*Triticum aestivum*) sequence*

P WEERA SINGHE[1], A S SIDHU[2] and G S SAROA[3]

Punjab Agricultural University, Ludhiana 141 004

Received: 27 February 2008

Key words: Farmyard manure, P fractions, Udaipur rock phosphate

Rice (*Oryza sativa* L.) – wheat (*Triticum aestivum* L. emend. Fiori & Paol.) system is showing a negative soil P balance due to application of P only to wheat crop (Yadvinder-Singh *et al*. 2000) while rice crop feeds on the release of soil P during summer submergence. A remedial measure is, therefore, needed to take care of the soil P fertility due to negative P balance. Direct use of rock phosphate under alkaline soil reaction does not find favour. Nevertheless, successful results have been reported by the combined application of rock phosphate with organic manures in acid and slightly acid soils (Dinesh *et al*. 2003, Oladeji *et al*. 2006). Hence, a study was undertaken to study the availability and the transformation of P in soils applied with Udaipur rock phosphate along with farmyard manure in the rice–wheat system in an alkaline soil.

A field experiment was conducted during 3 consecutive seasons starting during rainy (*kharif*) season 2006 to *kharif* 2007 on a sandy loam, Typic Ustochrept soil at the farm of the University. Olsen P content of the surface (0–15 cm) soil was 21.8 kg/ha and exchangeable K (1 M NH_4OA_c extractable K, *p*H 7) content was 89.6 kg/ha. Surface soil samples had *p*H of 7.2 (1 : 2.5 soil : water), electrical conductivity 0.21 dS/m, organic carbon 5.7 g/kg and available N (alkaline permanganate) 141.0 kg/ha. The DTPA extractable Zn, Fe, Mn and Cu were 0.86, 10.9, 9.05, 0.64 mg/kg respectively. Total P content of the Udaipur rock phosphate was 8.35% P (19.12% P_2O_5) while citrate soluble and water-soluble P were 1.62% and 0.14% respectively. Udaipur rock phosphate samples showed *p*H (1: 2.5 water) of 8.3.

Six treatments of phosphate replicated 5 times were applied using randomized complete block design to rice and wheat (Table 1). The Udaipur rock phosphate and farmyard manure were applied at first ploughing and incorporated into the soil before rice transplanting. A uniform dose of 120 kg N/ha was applied in 3 equal splits to rice and in 2 splits to wheat. 'PR 118' rice was transplanted during *kharif* 2006

Table 1. Effect of Udaipur rock phosphate in presence and absence of farmyard manure on soil *p*H and Olsen-P

Treatment		Soil *p*H (1 : 2.5 soil : water)			Olsen P (mg/kg)		
Rice	Wheat	Rice 1	Wheat	Rice 2	Rice 1	Wheat	Rice 2
P_0	SSP @ P_{60}	6.62	6.69	6.70	10.5	11.2	15.7
URP@ P_{60}	SSP @ P_{60}	6.69	6.45	6.84	11.1	10.6	19.7
URP @ P_{60} + 20 tonnes/ha FYM	SSP@ P_{60}	6.59	6.57	7.04	11.1	10.1	8.7
P_0 + 20 tonnes/ha FYM	SSP @ P_{60}	7.03	6.80	7.13	14.6	17.2	30.9
SSP @ P_{60}	SSP@ P_{60}	6.64	6.62	6.85	13.1	12.4	21.3
P_0	P_0	6.70	6.58	6.94	10.3	8.1	12.3
LSD (*P*= 0.05)		NS	NS	NS	3.1	3.8	6.1
CV%		5.02	5.38	3.90	19.2	22.6	21.4

P_0, no P; P_{60}, 60 kg P_2O_5/ha; SSP, Single superphosphate; FYM, farmyard manure; URP, Udaipur rock phosphate

*Based on a part of Ph D thesis of the first author submitted to PAU, Ludhiana during 2008.

[1]Research Officer, Regional Agricultural Research Centre, Angunakolapelessa, Sri Lanka (E-mail: priyantha_pau @yahoo.com)

[2,3]Senior Soil Chemists, Department of Soils

on 14 June 2006 and 'PAU 201' rice on 20 June 2007. 'PBW 343' wheat was sown on 5 November 2006. Transplanting of rice was done after puddling and water was kept standing in the field for 3 weeks after transplanting. Subsequently irrigation was applied 2 days after the water had drained. Wheat crop was sown after applying a pre-sowing irrigation. The first irrigation to wheat was applied 3 weeks after seeding at crown root initiation stage. Thereafter 3 more irrigations were given as and when required. Rice was harvested on 20 October 2006 and on 24 October 2007. Wheat crop was harvested on 18 November 2007. Grain and straw yield were recorded. Grain and straw samples of both the crops were analyzed for P content (Jackson 1962). Surface soil samples were collected after harvesting of the crops and analyzed for *p*H (1 : 2.5 water), Olsen P and different P fractions (Olsen and Sommers 1982).

Neither the application of farmyard manure nor Udaipur rock phosphate caused any significant change in soil *p*H (Table 1), although slight decrease in *p*H was observed compared to the initial value. Jena *et al*. (2004) observed an increase in *p*H from original value of 6.2 on application of 40 kg P_2O_5/ha from Jamarkota rock phosphate to maize (*Zea mays* L.) and Indian mustard (*Brassica juncea* L. czernj & coss.) crops. The lower rate of addition, poor dissolution of Udaipur rock phosphate and near neutral soil *p*H may be the probable reasons for no change in *p*H due to Udaipur rock phosphate application even after the third crop.

Olsen P status of soil after the first rice crop increased in the treatments, receiving farmyard manure, Udaipur rock phosphate and single superphosphate, but the increase was significant only for farmyard manure (Table 1). Significant increase in Olsen P content of the soil was observed after harvest of wheat and the second rice crop in the single super phosphate, Udaipur rock phosphate, Udaipur rock phosphate + farmyard manure and zero P + farmyard manure treatments over the zero P treatment. Olsen P status of Udaipur rock phosphate + farmyard manure and zero P + farmyard manure treatments was, however, comparable. Yadvinder-Singh *et al*. (2004) also observed increase in Olsen P after the application of organic amendment in rice-wheat system.

Despite the repeat application of Udaipur rock phosphate and farmyard manure to the second rice crop, there was no marked improvement in Olsen P content in the farmyard manure + Udaipur rock phosphate treatment compared with the farmyard manure alone treatment. It suggests that no marked enhancement in the mobilization of P from Udaipur rock phosphate occurred due to the combined application with farmyard manure.

There was no significant effect of different P treatments on grain and straw yield of crops (Table 2). High P status of the soil limits the response of crops to P application. The total P uptake by the first rice and wheat crop was not affected by the addition of Udaipur rock phosphate, single superphosphate and farmyard manure. In the second rice crop, the highest P uptake was observed in Udaipur rock phosphate + farmyard manure and the lowest in Udaipur rock phosphate and the absolute control. However when total P uptake by all the 3 crops was considered, farmyard manure + Udaipur rock phosphate treatment showed the maximum value indicating the possible accumulation of P in grain and straw without the yield response.

Though Olsen P was not affected, yet other P fractions in soil after harvest of crops showed marked variation among different treatments. Non–occluded P (NaOH + CB–P), an index of Fe- and Al- bound P, improved with the Udaipur rock phosphate + farmyard manure, farmyard manure and single super phosphate treatments (Table 3). But the significant differences over zero P appeared after wheat and the second rice crop. Enrichment of the NaOH-P fraction due to the addition of organic amendment and inorganic P fertilizer has been widely reported (Sui *et al*. 1999, Akhtar *et al*. 2005). In comparison to other treatments, Udaipur rock phosphate alone treatment did not show a significant improvement in this fraction over zero P treatment indicating

Table 2 Grain, straw yield and total P uptake by crops

Treatment		Grain yield (mg/ha)			Straw yield (mg/ha)			Total P uptake (kg/ha)			Total
Rice	Wheat	Rice 1	Wheat	Rice 2	Rice 1	Wheat	Rice 2	Rice 1	Wheat	Rice 2	
P_0	SSP @ P_{60}	6.54	4.86	8.84	9.65	9.57	8.57	31.0	14.1	30.0	75.1
URP @P_{60}	SSP @ P_{60}	6.94	4.84	8.72	9.21	9.59	8.31	32.1	12.5	27.1	71.7
URP @ P_{60} + 20 tonnes/ha FYM	SSP @ P_{60}	6.61	4.91	8.72	11.07	10.13	8.67	35.0	15.5	31.6	82.1
P_0 + 20 tonnes/ha FYM	SSP @ P_{60}	5.80	4.89	8.94	10.81	10.93	8.35	31.3	15.6	30.0	76.9
SSP @P_{60}	SSP @ P_{60}	6.58	4.84	8.33	10.18	9.99	8.46	34.3	15.0	28.4	77.7
P_0	P_0	6.76	4.73	8.55	10.01	9.95	7.91	33.2	11.9	26.7	71.8
LSD (*P*= 0.05)		NS	NS	NS	NS	NS	NS	NS	NS	3.6	
CV (%)		8.56	3.48	8.30	10.16	8.60	12.60	11.8	17.6	9.5	

P_0, No P; P_{60}, 60 kg P_2O_5/ha; SSP, single superphosphate; FYM, farmyard manure; URP, Udaipur rock phosphate

Table 3 Non-occluded, occluded and Ca-P fraction after the harvest of different crops

Treatment		Non-occluded P (mg/kg)			Occluded P (mg/kg)			Ca-P (mg/kg)		
Rice	Wheat	Rice 1	Wheat	Rice 2	Rice 1	Wheat	Rice 2	Rice 1	Wheat	Rice 2
P_0	SSP @ P_{60}	105.0	147.2	79.2	111.1	128.5	57.4	256.6	294.4	290.7
URP @ P_{60}	SSP @ P_{60}	111.2	140.0	76.5	110.5	140.4	59.1	270.2	358.6	359.2
URP @ P_{60} + 20 tonnes/ha FYM	SSP @ P_{60}	141.3	188.2	139.7	117.0	138.7	74.5	269.7	349.2	331.8
P_0 + 20 tonnes/ha FYM	SSP @ P_{60}	131.3	183.9	146.4	114.2	145.1	85.0	303.0	329.3	323.7
SSP @ P_{60}	SSP @ P_{60}	126.5	151.9	104.5	111.9	128.0	67.5	286.8	308.8	300.0
P_0	P_0	108.5	124.0	79.8	110.5	122.4	62.2	280.3	321.8	298.2
LSD (*P*=0.05)		NS	24.3	24.9	NS	NS	15.9	NS	NS	36.2
CV%		22.9	10.4	15.8	8.4	9.7	15.6	11.9	11.6	7.6

P_0, no P; P_{60}, 60 kg P_2O_5/ha; SSP, Single superphosphate; FYM, farmyard manure; URP, Udaipur rock phosphate

the ineffectiveness of Udaipur rock phosphate in releasing P to enrich this soil P fraction. Application of farmyard manure and single superphosphate increased Fe and Al-P fraction by lowering soil *p*H. This fraction after the harvest of the second rice crop was much lower than that after wheat harvest. This may be attributed to the mobilization of Fe and Al-P because of the reduced conditions prevailing during rice. The comparable values of non-occluded P fraction in the Udaipur rock phosphate alone and zero P treatment suggests no appreciable P mobilization due to Udaipur rock phosphate.

Occluded P (reductant soluble) fraction was not affected during the first 2 crops but it showed significant increase with the application of farmyard manure alone during the second rice crop (Table 3). In the absence of P fertilization to the rice crop, no significant change in the occluded P fraction occurred even after the third crop irrespective of P application treatments. Organic manuring increased the occluded P fraction (Akhtar *et al*. 2005).

Post-harvest Ca-P fraction was not affected significantly by different treatments after the first rice and wheat crop (Table 3). However after second rice crop there was a marked increase in Ca-P in both Udaipur rock phosphate and Udaipur rock phosphate + farmyard manure treatments with significant increase only in Udaipur rock phosphate alone. This behaviour suggested some solubilization of Ca-P in the farmyard manure treated soil. An increase in Ca-P fraction was recorded after wheat crop in all the treatments, followed by a general decrease after rice. Similar observations have been reported by other workers (Shen *et al*. 2004, Zhang *et al*. 2006). No decrease in Ca-P fraction with the application of Udaipur rock phosphate alone after the third crop may be the result of the repeat application of Udaipur rock phosphate during third crop season. This addition compensated the loss in soil Ca-P that could be expected in the same treatment during the second rice crop due to flooding. But with the addition of farmyard manure, Ca-P content showed a decrease in the Udaipur rock phosphate treatment. In Mollisols treated with high application rates of biosolids having alkaline *p*H, Sui *et al*. (1999) demonstrated transformation of Ca-P to more labile P forms.

SUMMARY

An investigation was carried out from rainy (*kharif*) season 2006 to *kharif* 2007 to evaluate the performances of Udaipur rock phosphate in combination with farmyard manure to safeguard the P fertility of the cropping system in an alkaline soil. Results of the present investigation revealed that no significant P mobilization took place due to combined application of Udaipur rock phosphate and farmyard manure in alkaline soil as no improvement in post-harvest Olsen P content or P uptake was observed. Phosphorus fractions were also not affected due to the combined application of Udaipur rock phosphate and farmyard manure relative to farmyard manure alone. The improvement in total P uptake by the 3 crops and the comparatively lower build up of Ca-P fraction with the combined application however, suggests a possible minor degree of solubuilization of Udaipur rock phosphate in this soil.

ACKNOWLEDGEMENTS

Senior author is thankful to Sri Lanka Council for Agricultural Research Policy (CARP) for sponsorship and CARP-ICAR work plan for placement at Punjab Agricultural University.

REFERENCES

Akhtar M, Mc Callister D L, Francis D D and Schepers J S. 2005. Manure source effects on soil phosphorus fractions and their distribution. *Soil Science* **170**: 183–90.

Dinesh R, Ganeshamurthy A N, Chaudhuri S G and Prasad G S. 2003. Dissolution of rock phosphate as influenced by farmyard manure, fresh poultry manure and earthworms in soils of an oil palm plantation. *Journal Indian Society Soil Science* **51**: 308 – 12.

Jackson M L. 1962. *Soil Chemical Analysis*. Prentice-Hall, Englewood Cliffs. NJ.

Oladeji O O, Kolawole G O , Adeoye G O and Tian G. 2006. Effects of plant residue quality, application rate and placement method on phosphorus availability from Sokoto rock phosphate.*Nutrient Cycling in Agroecosystem* **76**: 1– 10.

Olsen S R and Sommers L E. 1982. Phosphorus p 403–30. (*in*) *Methods of Soil Analysis Part 2*. *Chemical and Microbiological Properties*. Agronomy Monograph No 9 (Part 2). A L Page, R H Miller and D R Keeny (Eds). American Society of Agronomy and Soil Science Society of America. Madison, USA.

Shen J, Li R, Zhang F, Fan J, Tang C and Rengel Z. 2004. Crop yields, soil fertility, and phosphorus fractions in response to long-term fertilization under rice monoculture system on a calcareous soil. *Field Crops Research* **86**: 225–38.

Sui Y, Thompson M L and Shang C. 1999. Fractionation of phosphorus in a Mollisol amended with biosolids. *Soil Science Society America Journal* **63**: 1174 –80.

Yadvinder-Singh, Dobermann A, Bijay-Singh, Bronson K F and Khind C S. 2000. Optimal phosphorus management strategies for wheat–rice cropping system on loamy sand. *Soil Science Society America Journal* **64**: 1413–22.

Yadvinder-Singh, Bijay-Singh, Ladha J K, Khind C S, Gupta R K, Meelu O P and Pasuqin E. 2004. Long-term effects of organic inputs on yield and sol fertility in the rice- wheat rotation. *Soil Science Society America Journal* **68**: 845–53.

Zhang Q, Wang G H, Feng Y K, Sun Q Z, Witt C and Dobermann A. 2006. Changes in soil phosphorus fractions in a calcareous paddy soil under intensive rice cropping. *Plant Soil* **28**: 141–54.