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Comparison of Selectively Mined Apatite Crystals and Commercially Available Rock Phosphate from Eppawala, as P Fertilizers for Flooded Rice

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ABSTRACT. *The agronomic effectiveness of selectively mined primary apatite crystals (SERP) was compared with that of commercially available Eppawala rock phosphate fertilizer (ERP) and triple super phosphate (TSP) in a greenhouse experiment. In addition, the effect of mixing peat with rock phosphates on their effectiveness was investigated. Soils used in this experiment were Reddish Brown Earth (RBE-Rhodustalfs) from Maha Illuppallama and Red Yellow Podzolic (RYP- Rhodustults) from Makandura. Test crop was paddy (Oryza sativa L., variety BG-94-1). Initial available P content of RBE and RYP soils were 12.2 and 12.4 mg/kg of soil, respectively.*

It was observed that addition of rock phosphates (both SERP and ERP) and rock phosphate + peat mixtures did not increase the grain yield significantly in both RBE and RYP soils, as compared to the control treatment. However plant P uptake values were significantly higher in rock phosphate treated pots than in the control. In both soils, P uptake was significantly higher in SERP treatment than in ERP treatment. In treatments where peat was mixed with rock phosphates; significantly higher P uptake values were observed, when compared with the corresponding rock phosphate (without peat) treatments, except in the case of ERP in RBE soil. Chemical analysis of soil for Olsen -P at the end of the experiment showed a significantly higher residual -P content in SERP+peat treatment in RBE soil, whereas a significantly higher content was observed for TSP treatment in the RYP soil. Results, therefore, reveal that SERP is superior to ERP as a P fertilizer for flooded rice in these two soils. Mixing with peat further increased the agronomic effectiveness of SERP in both soils.

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INTRODUCTION

In Sri Lanka, imported phosphate fertilizers, such as, triple superphosphate (TSP) are being applied for the production of rice and other annual crops. Eppawala rock phosphate (ERP) is used as the major P fertilizer in the plantation sector; but it is not recommended for short term crops, due to its low solubility.

ERP is a mixture of primary apatite crystals and secondary matrix, which contains high amounts of Fe_2O_3 and Al_2O_3 . Recent studies by Dahanayake and Subasinghe (1991) and Ratnayake *et. al.* (1993 b) indicated, that selectively mined Eppawala rock phosphate (SERP) (primary apatite crystals) contains a higher total P_2O_5 content, higher citric acid and water soluble P contents and a lower Fe_2O_3 + Al_2O_3 content as compared to ERP. They noted that solubility of ERP could be greatly influenced by its Fe_2O_3 + Al_2O_3 content. The results obtained by Hammond *et. al.* (1986) in a greenhouse study also indicated the importance of considering properties of the rock phosphates when selecting them for application to crops.

In this study a greenhouse experiment was conducted to compare the agronomic effectiveness of SERP with that of ERP and TSP, as a P fertilizer for flooded rice. In addition, the effect of mixing peat with SERP and ERP on their P availability was investigated.

MATERIALS AND METHODS

Analysis of the phosphorus fertilizers, SERP, ERP and TSP respectively was as follows: Total phosphorus (% P_2O_5) 42, 30 and 46; and 2% citric acid extractable phosphorus (% P_2O_5) 5.8, 3.1 and 45.0. Rock phosphate and Muthurajawela peat were used as ground powder passing through a 100 mm mesh sieve, whereas TSP was used as 1-2 mm diameter granules.

Soils used in this study were namely RBE (Reddish Brown Earth, Rhodustalfs) from Maha Illuppallama and RYP (Red Yellow Podzolic, Rhodustults) from Makandura. Soil samples were analyzed for important chemical properties (Table 1).

Table 1. Chemical properties of RYP and RBE soils used in the study.

Property	RYP	RBE
pH 1:2.5 (soil:1M KCl)	3.9	5.8
Organic matter (%)	1.7	2.6
Available P (mg/kg of soil)	12.4	12.2
Total N (%)	0.3	0.1
Exchangeable cations (mg/100g of soil)		
Ca^{2+}	48.8	98.9
Mg^{2+}	7.0	42.5
K^{+}	7.2	46.5

The study was carried out as a greenhouse trial, where rice plants (*Oryza sativa* L., variety BG 94-1) were grown for 3 1/2 months in 7 kg of soil (air dry basis) in pots. Treatments were control (no P), SERP, ERP, SERP+peat, ERP+peat and TSP. The soil was submerged using demineralized water from two weeks before transplanting. Rock phosphate and TSP were added at a rate of 25 kg of total P_2O_5/ha at planting time. In the case of treatments where rock phosphates were applied mixed with air dried Muthurajawela peat (moisture content = 12%, w/w), the two were mixed at a ratio of 1:0.8 by weight as recommended in a previous incubation study (Ratnayake *et. al.* 1993 a). At the same time, all pots including the control treatment also received 30 kg N/ha in the form of urea and 20 kg K_2O/ha in the form of muriate of potash as basal dressing. The water level in the pots was maintained at 2.5 cm above the soil surface. All pots received 70 kg N/ha in the form of urea as a top dressing eight weeks after transplanting. All treatments were replicated four times in a randomized complete block design.

Plant height and number of tillers were taken at the stage of maximum tillering. After harvesting, panicles were dried at 65°C, and the total grain yield was determined. Above ground portions of the plant parts, including grains, were digested using the dry ash method (Jones, 1988); and P was determined by the vanadate -molybdate yellow method (Chapman and Pratt,

1961) using Shimdzu UV-160A spectrophotometer. Residual P in soil samples was analyzed by the Olsen method (Olsen *et. al.* 1954). The data were statistically analyzed using the SAS analyzing procedure (Anonymous, 1985).

RESULTS AND DISCUSSION

Some of the important chemical properties of the two soils are given in Table 1. RYP soil is strongly acidic in reaction, whereas RBE soil is moderately acidic. Both soils had a moderate content of available phosphorus.

A significant grain yield response was observed for TSP application over the control, in both soils (Table 2). In RBE soil, all the rock phosphate treatments (with and without peat) gave considerable yield increases, which however, were not statistically significant over the control (Table 2). In the RYP soil there was hardly any yield increase due to the rock phosphate treatments. Nagarajah *et. al.* (1979) in flooded rice culture, also noted a smaller increase in yield in the ERP treatment than in the TSP treatment. In both soils, none of the P treatments had a significant effect on 1000 seed weight (Table 2).

Table 2. Grain yield of paddy (g/pot) obtained with different phosphorus treatments in RYP and RBE soils.

Treatment	RYP		RBE	
	yield (g/pot)	1000 seed weight (g)	yield (g/pot)	1000 seed weight (g)
SERP	42.47[ab]	26.67[a]	57.24[ab]	25.30[a]
SERP+peat	46.17[ab]	26.29[a]	57.19[ab]	24.22[a]
ERP	42.17[b]	26.55[a]	56.58[ab]	25.02[a]
ERP+peat	43.22[b]	26.16[a]	55.36[ab]	24.88[a]
TSP	50.75[a]	25.46[a]	64.64[a]	25.24[a]
Control	42.00[b]	26.09[a]	46.46[b]	25.12[a]

Means with the same letter(s) within the column are not significantly different at $\alpha = 0.05$ level(DMRT).

P content in plant

In both soils, P content in all P-treated plants was significantly higher than that of the control (Table 3). The response to added P sources was similar in both soils. It has been noted that the P content in SERP-treated plants was higher than ERP-treated plants. In treatment where peat was mixed with rock phosphates, plant P content was significantly higher than in rock phosphate treatments without peat.

Total P uptake by paddy crop

In all P-treated plants, the uptake of phosphorus was significantly greater than that of control plants (Table 3). In both soils TSP treated plants had the highest P uptake, which was significantly different to the rock phosphate treatments. SERP (with and without peat) treated plants had a significantly higher P uptake than ERP (with and without peat) treated plants in both soils. The effect of mixing peat in increasing plant P uptake could be seen for both SERP and ERP in both soils. But, this effect was not statistically significant in the case of ERP treatment in RBE soil.

Table 3. Plant P content (mg /kg of plant) and total P uptake (mg/pot) by rice plants grown on different P treatments in RYP and RBE soils.

Treatments	RYP		RBE	
	P content (mg/kg plant)	P uptake (mg/pot)	P content (mg/kg plant)	P uptake (mg/pot)
SERP	50.96[c]	9.17[c]	68.76[d]	12.62[c]
SERP+peat	77.20[b]	9.59[b]	96.78[b]	13.71[b]
ERP	47.70[d]	8.98[d]	66.92[d]	12.22[c]
ERP+peat	76.30[b]	9.33[c]	82.20[c]	12.60[c]
TSP	82.46[a]	10.01[a]	115.42[a]	14.35[a]
Control	40.92[e]	7.74[e]	63.42[e]	8.38[d]

Means with the same letter(s) within the column are not significantly different at $\alpha = 0.05$ level (DMRT).

Residual P content

At the commencement of the experiment, both RYP and RBE soils had moderate available P contents (Table 1). After harvesting, the soil analysis showed that the residual P content of all P treatments was still higher than that of the control in both soils (Table 4). However, the amount of residual P recorded at end of the experiment markedly varied with the P sources. In RYP soil, the highest amount of residual P was recorded in TSP treatment, whereas in RBE soil it was for the SERP+peat treatment. In the control treatment the available P content decreased from 12.4 to 8.2 mg/kg of soil for RYP soil, and from 12.2 to 4.4 mg/kg of soil for RBE soil due to plant uptake. In the other treatments too for both soils the available P values were lower than the initial values.

Table 4. Soil available P (mg/ kg of soil) content at the end of the experiment.

Treatment	Available phosphorus (mg/kg of soil) RYP	RBE
SERP	8.8^{d}	7.8^{b}
SERP+peat	9.4^{b}	9.2^{a}
ERP	8.5^{e}	5.0^{e}
ERP+peat	9.1^{c}	6.5^{d}
TSP	11.7^{a}	6.9^{c}
Control	8.2^{f}	4.3^{f}

Means with the same letter(s) within the column are not significantly different at $\alpha = 0.05$ level (DMRT).

CONCLUSIONS

The findings of this experiment suggest that SERP is superior to ERP as a P fertilizer for lowland rice, but inferior to TSP. Mixing peat with rock phosphate (both SERP and ERP) increased the agronomic effectiveness in both soils. More research work is required to further evaluate the agronomic effectiveness of SERP as well as peat treated SERP mixtures, preferably under greenhouse and field conditions.

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