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Availability fluctuations of Soil Phosphorus Fractions during Paddy Growth under flooded conditions

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ABSTRACT

A pot culture experiment was conducted on three soils of Tamil Nadu to study the fluctuations of soil phosphorus fractions during paddy growth under flooded conditions. The study showed that the available P (Olsen's method) and aluminium phosphate content were higher on the 15th day after transplantation than at the post-harvest stage in all the three soils. An increase in calcium phosphate content was recorded with increase of time in all the three soils.

INTRODUCTION

Elucidation of availability fluctuations under flooded conditions during paddy growth is important from the point of view of uptake of plant nutrients. In the present investigation due consideration is given to the aspect of availability fluctuations of different forms of P such as available P, aluminium, iron and calcium phosphates.

REVIEW OF LITERATURE

Ghani and Aleem (1943) noted that non-availability of P under acid conditions was due to the formation of iron and aluminium phosphates and high accumulation of organic P. Yuan *et al.* (1960) observed that in acid soils 80 per cent of the added P was retained by the soil as aluminium and iron phosphates and 10 per cent in water soluble form. The rate of change of aluminium phosphate to iron phosphate increased with the rate of applied P. Laverty and McLean (1961) found that as the pH increased more phosphate was found to be in the calcium phosphate form. Soils with high phosphate fixing capacity showed a higher content of iron and aluminium phosphates.

Chiang (1963) studied the forms of inorganic phosphate in paddy soils of Japan. Iron phosphate was found to be abundant in most acid soils, especially laterite soils and calcium phosphate in most neutral and basic soils. Robertson *et al.* (1954) showed that liming soils relatively low in residual P increased the availability of applied P up to pH 6-6.5 whereas in soils having high residual P, the availability of P was reduced. Mandal (1964) observed that in the presence of lime, ferric and aluminium phosphates decreased, the former considerably and the latter very slightly. This might be due to the hydrolysis of ferric and aluminium phosphates as a result of liming. Calcium phosphate was increased appreciably in the presence of lime as the latter converted ferric phosphate to calcium phosphate. Rajaram (1964) indicated that liming increased water soluble P, available P and

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calcium phosphate and decreased iron and aluminium phosphate.

MATERIALS AND METHODS

A pot culture experiment was laid out using three representative paddy soils of Tamil Nadu viz., clayey soil from Coimbatore, loam from Sirugamani and sandy loam from Tirurkuppam. Two levels of green manure (*Glricidia maculata* L.) i.e., control and 5000 lb / acre, three levels of N, (ammonium sulphate)-control, 30 and 60 lb N/acre, three levels of P(single super phosphate) - control, 30 and 60 lb P_2O_5 / acre were applied with a constant dose of potassium sulphate - 30 lb K_2O / acre in each treatment. In all 54 pots of 20 lb capacity were used for the experiment (3 soils x 3 levels of N x 3 levels of P x 2 levels of green manure). The experiment was laid out in a factorial randomised block design. Twenty seven day old paddy seedlings of Co. 29 variety were transplanted at the rate of 10 seedlings per pot in five holes. Two inches of water above the soil surface in the pot were maintained throughout the major portion of the experiment. The addition of water was stopped one week prior to harvest. Soil samples were collected in two stages i. e., 15 and 80 (post harvest) days after transplanting. Dried soil samples were used for estimation of different P fractions.

Available P was estimated by Olsen's method (1954) and phosphates of aluminium, iron and calcium were estimated by the modified procedure of Chang and Jackson (1959).

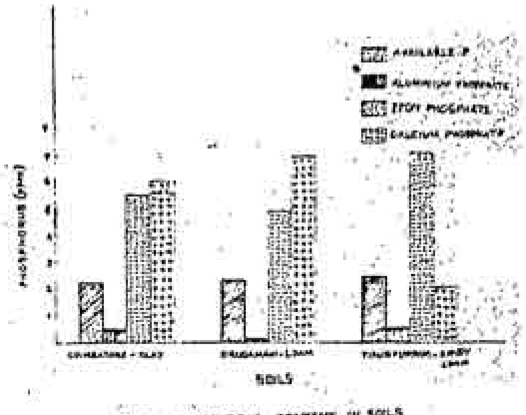

FIG. 1 PHOSPHORUS CONTENT IN SOILS

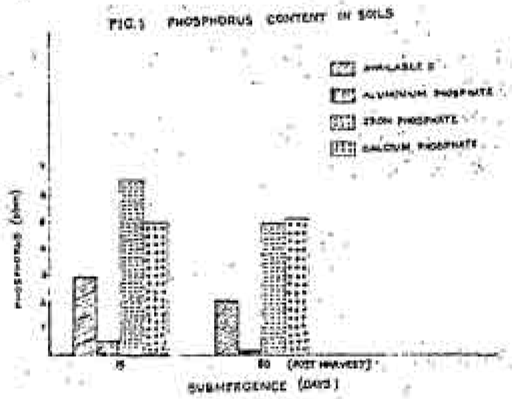

FIG. 2 - CHANGES IN PHOSPHORUS

RESULTS AND DISCUSSION

The results showing the soil P categories during different phases of plant growth are given in Tables 1 and 2 and Figures 1 and 2.

Available phosphorus

In the present studies, it was observed that the available P was high on 15th day after transplanting. The reason for the higher amount of available P might be attributed to various factors viz., (1) the reduction of ferric phosphate to ferrous phosphate, (2) hydrolysis of ferric and aluminium phosphates due to increase in alkalinity, (3) displacement of P from ferric and aluminium phosphates from complexing agents produced by the anaerobic decomposition of organic matter and (4) anion exchange between phosphate adsorbed on the clay and organic anions and hydration of ferric and aluminium phosphates under submerged conditions. (Aoki, 1941; Ponnamperuma, 1955; Islam and Elahi, 1955; Chin, 1957; Shapiro, 1958; and Mack, 1958). It was found that there was reduction in the available P in all the three soils at the post harvest stage, while it was high on 15th day after transplanting. The present finding is in agreement with the view of Basak and Battacharya (1962), who stated that the available P increased from planting to tillering, remained fairly constant, increased from tillering to pre-flowering and decreased by post-harvest time to its original value.

Loam and sandy loam contained more of available P than clay. The former soils contained low initial available P, while the latter contained more of this form. An inverse relationship between available P and initial total P in soil was observed. This was in agreement with the observations of Robertson *et al.* (1954).

Aluminium phosphate: All the three soils were found to contain high amount of aluminium phosphate on 15th day when compared to the post harvest time. The present finding is in accordance with the observations made by Chang and Chu (1961) and Chiang (1964). The high content of aluminium phosphate on 15th day when compared to the initial soil might be due to the response of added inorganic phosphate to the soil (Mackenzie and Amer, 1964). It was observed that the aluminium phosphate was more in clayey soil due to high sesquioxide ratio than the other two soils. This might be attributed to the fact that the phosphate fixed increased with amount of sesquioxides in all the soils (Raychaudhuri and Mukherjee, 1941; Coleman, 1944 and Geissler, 1962).

Iron phosphate: The general trend was similar to that of aluminium phosphate. Sandy loam was much richer in iron phosphate than the other two which were on a par. It was observed that iron phosphate was much higher on 15th day because of more reduction brought about by submergence than at the post harvest time (Chang and Chu, 1961 and Chiang, 1963). The decrease in iron phosphate might be attributed to the conversion of iron phosphate to occluded form. Bartholomew (1931) and Janardhanan Nair (1961) have also expressed the same view.

It was observed that iron phosphate content was more in sandy loam non-calcareous soil, followed by loam and clayey soil. The low amount of iron phosphate in clayey soil, a calcareous one, might be attributed to the presence of high calcium (Mandal, 1964).

Calcium phosphate: The calcium phosphate was higher in loam and clayey soil than in sandy loam. This might be due to initial calcium content of initial soils themselves. Chiang (1963) and Mackenize and Amer (1964) also stated that the abundance of calcium phosphate was due to the presence of calcium in large proportions in soils with alkaline reaction.

The present investigation showed that calcium phosphate was higher only in loam than the other two soils at the post harvest stage when compared to the first sample. The increase in calcium phosphate might be due to mineralisation of organic P (Janardhanan Nair 1961). It was observed that the amount of calcium phosphate was high in loam followed by clay and sandy loam. The presence of high calcium phosphate in the former two soils might be due to the conversion of iron phosphate to calcium phosphate because of the presence of high residual calcium in these soils, whereas calcium phosphate was found to be the least in sandy loam due to conversion of iron phosphate because of the low content of residual calcium in the soil.

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* Original not seen.

TABLE I. Aluminium, Iron and Calcium phosphates - ppm

Treatments	Coimbatore - Clayey Soil						Sirugamani - Loam Soil						Tirurkuppam - Sandy Loam Soil					
	Aluminium phosphate		Iron phosphate		Calcium phosphate		Aluminium phosphate		Iron phosphate		Calcium phosphate		Aluminium phosphate		Iron phosphate		Calcium phosphate	
	Days after transplanting																	
	15	80	15	80	15	80	15	80	15	80	15	80	15	80	15	80	15	80
Control [T_1]	0.82	0.24	4.24	4.25	4.77	5.84	0.15	0.26	4.63	2.57	8.23	8.49	0.54	1.15	5.11	3.84	2.56	1.79
P_1 alone [T_2]	0.90	0.27	7.69	4.43	4.51	5.31	0.23	0.67	4.37	5.11	8.49	10.80	0.72	0.31	7.66	4.10	2.31	1.54
P_2 alone [T_3]	0.93	0.27	5.83	7.16	4.25	5.34	0.28	0.39	5.15	5.15	9.00	8.49	0.79	0.38	5.11	4.10	2.31	1.79
N_1 alone [T_4]	0.61	0.24	7.69	4.43	4.25	5.04	0.18	0.41	4.37	4.21	9.77	8.74	0.49	0.26	5.11	3.84	2.05	1.54
$N_1 + P_1$ [T_5]	0.98	0.35	3.98	3.72	4.25	5.84	0.23	0.54	2.05	4.69	9.00	8.25	0.72	0.26	6.13	4.10	2.05	1.79
$N_1 + P_2$ [T_6]	0.58	0.42	3.71	5.31	3.98	5.31	0.36	0.26	5.92	3.86	8.49	8.60	0.69	0.26	13.78	4.10	2.31	1.05
N_2 alone [T_7]	0.61	0.32	15.93	2.66	8.22	5.31	0.33	0.36	5.40	6.95	3.86	8.49	0.49	0.18	5.11	3.84	2.56	2.56
$N_2 + P_1$ [T_8]	0.74	0.31	4.27	2.66	7.96	5.31	0.50	0.31	5.15	5.40	2.52	9.26	0.56	0.15	5.11	4.35	2.05	2.05
$N_2 + P_2$ [T_9]	1.01	0.35	4.77	3.19	7.96	4.25	0.57	0.25	3.86	4.21	2.52	8.60	0.69	0.26	15.82	5.89	2.05	2.08
GM alone [T_{10}]	1.06	0.32	5.83	5.31	8.22	5.31	0.23	0.26	3.86	3.09	4.37	9.52	0.59	0.18	5.11	5.12	2.05	1.09
GM + P_1 [T_{11}]	1.06	0.31	5.57	2.66	8.76	5.04	0.31	0.23	2.05	3.69	3.86	8.49	0.74	0.18	15.82	3.34	2.05	3.08
GM + P_2 [T_{12}]	0.82	0.31	15.93	5.31	9.19	4.78	0.19	0.28	3.09	5.66	4.37	8.25	0.72	0.33	5.11	6.40	2.56	4.10
GM + N_1 [T_{13}]	0.37	0.37	5.83	3.45	12.47	5.04	0.59	0.41	6.17	7.20	4.12	7.72	0.54	0.28	4.59	4.87	2.05	1.54
GM+N_1+P_1 [T_{14}]	0.45	0.35	4.24	9.29	8.49	6.10	0.56	0.23	10.55	5.66	4.37	6.95	0.59	0.54	7.15	6.40	1.79	1.54
GM+N_1+P_2 [T_{15}]	0.50	0.24	7.43	5.31	8.22	5.04	0.62	0.15	2.05	8.23	3.60	7.72	0.84	0.54	4.08	6.14	1.54	1.79
GM+N_2 [T_{16}]	0.40	0.24	5.30	3.13	8.49	5.31	0.50	0.12	5.66	5.40	3.60	6.17	0.56	0.44	6.63	7.68	1.54	2.05
GM + N_2 + P_1 [T_{17}]	0.53	0.40	5.30	3.48	7.96	5.31	0.15	0.33	3.35	7.46	4.37	7.12	0.64	0.49	35.72	8.45	1.79	1.54
GM+N_2+P_2 [T_{18}]	0.48	0.35	5.83	4.45	8.49	4.25	0.77	0.95	3.35	4.89	4.63	10.80	0.72	0.54	5.11	7.17	2.28	1.79

P_1 — 30 lb P_2O_5/acre N_1 — 30 lb N/acre GM - 5000 lb Green manure/acre

P_2 — 60 lb P_2O_5/acre N_2 - 60 lb N/acre

TABLE 2. Available Phosphorus - ppm

Treatments	Coimbatore Clayey soil		Sirugamani Loam soil		Tirurkuppam Sandy loam soil	
	15th Day	80th Day	15th Day	80th Day	15th Day	80th Day
Control [T_1]	2.49	2.44	2.42	2.68	3.18	1.64
P_1 alone [T_2]	2.12	2.23	2.46	1.84	3.23	1.59
P_2 alone [T_3]	2.55	2.97	5.76	1.76	3.74	2.41
N_1 alone [T_4]	2.44	2.49	2.62	1.72	2.66	1.43
$N_1 + P_1$ [T_5]	2.44	1.90	5.51	2.98	3.48	1.74
$N_1 + P_2$ [T_6]	1.86	2.23	2.57	2.52	4.35	2.56
N_2 alone [T_7]	2.49	2.02	2.47	1.08	1.79	4.12
$N_2 + P_1$ [T_8]	2.44	2.06	3.04	2.53	2.36	1.89
$N_2 + P_2$ [T_9]	2.60	2.71	3.09	1.72	4.04	2.16
GM alone [T_{10}]	2.12	2.44	5.00	3.97	3.48	1.52
GM + P_1 [T_{11}]	3.11	2.23	3.50	1.70	2.46	1.49
GM + P_2 [T_{12}]	5.62	2.44	2.37	1.65	2.97	2.04
GM + N_1 [T_{13}]	2.39	2.28	1.72	1.95	2.66	1.66
GM + $N_1 + P_1$ [T_{14}]	2.23	2.76	4.63	1.65	4.97	1.49
GM + N_1 + P [T_{15}]	2.44	1.43	2.68	1.65	2.56	1.64
GM + N_2 [T_{16}]	1.91	2.44	1.89	1.34	2.36	1.49
GM + $N_2 + P_1$ [T_{17}]	2.71	1.90	3.19	1.49	1.91	1.33
GM + $N_2 + P_2$ [T_{18}]	2.65	3.01	4.37	1.35	3.28	1.64

P_1 - 30 lb P_2O_5 / acre N_1 - 30 lb N / acre

P_2 - 60 lb P_2O_5 / acre N_2 - 60 lb N / acre

GM - 5000 lb Green manure / acre