Status of available phosphorus and forms of Phosphorus in soil under major cropping systems of Y.S.R. Kadapa district, A.P.

ABSTRACT

An investigation was carried out to study different forms of phoshorus under major cropping systems in Y.S.R. Kadapa district of Southern Zone of Andhra Pradesh. Five soil samples from each cropping system at 0-15 cm depth collected from each cropping system to study their physico-chemical properties, status of available P_2O_5 and different forms of P. Majority of the soils were moderately alkaline in reaction, non-saline, free lime content indicating that these soils are moderately calcareous, medium to high in available P_2O_5. Highest mean values for available P_2O_5 (182.41 kg ha^{-1}), Al-P (80.82 mg kg^{-1}), Ca-P (118.55 mg kg^{-1}) and total-P (434.35 mg kg^{-1}) were recorded in groundnut monocropping system whereas for saloid P (23.01 mg kg^{-1}), Fe-P (69.82 mg kg^{-1}) and other forms of P (228.35 mg kg^{-1}) highest mean values were recorded under sunflower-sesame, groundnut-groundnut and fallow-bengal gram cropping systems, respectively.

Key words: Forms of phosphorus, cropping systems, available P_2O_5, moderately calcareous and moderately alkaline.

Introduction

Phosphorus is the tenth most abundant element in the earth's crust and its average content is nearly 0.12 per cent. In lithosphere, it always occurs in the pentavalent oxidation state. Phosphorus is an essential element for plant growth. Therefore, maintainance of an adequate amount of soil phosphorus through application of inorganic and/ or organic phosphorus is critical for the sustainability of cropping systems.

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. Available P content increases with the application of P. The increase in available P is a function of certain physical and chemical soil properties, such as clay, organic carbon, Fe, Al and calcium carbonate contents. Marked variation in the different forms of inorganic P is a function of genetic differences among soils (Chang and Jackson, 1958).

Materials and methods

Five soil samples from each cropping system (Fallow-Bengalgram, Sunflower-Sesame, Paddy-Paddy, Groundnut monocropping, Groundnut-Groundnut) at 0-15cm depth were collected from calcareous soils of Y.S.R. Kadapa district of southern zone of A.P. Theses soil samples were analysed for status of available P_2O_5 (Olsen-P) and different P fractions (Sal-P, Al-P, Fe-P, Ca-P, total-P and other forms of P). The available phosphorus was extracted by using Olsen's extractant (0.5 M $NaHCO_3$ of pH 8.5) as described by Olsen *et al.* (1954) and the phosphorus content in the extract was determined by Murphy and Riley (1962) method using ascorbic acid as the reducing agent using spectrophotometer.

The inorganic phosphorus fractions *viz*., saloid-P, Fe-P, Al-P and Ca-P were estimated by following the sequential extraction procedure as given by Kovar and Pierzynski (2009). Total phosphorus in the soils was determined by perchloric acid digestion method as described by Jackson (1973). The other P forms were computed by deducting the estimated forms viz., saloid-P, Al-P, Fe-P and Ca-P from total-P. The other forms include org-P, RS-P, occl-P, etc.,

Results and discussion

Available P_2O_5

The available P_2O_5 of surface soils varied from 31.99 kg ha^{-1} in fallow-bengalgram system to 253.72 kg ha^{-1} in groundnut monocropping system with a mean value of 34.80 kg ha^{-1} and 182.41 kg ha^{-1}, respectively (Table 1). The highest mean values were obtained in groundnut monocropping system (182.41 kg ha^{-1}) followed by paddy-paddy system (118.42 kg ha^{-1}), groundnut-groundnut system (92.04 kg ha^{-1}), sunflower-sesame system (41.47 kg ha^{-1}) and fallow-bengalgram system (34.80 kg ha^{-1}).

The available P_2O_5 content was low in fallow-bengalgram system where farmers are applying low dose of P fertilizers. Whereas in groundnut monocropping system increase in the availability of P was due to continuous and excess application of P fertilizers, mineralization of Org-P and solubilization of native inorganic P and lesser fixation of added P. Similar results reported by Tomar *et al.* 1984 and Devra *et al.* 2014.

Saloid-P

The saloid-P of surface soils varied from 3.20 mg kg^{-1} in fallow-bengalgram system to 27.95 mg kg^{-1} in sunflower-sesame system with a mean value of 4.23 mg kg^{-1} and 23.01 mg kg^{-1}, respectively (Table 2). The highest mean values were obtained in sunflower-sesame system (23.01 mg kg^{-1}) followed by groundnut monocropping system (13.99 mg kg^{-1}), groundnut-groundnut system (13.96 mg kg^{-1}), paddy-paddy system (6.18 mg kg^{-1}) and fallow-bengalgram system (4.23 mg kg^{-1}).

The lowest saloid-P content in fallow-bengalgram system might be due to transformation of soluble P forms into less soluble forms with time during fallow period. Similar results reported by Sarkar *et al.* (2013). The low saloid-P under paddy-paddy system might be due to high P uptake and utilization by Paddy in two crop sequence. Highest values were obtained in sunflower-sesame system as a result of inorganic fertilization and FYM could be attributed to the transformation of applied P into saloid-P as reported by Sacheti and Saxena (1973), Viswanatha and Doddamani (1991) and Jatav *et al.* (2010) and Devra *et al.* (2014). Highest Saloid-P under groundnut monocropping and groundnut-groundnut cropping systems might be due to addition of excess P fertilizers and low utilization by the crop.

Al-P

The data on Al-P in soil under different cropping systems is presented in (Table 2). The Al-P of surface soils varied from 23.36 mg kg^{-1} in fallow-bengalgram system to 100.32 mg kg^{-1} in groundnut monocropping sequence with a mean value of 27.93 mg kg^{-1} and 80.82 mg kg^{-1}, respectively. The highest mean values were obtained in groundnut monocropping system (80.82 mg kg^{-1}) followed by groundnut-groundnut system (73.55 mg kg^{-1}), paddy-paddy system (61.85 mg kg^{-1}), sunflower-sesame system (36.53 mg kg^{-1}) and fallow-bengalgram system (27.93 mg kg^{-1}).

Higher values of Al-P recorded in groundnut monocropping, groundnut-groundnut and paddy-paddy systems might be due to acidic soil reaction, conjoint use of chemical fertilizers with FYM, and reduced soil conditions under paddy crop. Similar findings were observed by Sudhakaran *et al.* (2018). Low Al-P in fallow-bengalgram system system might be due to high pH prevailing in the system. Also under sunflower-sesame system it might be due to high uptake as both the crops are exhaustive in nature.

Fe-P

The data on Fe-P in soil under different cropping systems is presented in (Table 2). Fe-P of surface soils varied from 20.25 mg kg^{-1} in Sunflower-Sesame system to 91.87 mg kg^{-1} in groundnut-groundnut cropping sequence with a mean value of 21.94 mg kg^{-1} and 69.82 mg kg^{-1}, respectively. The highest mean values were obtained in groundnut-groundnut system (69.82 mg kg^{-1}) followed by groundnut monocropping system (69.35 mg kg^{-1}), paddy-paddy system (68.77 mg kg^{-1}), fallow-bengalgram system (32.79 mg kg^{-1}) and sunflower-sesame system (21.94 mg kg^{-1}).

Low amount of Fe-P in sunflower-sesame and fallow-bengalgram systems may be due to low organic carbon and higher utilization by the exhaustive sunflower and sesame crops and more fixation under fallow-bengalgram system. Higher conversion from other forms of P and reduced conditions resulted in high Fe-P in Paddy-Paddy system, low crop uptake in groundnut-groundnut and groundnut monocropping systems.

Ca-P

The data on Ca-P in soil under different cropping systems is presented in (Table 2). The Ca-P of surface soils varied from 16.94 mg kg^{-1} in groundnut-groundnut monocropping system to 156.43 mg kg^{-1} in groundnut monocropping system with a mean value of 23.91 mg kg^{-1} and 118.55 mg kg^{-1}, respectively. The highest mean values were obtained in groundnut monocropping system (118.55 mg kg^{-1}) followed by paddy-paddy system (103.47 mg kg^{-1}), fallow-bengalgram system (55.89 mg kg^{-1}), sunflower-sesame system (28.2 mg kg^{-1}) and groundnut-groundnut system (23.91 mg kg^{-1}).

Highest values of Ca-P were obtained in groundnut monocropping system due to high amount of $CaCO_3$ and also due to continuous application of high doses of P-fertilizers like diammonium phosphate for a longer period of time might have lead to accumulation of more Ca-P. Similar findings were observed by Laxminarayana and Rajagopal (2002) and Sowjanya *et al.* (2017) and lowest values recorded in groundnut-groundnut cropping system might be due to low $CaCO_3$, and high utilization of Ca-P by groundnut crop. High Ca-P recorded under paddy-paddy system might be due to more solubilization of $CaCO_3$ and high external addition of P fertilizers. The lowest Saloid-P under sunflower-sesame system might be due to exhaustive nature of the crops.

Total-P

The data regarding total-P presented in (Table 2). The total-P of surface soils varied from 120.85 mg kg^{-1} in sunflower-sesame system to 607.81 mg kg^{-1} to groundnut monocropping sequence with a mean value of 157.46 mg kg^{-1} and 434.35 mg kg^{-1}, respectively (Table 2). The highest mean values were obtained in groundnut monocropping system (434.35 mg kg^{-1}) followed by paddy-paddy system (348.89 mg kg^{-1}), fallow-bengalgram system (349.39 mg kg^{-1}), groundnut-groundnut system (311.71 mg kg^{-1}) and sunflower-sesame system (157.46 mg kg^{-1}).

The highest content of total P in surface layers in groundnut monocropping system may be attributed to continuous addition of fertilizers and manures to this layer. This observation is in conformity with the findings of Viswanatha and Doddamani (1991) and Sowjanya *et al.* (2017). Low amount of total-P in sunflower-sesame system may be due to high utilization of p forms by the exhaustive sunflower and sesame crops.

Other forms of P

The data on other forms of P in soil under different cropping systems is presented in (Table 2). The other forms of P of surface soils varied from 20.73 mg kg^{-1} in sunflower-sesame system to 432.7 mg kg^{-1} in fallow-bengalgram system with a mean value of 47.77 mg kg^{-1} and 228.55 mg kg^{-1}, respectively. The highest mean values were obtained in fallow-bengalgram system (228.35 mg kg^{-1}) followed by groundnut monocropping system (151.58 mg kg^{-1}), groundnut-groundnut system (130.54 mg kg^{-1}), paddy-paddy system (109.62 mg kg^{-1}) and sunflower-sesame (47.77 mg kg^{-1}) cropping system.

Conclusion

In calcareous soils of Y.S.R. Kadapa district, the highest mean values for available P_2O_5, Al-P, Ca-P and total-P were obtained in groundnut monocropping system whereas for saloid-P, Fe-P and other forms of P the highest mean values were obtained in sunflower-sesame, groundnut-groundnut and fallow-bengalgram cropping systems, respectively.

The sequential distribution of different forms of P under major cropping systems in Y.S.R. Kadapa district followed the order:

1. Fallow-Bengalgram: **Ca-P > Fe-P > Al-P > Sal-P**

2. Sunflower-Sesame: **Al-P > Ca-P > Sal-P >Fe-P**

3. Paddy-Paddy: **Ca-P > Fe-P > Al-P > Sal-P**

4. Groundnut monocropping: **Ca-P > Al-P > Fe-P > Sal-P**

5. Groundnut- Groundnut: **Al-P > Fe-P > Ca-P > Sal-P**

Table 1. Status of available P_2O_5 (kg ha^{-1}) under major cropping systems in calcareous soils of Y.S.R. Kadapa district

S.No.	Cropping system	Available P_2O_5 (kg ha^{-1})	
		Range	Mean
1	Fallow-Bengalgram	31.99-36.69	34.8
2	Sunflower-Sesame	34.81-50.27	41.47
3	Paddy-Paddy	99.28-146.61	118.42
4	Groundnut monocropping	128.33-253.72	182.41
5	Groundnut-Groundnut	49.01-138.97	92.04

Table 2. Distribution of different forms of P under major cropping systems in calcareous soils of Y.S.R. Kadapa district

S.No.	Cropping system	Sal-P	Al-P	Fe-P	Ca-P	Total-P	Other P forms
1	Fallow-Bengalgram	3.2-5.57 (4.23)	23.36-33.44 (27.93)	29.98-36.16 (32.79)	42.28-78.93 (55.89)	212.9-586.79 (349.39)	113.34-432.7 (228.55)
2	Sunflower-Sesame	19.71-27.95 (23.01)	31.61-42.28 (36.53)	20.25-23.21 (21.94)	27.22-29.54 (28.20)	120.85-237.91 (157.46)	15.65-114.74 (47.77)
3	Paddy-Paddy	3.62-7.82 (6.18)	54.63-75.03 (61.85)	61.89-80.61 (68.77)	79.67-120.02 (103.47)	342.58-359.18 (349.89)	80.14-142.77 (109.62)
4	Groundnut monocropping	10.16-24.8 (13.99)	69.45-100.32 (80.82)	60.85-91.57 (69.35)	101.8-156.43 (118.55)	333.9-607.8 (434.35)	96.5-234.39 (151.58)
5	Groundnut-Groundnut	11.56-16.09 (13.96)	55.71-99.18 (73.55)	53-91.87 (69.82)	16.94-30.52 (23.91)	255.51-364.01 (311.71)	116.11-159.54 (130.54)

Note : Figures in parentheses indicate the mean value.

References

Chang, S.C and Jackson, M.L. 1958. Soil phosphorus fractions in some representative soils. *Journal of Soil Science*. 9: 109-119.

Devra, P., Yadav, S.R and Gulati, I.J. 2014. Distribution of different phoshorus fractions and their relationship with soil properties in Western plain of Rajasthan. *Agropedology*. 24(01): 20-28.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall of India Private Ltd., New Delhi. 134-182.

Jatav, M.K., Sud, K.C and Trehan, S.P. 2010. Effect of organic and inorganic sources of phosphorus and potassium on their different fractions under potato-radish cropping sequence in a brown hill soil. *Journal of the Indian Society of Soil Science*. 58(4): 388-393.

Kovar, J.L and Pierzynski, G.M. 2009. *Methods of Analysis for Soils, Sediments, Residuals and Waters*, Second edition, Virginia Tech University. 50-53.

Laxminarayana, K and Rajagopal,V. 2002. Relative contribution of different inorganic fractions of soil phosphorus to P uptake by rice. *Journal of Research ANGRAU*. 30(4): 17-26.

Murphy, J and Riley, J.P. 1962. A modified single solution method for determination of phosphate in natural waters. *Analytical Chemistry*. 27: 31-36.

Olsen, S.R., Cole, C.V., Frank, S.W and Dean, L.A. 1954. *Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate*. United States Department of Agriculture Circular. 939.

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., Mandal, D and Haldar, A. 2013. Distribution and forms of phosphorus in some red soils of Chotanagpur plateau, West Bengal. *Agropedology*. 23(2): 93-99.

Sowjanya, P., Rani, P.P and Vani P.M. 2017. Distribution of inorganic phosphorus fractions in soils of Bobbili mandal, Vizianagaram District, Andhra Pradesh. *Journal of Indian Society of Coastal Agricultural Research*. 35(1): 1-7.

Sudhakaran, S.V., Patil, S.R., Kondvilkar, N.B., Naik, R.M., Pharande and Kadlag, A.D. 2018. Effect of 32 year long-term integrated nutrient management on soil p fractions and availability of phosphorus under sorghum-wheat cropping sequence in vertisol. *Journal of Pharmacognosy and Phytochemisty*. 7(4): 3410-3416.

Tomar, N.K., Khanna, S.S and Gupta, A.P. 1984. Transformation of phosphates varying in nitrate and water solubility in calcareous soil after incubation with cattle dung. *Journal of the Indian Society of Soil Science*. 32: 421-426.

Viswanatha, J and Doddamani, V.S. (1991). Distribution of phosphorus fractions in some vertisols. *Journal of the Indian Society of Soil Science*. 39: 441-445.