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Fractional Recovery of Applied Phosphorus in Soils of Akwa Ibom State, Niger Delta Region of Nigeria

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Abstract: Seven surface soil samples, representing the dominant soil parent materials in Akwa Ibom State, Niger Delta Region of Nigeria were treated to various concentration levels of P and the amounts of P measured at time intervals of 1, 10, 50 and 150 days. The phosphorus fixing capacity of the soils increased with increasing rate of added P and time of equilibration. At 1 day, P fixation capacities estimated by fractional recovery varied from 26-66% and at 150 days observation it ranged from 37-76%, respectively for soils of sandstone and beach sands origin. The amount of P required to increase the value of Bray P-1 by 1 mg L^{-1} (Fertilizer factor) at 150 days ranged from 2.6-5.3 mg L^{-1} with a corresponding mean of 3.9 mg L^{-1}. The fertilizer factor appears to provide a useful index of obtaining the P fertilizer needs of the soil, however, calibration and correlation studies in a wide range of soils could further the usefulness of this approach.

Key words: Fractional recovery, phosphorus fixing capacity, fertilizer factor, bray P-1

INTRODUCTION

Studies on the capacity of soils to retain and release phosphorus have been widely done. There have been general agreements that phosphorus adsorption and desorption reactions in soils depend on several factors such as soil type, amount of P applied in the soil, contact time, prevailing mechanisms of P reactions, soil reaction and microbiological activities, etc. In general fixation of phosphorus by soils controls its availability to plants in various degrees (Larsen, 1967; Holdford and Mattingly, 1976; Parfitt, 1979; Agbenin, 2003).

Methods of estimating the capacity of soils to retain or fix phosphorus also vary. Fractional recovery which involves the measurement of applied P in the soil by means of soil test method generally used in estimating available P form is one such approach in establishing a basis for P recommendations. The fraction of added P not recovered is taken as the P fixed or retained by the soil when known rates of P are applied to the soil and allowed to equilibrate after which Bray P-1 extracted values are determined at different time intervals.

Fractional recovery approach has been used by Ayodele and Agboola (1981) to establish P Fertilizer factor (Ff) from which P fertilizer recommendations could be based.

The objective of this study, was to evaluate the P retention ability of soils of Akwa Ibom State, Niger Delta region of Nigeria, with a view to establishing a general basis for P fertilizer recommendation.

MATERIALS AND METHODS

Five surface soil samples were used for the study to represent the 5 dominant soil parent materials in Akwa Ibom State. Two milliliter aliquots of graded concentration of P (0, 50, 100, 160, 240 mg L^{-1}) in 0.01 M $CaCl_2$ were equilibrated with 2 g of soil in duplicate cups and allowed to stand for 1, 10, 50 and 150 days, respectively. The soils were kept moist with distilled water and covered for the duration of incubation. After each incubation time, Bray P-1 extractant was used to determine the amount of plant available phosphorus in a set of samples. A measure of the Fractional Recovery (FR) of P by the soils was obtained from the relationship between phosphorus added and the amounts extracted by BrayP-1 method expressed as:

$$Y = a + bx$$

Where:

Y = Phosphorus extracted from each soil at a given rate of addition and time of incubation
x = The rate of P added (mg L^{-1})
a = Intercept of regression line corresponding to extractable P at zero P addition

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The slope (b) of the regression line represents fractional recovery which is the proportion of added P recovered at a particular period of time of incubation.

From the fractional recovery estimate, the amount of P adsorbed was obtained as the difference between P added and P extracted by Bray P-1, while, the Phosphorus Fixing Capacity (PFC) was obtained from the relationship:

$$PFC = (1\text{-}FR)\ 100$$

Where:

FR = Fractional Recovery at a given time

RESULTS AND DISCUSSION

The amount of P recovered as a function of time is presented in Table 1 and the relationship is described by regression data in Table 2. Amounts of P extracted at each time interval increased with increasing levels of P addition, 0 mg L^{-1} addition being the lowest and 240 mg L^{-1} addition being the highest for all the soil groups, a reflection of the fact that amount retained increases with increasing rate of addition. Ahmed *et al.* (2008) observed significant increase in P adsorption as a result of increasing levels of added P in some Australian soils. Also, the soils showed decreasing amounts of extracted (recovered) P from 1-150 days.

The decrease showed no uniform pattern for individual soil. The rate of decrease is the b term reflected in each regression equation (Table 2). The percentage recovery is presented in Table 3. Among the soils, beach sands (No. 18) had the highest amount of P recovered ranging from 66-76% (1-150 days) indicating the lowest affinity to retain P, whereas sandstone exhibited the least amount of P recovered ranging from 26% in days 1-37% at the terminal period of incubation inferring stronger affinity of sandstone soil to retain P compared to beach sand soil. Generally, these data indicate that the soils have low to medium capacities to adsorb or fix P. Ibia and Udo (1993), using the single point adsorption index method of Bache and Williams (1971) recorded wide range of P adsorption capacities in the soils of the same zone.

A useful derivation obtained from fractional recovery approach to estimating phosphorus fixing capacity of soils is the P Fertilizer factor (Ff). This factor defined as the amount of P needed to increase Bray p-I value by 1 mg L^{-1} in soil solution is obtained from the relationship:

$$Ff = Pa/Pr\text{-}Pu$$

Where:

Pa = Phosphorus added at a given rate

Pr = Phosphorus recovered at that rate of addition

Pu = Amount of P extracted from the control (soil without added P)

Table 1: Amount of P extracted by bray p-I extractant at different rates of P addition over different time periods

Soil/ parent material*	Rate added (mg L^{-1})	Time (days) 1	10	50	150
		Amount extracted (ppm)			
6	0	80.0	81.5	81.3	79.8
RA	50	102.0	95.5	89.8	87.0
	100	123.8	111.5	106.0	100.4
	160	153.8	140.0	132.0	124.0
	240	227.5	209.0	196.0	183.1
8	0	31.0	36.3	35.0	35.8
CPS	50	50.3	48.8	43.8	41.0
	100	90.6	82.0	78.4	65.3
	160	141.5	119.5	109.4	100.3
	240	187.5	163.0	148.0	121.0
13	0	17.0	10.3	11.4	11.6
CPS	50	38.3	36.3	34.1	28.6
	100	65.0	61.4	58.1	48.7
	150	103.4	99.5	85.3	77.8
	240	144.5	120.3	109.4	106.7
18	0	7.3	7.5	6.0	7.0
BS	50	22.0	20.5	18.3	15.4
	100	39.5	34.8	32.5	23.0
	160	53.8	48.8	43.8	38.2
	240	91.0	87.8	78.8	66.3
22	0	16.0	15.8	13.8	14.9
BS	50	28.5	26.8	26.3	22.8
	100	46.3	40.5	37.5	31.0
	160	73.0	67.5	65.8	60.9
	240	106.5	105.0	101.3	90.0
32	0	41.8	39.5	40.5	40.1
SS	50	67.8	60.0	54.3	50.0
	100	89.0	84.0	79.5	68.9
	160	132.8	129.5	121.3	102.0
	240	223.8	214.5	206.3	195.2
37	0	5.4	5.3	4.9	4.9
SH	50	20.0	18.9	16.8	16.3
	100	47.3	39.0	36.5	37.4
	160	60.8	56.1	50.4	47.4
	240	100.0	89.0	80.6	78.3

*RA = River Alluvium; CPS = Coastal Plain Sands; BS = Beach Sands; SS = Sand Stone; SH = Shale

Table 2: Regression equations for Fractional Recovery (FR) of selected surface soils at different times of incubation

Soil	Time (days) 1	10	50	150
6	y = 24.81 + 0.68x	y = 29.22 + 0.55x	y = 28.27 + 0.49x	y = 29.96 + 0.49x
8	y = 71.46 + 0.60x	y = 70.13 + 0.52x	y = 68.86 + 0.47x	y = 67.98 + 0.42x
13	y = 10.57 + 0.56x	y = 12.02 + 0.51x	y = 10.97 + 0.51x	y = 9.91 + 0.49x
18	y = 5.21 + 0.34x	y = 4.09 + 0.32x	y = 3.53 + 0.29x	y = 3.08 + 0.24x
22	y = 11.67 + 0.38x	y = 9.63 + 0.37x	y = 8.94 + 0.37x	y = 8.69 + 0.35x
32	y = 29.23 + 0.74x	y = 25.57 + 072x	y = 24.20 + 0.69x	y = 21.29 + 0.63x
37	y = 3.78 + 0.39x	y = 3.32 + 0.35x	y = 3.19 + 0.31x	y = 3.55 + 0.30x

Table 3: Phosphorus fixation capacity based on fractional recovery at different time periods

		Time (days)			
		1	10	50	150
Soil no.	Parent material	(%)			
6	River alluvium	32	45	51	56
8	Coastal plain sands	40	48	53	58
13	Coastal plain sands	44	49	49	51
18	Beach sands	66	68	71	76
22	Beach sands	62	63	63	65
32	Sand stone	26	28	31	37
37	Shale	61	65	69	70

Table 4: Data on fertilizer factor calculated from fractional recovery at 150 days of incubation

		Rate of P addition (mg L^{-1})				
Soil mean		0	50	100	160	240
No.	Parent material	P required (Ff)				
6	River alluvium	7.4	3.4	2.5	2.8	4.0
8	Coastal plain sands	6.9	4.9	3.6	2.3	4.4
13	Coastal plain sands	2.9	2.7	2.4	2.5	2.6
18	Beach sand	5.9	6.3	5.1	4.0	5.3
22	Beach sand	6.3	6.2	3.5	3.2	4.8
32	Sand stone	5.1	3.5	2.6	1.5	3.2
37	Shale	4.3	3.1	3.8	3.3	3.6

Ff = Fertilizer factor

The calculated Ff values for the soils are presented in Table 4. At 150 days of incubation, the mean values ranged from 2.6 mg L^{-1} in coastal plain sand to 5.3 mg L^{-1} with an overall mean for all the soils calculated to be 3.9 mg L^{-1}.

This value is slightly higher than the value of 3.5 mg L^{-1} but within the limits obtained for some savannah soils in Southwest Nigeria. The fertilizer factor has been found useful in making P fertilizer re-commendation when soil P test values and critical level of P have been established (Ayodele and Agboola, 1981). This usefulness need to be explored in a wide range of soils using correlation and calibration studies.

CONCLUSION

The study has confirmed that phosphorus fixing capacity of these soils increased with increasing rates of P addition over time of equilibration. At 150 days of incubating the soil samples with graded rates of P, the ability of the soils to fix P varied from 37-70%.

On the basis of fractional recovery, the Fertilizer factor (Ff) calculated from this would appear to provide a useful guide for estimating the P fertilizer requirements of soils.

This calls for further studies to calibrate the P fertilizer factor and correlate field responses of crops to P fertilizer applications on a wide range of soils based on fertilizer factor.

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