

## Studies on factors affecting the dissolution of low grade rock phosphates in rice soils

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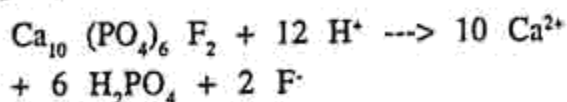
**Abstract :** An incubation study on the dissolution of rock phosphates with soils of different pH, was taken up at Tamil Nadu Agricultural University, Coimbatore. It was concluded from the experiment that the dissolution of Udaipur rock phosphate and Mussoorie rock phosphate were remarkably higher in soils with a pH of 5.8 both at 30 and 60 day of incubation, followed by neutral soil (pH 7.6) and saline soil (pH 8.75). During the initial stage of incubation upto 30 days, the dissolution was found to be higher with Udaipur rock phosphate, whereas at the end of 60 days, Mussoorie rock phosphate recorded higher dissolution.

**Key words:** Udaipur rock phosphate, Mussoorie rock phosphate, Dissolution, Soil pH.

### Introduction

Due to ever increasing cost of commercial phosphatic fertilizers, the shortage of raw materials coupled with energy crisis, a challenge has been posed for economic and direct use of phosphate rocks and considerable attention has been focussed on the use of cheaper alternate sources of P. The direct application of rock phosphate (RP) as fertilizer to acid soils has proved effective and economical around the world (Bolan *et al.* 1990).

Rock phosphate is insoluble in water and therefore, it needs to be dissolved for the P to become available for plant uptake. When Rock Phosphate is directly applied to soil, the dissolution of rock phosphate occurs according to the following reaction resulting in the release of  $H_2PO_4$  and Ca for plant uptake.



In soil, many factors influence the dissolution of rock phosphate. The pH of soil (Chien and Hammond, 1968), the concentration of P and Ca in the soil solution (Kirk and Nye, 1986; Mackay *et al.* 1986) and the particle size of rock phosphate (Bolan and Hedley, 1990) have all been reported to largely affect the

dissolution of rock phosphate in soil. They found that relative efficiency of North Carolina PR, Jordan PR and Naura PR were higher at low pH values than at high pH values. The increase in pH inhibit the dissolution of phosphate rock.

In India, the direct application of rock phosphate is recommended for rice soil. Flooded condition, the production of organic acids during the decomposition of organic matter and redox condition may influence the dissolution of rock phosphate. The mechanism of rock phosphate dissolution and the factors which are influencing the dissolution of rock phosphate in flooded rice soil have not been studied. Hence the present study was proposed to identify the important factors which limit rock phosphate dissolution in rice soils.

### Materials and Methods

An incubation experiment was conducted at Taniil Nadu Agricultural University, Coimbatore during 1996-97 to examine the effect of different soil pH on the dissolution of low grade rock phosphates (URP) and Mussoorie rock phosphate (MRP). An acid soil (pH 5.8; Initial Olsen-P 10.2 kg ha<sup>-1</sup>), a neutral soil (pH 7.6; Initial Olsen-P 14.6 kg ha<sup>-1</sup>) and saline soil (pH 8.75; Initial Olsen-P 17.8 kg ha<sup>-1</sup>) were collected

**Table 1.** Physico-chemical properties of soils used for incubation study

Properties	Acid soil	Neutral soil	Saline soil
<i>Particle size distribution</i>			
Clay (%)	29.8	43.4	36.2
Silt (%)	15.4	16.2	25.6
Fine sand (%)	32.6	20.6	18.2
Coarse sand (%)	20.1	18.0	16.4
Texture	Sandy loam	Clay	Clay loam
<i>Electro-chemical properties</i>			
pH	5.8	7.6	8.75
EC (dSm <sup>-1</sup> )	0.24	0.74	0.60
<i>Chemical properties</i>			
CEC C mol (p+) kg <sup>-1</sup>	13.4	29.8	30.3
Total N (%)	0.21	0.042	0.036
Total P (%)	0.046	0.068	0.032
Total K (%)	0.42	0.486	0.584
Available N (kg ha <sup>-1</sup> )	472	286	242
Available P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	10.2	14.6	17.8
Available K <sub>2</sub> O (kg ha <sup>-1</sup> )	446	354	452
Available Ca C mol (p+) kg <sup>-1</sup>	5.72	17.4	32.8
Available Mg C mol (p+) kg <sup>-1</sup>	0.72	6.5	20.6
Taxonomy	Ultic Tropudalf	Typic Ustropept	Typic Ustivertept

**Table 2.** Chemical composition of fertilizers used

Properties (per cent)	Phosphorus source	
	URP	MRP
Total P <sub>2</sub> O <sub>5</sub>	16.4	19.0
CaO	38.8	40.0
SiO <sub>2</sub>	9.2	20.1
MgO	10.1	6.9
Free Ca CO <sub>3</sub>	15.0	13.5

URP - Udaipur rock phosphate; MRP - Mussorie rock phosphate

and mixed with URP and MRP at a rate equivalents of 0, 100, 250 and 1000 g P/g soil. Water was added to bring the moisture content to about 60 per cent field capacity. After thorough mixing, the samples were incubated under laboratory condition for sixty days. Soil samples were collected at 30 and 60 days after incubation.

The extent of rock phosphate dissolved was determined both by measuring the increase in the amount of soluble and adsorbed P and extracted in NACI-TEA and NaOH, and from

decrease in the residual apatite P remain as undissolved rock phosphate (HCl - extractable) following a modified chemical fraction technique (Mahimairaja *et al.* 1995). The different P fractions in soil were determined following a modified P fractionation technique which involves both alkaline and acid extractants (Mahimai Raja *et al.* 1995). One gram of soil was pre treated with 40 ml of 0.5M NaCl buffered with triethanolamine (TEA) and shaken for 30 minutes in a 50 ml centrifuge tube. This pre treatment was included to remove both the solution P and exchangeable Ca, which otherwise may form Ca(OH)<sub>2</sub> and CaCO<sub>3</sub> during extraction within NaOH and reabsorb or co-precipitate with some of the dissolved P. After centrifuging at 8000 rpm for 10 minutes, the supernatant solution was filtered and analysed for solution P.

To the soil residue in the tube, 40 ml of IM HCl was added and shaken for 16 hours and then centrifuged and filtered. The P was determined in the solution as acid soluble or

apatite. P. The soil residue was transferred to 100 ml conical flask and digested using 10 ml of triacid at 260°C for 45 minutes and total P was determined as residual P. The physico-chemical properties of soil samples used for incubation are presented in Table 1. Samples of URP and MRP were analysed for their nutrient contents (Table 2).

### Results and Discussion

The results showed that among the soils, the soil with pH 5.8 (acid soil) registered higher NaCl-TEA-P followed by the soil with pH 7.6 and 8.75. Also, the NaCl-TEA-P increased along with the days of incubation irrespective of the soils. The highest NaCl-TEA-P fraction was registered by acid soil followed by near neutral and alkaline soil on 60th day of incubation both in the case of Udaipur rock phosphate and Mussorie rock phosphate. (Table 3).

The NaOH-P fraction was found to be higher in URP followed by MRP and also the magnitude of dissolution was higher in soil with pH 5.8 followed by pH 7.6 and 8.75 soils. The highest NaOH-P fraction was registered on 60th day of incubation followed by 30th day. However, higher values on 60th

day of incubation was recorded by Mussorie rock phosphate. Soil with pH 5.8 registered lower HCl-P fraction at initial stage whereas along with days of incubation, the former recorded higher values on 30 and 60 days of incubation both in case of URP and MRP.

The total dissolution was found to be maximum on 60th day of incubation and was the highest in case of MRP in (75.6%) in soils with pH 5.8 followed by URP. The soil with pH 8.75 recorded lower total dissolution of both the P sources. The extent of dissolution of rock phosphate as measured both from increase in NaCl-TEA-P and NaOH - P, and decrease in HCl-P are presented in Table 3. A very close relationship ( $r=0.927$  for MRP;  $r = 0.939$  for URP) was observed between these two methods. Irrespective of the sources, the net dissolution increased with incubation time, however the dissolution was rapid initially (up to 30 days) after which only a small increase was observed both for URP and MRP.

During initial stages (upto 30 days) the dissolution was found to be higher with URP than MRP, whereas at the end of 60 days, MRP recorded higher solution. The dissolution

Table 3. Net dissolution of rock phosphates as measured from increase in Na Cl - TEA-P and decrease in HCl-P (% added)

Soil pH	Dissolution methods	URP			MRP		
		0 Day	30 Days	60 Days	0 Day	30 Days	60 Days
pH 5.8	Δ Na Cl-TEA	2.0	24.9	33.0	2.4	18.5	34.9
	Δ Na OH	4.3	30.7	36.9	3.9	30.8	40.7
	Total Dissolution	-	55.6	69.9	-	49.3	75.6
	Δ HCl-P	1.3	66.0	66.0	2.4	37.1	70.2
pH 7.6	Δ Na Cl-TEA	1.2	16.8	20.6	1.6	14.2	21.4
	Δ Na OH	3.4	20.0	33.2	4.1	15.3	35.7
	Total Dissolution	-	36.8	53.8	-	29.5	57.1
	Δ HCl-P	4.5	38.3	55.1	2.8	37.1	59.5
pH 8.75	Δ Na Cl-TEA	0.9	9.0	11.8	1.1	6.5	14.1
	Δ Na OH	1.8	19.6	24.7	1.6	18.9	27.6
	Total Dissolution	-	28.6	36.5	-	25.4	41.7
	Δ HCl-P	3.8	31.3	30.8	1.7	27.1	37.4



of URP and MRP was remarkably higher in soils with a pH of 5.8 both at 30 and 60 days followed by neutral soil (pH 7.6) and saline soil (pH 8.75). The result revealed that irrespective of rock phosphates, the soil pH appears to play an important role in the dissolution of low grade rock phosphates in flooded rice soils. The phosphate rock dissolution in flooded soils due to roots which acidified the surrounding soil that dissolved organic P, may chelate Ca and P in the flooded soil solution. Significant amount of PR may be dissolved during the lag phase following flooding, before the soil pH increases (Kirk and Nye, 1986).

Bolan and Hedley (1989) determined different P fractions in soil which include NaCl-TEA-P, NaOH-P, HCl-P and residual P. The NaCl-TEA-P represents the solution P and NaOH-P represents the solution plus adsorbed P whereas, HCl-P represent the undissolved portion of P. With increasing rock phosphate dissolution, NaCl-TEA -P and NaOH -P increases and HCl-P decreases. With the increasing incubation period, both the fractions NaCl-TEA-P and NaOH-P increased indicating continuous dissolution of rock phosphate. This corroborated with the findings of Mackay *et al.* (1986) and Bolan and Hedley (1980). The low pH value and low exchangeable Ca of soil with pH 5.8 might be the reason for the higher dissolution of rock phosphate by registering higher value of NaOH-P. This is in line with the results of Zende (1983).

The highest HCl -P fraction was recorded on 60th day of incubation which indicated that there was a continuous dissolution of rock phosphate as reported by Mackay *et al.* (1986) and Bolan and Hedley (1989). Lesser amount of URP/ MRP was recovered in the NaOH and NaCl - TEA extracts whereas larger amounts were recovered in the HCl extract. In general, the dissolution was found to be higher for soils

with pH 5.8. The increased rock phosphate dissolution with reduction in pH reported by Kanabo and Gilkes (1987) lends support to the present finding.

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