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Phosphorus Status in the Soils of Imphal West District, Manipur (India)

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A B S T R A C T

The phosphorus fractions of the twenty surface soils (0-15 cm) of Imphal West district, Manipur and their relationship with some physico-chemical properties of the soils were studied. A significant relationship was obtained between organic-P and total-P in the soils. The average Sal-P, Fe-P, Al-P, Red-P, Occl-P and Ca-P content were 8.70, 73.38, 50.83, 82.54, 29.00 and 22.17 ppm, respectively. The inorganic P fractions in the soils were in the order: Red-P > Fe-P > Al-P > Occl-P > Ca-P > Sal-P. Sal-P had a significant correlation with E.C. (r = 0.661**) and C.E.C. (r = 0.455*). Fe-P had a negative correlation with soil pH (r = -0.565*) and positively correlated with O.C. (r = 0.502*). Al-P had a negatively correlated with soil pH (r = 0.510*) and positively correlated with O.C. (r = 0.698**), available N (r = 0.508**) and C.E.C. (r =0.699**). Red-P had a significant correlation with C.E.C. (r = 0.555*) and negatively correlated with silt (r = -0.455*). Occl-P had a significant negative correlation with silt content of the soil (r = - 0.530*) and positively correlated with C.E.C. (r = 0.577 **). Ca-P had a positive correlation with E.C. (r = 0.539*), clay (r = 0.583**) and C.E.C. (r = 0.605 **) and negative correlation with sand (r = -0.500 *). Among the different fractions Sal-P, Red-P and Occl-P was positively and significantly correlated with Ca-P (r = 0.534*), (r = 0.583**) and (r = 0.534*), respectively and negatively correlated with Org-P (r = -0.563*) and sal-P. Al-P was positively and significantly correlated with Red-P (0.506*).

Introduction

Phosphorus is the second most critical plant nutrient owing to its important role in root proliferation and thereby atmosphere nitrogen fixation. It is a major component of compound whose functions relate to growth, root development, flowering, and ripening. It also enhance the efficiency of utilization of atmospheric nitrogen and symbiotic process, thereby reducing dependence on nitrogenous fertilizer and this also helps to maintain the sustainability of farming systems. In general, overall improvement in growth and yield attributing character because of phosphorous increased the photosynthesis activity of plant and helps to develop a more extensive root system and thus enables the plant to extract more water and nutrients from the soil depth, resulting in better development of plant growth and yield and attributes (Kokani *et al.*, 2015). Increase in organic phosphorus decreases microbial phosphorus mineralization but C: P ratio of < 200 enhances organic phosphorus mineralization.

In soil, phosphorus (P) exists in both organic as well as inorganic forms. Indian soils usually contain 44 to 3580 mg kg^{-1} of total P (Kumar, 1999) and traces to 2160 mg kg^{-1} of organic P. The inorganic P occurs in combinations with various forms of Al, Fe, Mg, Ca and other elements most of which are not soluble and therefore, not available for both plant and microbial uptake. The insoluble fractions are neither available readily to growing plants nor to micro-organisms and constitute 94 to 99% of the total P. This fraction is mostly attached to Fe and Al in acid soils and to Ca in slightly acidic to alkaline soils.

Organic P compounds are mostly esters of orthophosphoric acid and have been identified primarily as inositol phosphates, phospholipids and nucleic acids (Havlin *et al.*, 2004)

Phosphorus deficiency in plants has been reported from various parts of India. Information on the chemical forms of P is fundamental to understand P dynamics and its interaction in acidic soils which are necessary for management of P (Abolfazli *et al.*, 2012)

Thus the basic idea of this study is to investigate the more actively cyclic forms of organic P which contribute to the available pool. Among the various inorganic forms, the reductant soluble P is mostly unavailable to plants and constituting about 19- 40 % of the total P in tea soils (Banerjee, 1993), the iron and aluminium phosphate fractions make up 7-17% of the total P and is considered to be slowly available pool of P (Dey and Bhattacharyya 1980). At the same time, organic P is an important source of plant nutrient in both natural and managed environment, since the mineralization of organic matter and then release of inorganic P is important for plant uptake. The importance of phosphorus had been reported by many workers but work on different forms of P and their relationship with soil characteristics in acid soils of Manipur are lacking. Therefore, the present investigation was undertaken to evaluate the different forms of inorganic and organic forms of P for effective management of Phosphorous.

Materials and Methods

Twenty surface soil samples (0-15 cm) for investigation were collected from cultivated farmer`s field of Imphal West district, Manipur. The collected soil samples were passed through 2 mm sieve for chemical analysis. The pH was measured in 1: 2.5, soil: water suspension and total nitrogen (Jackson 1973), C.E.C. (Dewis and Freitas, 1984), soil texture, available K, Ca and Mg (Chopra and Kanwar 1976) and available N (Subbiah and Asija, 1956). The processed soil samples (< 2 mm) were analyzed for soil texture, pH, CEC, total nitrogen, available nitrogen, K, Ca and Mg using standard procedures as described by Jackson (1973) and Chopra and Kanwar (1976). Organic carbon was determined by wet oxidation method of Walkley and Black (1934). Total phosphorus content of soil sample was determined by perchloric acid (60%) digestion with concentrated H_2SO_4 pretreatment for preliminary oxidation following the method of Mehta *et al.*, (1954) as described by Hesse (1971). The organic phosphorus fractions of the soil sample was determined by pre-extraction of soil with concentrated hydrochloric acid followed by two extractions with 0.5 M sodium hydroxide, one cold and the other at 90°C as outline by Mehta *et al.*, (1954). Inorganic phosphorus fractionation of soils was carried out following the modified procedure of Chang and Jackson as outlined by Peterson and Corey (1966).

Results and Discussion

Characteristics of the soils

The physical and chemical properties of the soils are presented in Table 1. Particle size analysis showed that the soils varied from clay to clay loam with a clay value from 34.83 to 83.12 per cent, silt value of 8.18 to 42.50 percent and sand value of 6.20 to 50.90 per cent. The result shows that pH of the soils ranged from 4.58 to 5.67 (mean 4.98), organic carbon content varied from 11.30 to 35.30 g kg^{-1} with mean value 22.20 g kg^{-1}. The mean total nitrogen, available nitrogen, available K, CEC, EC, Ca and Mg of the studied soils was 0.13 per cent, 315.51 kg ha^{-1}, 152.58 kg ha^{-1}, 16.15 [Cmol (P^+) kg^{-1}], 0.22 dSm^{-1}, 2.81[Cmol (P^+) kg^{-1}], 1.86 [Cmol (P^+) kg^{-1}], respectively.

Total phosphorus

The total phosphorus content of the studied soil ranged (Table 2) from 435.00 to 702.40 ppm, with an average of 563.99 ppm. Total phosphorus distribution in the studied soils had consistent trends. Total phosphorus was highly correlated positively with organic P (r = 0.775**) (Table 4). The association between organic P and total P, which is evident because of higher correlation value of organic P and total P, had been reported by many workers such as Loganathan and Sutton (1987), Dongale (1993) and Kaistha *et al.*, (1999).

Organic phosphorus

Organic-P content in the soil ranged from 205.00 ppm to 495.00 ppm with a mean value of 297.38 ppm, accounting 52.73 % of the total P. The high organic-P content in the soils may be due to high organic carbon content. There was no significant correlation with the soil properties. A significant relationship was obtained between organic P and total P in the soils (r = 0.775**) and negatively correlated with saloid P (r = -0.536*). The result is in close conformity with those reported by Loganath and Sutton (1987), Dongale (1993) and Kaistha *et al.*, (1999).

Inorganic phosphorus

The total inorganic phosphorus is divided into active and inactive forms. The former consists of Al-P, Fe-P and Ca-P and the latter consists of occluded, reductant-soluble and residual P (Chang and Jackson 1957). The active forms are the fractions most available to plants, with the degree of availability increasing in the order Ca-P, Fe-P and Al-P in the upland condition (Thomas and Peaslee, 1973).

Saloid phosphorus (Sal-P)

The saloid P content in the soils varied from 4.50 to 15.00 ppm. The average value of saloid P was 8.70 ppm of the studied soils. Saloid P was highly and significantly correlated with E.C. (r = 0.661**) and C.E.C. (r=0.455*). Among the different fractions Sal-P positively and significantly correlated with Ca-P (r = 0.534*) and Al –P (r = 0.530*) and negatively correlated with Org-P (r = -0.536*). The low content of saloid P in the soils might be due to low pH of the soils (Malakar *et al.*, 2015).

Iron phosphorus (Fe-P)

Iron phosphorus (Fe-P) in the soils ranged from 40.50 ppm to 112.00 ppm with a mean value of 73.38 ppm being greater than the Al-P and constituted 13.01 % of the total P. Fe-P content was negatively and significantly correlated with pH (r = - 0.565*) and positively significantly correlated with organic carbon (r = 0.502*). The positive relationship of organic carbon with Fe-P might be due to the mineralization of organic P and conversion into iron fraction due to high biological activities in the soils (Sacheti and Saxena, 1973).

Table.1 Some physico-chemical properties of soils

Soil properties	Range	Mean
Clay (%)	34.83 - 83.12	56.95
Silt (%)	8.18 – 42.50	25.37
Sand (%)	6.20 – 50.92	17.69
pH	4.58 – 5.67	4.98
EC (dSm^{-1})	0.14 – 0.31	0.22
O.C.(g kg^{-1})	11.30 - 35.30	22.20
Total N (%)	0.06 – 0.22	0.13
Available N (kg ha^{-1})	225.80 – 463.42	315.51
Available K (kg ha^{-1})	98.00 – 207.50	152.58
CEC [Cmol(P^+)kg^{-1}]	9.20 – 30.20	16.15
EC (dSm^{-1})	0.14 – 0.31	0.22
Ca [Cmol(P^+)kg^{-1}]	1.25 – 4.40	2.81
Mg [Cmol(P^+)kg^{-1}]	0.15 – 4.30	1.86

Table.2 Amount of phosphorous of the soils extracted by various extractants

Soil No.	ppm							
	Sal-P	Iron-P	Al-P	Red-P	Occl-P	Ca-P	Org.-P	Total-P
1	7.50	87.50	71.25	71.25	25.00	15.00	350.00	627.50
2	5.00	70.50	32.60	56.00	15.00	16.25	495.00	690.35
3	6.50	112.00	41.90	57.00	37.50	10.67	425.00	690.57
4	7.00	85.00	55.00	90.00	27.50	30.00	212.50	507.00
5	6.75	82.50	40.00	97.00	22.50	17.00	325.00	590.75
6	9.70	76.00	45.00	81.00	34.50	22.70	262.50	531.40
7	10.00	51.90	42.50	91.00	42.50	30.00	240.00	507.90
8	12.33	77.50	45.50	75.50	32.50	24.50	245.00	512.83
9	7.50	62.50	33.00	67.00	10.50	23.75	317.50	521.75
10	5.50	80.00	43.60	50.00	15.00	16.25	241.00	451.35
11	10.00	108.00	81.50	130.40	35.00	25.00	312.50	702.40
12	7.00	58.00	37.00	87.50	23.00	15.84	288.00	516.34
13	8.60	77.50	51.80	79.00	45.00	25.50	233.50	520.90
14	12.25	82.50	47.50	51.25	17.50	19.00	205.00	435.00
15	4.50	40.50	25.00	69.00	32.00	21.00	350.00	542.00
16	8.25	75.00	61.00	110.00	45.00	27.50	327.50	654.25
17	15.00	67.50	60.00	107.00	27.50	30.00	240.00	547.00
18	9.80	45.20	62.50	69.30	17.50	14.70	257.50	476.50
19	13.50	80.00	85.00	90.00	50.00	33.20	295.00	646.70
20	7.25	48.00	55.00	121.50	25.00	25.50	325.00	607.25
Mean	8.70	73.38	50.83	82.54	29.00	22.17	297.38	563.99

Table.3 Simple correlation co-efficient between the different forms of phosphorus and soil properties

		Sal-P	Fe-P	Al-P	Red-P	Occl-P	Ca-P	Org-P	Tot-P
1	pH	-0.056	-0.565*	-0.510*	-0.101	-0.243	0.058	0.257	-0.060
2	E.C	0.661**	0.233	0.318	0.255	0.273	0.539*	-0.200	0.112
3	O.C	0.428	0.502*	0.698**	0.033	0.206	0.131	-0.173	0.162
4	Av. N	0.326	0.167	0.508*	0.012	-0.038	0.375	-0.385	-0.158
5	Tot. N	0.180	-0.048	-0.260	0.130	0.101	0.314	-0.119	-0.054
6	Av. K	0.186	0.042	0.413	0.191	0.420	0.340	-0.421	-0.052
7	Sand	-0.186	0.041	-0.002	0.030	-0.020	-0.500*	0.322	0.274
8	Silt	0.044	-0.129	-0.411	-0.455*	-0.530*	-0.320	-0.093	0.153
9	Clay	0.117	0.047	0.252	0.255	0.339	0.583**	-0.193	0.375
10	Ca	-0.236	0.104	-0.021	0.039	0.297	-0.338	0.268	0.253
11	Mg	0.010	0.366	-0.014	-0.075	-0.259	-0.251	0.162	-0.413
12	C.E.C	0.455*	0.106	0.699**	0.555*	0.577**	0.605**	-0.098	0.056

Table.4 Simple correlation co-efficient among the different forms of phosphorus

Sl.No.	Forms	Sal-P	Fe-P	Al-P	Red-P	Occl-P	Ca-P	Org-P
1	Sal-P							
2	Fe-P	0.092						
3	Al-P	0.530*	0.368					
4	Red-P	0.275	-0.006	0.506*				
5	Occl-P	0.321	0.210	0.409	0.441			
6	Ca-P	0.534*	0.141	0.385	0.583**	0.536*		
7	Org-P	-0.536*	0.129	-0.206	0.122	-0.095	-0.444	
8	Tol-P	-0.151	0.436	0.343	0.379	0.349	-0.018	0.775**

Aluminum phosphorus (Al-P)

Al-P content in the soils was ranged from 25.00 ppm to 85.00 ppm. The mean value of Al-P was 50.83 ppm being greater than the Ca-P and constituted 9. 01% of the total P The low Al-P content in the soils to be indicative of strong weathering under well drained humid tropics (Sarkar *et al.,* 2014). Al-P content was negatively and significantly correlated with pH (r = - 0.510*) and positively significantly correlated with organic carbon (r = 0.698**), available nitrogen (r = 0.508*) and C.E.C (r = 0.699**). Among the different fractions Al-P positively and significantly correlated with Red-P (0.506*) and Sal-P (r = 0.530*) (Table 3).

Reductant soluble phosphorus (Red-P)

Red-P in the studied soils ranged from 50.00 ppm to 130.40 ppm with a mean value of 82.54 ppm constituted 14.6 % of the total P and it was the highest inorganic P fraction of the soil. Red-P was negatively and significantly correlated with silt fraction (r = -0.455*) and positively significantly correlated with CEC (r = 0.555*).

Red-P was positively and significantly correlated with Ca-P (r= 0.583**) and Al-P (r = 0.506*). Such correlation suggests that these p fractions are dynamic equilibrium in the soil and transformation among these fractions would be the key to understand the potential P release and availability to the plants.

Occluded phosphorus (Occl-P)

Occl-P content in the soil varied from 10.50 ppm to 50.00 ppm with a mean value of occl-P was 29.00 ppm. Occl-P was negatively and significantly correlated with silt fraction (r = -0.530*) and positively and significantly correlated with C.E.C. (r = 0.577**). Again Occl-P was found to be positively and significantly correlated with Ca-P (r= 0.536*).

Calcium phosphorus (Ca-P)

Amount of Ca-P ranged from 10.67 ppm to 33.20 ppm with a mean value of 22.17 ppm. The calcium P content in the soil was lower than the Fe-P and Al-P and constituted 3.93% of the total P. This might be due to the low reported by Sarkar *et al.*, (2015).Ca-P was significantly correlated with E.C. (r = 0.539*), clay fraction (r = 0.583**) and correlated C.E.C. (r = 0.605**) negatively and significantly correlated with sand fraction (r = -0.500*).

In conclusion, the relative abundance of inorganic forms also gives an indication of the degree of chemical weathering of the soils-the strongly weathered ones have a higher proportion of inactive inorganic forms and Fe-P than the others (Chang and Jackson, 1975).The average Sal-P, Fe-P, Al-P, Red-P, Occl-P and Ca-P content were 8.70, 73.38, 50.83, 82.54, 29.00 and 22.17 ppm, respectively. For the soil studied the amount of inorganic P fractions was in the order: Red-P > Fe-P > Al-P > Occl-P > Ca-P > Sal-P. A similar trend had been reported by several authors (Uzu *et al.*, 1975; Ibia and Udo, 1993; Loganathan *et al.*, 1982; Loganathan and Sutton, 1987 and Osodeke and Kamalu, 1962). The low percentages of Sal-P and Ca-P in the soils are due to the high rainfall leading to the leaching losses of bases resulting to low pH of these soils. Similar result was also reported by Loganathan and Sutton (1987). The Fe-P dominated the active P forms in the soils which may be due to intense chemical weathering of soils in these areas.

References

Banerjee, B. 1993. Tea production and processing. Oxford and IBH Pub. Co., New Delhi, pp. 188-225.

Chang, S.C. and Jackson, M.L. 1957. Fractionation of soil phosphorus. Soil Science. 84: 133-144.

Chopra, S.L. and Kanwar, J.S. 1976. Analytical Agricultural Chemistry. Kalyani Publisher Ludhiana, New Delhi.

Dewis, J. and Freitas, F. 1984. Physical and chemical methods of soil and water analysis. Oxford and IBH Pub. Co., New Delhi. pp**.** 51-106.

Dey, S.K. and Bhattacharyya, N.G. 1980**.** Studies on soil phosphate**.** Two Bud. 27: 21-23

Dongale, J. H. 1993. Depthwise distribution of different forms of phosphorus in lateritic soils of coastal region. Journal of the Indian Society of Soil Science. 41**:** 62-66.

Havlin, J.L., Beaton, J.D., Tisdale, S.L. and Nelson, W.L. 2004**.** Soil Fertility and fertilizers: An introduction to nutrient management, *Sixth Edn. Pearson Edn. Pvt. Ltd., New Delhi.* pp 162.

Hesse, P.R. 1971. A textbook of soil chemical analysis. John Murray (Publishers) Ltd. 50 Albemarle Street, London, W1X4BD.

Ibia, T.O. and Udo, E.J. 1993. Phosphorus forms and fixation of representative soils in Akwa Ibo, State of Nigeria. Geoderma. 95-106.

Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India Private Limited, New Delhi.

Kaistha, B.P., Sharma, P.C. and Dubey, Y.P. 1999. Effect of manure and phosphorus on the inorganic phosphorus fractions in mountain soil of Himalayas. Crop Research. 18(2): 206-210.

Khaswa, S.L., Dubey, R.K., Tiwari, R.C., Singh, S., Choudhary, B. S. and Singh, I.

2014 Nitrogen and phosphorous content and uptake, soil nutrient balance and soybean productivity under different levels and sources of phosphorous and plant growth regulators in sub-humid Rajasthan.. 9 (1): 1107-1112

Kokani, J.M., Shah, k.a., Tandel, B.M. and Bhimani, G.J. 2015. Effect of FYM, phosphorous and sulphur on yield of summer Black gram and post harvest nutrient status of soils. The Bioscan. 10(1): 379-383.

Loganathan, P., Dayaratne, M.N. and Shanmuganatham. 1982. Evaluation of the phosphorus states of some coconut growing soils of Sri Lanka. Jornal of agricultural Sciences. 99**:** 25-33.

Loganathan, P. and Sutton, P.M. 1987. Phosphorus fractions and availability in soils formed on different geological deposits in the Niger delta area of Nigeria. Soil Science. 143(1): 16-25.

Malakar, H, Gosh, D., Chatterjee, S. and Debnath, A. 2015. Inorgnaic and organic soil phosphorous fractions in humid tropical tea plantations of West Bengal, India. The Bioscan. 10(1): 313-318.

Mehta, N.C., Legg, J.O, Goring C.A.I. and Black, C.A., 1954. Soil Science Society of American Proceeding. 18: 443.

Osodeke, V.E. and Kamalu, O.J. 1962. Phosphorus status of Hevea growing soils of Nigeria. Indian Journal of Natural Rubber Research. 5: 107-112

Peterson, G.W. and Corey, R.B. 1966**.** A modified Chang and Jackson procedure for routine fractionation of inorganic soil phosphates. Soil Science. 163: 31-36

Sacheti, A. K. and Saxena, S. N. 1973. Relationship between some soil characteristics and various inorganic phosphate fractions of soils of Rajasthan. Journal of the Indian Society of Soil Science. 21: 143-149.

Sarkar,D., Haldar, A. and Mandal, D. 2014. Forms of phosphorous in relation to soil maturity along a toposequence under hot, dry sub-humid agro-ecological sub-region of West Bengal. Journal of the Indian Society of Soil Science. 62 (1): 29-37.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for estimation of available N in soils. Current Science.25: 259-260.

Sureshkumar, P. 1999. Final report of ICAR Adhoc Scheme on variability in Iron and Zinc availability in the Laterite and Lateritic Soils of Central Kerala with Reference to Rice Nutrition. Radiotracer Laboratory, College of Horticultural University, Thrissur

Thomas, G.W. and Peaslee, D.E. 1973. Testing soil for phosphorus in soil testing and plant analysis. Walsh and JD Beaton (eds.). Soil Science Society of America, Madison Wis. pp 115-132

Uzu, F.O., Juo, A.S.R. and Fayemi, A.P. 1975. Forms of phosphorus in some important agricultural soils of Nigeria. Soil Science. 120: 212-218

Wakley, A. and Black, I.A. 1934**.** An estimation of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science. 37: 29-38.

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