Annals of Plant and Soil Research 17(3): 262-265 (2015)

IMPACT OF CROP MANAGEMENT SYSTEM ON PHOSPHORUS FRACTIONS IN SOILS OF WESTERN PLAIN OF RAJASTHAN

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Received: May, 2014; Revised accepted: March, 2015

ABSTRACT

Impacts of crop management system on phosphorus fractions were studied under seventeen tehsils of three districts (Bikaner, Churu and Jaisalmer) of western plain of Rajasthan. According to irrigated and rainfed condition and based on inputs used for the crop management systems, these three districts were divided under four units. Among the various unit of crop management, the maximum amounts of all phosphorus fractions (mg kg^{-1}) i.e. saloid P (15.58), Fe-P (23.97), reductant soluble P (8.19), Ca P (142.20), Org. P (85.61), total P (268.48) and Olsen P (10.74) were recorded in unit iv under three districts of western plain of Rajasthan. which may be due to higher application of recommended dose of fertilizer under irrigated condition i.e.10 t ha^{-1} FYM with 120-140 kg urea and 60-80 kg DAP and followed by management unit III (Irrigated with low input (5t ha^{-1} FYM ha^{-1} +80 kg urea + 40 kg DAP), II (rainfed with low input 2-3 t ha^{-1} FYM + 40 kg urea + 20 kg DAP) and minimum in management unit I i.e. no input under rainfed condition.

Key words: Phosphorus fraction, crop management systems

INTRODUCTION

Phosphorus is an essential element for plant growth. Information on the chemical forms of P to understand P dynamics and its interactions in soils is necessary for management of P (Sharma and Paliyal 2014). Transformation and status of different P forms in soil depend upon soil texture, organic matter and calcium carbonate content, soil reaction and type and amount of phosphatic fertilizers applied. Inspite of these factors, distribution and content of P forms is also affected by different crop rotations and their durations (Aggrawal *et al.* 1987). Knowledge on active forms of soil phosphorus is very useful in appraisal of available P status and determining the fertilizer need of crops. Transformation of P into insoluble and unavailable compounds is considered as primary cause of inefficient utilization of phosphatic fertilizers. As crops utilize only a portion of fertilizer P, large amounts of residual P gets accumulated in the soil. Most of such studies have focused primarily on the Olsen-P, and P accumulations with increasing P application are well-documented (Sharma *et al.* 2005; Sharma *et al.* 2007). A few attempts, however, have been made to identify the changes in the amount of inorganic P (Pi) and organic P (Po) compounds in soil as induced by the long-term applications, despite the fact that plants are able to utilize substantial amounts of P from the less labile Pi and Po pools. Although sufficient information is available on forms of P but information under various cropping sequences is very meager. Therefore, the present investigation was carried out to study the impacts of different crop management systems on different phosphorus fractions.

MATERIALS AND METHODS

Two hundred nine surface soil samples (0-15 cm) were collected in GIS-GPS based soil fertility mapping project from irrigated and rainfed fields in seventeen tehsils covering three districts (Bikaner, Churu and Jaisalmer) of western plain of Rajasthan for the present study. The soil samples based on input used were grouped under various crop management system i.e. Unit-I Rainfed no input; Unit-II Rainfed with low input (2-3 t ha^{-1} FYM + 40 kg urea + 20 kg DAP); Unit-III Irrigated with low input (5 t ha^{-1} FYM + 80 kg urea + 40 DAP); Unit-IV Irrigated with RD of fertilizers (10 t ha^{-1} FYM with 120-140kg urea + 60-80 kg DAP). The soils of study area generally belong to the Aridsols or Entisols order. The soil was loamy sand in texture with pH (8.78), EC (0.13 dSm^{-1}), organic carbon (0.7g kg^{-1}) and $CaCO_3$ (77.4g kg^{-1}). Total P in soil was determined using di-acid digestion method as given by Bray and Kurtz, (1945). Organic P was determined by using ignition method of Saunders and Williams (1955), as modified by Walker and Adams (1958). The original fractionation procedures of Chang and Jackson (1957) with most important modifications were summarized by Kuo (1996) for investigation of different forms of inorganic P in soil and Olsen P by Olsen *et al (1954)* was used for analysis.

RESULTS AND DISCUSSION

The data on different forms of inorganic phosphorus showed that amount of P recovered in

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various fractions varied considerably depending upon the source which was applied to different crop management system. All the fractions of P had shown relatively better values under unit-IV, which may be ascribed to slightly higher rate of P application in relation to crop removal. The data (Table 1) indicate the impact of different crop management systems on different P fractions.

Table 1: Effect of crop management system on P fractions

Area	Management unit				Management unit			
	I	**II**	**III**	**IV**	**I**	**II**	**III**	**IV**
	Saloid P (mg kg^{-1})				**Fe-P (mg kg^{-1})**			
Bikaner	8.60 (17)	11.27(23)	12.99 (23)	14.64 (14)	14.49 (17)	16.68 (23)	18.08 (23)	19.36 (14)
Churu	12.02 (53)	14.50 (19)	15.40 (10)	15.58 (01)	16.29 (53)	17.79 (19)	18.64 (10)	22.54 (01)
Jaiselmer	12.38 (31)	14.64 (11)	15.97 (06)	16.52 (01)	15.89 (31)	17.48 (11)	20.22 (06)	30.02 (01)
Western plain of Rajasthan	11.00 (101)	13.47 (53)	14.78 (39)	15.58 (16)	15.56 (101)	17.31 (53)	18.98 (39)	23.97 (16)
	Reductant soluble P (mg kg^{-1})				**Ca-P (mg kg^{-1})**			
Bikaner	4.34 (17)	4.44 (23)	5.38 (23)	6.06 (14)	105.80 (17)	108.74 (23)	116.07 (23)	126.63 (14)
Churu	5.74 (53)	6.47 (19)	7.17 (10)	9.29 (01)	121.85 (53)	132.43 (19)	142.06 (10)	141.29 (01)
Jaiselmer	5.70 (31)	6.03 (11)	6.99 (06)	9.23 (01)	127.19 (31)	138.49 (11)	146.03 (06)	158.69 (01)
Western plain of Rajasthan	5.26 (101)	5.65 (53)	6.51 (39)	8.19 (16)	118.28 (101)	126.55 (53)	134.72 (39)	142.20 (16)
	Organic P (mg kg^{-1})				**Total P (mg kg^{-1})**			
Bikaner	60.49 (17)	66.71 (23)	70.91 (23)	75.91 (14)	193.71 (17)	210.92 (23)	223.43 (23)	241.88 (14)
Churu	60.03 (53)	64.60 (19)	66.91 (10)	74.08 (01)	215.93 (53)	235.25 (19)	247.13 (10)	249.61 (01)
Jaiselmer	66.42 (31)	70.01 (11)	79.31 (06)	106.85 (01)	227.60 (31)	246.65 (11)	267.80 (06)	313.94 (01)
Western plain of Rajasthan	62.31 (101)	67.11 (53)	72.38 (39)	85.61 (16)	212.41 (101)	230.94 (53)	246.12 (39)	268.48 (16)
	Olsen P (mg kg^{-1})							
Bikaner	4.61 (17)	7.74 (23)	9.19 (23)	11.00 (14)				
Churu	1.31 (53)	1.57 (19)	2.39 (10)	2.74 (01)				
Jaiselmer	4.17 (31)	4.36 (11)	7.05 (06)	18.48 (01)				
Western plain of Rajasthan	3.36 (101)	4.56 (53)	6.21 (39)	10.74 (16)				

Value in parentheses indicates the No. of soil samples

Saloid-P: It is evident from the data (Table 1) that saloid P varied from 8.60 to 16.52 mg kg^{-1} with a mean value of 13.71 mg kg^{-1} under unit IV. The minimum amount of saloid P was observed in Bikaner under unit I and maximum amount in Jaisalmer under unit IV. In general, the low value of saloid-P in soils having slightly high pH and low organic carbon content and higher content as a result of inorganic fertilization and FYM which may be attributed to the transformation of applied P into saloid-P. Similar results were made by Jatav *et al.* (2010). The significant increase in saloid-P, Fe-P and Ca-P as a results of inorganic fertilization and FYM could be attributed to the transformation of a part of freshly applied P into the saloid P and insoluble Ca-P in initial stages and later on to insoluble Fe-P.

Fe-P: It is clear from the table 1 that Fe-P varied from 14.49 to 30.02 mg kg^{-1} with a mean value of 20.90 mg kg^{-1} in unit IV. The highest value was noted in Jaisalmer and lowest in Bikaner. Organic carbon had positive relationship with Fe-P. This might be due to the mineralization of organic-P and conversion into iron fraction due to high biological activity in the soils. High amount of free $CaCO_3$ was found at high pH at which Fe activity is less to precipitate P into Fe-P. Similar findings were reported by Viswanatha and Doddamani (1991).

Reductant soluble-P: The reductant soluble-P was very low in comparison to all other forms of inorganic soil P and varied from 4.34 to 9.23 mg kg^{-1} with a mean value of 6.40 mg kg^{-1} under unit IV. Red-P refers to that part of inorganic P which is not immediately available to the plants. Increases in the dose of DAP resulted in higher build up of Red-P content .Since, DAP is a water soluble form, readily reacts with ferric hydroxides, leading to conversion of water soluble forms to water insoluble forms (Singaram andKothandaraman,1991). The reduction of Red-P with FYM treatment compared to no FYM ascribed to dissolution of iron oxide coatings with organic acids released during decomposition of FYM causing reduction in Red-P with subsequent increase in Fe-P, while in the combined application there is significant increase in Red-P in the soil (Mahapatra and Patrick, 1969).

Ca-P: Ca-P was observed a dominant form of inorganic P. It was varied from 105.80 to 158.69 mg kg^{-1} with a mean value of 142.60 mg kg^{-1} under unit IV followed by unit III, II and I. The Ca-P was the major inorganic P fraction in all the management units because calcareous soils are reported to retain larger amount of P as Ca-P, irrespective of nature and kind of added fertilizer. This might be due to the more stabilized nature of calcium system under high pH (Jaggi1991). Similar results on inorganic P fractions in long term experiments in calcareous soil have also been reported by Santhy *et al.* (1998), and Setia and Sharma (2007).

Organic-P: The minimum amount of organic-P was found in the Bikaner under unit I and maximum in Jaisalmer under unit IV followed by III, II and I of crop management system which might be due to higher application of input. It varied from 60.49 to 106.85 mg kg^{-1} with a mean value of 71.85 mg kg^{-1}. Organic carbon had significant positive relationship with Org.-P. It appears that several phosphorus containing organic compounds dominate the soils and on mineralization will be available to crops. Similar observation was also found by Viswanatha and Doddamani (1991).

Total-P: Total-P content ranged from 193.71 to 313.94 mg kg^{-1} with a mean value of 264.00 mg kg^{-1} under unit IV. The minimum value was observed in Bikaner and maximum in Jaisalmer under unit IV.

Olsen-P: The data (Table 1) revealed that Olsen-P varied from 4.61 to 18.41 mg kg^{-1} with a mean value of 24.87 mg kg^{-1}. Application of organic manure with phosphatic sources resulted in increase of Olsen P at all the periods. The increase in Olsen P might be due to the fact that organic ions produced during decomposition of organic matter compete with PO_4^{-3} ion for adsorption sites on soil particles and organic anions chelate Fe^{+3}, Al^{+3} and $Ca^{+2}$and thus decrease the phosphate precipitation power of the soils. This is in agreement with the observation made by Tisdale *et al.* (1993) who noticed the role of FYM in keeping the available P at higher level. The soil analysis showed higher P availability as evidenced by increase in available P and total P both under inorganic fertilizer and FYM application. The quantity and frequency of fertilizer addition as well as stage of crop growth influenced this dynamic equilibrium between these P forms.

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