

**EFFECTIVENESS OF
PARTIALLY ACIDULATED PHOSPHATE ROCK (PAPR)
PREPARED FROM EPPAWALA ROCK PHOSPHATE
AS A PHOSPHORUS FERTILIZER**

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ABSTRACT

Partially acidulated phosphate rocks (PAPR) prepared from Eppawala rock phosphate (ERP) (low reactive) and Sechura rock phosphate (high reactive) were mixed with an acidic soil and incubated for 3 days at 18% moisture. Bray-P and Δ Ca values were significantly increased in the case of partially acidulated Eppawala rock phosphate; for partially acidulated Sechura rock phosphate the increases for Bray-P and Δ Ca were very small. This agrees with the observation that partial acidulation improves the initial effectiveness of only low reactive rock phosphates. The results indicate that PAPR prepared from ERP may have a potential as a P fertilizer. However, greenhouse and field studies should be undertaken to evaluate its agronomic effectiveness.

KEY WORDS : Eppawala rock phosphate, Partially acidulated phosphate rock, Sechura rock phosphate

INTRODUCTION

After the discovery of Eppawala rock phosphate (ERP) in 1971, studies with rice have shown that ERP is not suitable for direct application and that its performance cannot be improved by high rates of application or by incorporating it in mixture with concentrated superphosphate. It also appears to have very little residual value (Nagarajah *et al.*, 1979).

Reactivity of rock phosphates can be improved by heat (Rhenania phosphate; fused magnesium phosphate) or acid treatments (superphosphates). Fused ERP prepared by heat treatment of ERP and Na_2CO_3 (Amarasiri and Ambepitiya, 1976) showed greater agronomic effectiveness than ERP (Amarasiri, 1978; Nagarajah *et al.*, 1979). However, these methods of conversion are costly.

Partially acidulated phosphate rock (PAPR) which is prepared by treating rock phosphate with H_2SO_4 or HCl is an alternative which may partially fill the gap between direct application of rock phosphate and the use of the more expensive soluble P fertilizers (Hammond *et al.*, 1980). This is especially important in the context that the local rock phosphate deposit is not suitable for direct application, for short term crops owing to its low reactivity, and the requirement of large quantities of acid in addition to larger capital cost for the production of conventional fertilizers.

Hydrochloric acid and H_2SO_4 have been used to prepare PAPR and it has been found that 50% acidulation with H_2SO_4 yields a suitable product with about 17% available P_2O_5 (Gunawardena, 1987). Despite the formation of a product with a better P availability, cost of PAPR will increase with increasing degree of acidulation. It is therefore advantageous to produce a PAPR at the lowest degree of acidulation that is still agronomically effective.

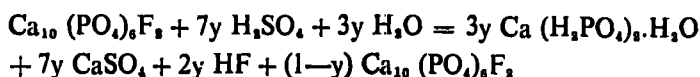
In the present study 30% acidulation with H_2SO_4 was carried out on two phosphate rocks of different reactivity and the P availability of the products were evaluated in the laboratory.

MATERIALS AND METHODS

The following experiments were carried out at the soils laboratory, Department of Soil Science, University of Reading, U. K.

Rock phosphates: Two phosphates rocks, Sechura rock phosphate (Bayovar), a fluorine deficient, sedimentary type carbonate hydroxy apatite phosphate rock from Peru, and Eppawala rock phosphate (ERP), a fluoro chloro igneous apatite from Sri Lanka were used to prepare PAPR (Table 1).

Preparation of PAPR: The amount of H_2SO_4 required for complete acidulation of the phosphate rock is calculated using the elemental analysis of the phosphate rocks. The equation for the reaction of H_2SO_4 to form single superphosphate (SSP) or PAPR is given by



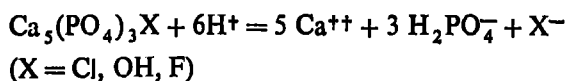
EFFECTIVENESS OF PARTIALLY ACIDULATED PHOSPHATE ROCK

In this equation y term represents the degree of acidulation (e.g. $y = 1.0$ for 100% acidulation (SSP) and $y = 0.5$ for 50% PAPR and $y = 0.3$ for 30% PAPR).

The rock phosphates were partially acidulated with 30% of the H_2SO_4 required for the complete conversion of P in the rock phosphate to SSP dried at $60^\circ C$, ground and sieved. The fraction passing through a 100 mesh sieve was taken for the experiments.

Incubation experiment: The fertilizers Sechura rock phosphate, PAPR (Sechura), Eppawala rock phosphate and PAPR (Eppawala) were added to an acidic soil (pH=4.1) from U.K. (200 μg P/g soil). The soil was maintained at 18% moisture content and incubated for 3 days. A control (soil without P fertilizers) was also treated in the same way.

Dissolution of P fertilizer in soil: Dissolution of phosphate rock has been shown to occur according to the equation ;



The soil conditions necessary for this to take place are a source of H^+ and sinks for Ca^{++} and $H_2PO_4^-$. Adsorption of these ions by soil influences the rate of dissolution of rock phosphate (Hammond *et al.*, 1986).

Dissolution of rock phosphate added to a soil was measured using (i) Bray method and (ii) ΔCa method. The details are as follows :

Bray method: One gram of soil or P fertilizer treated soil was shaken with 35ml of Bray 1 (0.03 N in NH_4F and 0.025 N in HCl) solution for 1 min and filtered. Phosphorus concentration in the filtrate was determined by the method of Murphy and Riley (1962). From the difference between Bray P of rock phosphate (RP) treated soil and soil alone (ΔP)% RP dissolution was calculated as $\frac{\Delta P}{\text{weight of RP added}} \times 100$

ΔCa technique: The ΔCa value was calculated as the difference in extractable ΔCa between the blank soil and the soil mixed with phosphate rock. The % of phosphate rock that has dissolved was calculated from the ΔCa value using the method of Hughes and Gilkes (1984) which is as follows :

Rock phosphate at 200 $\mu\text{g P/g}$ soil was added to 2 g of air-dried soil and mixed in 30 ml centrifuge tubes. After the addition of 0.5 ml of distilled water the tubes were sealed and incubated at 60°C for 3 days. Then 20 ml of extractant solution (BaCl_2 — T.E.A. pH 8.1) was added and the tubes shaken intermittently for one hour. After filtering, the ΔCa in solution was determined using an atomic absorption spectrophotometer. Lanthanum was added (1000 $\mu\text{g/ml}$) as lanthanum chloride to reduce interferences. The % P dissolution of the added rock phosphate was calculated as shown below :

$$\% \text{ P dissolution} = \frac{\Delta\text{Ca}}{\text{Total Ca added}} \times 100$$

RESULTS AND DISCUSSION

Partial acidulation resulted in a considerable increase in the P dissolution (338%) of Eppawala rock phosphate when measured by the Bray method (Table 2). In the highly reactive Sechura rock phosphate the increase in P dissolution is very small (8.8%). Even ΔCa values showed the same trend for the two rock phosphates (Table 2).

Similar results were obtained when 3 phosphate rocks of decreasing reactivities—North Carolina, Jordan and Nauru were partially acidulated. The highly reactive North Carolina rock phosphate showed the least increase in solubility while the least reactive Nauru rock phosphate showed the highest increase in solubility (Charleston *et al.*, 1989). These two sets of results are in agreement with the observation of Hammond *et al.* (1980) that partial acidulation brings about a substantial increase only in initial effectiveness of low reactivity rock phosphates and not in highly reactive rock phosphates.

These observed differences in PAPR and rock phosphate appear to result from an apatite-monocalcium phosphate interaction which occurs during storage after the main apatite-acid reaction has taken place.

Finally by the foregoing laboratory investigations, even though ERP is shown to be a useful P fertilizer, if converted to PAPR, it is essential to test the product for the interaction of different soils and crops before its manufacture can be recommended.

EFFECTIVENESS OF PARTIALLY ACIDULATED PHOSPHATE ROCK

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Table 1. Chemical analysis of the experimental rock phosphate samples

<i>Constituent</i>	<i>Eppawala rock Phosphate*</i>	<i>Sechura rock phosphate**</i>
P ₂ O ₅ (%)	36.4	30.5
Fe ₂ O ₃ (%)	4.8	0.6
MnO ₂ (%)	0.67	0.01
TiO ₂ (%)	0.66	0.06
CaO (%)	48.5	45.4
K ₂ O (%)	<0.01	0.16
SiO ₂ (%)	0.8	3.9
Al ₂ O ₃ (%)	1.9	0.9
MgO (%)	0.20	0.56
F (%)	2.6	3.8
Cl (%)	1.1	NA
Citric acid sol. P ₂ O ₅ (%)	2.8	5.3

* L. R. Gremillion and J. R. Lehr. 1979. Characterization of phosphate rock sample from Sri Lanka (sample No. MR — 648). Unpubl. report. TVA National Fertilizer Development Center, Muscle Shoals, Alabama, USA.

** Jose Sereno Melo, 1987. NA = Not available.

Table 2. Bray P, Δ Ca and per cent P dissolution of rock phosphate treated soils

<i>Treatment</i>	<i>Bray P method</i>		<i>Δ Ca method</i>	
	ΔP (μg P/g soil)	RP dissolution (%)	ΔCa (μg Ca/g soil)	RP dissolution (%)
Sechura rock phosphate	61.2	30.6	174	29.3
PAPR (Sechura)	66.5	33.3	141	24.4
Eppawala rock phosphate	8.7	4.4	7	1.6
PAPR (Eppawala)	38.5	19.3	73	14.1