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A Comparison of Citric Acid Solubilities of Commercially Available Eppawala Rock Phosphate and Selectively Mined Primary Apatite Crystals After Mixing With Peat

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ABSTRACT. *The low solubility of commercially available Eppawala Rock Phosphate (ERP) makes it unsuitable as a directly applied phosphorus fertilizer for annual crops. ERP consists essentially of primary apatite crystals, in a fine matrix of secondary phosphate. Recent studies have shown that the primary apatite crystals which form a significant fraction of the ore, has a higher P_2O_5 content than those of the matrix. Research have shown that burying ERP in Muthurajawela peat (MP) increases its solubility. The objective of this study is to compare the solubility of commercially available ERP with selectively mined Eppawala rock phosphate (SERP) when both these fertilizers are mixed with Muthurajawela peat.*

A laboratory incubation experiment of 30 days duration was conducted. Ground ERP and SERP were mixed with ground Muthurajawela peat at a ratio of 1:0.8 by weight and the mixtures were kept under submerged conditions at room temperature. Citric acid soluble phosphorus content and pH were determined periodically using two replicates at a time. The citric acid solubility of ERP increased with incubation time for upto 9 days, then decreased due to reprecipitation. This effect was not observed with SERP until the 20th day. At the commencement of the experiment, SERP and ERP contained 5.8% and 3.1% citric acid soluble P_2O_5 respectively. Mixing with peat increased the citric acid solubility of both SERP and ERP. Throughout the incubation period SERP had a higher solubility than ERP. Very often a more than two fold increase in solubility was observed in SERP when compared with ERP. These results therefore strongly suggest that SERP is superior to ERP as a phosphorus fertilizer source and that mixing with peat

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could increase the effectiveness of using ERP further as a phosphorus fertilizer.

INTRODUCTION

High cost of fertilizer is one of the constraints preventing the development of an intensive and economically rewarding agriculture in Sri Lanka. Doubling the cost of fertilizer since 1989 due to the withdrawal of the subsidies has encouraged the search for cheaper and effective fertilizers from local resources. Sri Lanka has a significant phosphate deposit at Eppawala in the Anuradapura district, with an estimated reserve of more than 40 million metric tonnes (Dahanayake and Subasinghe, 1991). The local production of rock phosphate was about 32,559 million tonnes in 1990 and the projection of consumption for the year 2000 has been estimated at 43.3 million tonnes of P_2O_5.

The direct application of ERP to soil as a source of phosphorus fertilizer has been practised over the years for long term crops such as tea, rubber and coconut (Silva, 1988). However, Eppawala rock phosphate has not yet been successfully used for annual crops because of its low solubility. At present, efforts are underway to make the ERP more soluble so as to use it for short term crops (Abeykoon, 1989; Amarasiri and Wijewardana, 1989; Thenabadu, 1989). Several methods have been suggested (Gunawardane and De Silva, 1987; Tennakoon, 1988) to convert the ERP to a more soluble form. Gunawrdane and De Silva (1987) mixed ERP with peat and allowed to cure for different periods of time. They have noted an increased availability of P after the curing.

Laboratory analyses of phosphate samples from Eppawala deposit have shown that the mineralogy of apatite is highly variable, with P_2O_5 content and solubility varying in different sectors of the deposit (Dahanayake and Subasinghe, 1991; Dahanayake, *et al.*, 1991). Currently, in the mining operations at Eppawala the superior phosphate ore of primary apatite crystal is mixed with the inferior secondary phosphate matrix which contains appreciable amounts of aluminous, ferruginous and siliceous materials. The greenish primary apatite crystals, generally occur in a loose secondary phosphate soil matrix and can be easily handpicked at the deposit. Therefore, selective mining has been suggested so as to separate the superior primary apatite from the inferior secondary phosphate matrix. The objective

of this study is to compare the citric acid solubilities of commercially available ERP and SERP after incubating with Muthurajawela peat.

MATERIALS AND METHODS

Incubation experiment

This incubation study was carried out at the Institute of Fundamental Studies using finely powdered, selectively mined crystals of ERP (SERP) with a particle size in between 149-177 μm, commercially available ERP with a particle size of 149 μm and Muthurajawela peat. A preliminary incubation experiment was conducted using finely ground primary apatite crystal from Eppawala and air dried Muthurajawela peat (MP). Varying proportions of rock phosphate:MP by weight was studied in order to find the optimum ratio of rock phosphate:MP giving the maximum solubility of ERP. It was found that rock phosphate:MP as 1:0.8 by weight was the best for highest water solubility of ERP. This ratio is used in the present study.

One gram each of ERP and SERP were thoroughly mixed with 0.8 g of ground MP in two separate extraction bottles and were kept under submerged condition by adding 5 ml of distilled water. Water level was kept constant by adding water to maintain the initial weight of the bottles. Two replicates of each treatment were analysed for pH and citric acid soluble phosphorus content, periodically upto 30 days.

Chemical analysis

pH of the incubation mixture suspension was measured before adding 2% citric acid for phosphorus extraction. 100 ml of 2% citric acid was added directly into each extraction bottle containing the rock phosphate:peat mixture. Each mixture was shaken for 30 min at the rate of 150 rpm. Clear supernatant portion was taken out for analysis of phosphate. Phosphorus was measured using ammonium meta vanadate (yellow) method at 420 nm using a spectrophotometer (Jeffery, 1975).

RESULTS AND DISCUSSION

Citric acid soluble P_2O_5 content and pH values in SERP-peat and ERP-peat mixtures are given in Table 1. The data were plotted against time (Figure 1) and statistically analyzed. Treatment means were compared using the T test whenever F values were significant at 5% level.

Table 1. Citric acid soluble P_2O_5% and pH in SERP-peat an CERP-peat incubation mixture.

Date of incubation	SERP-peat mixture		ERP-peat mixture	
	P_2O_5%	pH	P_2O_5%	pH
2	7.23	4.39	3.86	4.16
4	7.00	4.03	4.37	3.75
7	7.36	3.96	4.07	3.71
9	7.40	2.36	4.76	2.34
12	7.34	2.92	3.81	3.02
13	7.11	2.40	3.68	3.90
14	7.61	4.03	3.60	3.89
15	8.06	3.25	3.54	3.57
20	9.62	3.06	3.36	3.64
23	7.29	3.58	3.32	3.63
26	6.35	3.90	3.10	3.77
28	6.01	3.83	3.03	3.63
30	5.93	3.69	2.48	3.60

In general the pattern of change in citric acid soluble P_2O_5 content with time was similar in SERP-peat and ERP-peat mixtures (Figure 1). As illustrated in Figure 1, citric acid soluble P_2O_5 content increased with time and then gradually decreased. Similar observations where citric acid soluble P_2O_5 content was found to increase initially and then decline have been reported by Gunawardane and De Silva (1987) and Olsen and Flowerday (1971).

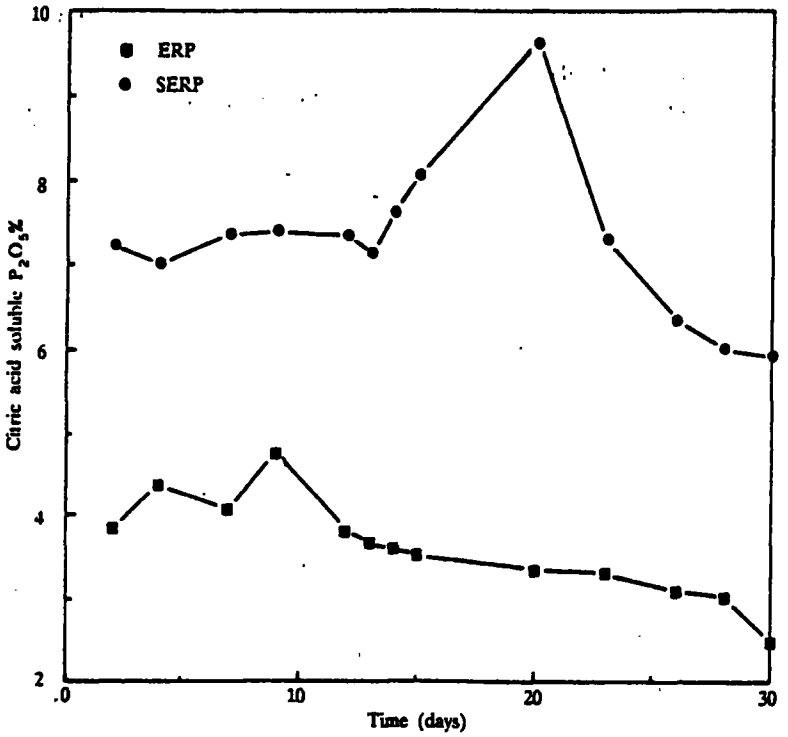

Figure 1. Citric acid soluble P_2O_5% in ERP-peat and SERP-peat incubation mixtures.

In SERP-peat mixture the highest citric acid soluble P_2O_5 content of 9.63% was observed after 20 days of incubation, whereas, in ERP-peat mixture the peak value of 4.76% P_2O_5 was reached at the 9th day of incubation (Table 1). The decrease of citric acid soluble P_2O_5 content in both SERP and ERP may have been the result of reprecipitation of phosphate. Citric acid soluble P_2O_5 of SERP and ERP (without mixing with peat) were 5.8% and 3.16% respectively. At the commencement of the incubation (soon after mixing with peat) citric acid soluble P_2O_5 content increased to 7.23% and 3.86% in SERP and ERP respectively.

Almost throughout the incubation period, citric acid solubility in SERP was significantly greater than that of ERP and very often it showed a more than two-fold increase when compared with that of ERP.

The initial pH values of SERP and ERP were 6.56 and 6.36 respectively and the initial citric acid soluble P_2O_5 content of SERP and ERP were 5.8% and 3.1% respectively. Mixing with peat decreases the pH in both SERP and ERP. In SERP-peat and ERP-peat mixtures the highest pH values of 4.39 and 4.16 respectively were observed at the 2 nd day of incubation (Table 1). Thereafter, pH decreased with time. The increase in solubility of both types of Eppawala rock phosphate when mixed with peat could be attributed to the lowering of pH. Similar conclusions have been made in several studies (Gunawardena and de Silva, 1987; Hammond *et al.*, 1989 and Hagin *et al.*, 1990).

CONCLUSION

The results of this study have shown that selectively mined ERP (SERP) has more citric acid soluble P_2O_5 (5.8%) than the commercially available ERP (3.1%). This finding indicates that selective mining of Eppawala phosphate deposit is more desirable if it is to be used as a directly-applied phosphorus fertilizer.

Both ERP fertilizers when mixed with peat showed an increase in citric acid soluble P_2O_5%. This effect was more pronounced for SERP than for ERP.

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REFERENCES

Abeykoon, V. (1989). Effectiveness of Partially Acidulated Phosphate Rock (PAPR) prepared from Eppawala rock phosphate as a P fertilizer. *In*: Proc. National Symposium on "Eppawala Phosphate Deposit-Recent Advances in Knowledge". pp. 14-15.

Amarasiri, S.L. and Wijewardana, J.D.H. (1989). Comparison of Phosphate sources on growth of vegetables on an acidic soil. *In*: Proc. National Symposium on "Eppawala Phosphate Deposit-Recent Advances in Knowledge". pp. 13.

Dahanayake, K. and Subasinghe, S.M.N.D. (1991). Mineralogical,chemical and solubility variations in the Eppawala phosphate deposit of Sri Lanka- A case for selective mining for fertilizers. Fertilizer Research, 28: 233-238.

Dahanayake, K., Senaratne, A., Subasinghe, S.M.N.D. and Liyanarachchi, P.A. (1991). Potential use of naturally occurring sulfuric acid to beneficiate poorly soluble phosphate from Eppawala, Sri Lanka. Fertilizer Research, 29: 197-201.

Gunawardane, R.P. and de Silva, H.K. (1987). Eppawala apatite - Muthurajawela peat mixture as a P fertilizer. Abstr. 43rd Annual Sessions, Sri Lanka Association for Advancement of Science E - 29: 222.

Hagin, J., Rajan, S.S.S., Boyes, M.K., and Upsdell, M. (1990). Partially acidulated phosphate rocks: phosphorus release characteristics. Fertilizer Research 22. (2): 109-117

Hammond, L.L., Chien, S.H., Roy, A.H. and Mokwunye, A.U. (1989). Solubility and agronomic effectiveness of partially acidulated phosphate rocks as influenced by their iron and aluminium oxide content. Fertilizer Research 19.(2): 93-98.

Jeffery, P.G., (1975). Chemical methods of rock analysis. Pregaman press. 163-171, 375-385.

Olsen, S.R. and Flowerday, A.D. (1971). Fertilizer phosphorus interaction in alkaline soils. pp. 153-185. In: Olsen, R.A., Army, T.J., Hanway, J.J. and Kilner, V.J. (Eds). Fertilizer Technology and Use. Soil Sci. Soc. Am. Inc. Madison, Wisconsin, U.S.A.

Silva, C. (1988). The significant of Eppawala Rock Phosphate Deposit for Sri Lankan's Agriculture. *In*: Economic Review Vol. 14: No. 06: 8-9.

Tennakoon, K. (1988). Production of ammonium phosphate containing fertilizers from apatite unsuitable for the wet process. Fertilizer Research. 17: 97-100.

Thenabadu, M.W. (1989). Investigation on efficiency of Eppawala apatite as a source of phosphorus for seedlings. *In*: Proceedings National symposium on "The Eppawala phosphate deposit - Recent Advances in Knowledge" 19.