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VERTICAL DISTRIBUTION OF PHOSPHORUS FRACTIONS IN ALLUVIAL SOILS OF SOUTH-WESTERN PLAIN ZONE OF UTTAR PRADESH

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ABSTRACT

Phosphorus fractions in profile samples of alluvial soils in Agra region of Uttar Pradesh were studied in relation to soil properties. The results indicated the decrease of Olsen-P, Al-P, Fe-P, Red-P, organic-P and total-P with depth but distribution of Ca-P did not follow a definite pattern. The Ca-P was the dominant P fraction (37.7 % of the total P) followed by reductant soluble–P (18.5%), Al-P (9.1%) and Fe-P (5.7%) in soil. Olsen-P showed significant positive relationship with organic carbon, $CaCO_3$ and silt and negative with pH, EC, sand and clay. The Ca-P was found to be positively significantly correlated with all the soil properties except organic carbon and silt. pH and clay showed negative significant relationship with Al-P. The relationship of Fe-P with pH, EC, $CaCO_3$, sand and clay was found to be negatively significant while organic carbon and silt showed positive significant association. The Red-P and total-P showed positive significant correlation with organic carbon, sand and clay, whereas it was negatively significant with $CaCO_3$. Total P showed a close relationship with other forms of P indicating the existence of equilibrium between total P and its different forms in the soil.

Keywords: Distribution, phosphorus fractions, alluvial soils, Uttar Pradesh

INTRODUCTION

Phosphorus is one of the major limiting factors for plant growth in many soils. Phosphorus, like any other plant nutrient, is present in soil in two major components i.e. organic and inorganic. Organic P, which mainly confined to the surface layer, is mineralized into inorganic forms. But the plants mainly depend on inorganic P forms for their P requirements. Saloid-P, Al-P, Fe-P and Ca-P fractions are the main source of P supply to the plants. The relative proportion of different forms of inorganic phosphorus depends on various soil characteristics like pH, organic carbon, $CaCO_3$, CEC and texture (Jaggi, 1991, Singh *et al*. 2005). Knowledge of forms of phosphorus and their relationship with these soil characteristics is very useful in assessing phosphorus nutrition of plants. The proportion of forms of phosphorus such as Ca-P, Al-P, Fe-P, occluded and organic-P governs the response to applied P (Singh *et al.*, 2003). Such information is meager particularly in the alluvial soils of south- western plain zone of Uttar Pradesh. Hence, a study was undertaken to know the distribution of P fractions with depth and their relationship with soil properties of alluvial soils.

MATERIAL AND METHODS

Twenty five profiles from Agra, Aligarh, Etah, Mainpuri and Mathura of south-western plain zone of Uttar Pradesh were selected for horizon wise sampling. Soil samples were collected at 0 – 30, 30-60, 60-90, 90-120 and 120-180 cm depth from each profile with the help of auger. Soil samples were dried and sieved through 2 mm sieve and stored for chemical analysis. The mechanical analysis for particle size of soil was carried out by Pipette method (Jackson 1973). The pH and EC of the soils were determined by glass electrode pH meter and conductivity bridge, respectively with 1:2.5 of soil and water. The organic carbon and calcium carbonate content of the soil were determined as describe by Jackson (1973). Fractionation of soil phosphorus was carried out by the method of Chang and Jackson (1969) and available P by Olsen *et al*. (1954). The organic P was calculated from the difference between total P and total mineral P.

RESULTS AND DISCUSSION

Important properties of the soils are presented in Table 1. An increase in pH and EC was found from surface to lower depth in all the profiles under study. Organic carbon content of all the soil profiles exhibited a decrease with an increase in soil depth. The soils in general are poor in organic carbon content and have wide variations in CaCO3 content in different horizons and it increased with depth. In general, the sand content of all the profiles was lower in sub surface horizons than in the surface horizon. Clay content of all the profiles increased from surface to lower depths. No definite trend of decrease or increase of silt content was observed in any of the soil profiles at different depths. The Olsen P ranged from 6.9 to 15.4 mg kg^{-1} and contributed to 16 % of the total P. The content of available P in Agra region soils varied over a wide range depending on cultivation practice (Singh *et al.* 2005). Its content decreased with depth. The low content of Olsen P at

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Table 1: Important characteristics of the soils (Mean of different layers)

Soil Series	Depth (cm.)	pH	EC (dSm^{-1})	Org.C ($g\ kg^{-1}$)	$CaCO_3$ (gkg^{-1})	Sand (%)	Silt (%)	Clay (%)
Agra	0-30	8.7	0.25	4.0	10.4	70.8	15.3	12.6
	30-60	8.9	0.23	3.4	15.8	68.8	11.8	15.5
	60-90	8.8	0.26	2.6	10.8	66.5	14.3	17.5
	90-120	8.8	0.25	2.4	11.6	55.9	19.0	20.1
	120-180	8.9	0.27	1.7	20.8	60.4	19.5	18.3
Aligarh	0-30	8.4	0.20	4.4	11.5	70.0	15.4	12.7
	30-60	8.5	0.22	3.2	16.0	69.2	13.2	16.4
	60-90	8.6	0.25	2.4	21.0	63.7	17.4	17.8
	90-120	8.9	0.35	2.4	22.5	68.1	14.0	16.8
	120-180	8.6	0.30	1.3	19.5	65.2	15.6	17.8
Etah	0-30	8.6	0.31	4.2	5.0	71.7	13.2	12.8
	30-60	8.7	0.32	2.8	16.2	72.0	13.0	13.5
	60-90	8.8	0.37	2.4	26.2	71.2	12.5	15.0
	90-120	8.7	0.24	2.1	22.0	69.5	12.5	15.7
	120-180	8.8	0.20	1.9	29.4	69.7	14.5	14.2
Mainpuri	0-30	8.5	0.19	4.3	9.0	58.4	20.6	19.5
	30-60	8.6	0.20	3.5	11.5	59.0	20.2	18.8
	60-90	8.8	0.17	2.5	12.8	57.4	23.2	17.8
	90-120	8.7	0.18	1.8	20.0	62.6	17.0	18.2
	120-180	8.8	0.18	1.6	19.0	58.8	19.2	20.0
Mathura	0-30	8.6	0.24	3.7	10.0	68.2	13.5	15.0
	30-60	8.7	0.24	2.7	20.0	67.7	15.25	15.2
	60-90	8.7	0.22	2.4	21.2	64.5	18.0	16.5
	90-120	8.8	0.25	1.7	33.0	66.5	14.5	18.2
	120-180	8.9	0.22	1.6	30.0	64.0	15.0	20.7

deeper layers may be attributed to decreasing trend of organic carbon in the profile. Trivedi *et al.* (2010) reported similar results. The Ca-P content in the soils varied from 189.7 to 290.2 mg kg^{-1} and its contribution was higher in deeper layers in all profiles. It accounted for 37.7% of total P in these soils. Similar result with respect to change in content with depth was also reported by Trivedi et al. (2010), which is evident as the $CaCO_3$ content also increased with depth Al-P content of the soils decreased with depth in all the profiles and the content varied from 45.7 mg kg^{-1} in Mainpuri to 87.4 mg kg^{-1} in Mathura and contributed to 9.1 % of the total P. The Fe-P content in the profiles followed the same trend as did the Al-P. The mean Fe-P content varied from 27.4 mg kg^{-1} (Aligarh) to 54.2 mg kg^{-1} (Mainpuri) and contributed to 5.7 % of the total P. Reductant soluble P is fairly rich as compared to Al-P and Fe-P. This content in the soil profiles ranged from 75.0 mg kg^{-1} in Mainpuri soils to 180.0 mg kg^{-1} in Mathura soils and it accounted for 18.5 % of the total P. In all Profiles, reductant soluble P was higher in surface horizons and the same decreased down the depth. Similar trend in profile was also reported by Dongale (1993) and Trivedi et al. (2010). Dry environment at surface is conducive for its accumulation instead of prolonged moist condition prevailing in deeper layers. Organic phosphorus was found to concentrate in surface layers and subsequently decreased with increasing depth. This may be due to distribution pattern of organic matter in the profiles. Dongale (1993) also reported a decrease in organic P in soil with depth. Organic P ranged between 40.2 and 151.6 mg kg^{-1} and comprised 13.1 % of the total P. Among all the district Agra soils were highest in organic P content. Whereas the soils from Mainpuri district were low in organic P content possibly caused by higher P mineralization. The total P in all the horizons within the soil profiles varied from 0.05 to 0.12 % (Table 2). In general, Agra soil showed relatively higher total P content as compared to soils of other districts. The wide variation in total P content of these soils seems to be caused by variation in their physic-chemical properties (Table 1). It generally decreased with depth in all the profiles. The decrease in total P content may be due to decrease in organic matter content down the profiles. Similar results were also reported by Dongale (1993) and Trivedi *et al.* (2010). The highest content of total P in surface layers may be attributed to continuous addition of manure and fertilizer in this layer.

Table 2: Distribution of different forms of phosphorus in soils

Soil Series	Depth (cm.)	Olsen-P (mg kg^{-1})		Ca-P(mg kg^{-1})		Al-P(mg kg^{-1})		Fe-P(mg kg^{-1})		Red-P(mg kg^{-1})		Org.-P(mg kg^{-1})		Total-P(mg kg^{-1})	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Agra	0-30	11.5-21.0	15.4	229.6-361.6	290.2	73.6-97.6	87.1	33.6-46.0	40.3	90.0-190.0	140.0	120.0-170.0	151.6	0.05-0.12	0.08
	30-60	9.0-16.5	13.6	197.6-363.2	238.3	64.0-86.4	72.4	32.0-43.6	37.3	110.0-170.0	131.6	90.0-160.0	139.1	0.05-0.10	0.07
	60-90	8.0-16.5	13.3	100.8-240.8	189.7	46.4-80.0	64.4	26.8-40.0	36.4	60.0-140.0	96.6	40.0-160.0	97.5	0.07-0.11	0.09
	90-120	8.0-21.0	14.5	173.6-308.8	245.7	38.4-80.0	60.4	24.4-52.8	34.6	60.0-250.0	130.8	40.0-105.0	75.8	0.05-0.10	0.07
	120-180	8.0-16.5	12.1	196.0-363.2	277.3	49.6-66.2	59.3	28.8-48.8	39.7	60.0-140.0	86.6	50.0-90.0	65.0	0.05-0.09	0.06
Aligarh	0-30	8.0-16.5	12.2	200.8-297.0	249.1	60.8-80.0	68.1	26.4-51.2	35.0	100.0-210.0	150.0	100.0-195.0	148.0	0.03-0.10	0.06
	30-60	7.5-15.0	10.8	198.4-361.6	214.4	51.2-72.0	61.7	26.0-38.4	31.3	80.0-150.0	115.2	75.0-150.0	107.0	0.05-0.10	0.06
	60-90	5.5-15.5	10.4	133.6-332.8	234.6	46.4-72.0	58.2	19.2-54.4	31.8	54.0-190.0	136.8	70.0-105.0	89.0	0.03-0.12	0.07
	90-120	8.5-16.5	12.9	131.2-239.2	201.0	36.8-67.2	51.0	20.4-41.6	27.4	60.0-180.0	112.0	40.0-80.0	63.0	0.05-0.11	0.08
	120-180	8.0-16.5	11.6	120.0-356.8	198.6	43.6-64.0	55.4	17.2-38.4	28.6	40.0-160.0	82.0	40.0-80.0	53.0	0.05-0.12	0.07
Etah	0-30	8.0-10.0	8.9	140.8-283.2	206.6	48.0-73.6	61.2	35.2-54.4	40.4	90.0-160.0	117.5	85.0-140.0	106.2	0.05-0.06	0.05
	30-60	8.0-10.5	9.2	202.0-344.0	275.9	46.4-64.0	56.0	25.6-60.8	38.0	80.0-170.0	122.5	60.0-135.0	90.0	0.05-0.07	0.06
	60-90	7.5-12.5	9.6	220.0-305.0	273.6	46.4-56.0	50.4	28.8-56.0	38.4	80.0-120.0	102.5	60.0-95.0	70.0	0.05-0.07	0.06
	90-120	6.5-10.5	8.5	131.2-252.0	206.4	27.2-68.8	48.7	28.8-64.0	39.4	90.0-160.0	120.0	35.0-55.0	41.2	0.03-0.07	0.05
	120-180	8.5-15.0	10.6	204.0-345.6	266.1	46.4-72.0	64.4	30.4-51.2	39.2	100.0-160.0	121.2	35.0-75.0	52.5	0.06-0.11	0.07
Mainpuri	0-30	8.0-16.5	11.1	206.4-368.0	265.0	49.6-64.0	56.6	40.0-60.0	54.2	80.0-220.0	121.0	72.0-144.0	105.2	0.05-0.09	0.06
	30-60	8.0-15.0	10.5	168.0-312.0	238.7	30.4-64.0	49.2	33.6-51.2	37.4	90.0-190.0	142.0	64.0-160.0	107.8	0.05-0.09	0.07
	60-90	5.0-8.5	6.9	215.0-268.0	241.4	30.4-64.0	46.0	22.2-46.4	33.6	60.0-150.0	96.0	40.0-160.0	86.0	0.03-0.07	0.05
	90-120	5.0-10.5	8.6	208-279.2	243.7	22.4-65.6	45.7	20.8-56.0	37.8	80.0-160.0	102.0	36.0-68.0	48.0	0.03-0.09	0.06
	120-180	7.0-12.5	9.3	120.0-280.8	225.3	20.8-60.0	49.4	16.0-35.2	27.8	35.0-160.0	75.0	20.0-82.0	42.6	0.05-0.12	0.07
Mathura	0-30	8.5-16.0	11.5	204.0-361.6	276.2	67.2-98.4	87.4	36.8-64.0	47.2	90.0-190.0	127.5	100.0-155.0	127.5	0.05-0.09	0.07
	30-60	5.5-12.5	8.5	169.6-369.6	248.2	49.6-84.8	68.8	30.4-51.0	41.0	110.0-160.0	137.5	85.0-105.0	95.0	0.03-0.07	0.06
	60-90	8.0-10.5	8.7	145.6-396.0	252.2	33.6-67.6	51.8	24.0-57.6	40.1	60.0-150.0	110.0	65.0-90.0	73.7	0.05-0.08	0.06
	90-120	5.5-12.5	8.6	209.6-326.4	283.0	40.0-60.8	50.4	27.2-40.0	35.2	100.0-320.0	180.0	50.0-65.0	56.2	0.03-0.09	0.05
	120-180	8.0-12.5	9.1	156.8-348.0	272.4	49.6-64.0	59.6	22.4-33.6	28.4	110.0-230.0	147.5	40.0-46.0	40.2	0.06-0.09	0.07

Table3: Correlation between soil properties and forms of phosphorus

	Olsen-P	Ca-P	Al-P	Fe-P	Red-P	Org-P	Total-P
pH	-0.485*	0.461*	-0.463*	-0.441*	-0.497*	0.173	-0.128
EC	-0.475*	0.371*	-0.165	-0.197	0.215	0.078	0.189
Org.C	0.455*	-0.450*	0.087	0.416*	0.449*	0.417*	0.553*
$CaCO_3$	0.424*	0.629**	0.038	-0.469*	-0.475*	0.356	-0.363*
Sand	-0.516**	0.484*	-0.168	-0.430*	0.505**	0.214	0.403*
Silt	0.422**	0.259*	0.444*	0.305	-0.152	0.356	-0.180
Clay	-0.479**	0.483*	-0.283	-0.407*	0.521*	0.343	0.468*

Correlation between the different forms of phosphorus and the soil characteristics are presented in Table 3. The pH bears a significantly negative correlation with Olsen P, Al-P, Fe-P, Red-P and positive with Ca-P and organic-P. This shows that increases in pH is associated with decrease in iron and aluminium–bound P content and raise the content of calcium–bound P. Similar findings were also reported by Jaggi (1991) and Singh *et al.* (2003). Organic carbon showed significant positive correlation with Olsen-P, Fe-P, Red-P, Total-P and organic-P and negative with Ca-P. This positive relationship with Fe-P and Al-P might be due to the mineralization of organic P and conversion into aluminium and iron fractions due to high biological activity in these soils. A further study of table 3 reveals that calcium carbonate is significantly and positively correlated with Olsen-P Ca-P while negative which and Fe-P, Red-P and Total-P. Similar relationships have also been reported by Tekchand and Tomar (1993). The dominance of calcium present in calcium carbonate might have suppressed the solubility of iron. It is well known that both iron and calcium bound phosphorus are controlled by soil pH, i.e. the calcium system is stable under high pH whereas iron system is unstable. As such, significant negative correlation between calcium carbonate and iron bound P is obvious. Trivedi *et al.* (2010) also observed negative correlation between $CaCO_3$ content and Fe-P. Sand and clay fractions of the soils showed significant negative correlation with Olsen-P, Al-P and Fe-P while these exhibited significant positive relationship with Ca-P, Red-P, organic-P and total-P. Organic P and P and all fractions of inorganic P showed positive correlation with total P (Table 4). Available P was significantly and positively correlated with Al-P. Organic P was also related significant with Al-P and Ca-P. Dongale (1993) reported similar relationships among P fractions.

Table 4: Correlation coefficients(r) among forms of phosphorus

Properties	Olsen-P	Ca-P	Al-P	Fe-P	Red-P	Org-P	Total-P
Olsen-P		0.175	0.399*	0.063	0.331*	0.196	0.613**
Ca-P			0.165	0.156	0.076	0.374*	0.435**
Al-P				0.186	0.253	0.570**	0.449**
Fe-P					0.101	0.145	0.113
Red-P						0.253	0.533**
Org-P							0.689**

The overall results show that the Olsen-P, Al-P, Fe-P, Red-P and Total-P decreased with increase in the depth of soil, whereas Ca-P was found higher in the lower horizons of these profiles. Calcium-P was the most predominant P fraction followed by reductant soluble P, Al-P and Fe-P. The pH and organic carbon are main contributing factors for the availability of Ca-P and total-P, whereas pH and calcium carbonate were the main characteristics of soil affecting the availability of Al-P and Fe-P.

REFERENCES

Chang, S.C. and Jackson, M.L. (1969)Soil phosphorus fraction in some representative soil. *Soil Science Society of America Proceedings* **9**, 109-119

Dongale, J.H. (1993) Depth distribution of different forms of phosphorus in lateritic soils of coastal region. *Journal of the Indian Society of Soil Science* **40**, 62-67.

Jackson, M.L. (1973) *Soil Chemical Analysis*, Prentice Hall of India Private Ltd. New Delhi.

Jaggi, R.C. (1991) Inorganic phosphorus as related to soil properties in some representative soils of Himachal Pradesh. *Journal of the Indian Society of Soil Science* **39**, 567-568.

Laxminarayana, K. (2007) Distribution of inorganic P fractions and critical limits of available P in rice soils of Mizoram. *Journal of the Indian Society of Soil Science* **55**, 481-487.

Olesn, S. R., Cole, C.V. Watanabe, F.S. and Dean, L.A.(1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate USDA *Circular No.* **939**, Washington D.C.

Singh, B.K., Krogstad, T., Shivay, Y.S. Shivakumar, B.G. and Bakkegard, M. (2005) Phosphorus fractionations and sorption in P enriched soils of Norway. *Nutrient Cycling in Agroeco Systems* 73, 245-256.

Singh, S.K., Baser, B.L., Shyampura, R.L. and Narain, P. (2003) Phosphorus fractions and their relationship to weathering indices in Vertisols. *Journal of the Indian Society of Soil Science* **51**, 247-251.

Tekchand and Tomar, N.K. (1993) Effect of soil properties on transformation of P alkaline calcarious soil. *Journal of the Indian Society of Soil Science* **41**, 56-61.

Trivedi, S.K., Tomar, R.A.S., Tomar, P.S. and Gupta, N.(2010)Vertical distribution of different forms of phosphorus in alluvial soils of gird region of Madhya Pradesh. *Journal of the Indian Society of Soil Science* **58**, 86-90.

Verma, L.P., Maurya, M.L. and Kumar, Suresh (2009) Forms of soil phosphorus under various forage cropping sequences. *Journal of the Indian Society of Soil Science **57**, 208-209.*