

Full length research paper

Evaluation of Rock Phosphate-Phosphorus Sorption and Release in Basement Complex Soil Cultivated to the Oil Palm

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In this study, a laboratory experiment was conducted to estimate the amount of P released/sorbed in soil supporting oil palm by varying moisture content of soil, amount of phosphate rock (PR) added to soil and time of equilibration. Soils from the NIFOR experimental station, Onishere, Ondo State were used for the study. Mean values of 2.27, 0.95, 0.58 and 0.47mg/kg, 1.38, 1.47, 1.25 and 1.51mg/kg and 1.54, 1.55, 1.51 and 1.23mg/kg P were obtained for 1:2, 1:3, 1:4, 1:5 and 15, 30 and 60mins equilibration time respectively used for the study. Statistical analysis showed significant difference in P released from phosphate rock with time and moisture content. The results showed that increase in time of equilibration and low level of moisture content favoured release of water extractable P. The use of PR as P fertilizer is therefore site specific as soils tend to have different properties

Keywords: Phosphate Rock, Release, Sorbed

INTRODUCTION

Phosphate Rock Deposits are found in many areas of tropical Africa (Kurtanjek and Tandy, 1984; McClellan, 1989). The high cost of soluble P fertilizer has generated considerable interest in the use of RP as a raw material in the manufacture of P fertilizer or as a direct amendment to soil (Nnadi and Haque, 1988; Akande, et al., 1998; Akande, et al., 2005). Direct application of PR has been considered most effective when reactive PR is finely ground and applied to moist, acid soils for crops of long duration (LeMare, 1991; Akande, et al., 2005). Phosphorus sorption is the removal of labile P from the soil solution followed by its entry on or unto solid phases of the soil. Many tropical soil sorbed large amount of applied phosphates applied as fertilizer that in turn reduce the use efficiency of these fertilizer trials on the use of PR in increasing the availability of phosphorous for eventual uptake in the nutrition of the oil palm. Despite the various promising result on the use of PR in the fertilization of oil cultivated to the oil palm, there is a dearth of information on the sorption properly of PR soil cultivated to the oil palm.

The objective of the present study was to evaluate the sorption characteristics of soil amended with PR and cultivated to the oil palm.

MATERIALS AND METHOD

The sorption of P by soil is quantified using sorption isotherm. A sorption isotherm describes the equilibrium relationship between sorbed and dissolved P species at a given temperature in characterization of soil. The quantity of P required to attain a specific P concentration in an equilibrated soil solution is a useful parameter obtained from the isotherm phosphorus. Sorption isotherm is obtained by plotting the values of P sorbed by the soil against the P remaining in the equilibrium supernatant solution (Fox and kamprath, 1970).

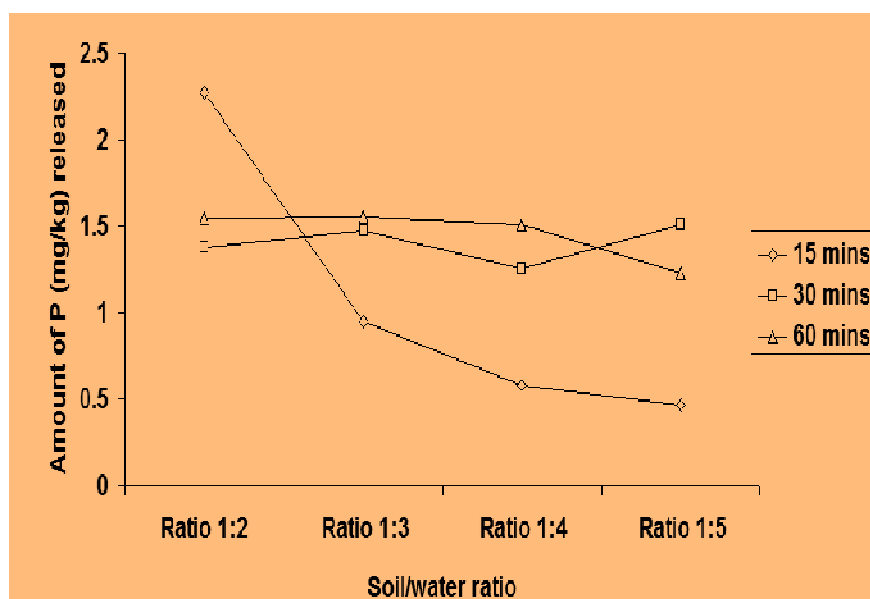
The use of phosphate rock mineral in the increased yield bunch production of the oil palm is well established (Isenmila, et al., 2003; Oviasogie, 2008). Furthermore, there exist various on-going.

Basement complex soils used in this study were obtained from the NIFOR experimental station located at Onishere. The phosphate rock mineral used in this study was obtained from a phosphate rock mineral deposit in Sokoto State, Nigeria. The milled phosphate rock had

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Table 1: Physico-chemical properties of soil

Parameters	Amount
pH	4.87 ± 0.18
Carbon (%)	1.08 ± 0.09
Calcium (cmol/kg)	2.74 ± 0.48
Magnesium (cmol/kg)	1.02 ± 0.13
Potassium (cmol/kg)	0.31 ± 0.12
Sodium (cmol/kg)	0.26 ± 0.01
CEC (cmol/kg)	4.33 ± 0.19
Available phosphorus (mg/kg)	5.23 ± 1.43

**Figure 1:** Amount of released from soil with different amount of water

earlier being characterized using standard methods. 40 soil samples were obtained at 0-15 and 15-30cm depths respectively using the soil augur, transferred into polyethylene bags for storage, processing and analysis.

Selected soil physicochemical properties such as pH, total organic carbon, total nitrogen, available phosphorus, cation exchange capacity (CEC) and particle size distribution were determined using standard methods (IITA, 1982).

The amount of water extractable P released/sorbed in soil with variation in moisture content of soil, amount of rock phosphate added to soil and time of equilibration were determined colorimetrically using ascorbic acid method. 0.1g of PR, 5g of soil and 1:2, 1:3, 1:4 and 1:5 soil/water ratios at various equilibration time intervals of 15mins, 30mins and 60mins was used for the study. Also different weights of PR (0.1 - 0.5g), 1:3 soil/water ratio

and 60mins equilibration time was used to determine the P sorption isotherm

Total soluble P was determined by weighing the different weight of PR (0.1g, 0.2g, 0.3g, 0.4g and 0.5g) into polyethylene bottles and extracting with 50mL of water. The mixture was equilibrated for 6hrs in a mechanical shaker for determination of amount of P released/sorbed from the PR of different weight and amount of water extractable P released/sorbed from the PR with variation in amount of water and time respectively. After equilibration, the mixture was filtered and water extractable P was determined using ascorbic acid method (Murphy and Riley, 1962).

All analyses were run in triplicate with mean values of P used in the sorption isotherm description. Analysis of variance (ANOVA) and regression was performed on data obtained.

Table 2: Amount of P (mg/kg) released from soil

Depth (cm)	1:2			1:3			1:4			1:5		
	15min s	30min s	60min s	15min s	30min s	60min s	15min s	30min s	60min s	15min s	30min s	60min s
A(0-15)	2.62	1.84	1.90	1.70	2.03	2.50	1.50	1.34	1.70	0.70	1.80	1.70
A(15-30)	2.83	1.44	1.77	0.77	1.89	1.97	1.79	1.29	1.20	0.02	1.32	1.02
B(0-15)	0.89	1.29	1.42	0.87	1.42	1.89	0.38	1.46	1.79	0.13	1.90	1.31
B(15-30)	0.45	1.18	1.35	0.42	1.36	1.45	0.07	0.37	1.38	0.02	0.88	1.20
C(0-15)	3.77	1.32	1.47	0.47	1.28	1.38	0.38	1.44	1.97	0.36	1.56	1.36
C(15-30)	0.97	1.18	1.15	0.15	1.20	1.17	0.00	0.22	0.77	0.00	0.32	0.70
D(0-15)	2.64	1.39	1.64	1.64	1.18	1.38	0.47	1.33	1.62	0.32	1.51	1.32
D(15-30)	2.07	1.35	1.56	0.56	1.17	1.20	0.13	1.31	1.40	0.02	1.42	1.02
E(0-15)	2.71	1.46	1.84	2.24	1.62	1.74	1.62	1.83	1.97	1.52	2.37	1.52
E(15-30)	2.16	1.28	1.57	1.57	1.20	1.31	1.40	1.66	1.64	1.08	2.16	1.08
F(0-15)	5.11	1.49	1.88	1.39	1.34	1.62	0.41	1.30	1.46	0.32	1.53	1.32
F(15-30)	2.34	1.28	1.39	0.88	1.34	1.40	0.69	1.24	1.30	0.46	1.43	1.30
G(0-15)	1.37	1.48	1.86	0.86	1.30	1.41	0.36	1.44	1.74	0.30	1.51	1.46
G(15-30)	1.23	1.39	1.68	0.88	1.30	0.69	0.19	1.33	1.71	0.12	1.49	1.12
H(0-15)	0.53	1.12	1.48	1.31	1.18	1.36	0.00	0.23	1.74	0.00	0.27	0.74
H(15-30)	0.71	1.10	1.31	0.48	1.17	1.19	0.14	1.21	1.35	0.00	1.26	0.35
I(0-15)	3.48	1.75	1.49	1.49	1.74	2.00	0.74	1.31	1.74	0.35	1.55	1.46
I(15-30)	2.41	1.58	1.09	1.09	1.45	1.41	0.71	1.25	1.71	0.07	1.36	1.12
J(0-15)	1.90	1.58	1.90	1.09	1.27	1.74	0.81	1.46	1.87	0.55	2.39	1.73
J(15-30)	0.86	1.31	1.45	0.45	1.19	1.17	0.32	1.42	1.32	0.21	1.81	1.21
K(0-15)	2.21	1.48	1.51	0.51	1.31	1.87	0.38	1.46	1.83	2.73	2.86	1.52
K(15-30)	1.33	1.33	1.15	0.15	1.24	1.52	0.03	0.25	0.80	0.01	0.32	1.08
L(0-15)	3.31	1.37	1.61	0.61	1.19	1.44	0.44	1.49	1.94	0.04	1.43	1.70
L(15-30)	0.52	1.26	1.34	0.34	1.19	1.34	0.74	1.47	1.74	0.05	1.34	1.50
M(0-15)	2.74	1.54	1.77	1.77	1.89	1.62	1.62	1.96	2.02	1.57	2.40	1.57
M(15-30)	1.02	1.49	1.61	0.88	1.75	1.04	1.04	1.84	1.92	0.94	1.96	1.16
N(0-15)	1.13	1.46	1.88	0.81	2.29	2.36	0.17	1.43	1.71	0.16	1.84	1.51
N(15-30)	1.92	1.37	1.81	0.61	2.24	2.07	0.26	1.29	1.36	0.15	1.41	1.40
O(0-15)	2.42	1.48	1.61	1.28	1.84	1.90	0.35	1.44	1.53	0.04	1.34	1.22
O(15-30)	2.46	1.28	1.28	0.86	1.53	1.35	1.03	1.25	1.30	0.22	1.26	1.01
P(0-15)	2.69	1.31	1.47	0.47	2.06	1.53	0.46	1.50	1.64	0.01	1.31	1.41
P(15-30)	2.45	1.28	1.15	0.15	0.97	1.65	0.04	1.26	1.40	1.41	1.29	1.14
Q(0-15)	3.29	1.80	2.05	2.05	2.23	1.81	0.70	1.64	1.70	1.81	2.57	1.50
Q(15-30)	2.74	1.41	1.62	1.62	1.78	1.92	1.18	1.43	1.38	0.82	1.88	1.28
R(0-15)	3.50	1.40	1.92	1.68	1.64	1.78	0.53	1.54	1.65	0.75	1.83	1.50
R(15-30)	1.57	1.21	1.68	0.92	1.47	1.65	0.65	1.32	1.41	0.50	1.65	1.41
S(0-15)	5.35	1.28	1.50	1.50	1.18	1.41	0.41	1.46	1.60	0.41	1.59	1.41
S(15-30)	2.78	1.15	1.39	1.39	1.14	1.35	0.60	1.24	1.30	0.51	1.34	1.14
T(0-15)	4.45	1.19	1.19	0.92	1.22	1.60	0.00	0.21	0.60	0.00	0.60	0.39
T(15-30)	1.93	1.16	0.92	0.19	1.13	1.20	0.30	0.11	0.30	0.00	0.29	0.19

RESULTS AND DISCUSSION

The physico-chemical properties of the basement complex soils expressed in mean \pm standard deviation are given in Table 1. The basement complex soils are acidic with mean pH value of 4.87 with high CEC value of

8.1Meq/100g and P value of 50.23 mg/kg. The amounts of P released from the 40 soil samples analyzed are given in Table 2. Amount of P varied from 0.45 – 5.35, 0.15 – 2.24, 0.00 – 1.79 and 0.00 – 1.81mg/kg for 1:2, 1:3, 1:4 and 1:5 soil/water ratio respectively equilibrated for 15mins. Mean values of 2.27, 0.95, 0.58 and

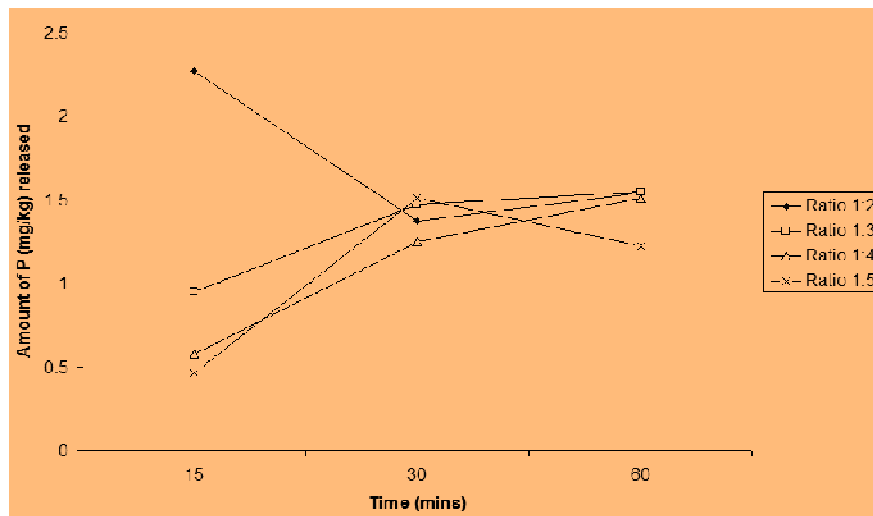


Figure2: Amount of P released from soil with time

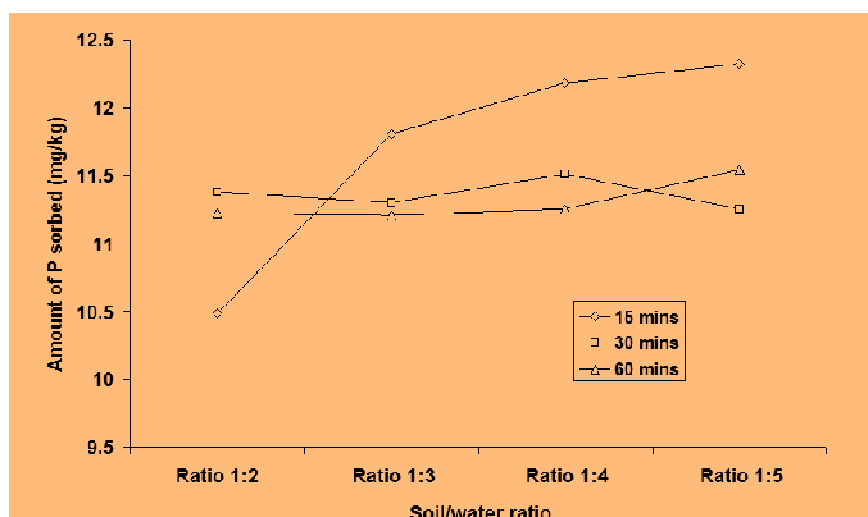


Figure 3: Amount of P sorbed in soil with different amount of water

0.47mg/kg were obtained using descriptive statistics in analyzing the result. Amount of P for 30 minutes varied from 1.10 – 1.84, 0.97 – 2.29, 0.11 – 1.96 and 0.27 – 2.86 mg/kg with mean values of 1.38, 1.47, 1.25 and 1.51mg/kg for 1:2, 1: 3, 1:4 and 1:5 soil/water ratio respectively. Amount of P for 60 minutes varied from 0.92 – 2.05, 0.69 – 2.50, 0.30 – 2.02 and 0.19 – 1.73mg/kg for the various soil/water ratios used for the study. In some soil samples analyzed, P was not extracted by water. This may be due to the low pH (4.87) value of the soil. Generally, decrease in pH increases positive surface charge on soil samples which have greater affinity for phosphate ions (Samadi, 2006). Analysis of variance test

conducted revealed that time of sorption, moisture content and weight of PR added to soil had significant effect on the test parameter.

The amount of P released from soil with different moisture content is shown in Figure 1. While the amount of P released from soil with time is shown in Figure 2. From the plots, the highest amount of P released from the mixture was obtained from soil/water ratio of 1:2 with 15 minutes equilibration time. On the average, the highest amount of water extractable P was obtained at 60mins equilibration time and 1:3 soil/water ratio.

Figure 3 and 4 shows amount of P sorbed in soil with different moisture content and time of equilibration respectively. From the plots, P was sorbed mostly to 1:3,

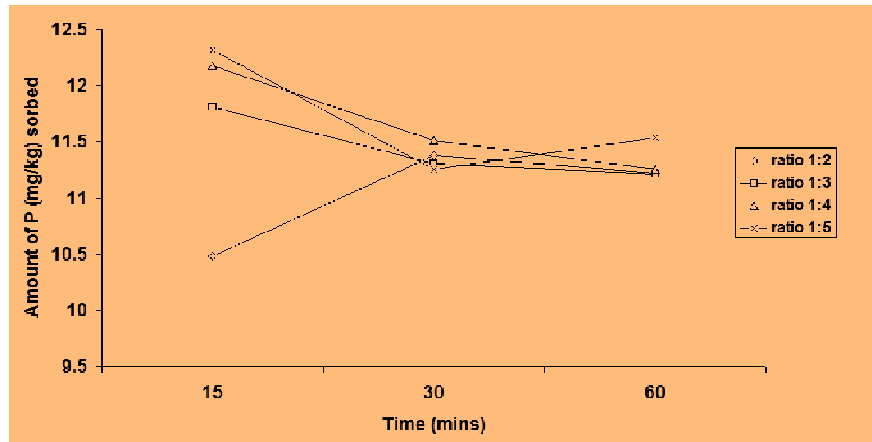


Figure 4: Amount of P sorbed in soil (Onishere) with time

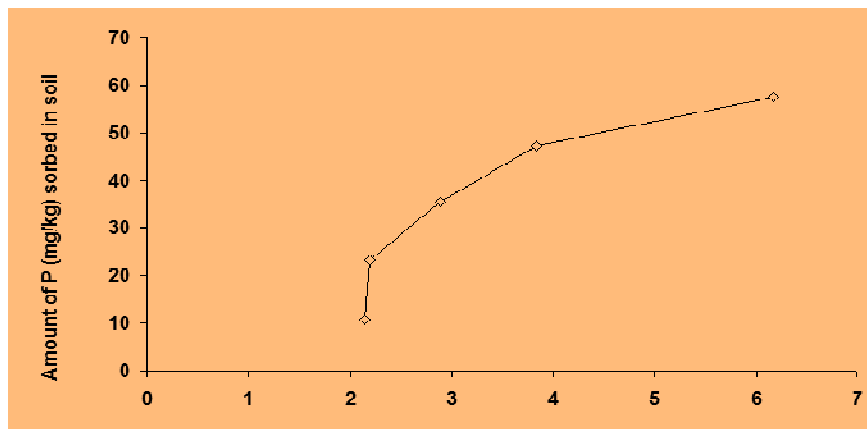


Figure 5: Amount of P (mg/kg) released from soil Sorption Isotherm

Table 3: Equilibrium studies

Weight m(g)	Final conc. c (ppm)	Amount sorbed (mg)	x (mg/g)	c/x	Log x	Log c
0.1	2.14	0.16	1.61	1.33	0.21	0.33
0.2	2.19	0.35	1.75	1.25	0.24	0.34
0.3	2.89	0.53	1.77	1.63	0.25	0.46
0.4	3.84	0.71	1.77	2.17	0.25	0.58
0.5	6.18	0.86	1.72	3.58	0.24	0.79

1:4, 1:5 soil/water ratio samples equilibrated for 15mins. The 15mins plot increase significantly with increase in soil moisture content. The amount of P sorbed in soil

equilibrated for 60mins varied slightly for all soil/water ratio used for the study except for ratio 1:5 were it increased sharply.

Table 4: Freundlich and Langmuir isotherm constants and coefficient of correlation

Langmuir			Freundlich		
k	b	R ²	a	b	R ²
25.16	0.5711	0.9966	0.2192	0.0375	0.1911

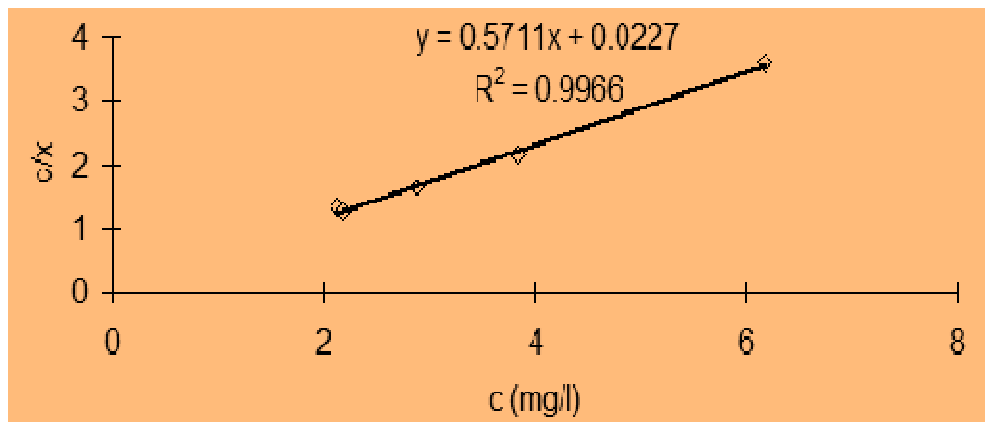


Figure 6: Langmuir isotherm

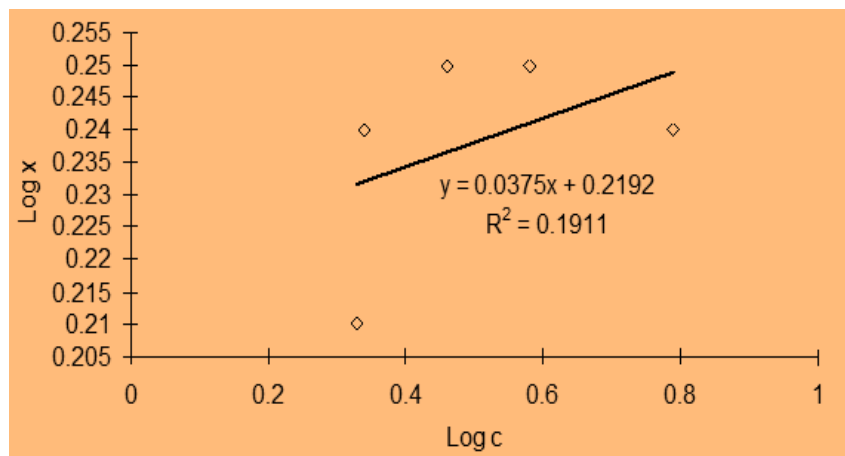


Figure 7: Freundlich isotherm

The P sorption isotherm in Figure 6 shows that although P release increase with increase in weight of PR added to soil, the amount of P sorbed in soil also increases.

Equilibrium results obtained by varying the mass of RP added to the soil are given in Table 3. Figure 6 and 7 are plots showing linearized Langmuir and Freundlich isotherms. The isotherm constants and coefficient of correlation obtained are presented in Table 4. Phosphorus sorption parameters were calculated from P sorption isotherm, using the Langmuir equation:

$$c/x = 1/kx_m + c/x_m$$

Where K is a constant related to bonding energy, x_m is the Langmuir sorption maximum (mg P/kg soil) c = concentration of P in the equilibrium solution

A plot of c/x vs c produced a straight line with a slope $1/x_m$ and intercept $1/kx_m$. The Langmuir constant k was obtained by dividing the slope ($1/x_m$) by the intercept ($1/kx_m$).

A linear form of the Freundlich equation can be written as: $\text{Log } x = \text{log } a_f + 1/n_f \text{ log } c$.

Where c is the concentration of P in the equilibrium

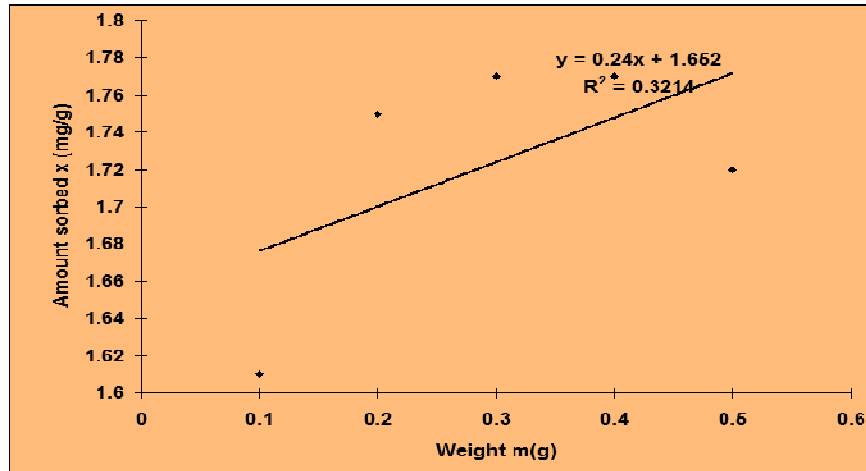


Figure 8: Regression Curve

solution (mg/l), x is the amount of P sorbed per unit weight of soil (mg P/kg soil) and a_f and n_f are empirical constants that relate to sorption surface (distribution coefficients) and sorption energy respectively. Thus a plot of $\log x$ vs $\log c$ produced a straight line with slope $1/n_f$ as shown in Figure 7.

Regression analysis conducted on amount of P sorbed by the soil amended with various amount of PR showed regression equation $b = 0.24$, $a = 1.652$. Also, regression equation of weight of PR (m) on amount of P sorbed (x) was found to be highly significant ($P < 0.01$)

CONCLUSION

The study revealed that low moisture content and longer time after PR application may favour release of more water extractable P from soils formed on basement complexes. The study also shows that the use of PR as P fertilizer is site specific as soils tend to have different properties.

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