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EFFECT OF SUBMERGENCE ON INORGANIC PHOSPHORUS FRACTIONS AND AVAILABLE PHOSPHORUS IN TWO ACID RICE SOILS OF KERALA

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Phosphate ion in the soil forms a wide array of compounds with varying solubility. The behaviour of phosphorus in waterlogged soils is remarkably different from that in upland soils. This difference in behaviour is of greatest practicai significance in the phosphorus nutrition of rice, growing in submerged soils. The practice of flooding for rice culture is recognized to increase the availability of phosphorus (Ponnamperuma, 1955, Chang and Chu, 1961; Basak and Bhattacharya 1962 and Singh and Bahaman, 1976). Kuttanad and lateritic alluvium are the two main rice growing tracts of Kerala, The knowledge of transformation of inorganic phosphorus during submergence is essential for a better phosphatic fertilizer management.

Materials and Methods

A laboratory incubation study was carried out with the two rice soils of Kerala namely laterite collected from Kodakara, Trichur district and kari (Kuttanad alluvium) collected from Karumadi, Alleppey district in a completely randomised design with two replications. The soils were collected to a depth of 0-15 cm, dried in shade, seived and transferred (500 g) into plastic containers of 1 kg capacity. Soils were continuously waterlogged, maintaining water at the level of 2 cm above the soil and incubated at room temperature (28-31°C) for a period of 180 days. Soil samples were drawn regularly at 15 days interval throughout the period of incubation for the determination of available P and fractions of inorganic P. Available P of the wet sample was extracted using Bray and Kurtz No. 1 extractant and P was determined by chlorostannous acid reduced molybdophosphoric blue colour method in hydrochloric acid system (Jackson, 1958). Fractionation of P was carried out using the modified procedure of Chang and Jackson (1957) after Peterson and Corey (1966) as described by Hesse (1971). The pH, electrical conductivity, total P, P fixing capacity, free iron oxides and available Fe were determined using the standard procedures described by Jackson (1958). The mechanical analysis of the soil was carried out by th3 International Pipette method (Piper, 1942).

Results and Discussion

Laterite soil was a sandy clay loam with a pH of 5.4, It contained 2.65 per cent of free iron oxides and 221.9 ppm of available Fe (DTPA extractable Fe).

The P fixing capacity of the soil was relatively high (332.04 ppm) and the total P content of the soil was 887.2 ppm. The organic carbon content of the soil was 1.08 percent. The kari soil selected for the study was more acidic (pH 3.1) than the iaterite soil and it was a sandy loam. The P

Table 1

Inorganic P fractions and available P at different

	Periods of					
	0	1	2	3	4	5
						In laterite
Saloid-P	0.000	0.245	0.371	0.589	0.593	0.744
Al-P	191.9	207.9	223.6	254.9	242.9	233.5
Fe-P	270.9	303 8	343.6	369,5	368.3	378.7
Reductant soluble P	73.06	69.14	63.55	59.30	60.20	59.05
Occluded P	68.15	55.45	47.10	45.30	43.05	40.50
Ca-P	44.95	41.65	44.85	45.60	45.80	43.60
Available P	4,79	5.38	8.74	9.26	14.43	14.18
						In kari
Saloid-P	0.000	0.236	0.426	0.939	0.949	1.103
Al-P	179.9	196.3	213.0	242.3	232,5	228,6
Fe-P	258.1	283.3	308.5	352.8	344.9	345.5
Reductant soluble P	67.59	64.28	63.05	62.25	57.80	60.60
Occluded P	48.05	41.65	43.65	41.85	40.55	38,25
Ca-P	50.45	49.45	46.85	46.40	55.25	55,55
Available P	3,84	5.27	8.04	10.19	11.43	11.41

periods of incubation in laterite and kari soils, ppm.

incubation, fortnights							
6	7	8	9	10	11	12	Mean
Soil							
1.121	1.130	1.005	0.948	1.041	0.932	0.825	0.734
238.1	237.1	244.7	242.5	255.7	264.7	263.2	238.5
368,4	367.0	374.2	380.5	381.4	390.1	388.4	360.4
57.97	58.55	57.05	53.85	52.10	51.85	52,05	59.05
41.50	34.05	33.00	34.40	32.70	32.55	35.45	41.78
48.55	48.45	46.45	45.25	42.75	43.05	41,00	44.77
14.21	11.51	9,84	9.58	9.49	9.69	9.51	9.95
Soil							
1.205	1.289	1.073	0.996	0.790	0.761	0.796	0.804
233.1	242.8	251.6	256.9	262.8	267.1	269.3	236.6
344.2	337.2	349.3	354.9	351.7	366.5	371.9	336.1
59.25	59.80	51.50	53.05	51.25	49.40	47.85	57.51
34.30	34.25	32.35	32.80	33.45	32.10	27.15	36.91
55.95	54.90	51.00	49.45	46.20	46.00	40.55	49.84
11.39	11,31	11.14	10.89	10.79	10.67	10.45	9.69

fixing capacity was relatively high (329.6 ppm) and the content of free iron oxide and available Fe were 2.14 per cent and 211.1 ppm respectively. The organic carbon content was 1.82 per cent.

Results on the effect of waterlogging on the various inorganic fractions and available P content in laterite and kari soils are presented in Table 1.

Results revealed that initially the total inorganic P fractions of the soil accounted to 74.65 per cent of the total P, which on incubation increased to 91.75 percent. The increase in the inorganic P fractions on incubation was obviously due to the mineralization of organic P into inorganic form brought about by the microbial action. The rate of increase in the inorganic fraction on incubation was 5.06 per cent more in kari soil than in laterite soil probably due to the high acidity and relatively high amount of organic matter.

Originally, before incubation, the saloid P content of both the soils was nil. But on incubation, saloid P was increased to a maximum of 1.130 and 1.289 ppm in laterite and kari soils respectively during the seventh fortnight. After attaining the maximum concentration, it tended to decrease upto the twelfth fortnight. However, the saloid P content even at the twelfth period was still higher than its concentration during the initial periods. The increase in the saloid P may be attributed to the mineralization of organic P and conversion of insoluble phosphatic compounds into more soluble forms especially that of ferric phosphate due to flooding. A slight decrease observed after the seventh fortnight may be due to the formation of more insoluble secondary minerals which can not be extracted by a neutral salt solution. The mean saloid P was relatively higher in kari soil (0.804 ppm) compared to laterite soi! (0.734 ppm) though the total P and available P was less in kari soil. This is because of the relatively low P fixing capacity of kari soil. The proportion of saloid P to the total inorganic phosphate pool was negligible.

Among the various inorganic P fractions, Fe-P was the predominant form representing 42.23 per cent of the total inorganic P during the first period. With the advancement of period, the contribution of Fe-P to inorganic P was increased to 49.42 per cent. The peak content of Fe-P was observed during eleventh and twelfth fortnights of sampling in both the soils. The relatively higher content of Fe-P in laterite soil was due to its higher free iron oxide and available Fe content. Balasubramanian and Raj (1969) and Singh and Ram (1977) also obtained higher amount of Al-P in the laterite soils. The rate of increase in the Fe-P on incubation was 44 per cent of the initial concentration in both the soils. The general increase in the content of Fe-P due to submergence was mainly brought about by the conversion of reductant soluble P and occluded P consequent of flooding apart from the mineralization of organic P.

The second most predominant inorganic fraction is the Al-P representing 26 and 30 per cent of the total inorganic P in taterite and kari soils respectively during the first period, which on incubation increased to 29 and 34 per cent in lalerite and kari soils during the final periods. The peak content of Al-P was observed during the eleventh and twelfth periods of incubation in both the soils. The slight decrease in the content of Al-P and Fe-P observed during certain periods was due to their conversion to other forms, The rate of increase in the content of Al-P on incubation was 11.75 per cent more in kari soil than in laterite soil (37.94%) due to the higher acidity in kari soil.

The contents of reductant soluble P and occluded P were less compared to Fe-P and Al-P. Laterite soil recorded relatively higher level of reductant soluble (59.05 ppm) and occluded P (41.78 ppm) compared to kari soil because of the highly weathered and oxic nature of laterite soil. Debnath and Hajra (1972) and Kothandaraman and Krishnamoorthy (1977) also reported the higher content of reductant soluble P in laterite soil. Due to incubation, on an average there was 29.12 per cent reduction in the reductant soluble P content in both the soils, while occluded P showed 47.93 per cent reduction in laterite soil and 43.49 per cent reduction in kari soil. The rate of decrease in both these fractions during the first fortnight of flooding was higher in laterite soil compared to kari soil. Since the chemical components of the laterite soil exist in a highly oxidized state as compared to that of the kari soil, the degree of reduction caused by incubation will be more intense in laterite soil, thus registering a relatively high rate of decrease in the content of these fractions. The general decrease observed in the reductant soluble P and occluded P with the lapse of time gave an indication of their conversion to other fractions.

The content of Ca-P was relatively higher in kari soil (49.84 ppm) compared to laterite soil (44.77 ppm) because of the relatively larger proportion of Ca in kari soil due to the marine influence and the presence of organic matter. This observation was in line with that of Nair (1978). The contribution of Ca-P to the pool of inorganic P was low. In general, in both the soils, Ca-P tended to decrease with the advancement of time. But a gradual increase was observed during the sixth and seventh periods of incubation in laterite soil and during fourth to sixth periods in kari soil. This gradual increase was due to the conversion of other fractions and due to th3 mineralization of organic P.

The low content of available P in both the soils was attributed to their high P fixing capacity. The level of available P in the soil increased on incubation and this increase was more pronounced in laterite soil In laterite soil, the increase in available P on incubation was 9.64 ppm while it was 7.59 ppm in kari soil. The increase in the content of available P on incubation may be due to the enhanced solubility of Fe-P and Al-P consequent to flooding. In addition to this phenomenon. mineralization of organic P would also have contributed to the pool of available P. The relatively higher content of available P in laterite soil was attributed to its high content of total P and enhanced rate of reduction reactions occurring due to its highly oxidized nature compared to kari soil. In both the soils, the peak values of available P was observed during the fourth fortnight of sampling. The decrease observed in the subsequent periods may be due to the formation of secondary minerals that cannot be extracted by the weak extractants.

In general, the rate of change in the concentration of various inorganic fractions and available P was high in the early stages of incubation due to the enhanced chemical and biological reactions consequent to flooding.

Summary

Flooding the soil resulted in an increase in the content of available P, Fe-P, Al-P and saloid P, while the concentration of reductant soluble P, occluded P and Ca-P showed a gradual decrease. The levels of Fe-P, Al-P, reductant soluble P, occluded P and available P were high in laterite soil compared to kari soil. The mean values of saloid P and Ca-P were relatively high in kari soil.

സംഗ്രഹം

ചെങ്കൽ മണ്ണിലും കരിമണ്ണിലും ജലം കെട്ടിനിൽക്കുമ്പോൾ മണ്ണിലെ അജൈവ ഭാവഹത്തിന്റെ വിവിധ രൂപങ്ങൾക്കുണ്ടാകുന്ന രാസപരിണാമങ്ങൾ ഈ പഠനത്തിൽ വിവരിച്ചിരിക്കുന്നു.

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