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RELATIONSHIP BETWEEN AVAILABLE PHOSPHORUS AND ITS FRACTIONS IN CALCAREOUS SOILS OF WESTERN RAJASTHAN

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ABSTRACT

About 209 surface (0-15cm) soil samples from three districts (Bikaner, Churu and Jaisalmer) of western Rajasthan were collected to study the relationship between available P and various P fractions. The results showed significant positive relationship between Olsen P and organic carbon (0.559), (0.617), (0.541) but negative with pH (-0.591) (-0.164), (-0.109) and $CaCO_3$ (-0.317), (-0.249), (-0.548) in soils of Bikaner, Churu and Jaisalmer respectively. Among the different P fraction vig. Saloid-P (0.558), (0.016), (0.390), Fe-P (0.481), (0.050), (0.397) and Org-P (0.708) (0.509) (0.603) had shown significant positive correlation with Olsen P in soils of Bikaner, Churu and Jaisalmer, respectively. The pH varied from 7.04-9.57, 8.32-9.98 and 7.19-9.38, organic carbon content from 0.1-2.3, 0.1-1.5 and 0.1-2.5 g kg^{-1} and $CaCO_3$ content varied from 0.5-203, 3.0-268.2 and 1.0-250.5 g kg^{-1} in soils of Bikaner, churu and Jaisalmer respectively. The soils were alkaline and calcareous with low organic carbon. Ca-P was dominating P fraction in these soil followed by Organic P, Fe P, and Saloid P.

Key words: Phosphorus fractions, soil properties, calcareous soils

INTRODUCTION

Phosphorus, like any other plant nutrient is present in soil in two major compotents i.e. organic and inorganic. Organic P, which is mainly confined to the surface layer, is mineralized in to inorganic forms. But the plants mainly depend on inorganic P forms for their P requirements. Inorganic phosphorus fractionations have been widely used to interpretate native inorganic P status and the applied P to soils. It has been established that saliod-P, Al-P, Fe-P and Ca-P fractions are the main sources of P supply to the plants (Mishra 1994, Singh *et al.* 2014). Knowledge of amount of each fraction and their relationship with soil characteristics is very useful in assessing phosphorus nutrition of plants. Since various P fractions and their contribution to available phosphorus provide useful information in assessing the available P status of soils and various forms of soil phosphorus have different solubility under varying soil condition. Such information is meager particularly in the calcareous soils of western Rajasthan. Therefore, an investigation was made to study the relationship between Olsen P and various inorganic P fractions in calcareous soils of western Rajasthan.

MATERIALS AND METHODS

Two hundred nine surface (0-15cm depth) soil samples were collected from three districts (Bikaner, Churu and Jaisalmer) of western Rajasthan. These soil samples were analysed to their physicochemical properties, different P fractions and Olsen P. The soils of study area generally belong to the Aridsols or Entisols order. The soil was loamy sand in texture. The physico – chemical properties of these soils were determined by adopting standard procedures (Jackson, 1973).The original fractionation procedures of Chang and Jackson (1957) with modifications made by Kuo (1996) were followed for different fractions of P. Olsen *et al* (1954) method was used for analysis of available P. Organic P was determined by using ignition method of Saunders and Williams (1955), as modified by Walker and Adams, (1958). Simple correlations coefficient between soil properties and fractions of P were computed by standard statistical methods.

RESULTS AND DISCUSSION

The data (Table 1) indicated that pH ranged in soils of Bikaner, churu and Jaisalmer from 7.04 to 9.57, 8.32 to 9.98 and 7.19 to 9.38, respectively. The alkaline reaction of soils of arid region may be attributed to limited leaching of bases and higher calcium carbonate accumulation. The organic carbon content of Bikaner, churu and Jaisalmer soils varied from 0.1 to 2.3, 0.1 to 1.5 and 0.1 to 2.5 g kg^{-1} respectively. Occasional addition of organic materials, lack of natural vegetation, poor decomposition due to low rainfall, high oxidation rate due to high summer temperature and wind erosion are the probable reasons for low organic carbon in these soils. The $CaCO_3$ content varied from 0.5 to 203, 3.0 to 268.2 and 1.0 to 250.5 g kg^{-1} in soils of Bikaner, churu and Jaisalmer, respectivly. Calcium carbonate

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accumulation is considered to be an important pedogenic feature of desert soils (Boul *et al.* 1997). Torric moisture regime being in arid region might have caused the accumulation of calcium carbonate in these soils. The variation in calcium carbonate content in the area might be due to variation in the parent material and pedogenic processes by which these soils have developed.

Table 1: Some physicochemical properties of the soils of western Rajasthan

Location	No. of samples	pH	Org. C (g kg^{-1})	$CaCO_3$ (g kg^{-1})
Bikaner	77	7.04-9.57 (8.75)	0.1-2.3 (0.9)	0.5-203 (61.60)
Churu	83	8.32-9.98 (8.92)	0.1-1.5 (0.6)	3.0-268.2 (71.60)
Jaisalmer	49	7.19-9.38 (8.64)	0.1-2.5 (0.7)	1.0-250.5 (109.2)
Total	209	7.04-9.98 (8.78)	0.1-2.5 (0.7)	0.5-268.2 (77.40)

Figures in parentheses indicates the mean value of soil properties

The correlation coefficient indicated significant negative correlation of Olsen-P with pH (-0.591) in Bikaner and negative non significant correlation (-0.164), (-0.109) in Churu and Jaisalmer soil, respectively (Table 3). The significantly negative correlation of Olsen-P between $CaCO_3$ (-0.3169), (-0.2489) and (-0.5485) in Bikaner, Churu and Jaisalmer was found because at higher pH calcium can precipitate with phosphorus as Ca-phosphate and thereby reduced availability (Tisdale *et al.* 1997).

Organic-P: Organic P varied from 47.82-94.65, 42.69-86.71 and 43.80-106.85 mg kg^{-1} with mean values of 67.60, 62.87 and 69.99 mg kg^{-1} in soils of Bikaner, Churu and Jaisalmer, respectively (Table 2). The Olsen-P had significant positive correlation with organic carbon and organic P in soils of western Rajasthan which might be due to the presence of more than 50% phosphorus in organic forms and after the decomposition of organic matter as humus is formed which forms complex with Al and Fe thus reduced phosphorus fixation (Tisdale *et al.* 1997). Organic carbon showed positive and highly significant correlation with Org-P. It appears that several phosphorus containing organic compounds dominate in soils and on mineralization will be available to crops. The increase in Olsen-P with increase in the organic carbon content might be due to the solubilization of native phosphorus compounds contained in the soil by organic acid produced as a result of decomposition of organic matter and leading to increased P availability. Similar observation was also made by Viswanatha and Doddamani (1991). Further the organic anions, the product of decomposition compete with phosphate anion for the fixation sites, saturated the adsorption sites and dislodge the phosphate anion resulting in the enhanced P availability. The inherent P content of organic materials also enriches the soil with P and through mineralization mode P become available for crop growth.

Table 2: Distribution of different P fractions and Olsen P of soil

Location	Org. P (mg kg^{-1})			Ca-P (mg kg^{-1})			Fe-P (mg kg^{-1})			Sal-P (mg kg^{-1})			Olsen-P (mg kg^{-1})		
	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD
Bikaner	47.82-94.65	67.60	10.53	89.21-174.80	113.17	17.12	10.65-22.17	17.03	2.44	6.84-20.11	11.68	3.40	1.01-18.89	7.39	4.94
Churu	42.69-86.71	62.87	7.96	87.40-215.71	121.90	33.48	12.34-22.54	17.15	1.99	7.02-18.85	13.23	2.69	0.11-4.27	1.42	1.17
Jaisalmer	43.80-106.85	69.99	10.77	82.28-198.21	137.14	28.30	10.08-30.02	17.08	3.66	7.17-18.46	12.90	2.87	0.98-18.48	5.35	4.01

Ca-P: Ca-P was found the dominated fractions in calcareous soil of western Rajasthan. It varied from 89.21-174.80, 87.40-215.71 and 82.28-198.21 mg kg^{-1} with mean values of 113.17, 121.90 and 137.14 mg kg^{-1} in soils of Bikaner, Churu and Jaisalmer, respectively. The Ca-P constituted a major portion (54.61%) of total-P followed by Org-P (29.61%), Fe-P (7.63%), Saloid-P (5.62%). The high Ca-P content in these soils could be attributed to high $CaCO_3$ content indicating greater availability of calcium in calcareous soil (Viswanatha and Doddamani 1991).

Fe-P: Fe-P ranged from 10.65-22.17, 12.34-22.54 and 10.08 - 30.02 mg kg^{-1} with mean value 17.03, 17.15 and 17.08 mg kg^{-1} in soils of Bikaner, churu

and Jaisalmer, respectively. Among the various forms of phosphorus Fe-P was found to have significant positive correlation with Olsen P expect Ca-P, where values were non significant with Olsen P in western Rajasthan soils (Table 3). This might be due to low Fe activity as a consequence of its precipitation at higher pH where the Ca-P usually is the dominate fraction. Similar observation was also made by Prasad *et al.* (1996).

Table 3: Correlation coefficients between Olsen P & different P fractions and chemical properties of soil

Olsen P versus	Location		
	Bikaner	Churu	Jaisalmer
Org. P	0.708**	0.509**	0.603**
Ca-P	0.115	0.222	0.244
Fe-P	0.481**	0.050	0.397**
Sal.P	0.558**	0.016	0.390**
Organic C	0.559**	0.617**	0.541**
pH	-0.591**	-0.164	-0.109
$CaCO_3$	-0.317*	-0.249*	-0.548

Saloid-P: The saloid P content showed lowest P reserve ranging from 6.84-20.11, 7.02-18.85 and 7.17-18.46 mg kg^{-1} with mean value 11.68, 13.23 and 12.90 mg kg^{-1} in soils of Bikaner, churu and Jaisalmer, respectively. On the other hand, significant positive correlation of saloid-P with Olsen-P in these soils may be due to the more release of P into easily available P form (Saloid-P) from organic matter and available P pool of the soils. Chand and Tomar (1993) and Singh and Sharma (2007) also reported similar results.

Olsen P: it is reveled from Table 2 that Olsen P varied from 1.01-18.89, 0.11-4.27 0.98-18.48 mg kg^{-1} with mean values of 7.39, 1.42 and 5.35 mg kg^{-1} in soils of Bikaner, churu and Jaisalmer, respectively. The range is quite large which might be due to variation in soil properties viz, pH, $CaCO_3$, organic matter content, texture and various soil management and agronomic practices. The P transformation in soils involves complex microbiological, chemical and biological processes. Plant availability of inorganic phosphorus can be limited by formation of sparingly soluble Ca phosphate, particularly in alkaline and calcareous soils.

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