RP-22

Isotopically Exchangeable Phosphorus in Major Coconut Growing Soils of Kerala State

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Abstract : *Isotopically exchangeable phosphorus (E-value) has been determined in 40 randomly selected soil samples covering the major coconut growing areas representing six major soil groups of Kerala State. Effect of shaking period on surface exchange equilibrium was studied in these soils. It appears that the apparent equilibrium is attained within 4 hours in all the soils. Effect of 1 ppm and 2 ppm carrier levels on E-values was investigated. 2 ppm carrier level was found better than 1 ppm carrier level in most of the soils. Olsen P showed significant negative correlation with E-values at both the carrier levels.* (Key words : Coconut growing soils ; surface exchange equilibrium ; isotopically exchangeable P ; carrier levels).

Characterisation of available P status of soils is usually done by employing different chemical extractants, biological methods and also by tracer technique using P^{32}. The last method determines the amount of phosphorus which is exchangeable against itself by means of isotopic exchange and could be expected as a less arbitrary estimation than the extractable P. The amount of isotopically exchangeable P is called E-value of soil. The E-value determination was found to depend on the duration of equilibration and the carrier level. As the initial fast exchange reactions are believed to be more important in the evaluation of available P, different workers have suggested different exchange reaction periods such as ½ hour (Amer 1962), 1 hour (Beckett & White 1964) 24 hours (Chu & Chang 1966), 48 hours (Russell *et al.* 1954), 60 hours (Dunbar & Baker 1965), 96 hours (Al-Abbas *et al.* 1967) and 168 hours (Russell *et al.* 1955). The validity of E-value determinations as an estimate of available P in acid soils has been questioned by Russell *et al.* (1954) in view of the high P fixing capacity of the acid soils. This limitation may perhaps be overcome by the use of suitable level of carrier P in the determination of E-value in acid soils. No attempt has, however, been made to determine E-value of acid soils of India by E-value technique using different carrier levels.

The present study aims at the determination of E-value of six major coconut growing soil groups of Kerala State which are mostly acidic in reaction and to study the signific-

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ance of E-value in predicting the available P status of these soils.

EXPERIMENTAL

Soil samples representing coastal sand, alluvial, laterite, red sandy loam, loamy sand and reclaimed marshy soils were collected from 0-50 cm depth from coconut palm basins. Eight samples were taken at random for each soil type from different localities excepting for loamy sand and red sandy loam where only four samples have been considered. The soil pH varied from 4.5 to 8.4 ; organic C, 0.08 to 2.31% ; total P, 0.01 to 0.10% ; R_2O_3, 3.13. to 15.20%; Ca, 75 to 875 ppm ; Mg, 60 to 240 ppm; K, 0.02 to 2.16% ; Fe, 0.1 to 7.3% ; Mn, 62 to 1312 ppm ; Zn, 100 to 725 ppm and texture varied from sand to clay.

For E-value determination 5 g soil was taken in 100 ml polythene bottle to which 50 ml of 0.01M $CaCl_2$ soln. having 1 and 2 ppm P labelled with P^{32} was added (10μC P^{32} per 100 ml standard P soln. in $CaCl_2$). The bottles with the contents were shaken for four hours. The suspensions were filtered through Whatman No. 42 filter paper. P was estimated in the filtrate by Dickman and Bray's method (Jackson 1958) and for activity measurements, 1 ml filtrate was transferred into a planchet, dried under infra-red lamp and counts were taken using an end window G. M. tube connected to a scaler. The E value was calculated using the equation : $E=b\ (S_a/S_e-1)$ where E is the isotopically exchangeable P in ppm, b is added in ppm, S_a is the specific activity of added P and S_e is the specific activity of P in the filtrate.

For finding out the suitable exchange reaction period, same procedure was followed except that only 2 ppm P soln. was employed for different periods of shaking and activity of 1 ml filtrate was measured after drying. P fixation capacity was also determined using 2 ppm P soln. and was expressed in percentage of added P.

RESULTS AND DISCUSSION

Effect of shaking period on surface exchange equilibrium

It is essential to establish the period for which the soil must be shaken with tagged solution of phosphorus in order to attain the surface exchange equilibrium. Results of many studies indicate that even after several days of shaking with tagged solution, true equilibrium is not attained. This has been attributed to the slow reactions that follow the initial rapid exchange reactions. The slow reactions are mainly due to the incorporation of the tracer into the solid surface by self diffusion and recrystallisation. The initial rapid reaction is of more importance for the evaluation of the highly reactive surface of the phosphate compound which contributes towards the exchangeable P and regulates the availability of soil and fertilizer P.

The results of the P^{32} equilibration study have been presented in figure 1 for all the soils (except loamy sand) studied. It is evident from the results that there was a rapid exchange of solution P^{32} with solid P^{31} as indicated by the steep fall in the activity at the initial period of equilibration. In all cases the initial quick exchange reactions were found to be completed by about 1 hour shaking period at room temperature of 25°C. However, the rate of exchange varied with different soils. The apparent equilibrium was attained after 1 hr of shaking in coastal sandy soils and as expected, the activity of the equilibrium solution remained fairly constant when the shaking period was extended upto six hours. This is possibly due to the low content of clay and sesquioxides in these soils. It is also evident from the figures that in all the soils after one or two hours, the activity in the solution comes very close to equilibrium with the solid phase phosphorus and upto six hours there seems to have been very little change in the activity of the equilibrium solution. From the results it therefore, appears reasonable to take four hours shaking period as adequate to establish the surface exchange

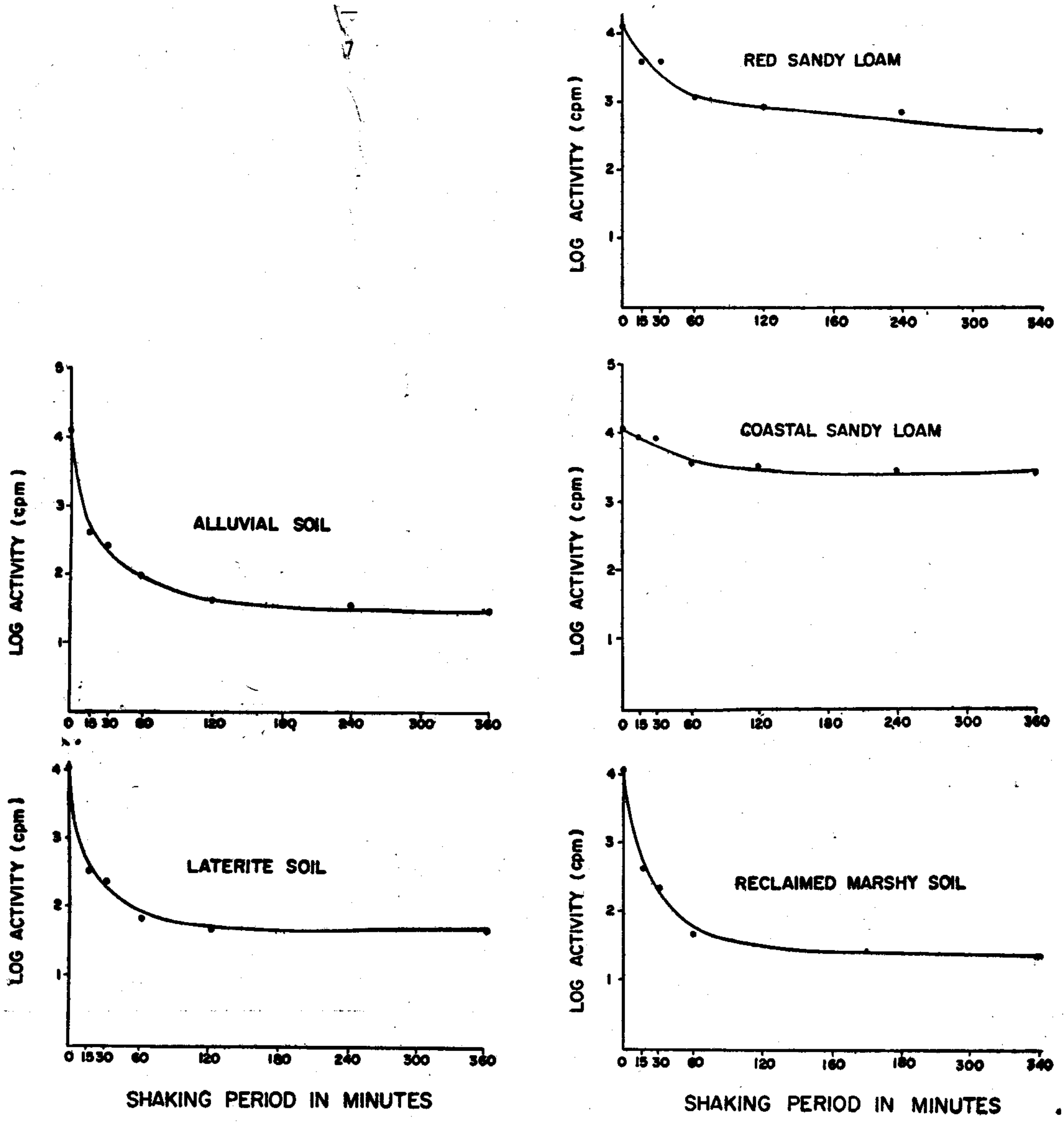

Fig. 1. Effect of shaking period on surface exchange equilibrium in different soils of Kerala State

TABLE 1

Isotopically exchangeable P, P fixing capacity and available P in different soil groups of Kerala State

Soil Group	Soil No.	pH	Isotopically exchangeable P (ppm) Carrier level			Carrier P fixed (%)	Available P (ppm)	
			1 ppm	2 ppm	Ratio		Bray	Olsen
1	2	3	4	5	6	7	8	9
Alluvial	1	4.9	317.0	283.8	0.89	99.6	1.2	1.4
	2	4.7	220.5	251.2	1.13	99.5	2.2	3.5
	3	5.6	44.9	53.6	1.19	93.9	41.0	17.4
	4	5.9	47.0	32.2	0.68	95.2	15.6	13.6
	5	5.4	79.8	45.0	0.56	96.9	4.4	4.4
	6	5.1	129.1	41.0	0.32	98.0	2.4	4.6
	7	5.1	318.2	16.2	0.05	95.2	0.6	2.1
	8	4.8	173.5	24.8	0.14	98.3	5.8	6.1
Coastal Sand	9	8.4	106.4	12.4	0.12	40.2	16.8	3.6
	10	6.8	48.8	16.0	0.33	29.4	20.9	8.4
	11	6.6	133.0	14.3	0.11	29.2	7.4	2.8
	12	6.6	230.7	9.3	0.04	28.1	7.6	2.3
	13	7.5	34.5	10.1	0.29	32.8	7.7	2.1
	14	6.8	24.8	18.5	0.74	26.6	10.2	9.8
	15	6.9	21.3	4.8	0.23	66.8	7.2	4.0
	16	6.5	31.1	14.6	0.46	31.2	11.7	7.6
Laterite	17	5.3	76.8	19.0	0.24	97.4	13.5	4.6
	18	5.4	36.2	107.6	2.94	99.2	3.1	2.3
	19	5.3	58.8	26.8	0.46	98.9	3.5	3.0
	20	5.4	86.1	89.6	1.03	99.1	9.7	10.1
	21	6.1	109.7	7.2	0.07	92.7	17.0	16.6
	22	5.5	86.6	88.8	1.02	99.3	3.1	4.4
	23	6.0	79.9	104.4	1.30	99.4	11.6	5.6
	24	5.6	102.6	166.8	1.61	99.6	4.1	9.6
Reclaimed Marshy	25	4.5	93.8	89.6	0.96	99.6	2.1	3.5
	26	4.6	48.8	14.2	0.29	89.8	21.0	22.0
	27	4.5	40.4	23.8	0.59	98.8	17.0	18.8
	28	4.5	21.4	10.5	0.49	95.9	11.2	11.4
	29	6.7	21.4	123.0	5.88	93.5	0.8	2.3
	30	4.7	28.9	17.8	0.62	98.0	8.4	15.0
	31	5.0	23.1	8.2	0.36	80.6	15.5	9.8
	32	5.4	19.5	6.0	0.31	90.4	11.8	17.4

TABLE 1—*contd.*

1	2	3	4	5	6	7	8	9
Red Sandy loam	33	5.3	92.6	38.2	0.41	93.1	41.1	25.4
	34	5.5	30.2	49.4	1.63	99.3	3.5	4.6
	35	5.9	81.4	40.7	0.50	99.2	18.5	12.6
	36	6.2	81.8	148.0	1.81	98.0	12.0	6.6
Loamy Sand	37	6.2	46.5	18.0	0.39	69.0	29.5	19.6
	38	4.3	70.2	19.6	0.28	83.6	22.8	28.0
	39	6.3	110.4	32.0	0.29	75.6	27.6	17.4
	40	6.6	54.5	25.4	0.46	72.6	22.9	17.8

equilibrium in the determination of isotopically exchangeable phosphorus in the soils studied. At this point of equilibrium, however, the possibilities of incorporation of the tracer into the solid surface by slow rate of diffusion is not completely overruled.

Phosphate fixing capacity and isotopically exchangeable phosphorus by carrier method

The phosphate fixing capacity, the isotopically exchangeable P at two carrier levels and the available P by Olsen and Bray's-I extractants for the soils are presented in table 1. The phosphate fixing capacity of all the soils are very high except coastal sand and loamy sand soils. Therefore, 1 and 2 ppm P carrier levels were used for the determination of isotopically exchangeable P in order to have low experimental error.

A significant decrease in the E-value has been observed as the carrier level was increased from 1 ppm to 2 ppm P in most of the cases. In all the groups of soil some exceptions were observed. Such exceptions are possibly the results of no carrier losses on those soils in non-exchangeable form. The ratio of E—values obtained under two carrier levels showed three distinct patterns. Some soils are having the E-values ratio of 1, some showed values higher than 1 and some showed values less than 1. When the ratio of E-values is around 1, it may be assumed that E-values measured by both the carrier levels in those soils are equally accurate within the expected range of experimental error. The soils which showed the ratio less than 1 indicate tracer losses at 1 ppm carrier level giving an over estimation of exchangeable P in those soils. The lower the ratio, the greater is the tracer loss in non-exchangeable form which usually occurs in high P fixing soils. Lastly, the soils which showed the ratio higher than 1, indicate release of P from the solid phase to the solution phase and tracer losses have been reduced or avoided by higher carrier level. It may be mentioned here that with the exceptions of few soils (Nos. 18, 23, 24, 29, 34 & 36), all the other soils showed values either around 1 or less than 1. The results are in good agreement with the findings of Amer (1962).

It has been reported by many workers that the error in the determination of exchangeable P by P^{32} equilibration is reduced when sufficient carrier is added to P^{32}. But very high level of carrier results in increased precipitation and if the amount of P added to the soil is much greater than the exchangeable P, the difference in the initial and final specific activities may not be very much different and accurate measurement of 'E' will be difficult because of the decrease in

TABLE 2

Correlation coefficients between isotopically exchangeable P and available P in soils

Isotopically exchangeable P	Available P	
	Bray's P	Olsen P
1 ppm carrier P	—0.160	—0.340*
2 ppm carrier P	—0.262	—0.327

* Significant at 5% level

the sensitivity of the estimation method. The results of the present investigation indicate that 2 ppm P carrier level was better than 1 ppm P carrier level in the determination of isotopically exchangeable P in soils which are acidic in reaction and having high P fixing capacity.

The results of correlation studies between E-values and Olsen and Bray's 1 P values are given in table 2. It is interesting to note that both 1 ppm and 2 ppm P carrier levels gave significant correlation with Olsen P, whereas Bray's 1 P did not show any significant relationship. It is conceded that the prediction value of such relationship is very low. The lack of strong association may be ascribed to the fact that the availability of different phosphate compounds is governed by their solubility product and particle size whereas exchangeable P is a measure of all the phosphate compounds covering all particle sizes. It appears rather strange that Bray's 1 P values did not show any significant relationship with E-values in these soils, rather Olsen P has shown to be a better measure of available P. It is not, however, understood why Olsen P showed significantly negative correlation with isotopically exchangeable P. This needs further investigation.

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