International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(6): 2042-2045

Received: 25-09-2019
Accepted: 27-10-2019

Samanyita Mohanty
Department of Agricultural Chemistry and Soil Science, BCKV, Mohanpur, West Bengal, India

GH Santra
Department of Soil Science and Agricultural Chemistry, OUAT, Bhubaneswar, Odisha, India

Corresponding Author:
Samanyita Mohanty
Department of Agricultural Chemistry and Soil Science, BCKV, Mohanpur, West Bengal, India

Effect of phosphorus sources combination on productivity and nutrient uptake of maize and groundnut cropping sequence in *Alfisols* of Odisha

Samanyita Mohanty and GH Santra

Abstract
A field experiment was conducted during 2016-17 in *Alfisols* of Odisha to monitor the effects of different sources of phosphorus and its combination on productivity and nutrient uptake by maize-groundnut cropping sequence. Low Grade Rock phosphate (RP) and its various combination with SSP were used as nutrient sources during Kharif 2016 (Maize crop) and Rabi 2016-17 (Groundnut crop). The study comprised of eight treatments with lone sources of RP and SSP along with their different combinations, replicated thrice and they were evaluated for their effectiveness in the cropping system. Better performance of rock phosphate in combination with SSP at various proportions was observed as compared to lone rock phosphate or SSP sources. The combination significantly influenced the yield attributes and nutrient uptake of both maize and groundnut crops. Among the combination, equal proportion mixture of soluble (SSP) and insoluble (RP) source of P outreached the other combination ratios. The performance of the treatment which received lime along with water soluble P source proved to be best under acidic soil condition.

Keywords: Rock phosphate, single super phosphate, direct and residual effect, acid soil, maize, groundnut, nutrient uptake

Introduction

Phosphorus is an essential element in crop production. It plays an important role in crop maturation, root development, photosynthesis, N fixation and other vital processes (Uchida, 2000) [17]. Phosphorus which makes up 0.1 to 0.4 percent of the dry matter of the plants plays a key role in the transfer of energy. In the soil, P is present in the soil solution, soil organic matter or occurs as inorganic P. The chemistry of P in most mineral soils is rather complex owing to occurrence of series of instantaneous and simultaneous reactions such as dissolution, precipitation, sorption and oxidation-reduction. The P soluble compounds have very high reactivity, low solubility indices and low mobility (Phiri *et al.*, 2010) [13].

Rock phosphate is one of the basic raw material for the manufacture of commercial phosphatic fertilizers. Rock phosphate contains good P content (28-30%) but cannot be directly used as a fertilizer because of its poor release of P for the use of plant (Reddy *et al*., 2002) [15]. After industrial processing it gives rise to different soluble P fertilizers such as single super phosphate and triple superphosphate, with different levels of soluble P (Yingben *et al*., 2012) [19]. Its use as an input for phosphatic fertilizer production depends on its chemical and mineralogical properties. Besides rock phosphate, sulphur is another raw material required for the manufacture of H_2SO_4, which is imported and is used for the production of phosphatic fertilizers resulting in further increase in the price of processed phosphatic fertilizers. After decontrol of phosphatic fertilizer and subsequent price increase, the fertilizer consumption has become more imbalanced in India.

In Odisha, the acid soils occupy nearly 70 per cent of the total cultivated area (Misra *et al.*, 2002) [10]. Entire upland (46%) and major part of the medium lands (30%) are acidic. About 21.2 per cent of the acid soil (pH < 5.5) is strongly acidic in nature. Since seventy percent of cultivable land of Odisha is covered by acid soil so rock phosphate being a cheaper and environmentally safer source can be profitably used to maintain the P requirement for optimising production. Thus, an experiment was targeted with the objective of formulating means to increase the efficiency of Rock phosphate in soil either by providing the soil conditions most conducive for maximum dissolution of it in soil or by using a mixture of SSP & Rock phosphate to utilize the natural resource of Rock phosphate most effectively and economically.

Materials and Methods

Study sites

The experimental site was located in the Central Farm, OUAT, Bhubaneshwar at 85^0 47' 18" E latitude 20^0 16' 51" N longitudes with an elevation of 25.9 meter above mean sea level. The zone falls under hot and humid climate having mean minimum and maximum temperature 22.6 °C and 32.6 °C respectively. The soil is hyperthermic (ustic haplustalf, US Soil Taxonomy, Soil Survey Staff 2003) and loamy in texture. The pH of the initial soil was 5.2 in reaction with sand, silt and clay values of 64.6, 14.8 and 20.6 per cent respectively. The soil had available Bray's P- 15.68 kg ha^{-1} (medium), Available N -239 kg ha^{-1}(low), Available K-150 kg ha^{-1} (medium) and Organic carbon- 3.4 g kg^{-1} soil while exchangeable Ca and Mg were 0.89 and 0.13 c mol (P^+) kg^{-1} respectively.

Field layout and treatments

Field experimental trial was conducted out in dominant acid soil regions of the Dry land Farm, OUAT with Maize-Groundnut cropping sequence (maize var. PAC-752 and groundnut var. TAG-24) during Kharif 2016 – Rabi session 2016-17 following Randomized Block Design with eight treatments - T_1 Control, T_2 100% P(RP),T_3 100% P(SSP), T_4 75% P(RP) + 25% P(SSP), T_5 50% P(RP) + 50% P(SSP), T_6 25% P(RP) + 75% P(SSP), T_7 200%P(RP) (only on first crop) and T_8 100% P(SSP) + Lime @ 0.2 LR and each treatment was replicated thrice.

Collection, processing and analysis of Plant samples

Five plants (both maize and groundnut) from each treatment were selected randomly (avoiding boundary line) and biometric observations were recorded. After washing and drying, the samples were kept inside the oven at 75 ^{0}C temperature till constant weight was attained. The different plant parts were grinded and preserved for analysis of P, K, Ca, and S concentration. Yield data for both the crops (cob, grain, pod and haulm) were recorded from a harvest area of 10 m^2 and expressed in a common unit.

Statistical Analysis

The experimental data pertaining to nutrient uptakes and yield was recorded and analyzed statistically as per the procedure appropriate to the design (Panse and Sukhatme, 1978) [11] and Gomez and Gomez (1976) [6].

Empirical formula

Uptake of different nutrients viz. P, K, S and Ca by both maize and groundnut crop was calculated using the formula below;

$$\text{Nutrient uptake (Kg ha}^{-1}) = \frac{\text{Nutrient concentration (\%)} \times \text{Dry matter (Kg ha}^{-1})}{100}$$

Result and discussion

Total biomass production in the cropping sequence:

The grain and stover yields of maize with different P treatments and their combination revealed that grain yield ranged from 2.43 to 5.14 t ha^{-1} and stover yield ranged from 3.04 to 5.97 t ha^{-1} in different treatments. Lowest yield was recorded in no P (control) whereas highest was with treatment which received 100%P (SSP) along with lime. The grain and stover yield increased by 69.5 to 111.5 per cent and 58.5 to 96.3 per cent respectively due to application of various P sources over control. Rock phosphate along with SSP at various combinations did not differ among themselves and yield was at par with treatment that received 100% P (SSP). The better performance of rock phosphate in combination with SSP over lone rock phosphate source may be attributed to greater dissolution of rock phosphate through SSP which improved the nutrient availability to the crop. Similar results were reported by Jena *et al*., 2004 [8] for rock phosphate and SSP combination in acid soils.

The effect of all P sources and their combination significantly altered the pod and haulm yield of groundnut over control (no P), the percent increase being 28.8 to 63.3 per cent and 23.6 to 100 per cent respectively (Table 1). Highest effect was observed in treatment that received100%P (SSP) along with lime (2.94 t ha^{-1}) followed by treatments which received rock phosphate and SSP in equal and 3:1 proportion. The residual effect of rock phosphate source (200%) produced at par yield with the treatments that received lone rock phosphate and SSP sources. The total biomass of the cropping sequence ranged from 9.81 to 19.13 t ha^{-1}.

Table 1: Total biomass production (t ha^{-1}) as influenced by various P-sources and their combination

Treatment		Biomass production(t ha^{-1})						
		Maize			Groundnut			Combined
		Grain	Stover	Total	Pod	Haulm	Total	Total Biomass
T_1	Control	2.43	3.04	5.47	1.80	2.54	4.34	9.81
T_2	100% P(RP)	4.18	5.01	9.19	2.52	3.62	6.14	15.33
T_3	100% P(SSP)	4.51	5.43	9.94	2.45	3.91	6.36	16.3
T_4	75%P(RP)+25% P(SSP)	4.37	5.68	10.05	2.62	4.08	6.70	16.75
T_5	50%P(RP)+50% P(SSP)	4.94	5.80	10.74	2.71	4.95	7.66	18.4
T_6	25%P(RP)+75%P (SSP)	4.62	4.97	9.59	2.43	3.73	6.16	15.75
T_7	200%P(RP)(only on 1st crop)	4.12	4.82	8.94	2.32	3.14	5.46	14.4
T_8	100%P(SSP)+Lime@0.2 LR	5.14	5.97	11.11	2.94	5.08	8.02	19.13
LSD(p=0.05)		0.76	0.71	-	0.42	0.72	0.88	-
CV(%)		7.04	5.14	-	6.13	6.73	5.02	-

Nutrient uptake in the cropping sequence

The uptake of phosphorus, sulphur and calcium in the cropping sequence under different treatments revealed that uptake of all these nutrients was more in maize crop as compared to groundnut as because maize is an exhaustive crop (Table 2). The total phosphorus uptake in the cropping sequence ranged from 10.14 to 30.15 kg ha^{-1}. The total uptake of sulphur and calcium in the cropping sequence ranged from 10.27 to 29.42 kg ha^{-1} and 39.68 to 92.23 kg ha^{-1} respectively. The phosphorus, sulphur and calcium uptake (x) was significantly related to the total biomass production (Y) with R^2 values of 0.968, 0.973 and 0.993 respectively (Table 3). Combination of rock phosphate and SSP significantly enhanced the uptake of phosphorus, sulphur and calcium in the cropping sequence over the lone rock phosphate source and control (no P) which may be due to better availability of calcium and sulphur to the crops under such treatments.

Table 2: Uptake of phosphorus, sulphur and calcium (kg ha^{-1}) as affected by addition of various P sources and their combinations in the cropping sequence.

Treatment		Phosphorus (kg ha^{-1})			Sulphur (kg ha^{-1})			Calcium (kg ha^{-1})		
		Maize	G.nut	Total uptake	Maize	G.nut	Total uptake	Maize	G.nut	Total uptake
T_1	Control (-P)	5.17	4.97	10.14	5.87	4.40	10.27	29.73	9.95	39.68
T_2	100% P(RP)	9.93	11.16	19.97	10.60	8.66	19.26	54.78	15.40	70.18
T_3	100% P(SSP)	12.99	10.56	24.99	12.57	10.91	23.48	62.88	15.69	78.57
T_4	75% P(RP)+25% P(SSP)	13.10	11.25	24.35	12.98	10.22	23.20	63.75	16.85	80.60
T_5	50% P(RP)+50% P(SSP)	14.12	13.30	27.57	14.85	10.32	25.17	70.72	19.61	90.33
T_6	25% P(RP)+75% P(SSP)	12.82	9.79	22.61	12.31	8.75	21.06	57.20	15.00	72.20
T_7	200% P through RP (Only on 1st crop)	8.80	8.20	17.00	11.33	7.21	18.54	55.07	13.24	68.31
T_8	100% P (SSP) + 0.2LR	16.25	13.7	30.15	17.59	11.83	29.42	73.46	18.77	92.23
LSD(p=0.05)		3.38	1.79	-	3.34	1.67	-	8.11	2.25	-
CV(%)		15.0	6.24	-	9.83	6.61	-	5.02	5.27	-

Table 3: Relationship between nutrient uptake with total biomass yield of (Maize + Groundnut) crop

Correlation of variables			
Dependent Variable (Y)	**Independent Variable (x)**	**R^2 value**	**Regression equation**
Total biomass yield	Phosphorus uptake	0.968	$Y= 0.057x^2+0.526x-0.802$
Total biomass yield	Sulphur uptake	0.973	$Y= 0.038x^2+0.847x-1.856$
Total biomass yield	Calcium uptake	0.993	$Y= 0.021x^2+5.252x-13.80$

Conclusion

From the above study it was concluded that in weakly acidic soil, application of lime as an ameliorant along with single super phosphate source resulted in higher yield as well as uptake of various nutrients in the cropping sequence as compared to other treatments. Application of rock phosphate in combination with single super phosphate at various proportions resulted in higher yield and uptake in the cropping sequence over lone source of rock phosphate and single super phosphate. Although the direct effect of high dose of rock phosphate influenced the maize crop but its residual effect was very poor to influence the yield and uptake of nutrients of the succeeding groundnut crop.

References

1. AOAC. Official methods of Analysis. Association of Official Agricultural Chemists (10th edition) Washington D.C., 1960.
2. Black CA. Methods of soil analysis, Part-II, America Society of Agronomy. Inc. Madison. USA, 1965.
3. Bray's RA, Kurtz LT. Determination of total, organic and available forms of phosphorus in soil. Soil Science, 1945; 59:39-45.
4. Chapman HD. Methods of Soil Analysis, Part-II, American Society of Agronomy. Inc. Wisconsin, USA: 1965, 891-900.
5. Chesnin L, Yien CH. Turbidimetric determination of available sulphur. Soil Science Society of America Proceedings. 1955; 15:149-151.
6. Gomez KA, Gomez AA. Statistical procedures for agricultural research (2 ed.), John Wiley and Sons, New York, 1984.
7. Jackson ML. Soil chemical analysis, Prentice Hall of India, Pvt. Ltd. New Delhi, 1973.
8. Jena D, Jena MK, Pattanayak SK, Sahu D. Direct effect of compacted rock phosphates on Maize and their residual effect on succeeding mustard crop in the sequence. Indian Journal of Dryland Agriculture Research and Development. 2004; 19(2):117-112.
9. Hesse PR. A text book of soil chemical analysis John Murry (Publishers) Ltd, Albemarle Street, London. Wis-4 B.D. 1971, 50.
10. Misra UK, Das N. Phosphorous availability to maize as influenced by organic amendments, Journal of Indian Society of Soil Science. 2002; 48:298-305.
11. Panse VG, Sukhatme PV. Statistical methods for Agricultural workers. ICAR, New Delhi, 1978.
12. Page AL, Miller RH, Keeney DR. Methods of soil analysis-part 2. Chemical and microbiological properties, 2nd (Ed) No. 9, Agronomy series ASA-SSSA publishers, Madison Wisconsin, USA, 1982.
13. Phiri AT, Njoloma JP, Kanyama GY, Snapp S, Lowole MW. Maize yield response to the combined application of Tundulu rock phosphate and Pigeon Pea residues in Kasungu, Central Malawi, African Journal of Agricultural Research. 2010; 5(11):1235-1242.
14. Piper CS. Soil and Plant analysis University of Adelaide, Australia, 1950.
15. Reddy MS, Kumar S, Khosla B. Biosolubilization of poorly soluble rock phosphates by *Aspergillus tubingensis* and *Aspergillus niger*. Bio Resource Technology. 2002; 84:187-189.
16. Subbiah BV, Asija GL. A rapid procedure for determination of available nitrogen in soils, Current Science. 1956; 25:259-260.
17. Uchida R. Essential nutrients for plant growth: nutrient functions and deficiency symptoms (from Plant nutrient management in Hawaii soils (eds) Silva, J. & Uchida, S., College of tropical agriculture and human resources, 2000; 3:31-56.
18. Vasundhara. Evaluation of low grade rock phosphate combination with SSP as a source of P in groundnut-maize cropping sequence in *Alfisols* of Odisha. Thesis

submitted to the OUAT, Bhubaneswar for the degree of Master of Soil Science in Agriculture, 2016.

19. Yingben W, Yualin H, Hangmei Y, Wei C, Zhen W, Lijuan X *et al*. Isolation of phosphate solubilizing fungus and its application in solubilizing rock phosphate, Pakistan Journal of Biological Sciences. 2012; 15(23):1144-1151.