



Status of Available Phosphorus and Forms of Phosphorus in Soil under Major Cropping Systems of Y.S.R. Kadapa District, A.P.

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Authors' contributions

This work was carried out in collaboration among all authors. Author GSK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors TGK and VM managed the analyses of the study. Author YRR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

An investigation was carried out to study different forms of phosphorus 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 physicochemical properties, status of available P₂O₅ 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 P₂O₅. Highest mean values for available P₂O₅ (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

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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.

Keywords: Forms of P; olsen-P; calcareous soil; alkaline soil; cropping systems.

1. 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, maintenance of an adequate amount of soil phosphorus through application of P inorganic and/ or organic 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 P nutrition of plants. Since various P fractions and their contribution to available P provide useful information in assessing the available P status of soils and various forms of soil P 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 [1].

2. MATERIALS AND METHODS

Five soil samples from each cropping system (Fallow-Bengalgram, Sunflower-Sesame, Paddy-Paddy, Groundnut monocropping, Groundnut-Groundnut) at 0-15 cm depth were collected from calcareous soils of Y.S.R. Kadapa district of southern zone of A.P. These soil samples were analysed for status of available P₂O₅ (Olsen-P) and different P fractions (Sal-P, Al-P, Fe-P, Ca-P, total-P and other forms of P). The available P₂O₅ was extracted by using Olsen's extractant (0.5 M NaHCO₃ of pH 8.5) as described by Olsen et al. [2] and the P content in the extract was determined by Murphy and Riley [3] method using ascorbic acid as the reducing agent using spectrophotometer.

The inorganic P 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 [4]. Total P in the soils was determined by perchloric acid digestion method

as described by Jackson [5]. 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.

3. RESULTS AND DISCUSSION

3.1 Physicochemical Properties of Soil

In calcareous soils of Y.S.R. Kadapa district, the pH of surface soils varied from 7.64 in paddy-paddy system to 8.81 in groundnut monocropping system with a mean value of 7.82 and 8.36, respectively (Table 1). The mean pH values in different cropping systems were in the order of groundnut monocropping system (8.36) followed by fallow-bengalgram system (8.33), groundnut-groundnut system (8.09), sunflower-sesame system (7.91) and paddy-paddy system (7.82).

The electrical conductivity measured was non-saline and below the critical limits. In calcareous soils of Y.S.R. Kadapa district, the EC of surface soils varied from 0.007 dSm⁻¹ in fallow-bengalgram cropping system to 0.117 dSm⁻¹ in paddy-paddy cropping sequence with a mean value of 0.014 and 0.097 dSm⁻¹, respectively (Table 1). The highest EC mean values were obtained in paddy-paddy system (0.097 dSm⁻¹) followed by groundnut monocropping system (0.066 dsm⁻¹), sunflower-sesame (0.03 dsm⁻¹), groundnut-groundnut system (0.025 dsm⁻¹), and fallow-bengalgram system (0.014 dsm⁻¹).

The free CaCO₃ varied from 4.5% in groundnut-groundnut cropping system to 15.5% in groundnut monocropping system with a mean value of 6.1% and 11.8%, respectively (Table 1). The highest free CaCO₃ mean values were obtained in groundnut monocropping system (11.8%) followed by paddy-paddy system (9.5%), fallow-bengalgram system (7.2%), sunflower-sesame system (7%) and groundnut-groundnut system (6.1%).

The available P₂O₅ of surface soils varied from 31.99 kg ha⁻¹ in fallow-bengalgram system to 253.72 kg ha⁻¹ in groundnut monocropping

Table 1. Physico-chemical properties of calcareous soils under different cropping systems in calcareous soils of Y.S.R. Kadapa district

S. no.	Cropping system	pH	EC (dSm ⁻¹)	CaCO ₃ %
1	Fallow-Bengalgram	8.22-8.45 (8.33)	0.007-0.018 (0.014)	5-11 (7.2)
2	Sunflower-Sesame	7.85-8.07 (7.91)	0.014-0.059 (0.03)	5-8.5 (7)
3	Paddy-Paddy	7.64-7.95 (7.82)	0.072-0.117 (0.097)	6-15 (9.5)
4	Groundnut monocropping	8.15-8.81 (8.36)	0.049-0.079 (0.066)	10.5-15.5 (11.8)
5	Groundnut-Groundnut	7.88-8.51 (8.09)	0.008-0.085 (0.025)	4.5-7.5 (6.1)

Note: Figures in parentheses indicate the mean value

system with a mean value of 34.80 kg ha⁻¹ and 182.41 kg ha⁻¹, respectively (Table 2). 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).

Available P₂O₅: The available P₂O₅ 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. [6] and Devra et al. [7]. These results help to reduce P doses for crops and reduce cost of cultivation to farmers.

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 3). 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. [8]. 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 [9], Viswanatha and Doddamani [10] and Jatav et al. [11] and Devra et al. [7]. 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 3). 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. [12]. Low Al-P in fallow-bengalgram 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. Sunflower and Sesame crops uptake much of

Table 2. Status of available P₂O₅ (kg ha⁻¹) under major cropping systems in calcareous soils of Y.S.R. Kadapa district

S. no.	Cropping system	Available P ₂ O 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

available nutrients from soil and leave the soil exhausted in fertility which is clearly visible in succeeding crops grown after maize and sesame.

Fe-P: The data on Fe-P in soil under different cropping systems is presented in (Table 3). 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 3). 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 CaCO₃ 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 [13] and Sowjanya et al. [14] and lowest values recorded in groundnut-groundnut cropping system might be due to low CaCO₃, and high utilization of Ca-P by groundnut crop. High Ca-P recorded under paddy-paddy system might be due to more solubilization of CaCO₃ 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 3). 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 [10] and Sowjanya et al. [14]. 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. Due to depletion of nutrients under the crops Sunflower and sesame, the total-P was observed low in soil.

Table 3. Distribution of different forms of P (mg kg⁻¹) 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

Other forms of P: The data on other forms of P in soil under different cropping systems is presented in (Table 3). 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. The results clearly indicate the accumulation and underutilization of other forms of P in fallow-bengalgram and groundnut monocropping systems compared to other systems in which the crops deplete the P form for their requirements.

4. CONCLUSION

In calcareous soils of Y.S.R. Kadapa district, the highest mean values for available P₂O₅, 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

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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