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# Dissolution and release pattern of phosphorus from Jhabua rock phosphate as influenced by single super phosphate, farmyard manure and phosphobacteria

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**Abstract:** An incubation experiment was conducted with the soil collected from Noyyal series (Vertic Ustochrept - Coimbatore) to study the dissolution and release pattern of phosphorus from Jhabua rock phosphate by following the modified phosphorus fractionation technique, which involved both alkaline and acid extractants. The solution P (NaCl TEA - P) and solution plus adsorbed P (NaOH - P) were high in the treatment receiving 50 per cent JRP plus 50 per cent SSP followed by the application of 100 per cent JRP along with PB and FYM. Acid soluble P or apatite - P (HCl-P) was the highest in 100 per cent JRP alone and along with FYM or PB or both whereas the residual P content of the different treatments were comparable. With advancement of the incubation period upto 60 days, a increased trend in extractable P was found in NaCl TEA-P and NaOH-P and a decreased trend was noticed in HCl-P and Residual - P fractions.

*Key words : Dissolution, Jhabua rock phosphate, Incubation*

## Introduction

Super phosphate is one of the most commonly used phosphatic fertilizers in the country. However, the problem with SSP is that it often gets fixed or rendered insoluble or less soluble in acid and calcareous soils. In this context, it is worth while to exploit the phosphate rock resource available in India. In India, PR deposit was estimated to about 260 m.t (Narayanasamy and Biswas, 1998). But the direct application of PR alone was often unable to produce and maintain significantly optimum concentration of P in soil. The organic manure and phosphobacteria were found to increase the dissolution rate of P from PR. The present investigation was carried out to study the dissolution and release pattern of P from Jhabua rock phosphate (JRP) when applied alone and with SSP, FYM and Phosphobacteria (PB).

## Materials and Methods

An incubation study was carried out at Tamil Nadu Agricultural University, Coimbatore to study the dissolution and release pattern of P from Jhabua rock phosphate (JRP) when applied alone and with SSP, FYM and PB. The soil collected from Noyyal series (Vertic Ustochrept - Coimbatore) was subjected to the incubation study. The soil was clay loam in texture with pH - 8.4 and EC - 0.4 $dSm^{-1}$, OC - 0.82 per cent and CEC-29.8 c mol (P+) $kg^{-1}$. The available status of N, P and K were 226.8, 16.0 and 368 kg $ha^{-1}$, respectively. The incubation study was conduced upto 60 days in Completely Randomized Design (CRD) with six treatments and replicated four times.

$T_1$ - Control
$T_2$ - 100% JRP (50 kg $P_2O_5$ $ha^{-1}$)
$T_3$ - 100% JRP + PB (2 kg $ha^{-1}$)
$T_4$ - 100% JRP + FYM (12.5 t $ha^{-1}$)
$T_5$ - 100% JRP + PB + FYM
$T_6$ - 50% JRP + 50% SSP

### *Details of incubation study*

A representative soil sample of 250 grams (2 mm mesh) was weighed and placed in glass containers of 500 ml capacity having an internal diameter of 8 cm. JRP, SSP, FYM and PB were applied to the soil as per treatment. The fertilizer materials were mixed thoroughly with the soil and the soil was brought to puddled condition with the addition of water. The containers were covered with polythene paper and air holes were made for easy aeration.

**Table 1.** Effect of treatments on NaCl TEA - P (mg $kg^{-1}$) at different days of incubation

| Treatments | Initial day | 15th day | 30th day | 45th day | 60th day | Mean |
|---|---|---|---|---|---|---|
| $T_1$ - Control | 33.37 | 34.35 | 34.35 | 35.36 | 36.33 | 34.75 |
| $T_2$ - 100% JRP | 34.35 | 36.33 | 37.39 | 39.25 | 40.67 | 37.58 |
| $T_3$ - 100% JRP + PB | 34.38 | 36.39 | 37.40 | 40.18 | 41.75 | 38.02 |
| $T_4$ - 100% JRP + FYM | 34.65 | 37.50 | 39.80 | 41.62 | 42.89 | 39.27 |
| $T_5$ - 100% JRP + PB + FYM | 34.88 | 37.62 | 40.34 | 42.86 | 43.72 | 39.88 |
| $T_6$ - 50% JRP + 50% SSP | 40.36 | 44.23 | 45.10 | 46.18 | 47.75 | 44.68 |
| Mean | 35.32 | 37.72 | 39.05 | 40.91 | 42.17 | 39.03 |
| | T | | D | | TxD | |
| CD (P=0.05) | 0.656 | | 0.599 | | 1.467 | |

**Table 2.** Effect of treatments on NaOH-P (mg $kg^{-1}$) at different days of incubation

| Treatments | Initial day | 15th day | 30th day | 45th day | 60th day | Mean |
|---|---|---|---|---|---|---|
| $T_1$ - Control | 175.40 | 175.40 | 176.50 | 177.70 | 179.10 | 176.82 |
| $T_2$ - 100% JRP | 176.72 | 176.72 | 178.91 | 180.47 | 182.14 | 178.99 |
| $T_3$ - 100% JRP + PB | 176.73 | 178.91 | 180.53 | 183.12 | 185.35 | 180.92 |
| $T_4$ - 100% JRP + FYM | 177.58 | 181.53 | 183.20 | 186.60 | 188.15 | 183.41 |
| $T_5$ - 100% JRP + PB + FYM | 177.59 | 181.70 | 184.30 | 187.14 | 189.28 | 184.01 |
| $T_6$ - 50% JRP + 50% SSP | 184.20 | 184.50 | 186.40 | 187.78 | 190.63 | 186.72 |
| Mean | 178.04 | 179.82 | 181.64 | 183.80 | 185.80 | 181.81 |
| | T | | D | | TxD | |
| CD (P=0.05) | 3.043 | | 2.778 | | NS | |

**Table 3.** Effect of treatments of HCl-P (mg $kg^{-1}$) at different days of incubation

| Treatments | Initial day | 15th day | 30th day | 45th day | 60th day | Mean |
|---|---|---|---|---|---|---|
| $T_1$ - Control | 264.60 | 263.59 | 262.10 | 260.73 | 257.40 | 261.67 |
| $T_2$ - 100% JRP | 259.19 | 290.31 | 287.04 | 283.58 | 280.42 | 287.31 |
| $T_3$ - 100% JRP + PB | 295.99 | 290.26 | 185.31 | 280.23 | 276.58 | 285.67 |
| $T_4$ - 100% JRP + FYM | 295.19 | 285.39 | 283.34 | 277.13 | 273.80 | 282.97 |
| $T_5$ - 100% JRP + PB + FYM | 295.22 | 283.35 | 280.16 | 277.70 | 272.10 | 281.71 |
| $T_6$ - 50% JRP + 50% SSP | 278.17 | 268.29 | 266.13 | 263.56 | 260.09 | 267.25 |
| Mean | 289.39 | 280.19 | 277.34 | 273.82 | 270.06 | 277.76 |
| | T | | D | | TxD | |
| CD(P= 0.05) | 4.41 | | 4.03 | | NS | |

Water level in each container was maintained at 1 cm above the soil level throughout the period of experimentation. Treatments were incubated upto 60 days at room temperature of 27 °C.

Soil samples were drawn at fifteen days interval and subjected to the estimation of P fractions by following a modified P fractionation technique, which involved both alkaline and acid extractants (Bolan and Hedley, 1989). The fractions include:

(i) NaCl TEA - P - represents solution P
(ii) NaOH - P - represents both solution plus adsorbed P
(iii) HCl - P - represents apatite (or) acid soluble P
(iv) Residual P

These four types of extractant enable the dissolution of P from PR.

*Method of extraction*

1 gram of soil was pretreated with 40 ml of 0.5 M NaCl buffered with triethanolamine (TEA) and shaken for 30 minutes in a 50 ml centrifuge tube. This pretreatment was included to remove both the solution P and exchangeable calcium, which otherwise may form $Ca(OH)_2$ and $CaCO_3$ during extraction with 1 M NaOH and it may 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.

The soil residue was subsequently shaken end over end with 1 M NaOH (at 1:40 sample: solution ratio) for 16 hours. After centrifuging and filtering, the solution was analysed for inorganic P (Pi) which include both solution and adsorbed P.

To the residue in the tube, 40 ml of 1 M HCl was added and shaken for 16 hours and then centrifuged and filtered. The P was determined in the solution as acid soluble (or) appetite P. The soil residue was then transfered to 100 ml conical flask and digested by using 10 ml of triacid ($HNO_3$ : $H_2SO_4$: $HClO_4$ 9:2:1) at 260°C for 45 minutes and the total P was determined as residual P. The dissolution of P from JRP was measured through increase in NaCl TEA-P and NaOH - P, as well as decrease in HCl-P and residual P.

This method has been used extensively in short - term incubation studies and less time consuming process. It will overcome the other methods where the extractants remove some of the undissolved PR during the extraction process.

Per cent dissolution of PR was calculated by,

$$\text{Per cent dissolution of PR} = \frac{\Delta P \text{ (mg kg}^{-1} \text{ soil)}}{\text{P added (mg kg}^{-1})} \times 100$$

## Results and Discussion

*(i) Sodium chloride Triethanolamine - P (NaCl TEA - P), sodium hydroxide - P (NaOH - P) (mg kg$^{-1}$) and per cent P dissolution based on NaCl TEA-P and NaOH-P*

The data from Table 1 indicated that the treatment T6 recorded significantly the highest NaCl TEA-P (44.68 mg kg$^{-1}$) followed by T5 (39.88 mg kg$^{-1}$). Similarly the treatment $T_6$ recorded the highest NaOH-P (186.72 mg kg$^{-1}$) which was comparable with the treatment $T_5$ (184.01 mg kg$^{-1}$) (Table 2). The highest NaCl TEA-P and NaOH-P registered by $T_6$ might be due to the combined application of readily water soluble nature of SSP along with JRP. This is in line with findings of Dhanasekaran (2000). The net highest values recorded by $T_5$ treatment might be due to synergistic effect of PB and FYM in the treatment. As the days of incubation period incresed, P fractions *viz.* NaCl TEA-P and NaOH-P also increased indicating the continuous dissolution and accumulation from the added rock phosphate in the soil. Among the treatments, $T_6$ recorded the highest dissolution NaCl TEA-P (39.89%) (Table 5). This might obviously be due to the readily water soluble nature of SSP applied. Apart from this, contribution of SSP in enhancing the dissolution of JRP may be explained as follows.

**Table 4.** Effect of treatments on Residual-P (mg $kg^{-1}$) at different days of incubation

| Treatments | Initial day | 15th day | 30th day | 45th day | 60th day | Mean |
|---|---|---|---|---|---|---|
| $T_1$ - Control | 95.90 | 94.75 | 94.33 | 94.31 | 93.60 | 94.58 |
| $T_2$ - 100% JRP | 101.57 | 100.75 | 100.32 | 99.76 | 98.89 | 100.26 |
| $T_3$ - 100% JRP + PB | 101.57 | 100.74 | 100.31 | 99.76 | 98.89 | 100.25 |
| $T_4$ - 100% JRP +FYM | 100.74 | 100.04 | 100.04 | 99.56 | 98.87 | 99.85 |
| $T_5$ - 100% JRP + PB + FYM | 101.82 | 100.83 | 100.84 | 100.05 | 99.67 | 98.28 |
| $T_6$ - 50% JRP + 50% SSP | 99.07 | 99.06 | 99.05 | 97.38 | 96.86 | 98.28 |
| Mean | 100.11 | 99.36 | 99.15 | 98.47 | 97.80 | 98.98 |
| | T | | D | | TxD | |
| C (P=0.05) | 1.606 | | 1.466 | | NS | |

**Table 5.** Effect of treatments on per cent P dissolution based on ΔNaCl TEA-P, ΔNAOH-P and ΔHCl-P

| Treatments | Initial | 15th day | 30th day | 45th day | 60th day | Mean |
|---|---|---|---|---|---|---|
| | | | | | | ΔNaCl TEA-P |
| $T_2$ - 100% JRP | 3.92 | 7.92 | 12.16 | 15.56 | 17.36 | 11.38 |
| $T_3$ - 100% JRP + PB | 4.04 | 8.16 | 12.20 | 19.28 | 21.68 | 13.70 |
| $T_4$ - 100% JRP + FYM | 5.12 | 12.60 | 21.80 | 25.04 | 26.24 | 18.16 |
| $T_5$ - 100% JRP + PB + FYM | 6.04 | 13.08 | 23.96 | 30.00 | 29.56 | 20.53 |
| $T_6$ - 50% JRP + 50% SSP | 27.96 | 39.52 | 43.00 | 43.28 | 45.68 | 39.89 |
| Mean | 9.42 | 16.26 | 22.62 | 26.63 | 28.10 | 20.61 |
| | | | | | | ΔNaOH-P |
| $T_2$ - 100% JRP | 5.28 | 5.28 | 9.64 | 11.08 | 12.16 | 8.69 |
| $T_3$ - 100% JRP + PB | 5.32 | 14.04 | 16.12 | 21.68 | 25.00 | 16.43 |
| $T_4$ - 100% JRP + FYM | 8.72 | 24.52 | 26.80 | 35.60 | 36.20 | 26.37 |
| $T_5$ - 100% JRP + PB + FYM | 8.76 | 25.32 | 31.20 | 37.76 | 40.72 | 28.75 |
| $T_6$ - 50% JRP + 50% SSP | 35.20 | 36.40 | 39.60 | 40.32 | 46.12 | 39.53 |
| Mean | | | | | | |
| | | | | | | ΔHCl-P |
| $T_2$ - 100% JRP | | 12.65 | 18.47 | 25.30 | 24.75 | 20.29 |
| $T_3$ - 100% JRP + PB | | 15.04 | 26.06 | 37.88 | 38.90 | 29.47 |
| $T_4$ - 100% JRP + FYM | | 28.73 | 3057 | 46.39 | 46.39 | 38.02 |
| $T_5$ - 100% JRP + PB + FYM | | 35.47 | 41.02 | 44.58 | 51.99 | 43.27 |
| $T_6$ - 50% JRP + 50% SSP | | 65.36 | 70.30 | 79.15 | 80.18 | 73.75 |
| Mean | | 31.45 | 37.28 | 46.66 | 48.44 | 40.96 |

The dissolution of SSP involves the following chemical reaction (Sanyal and De Detta, 1991).

$$Ca(H_2PO_4).H_2O + x\ H_2O \text{ ----------> } Ca\ HPO_4 + H_3PO_4 + (x+1)\ H_2O$$

As the SSP dissolves, $H_3PO_4$ is formed, resulting in a solution pH 1.5 near the granule which might have enhanced that PR dissolution. With advancement of incubation period the dissolution rate of ΔNaCl TEA-P and ΔNaOH-P were increased. The lowest dissolution rate of both ΔNaCl TEA-P and ΔNaOH-P were recorded by $T_1$ (11.38 and 8.69 per cent respectively) because no P fertilizer was applied followed by $T_2$ (13.07, and 16.43 per cent respectively) (Table 5). This is in line with the findings of Dhanasekaran (2000) and Malathi (1999).

*ii) Changes in Hydrochloric acid - P, Residual - P (mg kg$^{-1}$) and per cent P dissolution based on HCl-P*

Acid soluble or apatite phosphorus representing the water undissolved fraction of P was the highest in the treatment $T_2$ (287.31 mg kg$^{-1}$) which was comparable with $T_3$ (285.67 mg kg$^{-1}$) and $T_4$ (282.97 mg kg$^{-1}$) (Table 3). This might be due to the fact that the RP is water insoluble but acid soluble and so the added JRP was accounted as HCl-P. The lower HCl-P recorded by the treatment $T_5$ (261.71 mg kg$^{-1}$) when compared to $T_2$ (287.31 mg kg$^{-1}$) might possibly be due to the increased dissolution of added JRP by organic acids released from FYM and PB. The lowest HCl-P was recorded by control (281.67 mg kg$^{-1}$) ($T_1$) because of no application of P, followed by $T_6$ (267.25 mg kg$^{-1}$) due to the addition of 50 per cent JRP only which accounts for acid soluble P and remaining 50 per cent as SSP represents for water soluble form. The highest HCl-P fraction was recorded on the initial day and decreased thereafter upto 60 days. This indicated the continuous dissolution of RP into forms as reported by Mackay *et al.* (1986). The highest per cent HCl - P dissolution was recorded by the treatment $T_6$ (73.75%) followed by $T_5$ (43.27%). The lowest dissolution rate was recorded by $T_1$ (20.29%) followed by $T_2$ (29.47%) (Table 5). With the advancement of incubation period, the per cent HCl - P dissolution increased.

The treatment $T_1$ recorded the lowest residual - P (94.58 mg kg$^{-1}$) followed by $T_6$ (98.28 mg kg$^{-1}$) (Table 4). The residual P content of other treatments were comparable with each other. With the advancement of the incubation period, there was no significant reduction in the residual P content because the residual P fractions were highly insoluble. This is in line with the findings of Dhanasekaran (2000).

From the results, it is concluded that the application of 1:1 JRP and SSP increased the fraction of both solution and solution plus absorbed-P and decreased the fraction of acid soluble-P and residual-P. This indicates the increased dissolution of P by this treatment.

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