Phosphorus Fixation in Nilgiri Soils*

by

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Introduction : Rotry (1946) as quoted by McKelvy *et al* (1953) declared rightly that phosphorus is the bottleneck of world's hunger. Acid soils as those found in the Nilgiris pose an economic problem, due to the undesirable nature of the transformation phosphorous undergoes in acid soils. The applied phosphorus is rapidly fixed as insoluble and unavailable compounds. The native reserve of phosphorus also remains unavailable due to the acid conditions which prevent the sesquioxidic phosphates from being released as phosphorus in available forms, as is possible in a limed soil. The magnitude of this problem of phosphorus unavailability can be seen from the abnormal rate of 214 lb of P_2O_5 in the Nanjanad mixture used extensively on the Nilgiris, though a normal potato crop removes on an average 40 lb P_2O_5 per acre. Detailed information regarding the phosphorus fixation problem in Nilgiris is not available. Therefore, a detailed study of the tract is indispensable to supply information on this aspect.

Review of literature : Wild (1950) reviewed the work done on phosphorus fixation and suggested the following as the factors affecting phosphate retention: (a) mechanical composition (b) phosphorus concentration (c) time and temperature (d) effect of salts (e) nature of the soil phosphorus fractions (f) other inorganic soil constitutions (g) organic matter and (h) pH. Murphy (1939) noted the highest fixation of phosphate under acid conditions. Chandler (1941) attributed fixation in acid soils to the formation of iron and aluminium phosphates. Chai Moo Cho and Caldwell (1959) and in India, Kanwar and Grewal (1960) showed that phosphate retention capacity decreased with increases in pH and degree of base saturation of acid soils. Heck (1934) found least penetration of soil phosphorus in laterites which contained relatively large amounts of sesquioxides. Tiulin (1936) ascribed phosphorus fixation to the sesquioxides. In the following year, he showed that the removal of sesquioxides reduced phosphorus retention. Leaver and Russell (1957) showed that fixation was associated with sesquioxides. Murphy (1939), Patel and Viswanath (1946) noted that the higher the silica-sesquioxide ratio, the lower the fixation of phosphorus. Raychaudhuri and Mukherjee (1941) studied phosphate fixation by gels of

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ferric oxide and titanium oxide. Ferric oxide showed higher power of fixation as compared to aluminium oxide. Scarseth and Tidmore (1934) found that clays with a low silicasesquioxide ratio fixed more phosphates. Eurphy (1939) reported more fixation of phosphorus in kaolinite clays. Black (1941) attributted fixation of phosphorus in kaolinite crystals to penetration of phosphate between the lattice layers, from which it was no longer readily extracted. Low and Black (1947) showed decomposition of kaolinites and the precipitation of phosphate by the alumina of the dissociated kaolinite as the main source of retention as aluminium phosphate, but not as kaolinite phosphate. In 1950, they concluded that phosphate fixation by kaolinite was due to the replacement of silicon tetrahedrons by phosphate tetrahedrons. Murphy (1939) showed that kaolinite had a larger capacity to take up phosphate because of an exchange of phosphorus with layers of hydroxyl ions on the surface of the minerals.

Experimental details: With the object of assessing the extent of phosphorus fixation and its relation to various chemical components and the discrete forms of soil phosphorus, forty surface soil samples were collected, representing the wide range of rainfall and elevation on the Nilgiris. The surface soils collected from various parts of the Nilgiris district were examined for chemical and physical properties pertaining to the study, by methods described by Piper (1950), Jackson (1958) and methods of Association of Official Agricultural Chemists (U. S. A.) (1955). The fixation capacity of soil was determined by the method described by Patel and Viswanath (1946) (Table 1). Ten grams of the air dried soil were placed in a 250 ml glass stoppered measuring cylinder and 100 ml of the phosphate solution of known concentration were added. The mixture was shaken for 24 hours in a mechanical shaker, filtered through Whatman No. 2 filter paper. Five ml of the filtrate were used for the estimation of phosphorus in Klett-Summerson colorimeter. From this phosphorus fixation capacity was calculated and expressed as percentage. An incubation study was carried out to evaluate the effect of phosphates with and without lime on the availability of phosphorus in the soil. At regular periodical intervals representative samples were drawn from each of the incubated beakers and analysed for available phosphorus by Bray and Kurtz No. 2 extraction method (Jackson 1957). The Klett-Summerson colorimeter was used for the estimations. The results were statistically worked out and relationships established (Table 2).

Results and Discussions: The capacity for phosphorus fixation was found to be very high and ranged from nil as in sample No. 7 and 26 to as high as 100 per cent as in sample No. 28 with a mean of 79.6 per cent.

(Table 1). The correlation study indicated a negative correlation between phosphorus fixing capacity of the soil and calcium phosphate ($r = -0.562$) (Fig. 1) or occluded iron phosphate ($r = -0.664$) (Fig. 2). Tiulin (1936) and Metzger (1940) showed that fixation was positively related to sesquioxides. In the present study a positive correlation between sesquioxides and fixation was observed, which however was not significant. The fixing capacity of soil did not correlate with soil pH, calcium, magnesium, rainfall or elevation.

TABLE 1. *pH, Sesquioxides, Fractions of Soil Phosphorus and Phosphorus fixation capacity.*

				Fractions of soil phosphorus as percentages of total phosphorus						
Serial No.	pH	Iron oxide (Fe_2O_3) percent	Alumina (Al_2O_3) percent	Phosphorus in Aluminium phosphate	Phosphorus in Iron phosphate	Phosphorus in Calcium phosphate	Phosphorus in Occluded Aluminium phosphate	Phosphorus in Occluded Iron Phosphate	Phosphorus in organic phosphate	Phosphorus fixation capacity
1	2	3	4	5	6	7	8	9	10	11
1	6·0	8·39	20·35	20·6	1·3	0·4	18·0	38·7	21·0	84
2	6·1	7·39	13·90	24·5	13·4	2 0	16·3	44·9	...	90
4	4·7	5·46	12·36	6·8	3·8	1·4	8 8	17·1	62·2	80
4	4·9	8·38	14·82	8·8	11·1	1·4	7·8	14 5	67·4	84
5	5·9	9·41	2·88	29·1	...	5·3	18·0	45 7	1·9	76
6	5·9	3·38	8·33	11·7	3·0	3·7	10·4	21·2	49·3	40
7	6·9	5·09	22·73	5·2	40·0	7·2	5·9	16·1	25·0	...
8	4·9	13·11	12·17	25·6	...	1·3	13·1	55·1	5·1	82
9	5·0	7·22	9·06	37·8	...	2 0	24·1	37·2	...	80
10	5·5	17·70	12·36	6·8	4·3	0·3	7·3	7·3	73·7	94
11	5·8	4·30	7·57	20·8	4·0	3 9	20·0	11·1	41·7	84
12	4·7	8·92	15·31	9·9	6·9	0·4	8·1	7·9	66·8	84
13	4·5	10·17	19·02	3·9	5·4	0·3	3·1	6·0	57·1	82
14	4·8	8·19	22·12	5·8	8·0	0·4	4·3	8·4	69·4	81
15	4·5	11·19	17·65	9·9	16·5	0·7	9·2	6·6	57·1	82
16	5·6	13·62	9·34	4·1	1·6	0·2	2·7	4 4	87·0	93
17	4·8	10·04	17·22	6·3	4·3	0·3	5·6	5·2	77·9	88
18	4·3	10·48	18·65	14·2	...	0·8	10·9	19·9	54·3	80
19	5·5	7·11	14·80	4·7	0·9	1·1	3·4	7·3	76·4	82
20	5·7	13·25	13·23	8·0	13·1	0·1	6·3	6·9	66·7	98
21	5·0	12·18	20·2o	12·6	10 9	12·6	12·6	27·9	23·6	74
22	5·5	13·11	10·78	5·3	3·5	0·2	5 1	5·8	80·2	98
23	5·0	9·30	10·74	7·5	11·5	1·1	5·0	14·6	60·4	72

TABLE 1 (*Contd*)

				Fractions of soil phosphorus as percentages of total phosphorus						
Serial No.	pH	Iron oxide (Fe_2O_3) percent	Alumina (Al_2O_3) percent	Phosphorus in Aluminium phosphate	Phosphorus in Iron phosphate	Phosphorus in Calcium phosphate	Phosphorus in Occuded Aluminium phosphate	Phosphorus in Occluded Iron Phosphate	Phosphorus in organic phosphate	Phosphorus fixation capacity
1	2	3	4	5	6	7	8	9	10	11
24	5·6	10·47	19·05	8·9	0·9	0·8	7·7	8·8	64·5	88
25	6·1	10·79	13·00	5·9	10·9	0·8	1·5	7·2	73·7	80
26	4·6	10·16	17·08	10·5	18·9	0·5	5·5	9·1	55·4	....
27	5·0	5·01	24·39	3·9	...	0·8	3·3	6·3	85·9	80
28	4·2	9·75	20·76	11·2	18·1	...	22·5	10·6	47·5	100
29	4·3	10·92	14·44	9·6	12·0	2·3	12·1	7·7	56·2	84
30	4·7	12·75	17·29	7·9	8·8	0·6	7·1	3·9	71·1	98
31	5·6	11·53	13·85	20·8	34·2	1·7	19·2	23·9	...	80
32	4·8	11·18	14·80	15·2	13·2	1·3	16·2	14·8	39·3	92
33	5·6	14·73	14·88	8·9	0·2	1·1	10·3	8·3	71·2	92
34	5·0	11·68	17·78	4·2	7·7	0·7	3·6	4·5	79·4	82
35	4·9	11·31	20·38	4·2	2·3	0·2	3·7	3·7	85·6	34
36	4·9	7·36	17·79	13·0	4·3	0·1	12·5	11·3	58·9	92
37	4·7	14·06	19 3J	8·1	10·9	1·0	7·7	3·0	69·3	90
38	4·6	10·65	9·16	17·9	33·7	3·1	14·7	30·5	1·2	76
39	4·9	10·44	22·50	18·3	7·6	0·3	16·4	20·9	36·2	94
40	4·6	11·20	20·61	7·6	14·1	0·7	6·9	6·9	63·8	76

The soil which was observed to have minimum pH of 4·2 and only traces of calcium phosphate showed the highest fixation of 100 per cent, while that which registered the highest calcium phosphate and pH showed minimum fixation. The available phosphorus estimated both by Bray and Kurtz No. 2 and Olsen's method, was found to be maximum where the phosphorus fixation capacity of the soil was minimum.

Kurtz, DeTurk and Bray (1946) observed a decrease in the amount of phosphate which could be removed by extractants with passage of time. Chatterjee and Datta (1951) demonstrated the possibility of increased fixation of phosphorus with time. From the incubation experiment of the present study (Table 2) a similar result could be arrived at, since the extractable phosphorus (Bray and Kurtz No. 2) decreased gradually with passage of time, thereby showing conversion of added phosphate into unavailable forms.

TABLE 2. *Availability of Phosphorus.*

(1) EFFECT OF PERIODS:

Period (Days)	Mean ppm, P
I (3)	4·9614
II (40)	2·5304
III (60)	2·3112
S. E.	0·2257
C. D. = (P = 0·05)	0·4452

Conclusion: I $\overline{\text{II} \quad \text{III}}$

(2) EFFECT OF SOILS:

Soil No.	(3)	(6)	(12)	(14)	(15)	(23)	(35)	(36)	(38)	(40)
Mean ppm, P	3·577	4·788	2 869	2·841	3·273	2·707	2 807	2·686	3·876	3·26

S. E.   0·4092
C. D.   0·8143

(P = 0·05)   Conclusion: 6 38 3 15 40 12 14 35 23 36

An attempt has been made to classify the soils of Nilgiris based on observed chemical properties during analysis of variance as follows:

Class A = Soils having fairly lower capacity to fix added phosphate fertilizers and

Class B = Soils having a higher capacity to fix added phosphates.

The details of some of the important properties or influencing factors are presented in the table 3 below :—

TABLE 3

Properties or influencing factors	Class A	Class B
Rainfall	Below 55 inches	More than 55 inches
Soil reaction	5·7 to 6·9	Less than 5·7
Sesquioxides	Less than 15·0 per cent	More than 15·0 per cent
Iron oxide	Less than 6·0 ,,	More than 6·0 ,,
Alumina	Less than 9·0 ,,	More than 9·0 ,,
Calcium oxide	More than 0·2 ,,	Less than 0·2 ,,

Summary and Conclusion: The effect of the chemical forms of phosphorus of Nilgiris and the rainfall and elevation on the fixation of phosphorus was observed in the study and the following conclusions could be made:

In spite of appreciably high phosphorus content, only very little is available. The phosphorus mineralised from the organic phosphates was very rapidly occluded and fixed as iron and aluminium phosphates. Phosphorus in aluminium phosphate was converted to occluded phosphates which might become available under favourable conditions. As one moved from a lower rainfall area to a higher rainfell area, the phosphorus was present more as insoluble aluminium phosphates than as soluble calcium phosphates and *vice versa*. Both aluminium and iron phosphates increased with elevation.

The phosphorus fixing capacity of the acid soils of Nilgiris was very high. Phosphorus fixing capacity however, did not correlate with pH, calcium, magnesium, rainfall or elevation, but gave a negative correlation with calcium phosphate and occluded iron phosphate.

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Studies on the Control of the Castor Semilooper, *Achaea janata* Linn

by

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Introduction: Among the insect pests of castor plant, *Ricinus communis* L., the castor semilooper, *Achaea janata* L., is of major importance causing considerable damage to the crop. The first instar larva nibbles the epidermis of the leaves while the later instars completely defoliate the plants leaving only the veins. The full-grown caterpillar measures 55 mm. to 60 mm. in length and occurs in a wide variety of colour patterns. Field experiments on the control of this pest were conducted at the Agricultural College and Research Institute, Coimbatore during 1964 and 1965 with news insecticides and their results are presented.

Review of Literature: Ayyar (1935) recommended prompt hand picking of caterpillars in mild cases and the application of stomach poisons like calcium arsenate or lead arsenate either in dust or spray from when they appeared in large numbers. Vevai and Talgeri (1948) have stated that three to four sprayings of 0·15 per cent DDT water suspension or dusting of 5 per cent DDT (Guesarol 405) at 20 days interval would control the

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