Available online at www.scholarsresearchlibrary.com

Scholars Research Library

Annals of Biological Research, 2015, 6 (11):11-16
(http://scholarsresearchlibrary.com/archive.html)

ISSN 0976-1233
CODEN (USA): ABRNBW

Effect of organics and inorganic phosphorus on inorganic P-fractions in soil of soy bean (*Glycine max* L.) crop

K. Kalyani, V. Sailaja, P. Surendra Babu, Syed Ahammad Hussain and B. Sreekanth

Department of Soil Science and Agricultural Chemistry, College of Agriculture, PJTSAU, Rajendranagar, Hyederabad

---

ABSTRACT

A field experiment was conducted during kharif, 2012 in a sandy clay loam, high P Alfisol at college farm College of agriculture, Rajendranagar, Hyderabad to study the response to P levels (0, 30 and 60 kg P_2O_5 ha^{-1}) either alone or in combination with PSB @ 5 kg/ha, biochar @ 5 t/ha, humicacid @ 20 kg ha^{-1} and citricacid @ 10 mM on the inorganic Phosphorus fractons in the rhizosphere soils of soybean crop. Among the inorganic P fractions estimated, Saloid-P is the smallest pool and Ca-P is the largest pool accounting for 0.5 and 77.4 per cent respectively of the total inorganic pool in initial soil. Saloid-P at flowering was 5.27 ppm, which was higher than that of 4.11 ppm at harvest. The Ca-P is the largest fraction of inorganic P and accounted for 75 % of total inorganic P at flowering that increased to 83.6 per cent at harvest. Inorganic P application increased the inorganic P fractions indicating the fixation of applied and native P. At both flowering and harvest stages, showed a significant reduction in the size of fixed P pool or increased the available P due to the application of biochar @ 5t/ha followed by the humic acid @ 20 kg/ha. When interaction effect was considered, application of inorganic at 30 kg P_2O_5 ha^{-1} incombination with biochar @ 5 t/ha recorded significantly higher inorganic P fractions.

Key words: Inorganic P fractions, biochar, humic acid, saloid-P, Al-P, Fe-P, Ca-P, Occluded-P, Soy bean

---

INTRODUCTION

Phosphorus is an important nutrient especially for pulses as a high phosphorus supply is needed for nodulation. It also influences N availability through N fixation. Phosphorus plays a pivotal role for the structure and regulatory functions in photosynthesis, root development, energy conservation and transformation, carbon metabolism, redox reactions, enzyme activation and inactivation, signaling and nucleic acid synthesis (Vance *et al.*, 2003). Organic matter additions were found to mobilize the fixed phosphates in the soil thus increasing the available P to crops (Venkateswarlu, 2000). The available information on the role of organics like PSB, biochar, humicacid and citricacid in combination with inorganic P sources is scanty, Hence, the present work was aimed at studying the effect of combined application of organic and inorganic sources of P on inorganic P fractions of rhizosphere soils of soybean.

MATERIALS AND METHODS

A field experiment was conducted during *kharif*, 2012 on high P Alfisol at college farm of college of agriculture, Rajendranagar, Hyderabad. The soil was sandy clay loam in texture, slightly alkaline (7.2 pH) in reaction, non saline (0.195 dS/m) in nature and medium in organic carbon (0.57 percent). The soil under study was low in available nitrogen (176.4 kg N/ha), high in phosphorus (68.50 kg P_2O_5/ha) and potassium (538.8 kg K_2O/ha) (Table 1). The experiment was laid out in split plot design with three replications. 3 main levels of Phosphorus (0, 30 and 60 kg P_2O_5 ha^{-1} viz., P0, P30 and P60) and five sub levels of organics (No organics, PSB, Biochar, Humicacid and Citricacid). PSB will be applied @ 5 kg/ha, Biochar @ 5 t/ha, Humic acid @ 20 kg/ha and Citric acid @ 10 mM concentration as basal application. Soybean J.S-335 variety was used for the study. All the cultural practices were followed as per the standard recommended practices. The plants were uprooted from the plot without disturbance and then the plant roots were shaken softly to remove the root-zone soils. The soil adhering to the surroundings of a root was called 'rhizosphere soil' in general, and the soil shaken off is 'root-zone soil'. Collected soils were sieved in a 1 mm mesh removing root hair as much as possible. The soil samples from individual treatmental plot were collected at flowering and harvest and analysed for inorganic P fractions. The soil samples from individual treatmental plot were collected at flowering and at harvest and assayed for inorganic P-fractions (Saloid-P, Al-P, Fe-P, Ca-P and Occluded-P) in the soil as described by Chang and Jackson, 1967.

Table 1. Salient soil characteristics of experimental site

S.No.	Name of the property	value
I.	**Physical properties**	
a)	Textural fraction	
	1) Sand (%)	72.04
	2) Silt (%)	7.4
	3) Clay (%)	20.56
b)	Textural class	Sandy clay loam
II.	**Physico-chemical analysis**	
a)	Soil reaction (pH)	7.64
b)	Electrical conductivity (dSm^{-1})	0.195
III.	**Chemical properties**	
a)	Organic carbon (%)	0.57
b)	Available Nitrogen (kg ha^{-1})	177
c)	Available phosphorus (kg P ha^{-1})	29.9
d)	Available potassium (kg K ha^{-1})	449
e)	Saloid-P (mg kg^{-1})	2.21
f)	Al-P (mg kg^{-1})	7.23
g)	Fe-P (mg kg^{-1})	35.2
h)	Ca-P (mg kg^{-1})	339
i)	Occluded-P (mg kg^{-1})	54.0

RESULTS AND DISCUSSION

Saloid-P

Saloid-P at flowering and harvest was presented in the table 2. At flowering, application of inorganic P at 30 and 60 kg P_2O_5 ha^{-1} resulted in a significant increase in saloid P to 5.18 and 6.52 mg kg^{-1} accounting for 26 and 59 per cent increase against 4.1 mg kg^{-1} when inorganic P was not applied. Biochar recorded significantly higher mean Saloid-P of 5.78 mg kg^{-1} across the inorganic P treatments against control and other organics. In alkaline soils, P solubility is primarily regulated by its interaction with Ca^{2+} where a cascading apatite mineral pathway develops. Biochar due to its high CEC might have adsorbed Ca^{2+} that otherwise may precipitate P thus reduce the precipitation of P with Ca. Biochar induced surface sorption of chelating organic molecules (Liang *et al*., 2006).

At harvest, Inorganic P when applied in graded levels increased significantly the mean saloid-P fraction at harvest from 3.14 mg kg^{-1} in control to 4.52 and 4.67 mg kg^{-1} respectively with 30 and 60 kg P_2O_5 ha^{-1} across the organics. Indiati and Sharpley (1998) also found that the there was an increase from 1-26 per cent in saloid P due to the applied P. Biochar recorded significantly higher mean saloid-P fraction of 4.47 mg kg^{-1} across the inorganic P treatments against control and other organics.

Al-P:

Al-P at flowering and harvest was presented in the table 3. At flowering, application of inorganic P at 60 kg showed a significant increase in mean Al-P by 37 per cent enhancing to 17.4 mg kg^{-1} against 10.9 mg kg^{-1} when inorganic P was not applied. This could be due to the release of soluble P into the soil by the application of inorganic P which might have entered into different inorganic P pools like Al-P. Biochar recorded significantly higher mean Al-P fraction of 15.5 mg kg^{-1} across the inorganic P treatments against control and organics. Biochar might have bound the phosphate with the bridging cations like Al^{3+}, Fe^{2+} and Ca^{2+} since it has high CEC thus resulting in high active P forms like Al-P.

At harvest, inorganic P at 30 kg P_2O_5 ha^{-1} showed significant influence on Al-P at harvest, the value being 12.0 mg kg^{-1} against 8.2 mg kg^{-1} when inorganic P was not applied. Biochar recorded significantly higher mean Al-P fraction across the inorganic P treatments when either PSB or citric acid were applied or when organics were not applied. However, the Al-P contained in the soil when either biochar or humic acid were applied was at a par with the corresponding Al-P of 11.8 and 11.1 mg kg^{-1}. The higher value could be due to the higher adsorption sites which may bind the phosphates with the bridging cations like Al^{3+}. At the highest level of inorganic P, the binding sites are the limiting factor for holding the excess phosphates released into the soil solution and hence the extent of adsorption remained almost same. Humic acids may result in the acidification of the rhizosphere. With the increase in acidity by the removal of exchangeable bases, there is an increase in Fe and Al activity and the more soluble fractions of P bound to Ca are converted to phosphorus bound to Al and Fe (Chang & Jackson, 1958).

Fe-P:

Fe-P at flowering and harvest was presented in the table 4. At flowering, application of inorganic P at 60 kg P_2O_5 ha^{-1} recorded significantly higher mean Fe-P fraction of 51.1 mg kg^{-1}. Biochar recorded significantly higher mean Fe-P fraction of 54.4 mg kg^{-1} across the inorganic P treatments against control and organics. Biochar might have encouraged the extensive root system and release of organic acids and phosphatases as root exudates. The root exudates might acidify the rhizosphere thus increasing the Fe-P. Fe-P fraction was significantly higher in the treatment receiving inorganic P at 60 kg P_2O_5 ha^{-1} when applied in integration with organics except citric acid; amongst them biochar recorded significantly higher Fe-P fraction of 58.2 mg kg^{-1}. When organics were not applied, all the values were at a par. Biochar adsorbs phosphates with Ca^{2+}, Al^{3+} and Fe^{3+} as bridging cations due to its high CEC thus increasing the size of the respective pools in soil that may form the quantity factor for long term availability. The results are concomitant with the findings of Gang *et al.* (2012).

At harvest, inorganic P application at 60 kg P_2O_5 ha^{-1} over organics showed a significant increase in mean Fe-P to 46.3 mg kg^{-1} against 37.9 mg kg^{-1} when inorganic P was not applied. Biochar was significant in increasing the mean Fe-P to 51.1 mg kg^{-1} against the mean value of 38.2 mg kg^{-1} obtained when inorganic P was applied alone. The Fe-P fraction was significantly higher in the treatment receiving inorganic P at 60 kg P_2O_5 ha^{-1} when applied alone and in integration with organics; amongst them biochar recorded significantly higher Fe-P fraction of 55.2 mg kg^{-1}. Fe-P fraction by biochar and P at 60 kg P_2O_5 ha^{-1} showed at a par with Fe-P fraction of inorganic P at 30 kg P_2O_5 ha^{-1}. Combined application of inorganic P at 30 kg P_2O_5 ha^{-1} with biochar was found to be significantly superior over any other combination of organics with inorganic P. Indiati and Sharpley (1998) also indicated 1 to 70 per cent enhancement in Fe-P due to the application of 100 mg P kg^{-1} of inorganic P.

Ca-P:

Ca-P at flowering and harvest was presented in the table 5. At flowering, application of inorganic P at 60 kg P_2O_5 ha^{-1} recorded significantly higher mean Ca-P fraction of 396 mg kg^{-1} against 383 mg kg^{-1} obtained when inorganic P was not applied. Significantly higher mean Ca-P of 421 mg kg^{-1} was obtained with biochar across the inorganic P, while significantly lower contents were found when either organics were not applied or integrated with PSB and citric acid. The dissolution of hydroxyl apatite can be enhanced if protons are supplied or if P or Ca ions are removed from the solution. Adsorption of P ions by other soil constituents may thus favour the dissolution as would the adsorption of Ca via cation exchange (Bolan *et al.*, 1990, Rajan *et al.*, 1996) or the complexation of Ca by an organic ligand such as citrate.

At harvest, application of inorganic P at 60 kg P_2O_5 ha^{-1} recorded significantly higher mean Ca-P of 380 mg kg^{-1}. Significantly higher mean Ca-P of 394 mg kg^{-1} was present in the soil when biochar was applied across the inorganic P, while it was on par with the Ca-P of 382 mg kg^{-1} due to humic acid. There was a decline in Ca-P from flowering to harvest by 6.4 and 2.6 per cent due to the integration with biochar and humic acid respectively and on a whole there was a reduction to the extent of 5.4 per cent. Similar decrease in CaP due to the application of humic acid was also reported by Wang *et al.* (1995).

Occluded-P:

Occluded-P at flowering and harvest was presented in the table 6. At flowering, Biochar recorded significantly higher mean Occluded-P fraction of 76.7 mg kg^{-1} across the inorganic P treatments against control and organics. Biochar recorded significantly higher occluded-P fraction of 73.4, 76.2 and 80.4 mg kg^{-1} respectively when inorganic P was not applied, applied at P 30 and 60 kg P_2O_5 ha^{-1}. At P_{30} and P_{60} level, occluded Fe-P fraction of biochar was at a par with humic acid.

At harvest, application of inorganic P at 60 kg P_2O_5 ha^{-1} recorded significantly higher mean Occluded-P fraction of 16.1 mg kg^{-1} against 14.7 mg kg^{-1} when inorganic P was not applied. However, P_{60} was at a par with the value obtained by P_{30}. Biochar recorded significantly higher mean occluded-P fraction of 17.4 mg kg^{-1} against control and organics. Significantly lower occluded P was obtained when organics were not added, which was on par with citric acid. Citric acid could decrease occluded P by reducing the pH. Rhizosphere acidification was due to the dissociation of protons from the functional groups. Similar occluded P values were reported by Galvani *et al.* (2008).

Table 4. Effect of inorganic P, organics and their interaction on Fe-P (mg kg^{-1}) at flowering and harvest in soils of soybean

Main Sub	Flowering				Harvest			
	Inorganic P levels (P_2O_5 kg ha^{-1})				Inorganic P levels (P_2O_5 kg ha^{-1})			
	P_0	P_{30}	P_{60}	Mean	P_0	P_{30}	P_{60}	Mean
No organics	44.8	45.0	46.3	**45.4**	36.5	38.9	39.3	**38.2**
PSB	43.2	45.4	49.3	**46.0**	36.2	39.1	45.1	**40.1**
Biochar	49.5	55.4	58.2	**54.4**	42.9	55.2	55.2	**51.1**
Humic acid	46.7	53.8	56.3	**52.3**	37.0	37.7	47.5	**40.7**
Citric acid	40.7	49.5	45.1	**45.1**	36.7	37.6	44.2	**39.5**
Mean	**45.0**	**49.8**	**51.1**		**37.9**	**41.7**	**46.3**	
	S.Em.±		**CD (*P*=0.05)**		**S.Em.±**		**CD (*P*=0.05)**	
M	0.5		1.9		0.3		1.1	
S	0.5		1.3		0.8		2.5	
M at S	0.8		2.3		1.5		4.3	
S at M	1.0		3.3		0.9		2.6	

Table 5. Effect of inorganic P, organics and their interaction on Ca-P (mg kg^{-1}) at flowering and harvest in soils of soybean

Main **Sub**	Flowering				Harvest			
	Inorganic P levels (P_2O_5 kg ha^{-1})				Inorganic P levels (P_2O_5 kg ha^{-1})			
	P_0	P_{30}	P_{60}	Mean	P_0	P_{30}	P_{60}	Mean
No organics	367	377	373	**373**	333	345	351	**343**
PSB	378	386	395	**386**	358	358	387	**367**
Biochar	407	425	430	**421**	384	394	403	**394**
Humic acid	386	391	399	**392**	369	385	393	**382**
Citric acid	376	383	384	**381**	344	376	365	**361**
Mean	**383**	**392**	**396**		**357**	**371**	**380**	
	S.Em.±		**CD (*P*=0.05)**		**S.Em.±**		**CD (*P*=0.05)**	
Main	2		8		3		11	
Sub	6		18		4		12	
Main at Sub	11		NS		7		NS	
Sub at Main	10		NS		7		NS	

Table 6. Effect of inorganic P, organics and their interaction on occluded-P (mg kg^{-1}) at flowering and harvest in soils of soybean

Main **Sub**	Flowering				Harvest			
	Main treatments (P_2O_5 kg ha^{-1})				Main treatments (P_2O_5 kg ha^{-1})			
	P_0	P_{30}	P_{60}	Mean	P_0	P_{30}	P_{60}	Mean
No organics	55.0	56.2	57.5	**56.2**	13.8	14.5	14.8	**14.4**
PSB	62.7	62.0	62.0	**62.2**	14.5	14.9	15.7	**15.0**
Biochar	73.4	76.2	80.4	**76.7**	16.2	17.7	18.4	**17.4**
Humic acid	66.2	73.6	75.9	**71.9**	14.9	15.9	16.1	**15.6**
Citric acid	61.3	59.6	62.7	**61.2**	14.3	14.6	15.3	**14.7**
Mean	**63.7**	**65.5**	**67.7**		**14.7**	**15.5**	**16.1**	
	S.Em.±		**CD (*P*=0.05)**		**S.Em.±**		**CD (*P*=0.05)**	
Main	0.5		1.8		0.1		0.4	
Sub	0.6		1.8		0.2		0.6	
Main at Sub	1.1		3.1		0.4		NS	
Sub at Main	1.0		3.2		0.3		NS	

CONCLUSION

Significantly higher mean Ca-P of 390 mg kg^{-1} was present in the soil at flowering and 369 mg kg^{-1} at harvest stage of soybean crop. Ca-P contributes to 75 % in total inorganic P. whereas, saloid-P was very low *i.e.*, 1 per cent of the total inorganic P content. Saloid-P at flowering and harvest was presented in the table 1. In rhizosphere soils, the degree of availability follows the order Ca P > Occluded-P > Fe P > Al P > saloid P. Among the organics biochar recorded significantly higher inorganic P fractions followed by humic acid.

REFERENCES

[1] NS Bolan; RE White; MJ Hedley. *Australian Jrnl. of Experimental Agrl.*, **1990**, 30, 297-313.
[2] SC Chang and ML Jackson. *Soil Science*, **1957**. 84, 133.
[3] SC Chang and ML Jackson. *Journal of Soil Science*, **1958**, 9, 109-119.
[4] R Galvani; LF K Hotta ; CA Rosolem. *Sci. Agric*., **2008**, 65 (4), 415-421.
[5] X Gang; S Hongbo; X Rongfu; Y Nie; Z Sun ; MSA Blackwell. *African Jrnl. of Microbiol. Research*. **2012**, 6(3), 674-679.
[6] R Indiati and AN Sharpley, A.N. *Communication in Soil Science Plant Analysis*, **1998**, 29(5&6), 625-634.
[7] B Liang; J Lehmann; D Solomon; J Kinyangi; J Grossman; 'O Neill; JO Skjemstad; J Thies; FJ Luizao; J Petersen; EG Neves. *Soil Sci. Society America Jrnl.*, **2006**, 70, 1719-1730.
[8] SSS Rajan; JH Watkinson; AG Sinclair. *Advances in Agronomy*, **1996**, 30, 159-206.
[9] CP Vance; CU Stone and DL Allan. *New Phytologist*, **2003**, 157, 423-457.
[10] B Venkateswarlu. *Ph.D. thesis*. Gujarat Agricultural University, Sardar Krishinagar, Gujarat, India, **2000**.
[11] XJ Wang; ZQ Wang ; SG Li. *Soil use manage*. **1995**, 11, 99-12.