

Effect of Phosphorus Sources on Maize Productivity in Alfisols

Vasundhara, C. Sarangi, G. H. Santra

Received 2 June 2017; Accepted 5 July 2017; Published online 22 July 2017

Abstract A field experiment was laid out in Alfisols at OGUAT of during *kharif* 2015 to study effect of phosphorus sources on maize productivity, relative agronomic efficiency and agronomic use efficiency of P in RBD with seven treatments replicated thrice. The soil was loamy textured with pH 5.2 and exchangeable Ca $0.89 \text{ [cmol (p)}^+\text{kg}^{-1}]$. The soil had the available Bray's P 15.68 kg ha^{-1} (low), available N 239 kg ha^{-1} (low), available K 150 kg ha^{-1} (medium) and organic carbon 3.4 g kg^{-1} . Maximum productivity of 21.3 q ha^{-1} was produced by 100% P (SSP) + Lime @ 0.2 L.R. The highest RAE of 144% and maximum agronomic use efficiency of P (55.4) was with the same treatment.

Keywords Phosphorus, Maize, Relative agronomic efficiency, Agronomic use efficiency.

Introduction

Phosphorus is regarded as the master key element in crop production because of its pivotal role in the normal growth and establishment of root system, seed formation and maturity besides being an essential constituent of nucleic acids. It also plays an important role in photosynthesis, nitrogen fixation and other vital processes. As a nutrient it is second in importance only to nitrogen. In the soil, P is present in the soil solution, soil organic matter or occurs as inorganic P. Unlike nitrogen, phosphorus cannot be fixed from the atmosphere. It is generally regarded as the nutrient that is most limiting in tropical soils including Malawainsoils. The work on phosphorus nutrition of plant carried out in India suggest that above 15.25% applied P is only utilized by the crop, the fertilizer use efficiency being on the lower side when the soil is acidic

In India, about 49 million hectares of cultivated area are considered acidic, out of which 26 million hectares have pH below 5.6 and 2.3 million hectares between 5.5 and 6.5. In Odisha the acid soils occupy nearly 70% of the total cultivated area. Entire upland (46%) and major part of medium land (30%) are acidic. About 21.2% of the acid soil ($\text{pH} < 5.5$) is strongly acidic in nature. Out of the 30 districts of the state in 15 districts more than 70% of the soils are acidic (Cuttack, Kendrapada, Mayurbhanj, Nayagarh, Anugul, Kandhamal Jagatsinghpur, Jaipur, Koraput, Khurda, Navrangpur, Malkangiri, Dhenkanal, Puri and Raygada). The acidic soils develop physical, chemical, nutritional and biological constraints, for crop

Vasundhara, G. H. Santra
Department of Soil Science and Agricultural Chemistry, CA
Bhubaneswar 751003, India

C. Sarangi*
Assistant Professor, College of Horticulture,
Chiplima 768025, India
e-mail: crsarangi2014@yahoo.com

*Correspondence

production in terms of soil crusting (affecting seed germination), high infiltration rate, low water holding capacity, high permeability, low pH, low cation exchange capacity (due to dominance of 1 : 1 type of clay), low base saturation (16-67%), high Al, Fe and Mn saturation percentage, high P fixing capacity (92%), poor availability of essential plant nutrients like Ca, Mg, P, Mo, B and Si, poor microbial activity and biologically mediated nutrient transformation processes, low N_2 fixation due to poor *Rhizobial* activity. Restoration of lost basic cations, amelioration of acidity, supplementation of different nutrients as per crop requirement, judicious use of chemical fertilizers can help in management of acid soils. To create a favorable environment for uptake of other essential nutrients and higher crop yields, liming is an important management option in acid soils. Liming is the addition of any compound containing calcium or calcium plus magnesium to the acid soils that are capable of reducing the acidity of the soil. The main aim of liming is to neutralize acidic inputs and to recover the buffering capacity of the soil. In the present agricultural scenario, the high cost of conventional water soluble phosphatic fertilizers like SSP and DAP restricts their use by resource-poor farmers in developing countries like India. Thus, phosphatic fertilizers can be completely or partly substituted by rock phosphates depending on the reactivity of the rock and soil pH [1]. Crop response to phosphate rock application is strongly dependent upon the rate of dissolution of rock which can be recommended for direct use as it is economic, has longer residual effect and has a potential use in plantation and long duration crops, minimizes phosphorus fixation in acid soils, has considerable liming action by reducing soil acidity, increases the availability of other essential nutrient elements including calcium, magnesium, boron. Maize is one of the most popular crops in Odisha. However research on use of rock phosphates compacted with water soluble sources is very meager. Therefore, the present investigation aims at studying the efficiency of rock phosphate, namely sourced from FCI Aravali Gypsum and Minerals India Ltd, Jodhpur alone and its different combinations with single super phosphate in maize with the objective to study the direct effect of low grade rock-phosphate alone its combinations with SSP on productivity and nutrient use efficiency of maize.

Table 1. Physico-chemical properties of experimental soil (as in 2014).

Physical parameter	Value
Sand (%)	64.6
Silt (%)	14.8
Clay (%)	20.6
Texture	Loam
Bulk density ($Mg\ m^{-3}$)	1.57
Water holding capacity (%)	31
Exchangeable acidity	
Exchange acidity [$cmol\ (p^+) \ kg^{-1}$]	0.11
Exchangeable Al^{3+} [$cmol\ (p^+) \ kg^{-1}$]	0.05
Exchangeable H^+ [$cmol\ (p^+) \ kg^{-1}$]	0.06
Chemical parameters	
EC (dSm^{-1})	0.09
pHw (1:2.5)	5.2
Organic carbon ($g\ kg^{-1}$ Soil)	3.4
Available nitrogen ($kg\ ha^{-1}$)	239
Available phosphorus (Bray's) ($kg\ ha^{-1}$)	15.68
Available potassium ($kg\ ha^{-1}$)	150
Available sulfur ($kg\ ha^{-1}$)	27
Exchangeable Ca^{2+} [$cmol\ (p^+) \ kg^{-1}$]	0.89
Exchangeable Mg^{2+} [$cmol\ (p^+) \ kg^{-1}$]	0.13
Lime requirement [$t\ CaCO_3\ ha^{-1}$]	1.75

Materials and Methods

The efficiency of rock phosphate namely sourced from FCI Aravali Gypsum and Minerals India Ltd., Jodhpur alone and its different combinations with Single Super Phosphate (SSP) in maize crop during *kharif* 2015-16 was studied with the help of a field experiment. The Central Farm, OUAT, Bhubaneswar ($85^{\circ} 47' 18'' E$ and $20^{\circ} 16' 51'' N$) with an elevation of 25.9 m msl in a well drained medium land with rolling topography with assured irrigation. The field experimental was conducted with maize during *kharif* 2015-16 following randomized block design with seven treatments and three replications. Each plot measured ($10\ m \times 10\ m$). Initial soil samples were collected and recommended agronomic package of practices were followed. The treatments were- T_1 Control, T_2 100% P (rock phosphate), 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) and T_7 100% P (SSP) + Lime @ 0.2 LR with genotype PAC-752 (120 days). The fertilizer dose was 150-50-50 ($N-P_2O_5-K_2O$) $kg\ ha^{-1}$. The soil

samples were analyzed for different physico-chemical parameters by adopting standard methods [2]. The results are presented in Table 1.

The cob and stover yields were recorded, compiled in appropriate tables, and analyzed statistically [3]. The nutrient use efficiencies were calculated using the following formulae :

$$\text{Relative Agronomic Efficiency (\%)} = \frac{\text{Grain Yield}_F - \text{Grain Yield}_C}{\text{Grain Yield}_{St} - \text{Grain Yield}_C} \times 100 \quad (1)$$

$$\text{Agronomic Use Efficiency of P} = \frac{\text{Grain Yield}_F - \text{Grain Yield}_C}{\text{Amount of Nutrient Applied (kg)}} \quad (2)$$

Where F, C, and St. denotes fertilized, control and standard plot respectively. The data are presented in Table 2.

Results and Discussion

From Table 1 it is revealed that the soil was loamy textured with pH 5.2 and exchangeable Ca 0.89 [cmol (p)⁺ kg⁻¹]. The soil had the available Bray's P 15.68 kg ha⁻¹ (low), available N 239 kg ha⁻¹ (low), available K 150 kg ha⁻¹ (medium) and organic carbon 3.4g kg⁻¹.

Effect of P sources on maize productivity

Grain and stover yield

It is revealed from Table 2 that the application of P significantly increased the grain yield of maize. The grain yield varied from 9.2 to 21.3 q ha⁻¹, lowest being in no-P control and highest in 100% P (SSP) + Lime @ 0.2 LR. Yield due to 50% P (RP) + 50% P (SSP) (19.5 q ha⁻¹) was higher than 75% P (RP) + 25% P (SSP) (18.0 q ha⁻¹).

The soil having pH 5.2 and low available P as Bray's P (15.68 q ha⁻¹) upon application of 50 kg P₂O₅ ha⁻¹ through various sources responded well, increasing the productivity to a maximum of 21.3 q ha⁻¹. It was achieved with addition of lime @ 0.2LR to soluble source (SSP) of P which when applied alone yielded 17.6 q.ha⁻¹. Liming improved the productivity to the tune of 21%. Decreasing the proportion of water

Table 2. Effect of phosphorus sources on yield, RAE and agronomic use efficiency of P of maize crop.

Sl. No.	Treatments	Yield (q ha ⁻¹)		Agronomic use efficiency of P	
		Grain	Stover	RAE	
1	Control	9.2	7.2	-	-
2	100% P (RP)	14.9	12.4	68	26.1
3	100% P (SSP)	17.6	15.3	100	38.5
4	75% P (RP)+25% P (SSP)	18.0	16.7	105	40.3
5	50% P (RP)+50% P (SSP)	19.5	17.9	123	47.2
6	25% P (RP)+75% P (SSP)	17.0	15.5	93	35.7
7	100% P (SSP)+ Lime @0.2 L.R	21.3	20.8	144	55.4
	SEm (±)	0.344	0.153	-	-
	CD (0.05)	1.06	0.473	-	-

soluble source by 25% and adding that amount through low grade rock phosphate decreased the productivity by 3.4%. Increasing the ratio to 50%, the productivity increased by 10.8%. Reducing the proportion of water soluble source (SSP) by 75% and adding that amount through rock phosphate raised the productivity only by 2.3%. Substituting the soluble source by 100% P (RP), reduced the productivity by 15.3%. It corroborates [4, 5].

The stover yields were significantly different from each other. The yields obtained by application of 100% P (SSP) + Lime @ 0.2 LR (20.8 q ha⁻¹), 50% P (RP) + 50% P (SSP) (17.9 q ha⁻¹), 75% P (RP) + 25% P (SSP) (16.7 q ha⁻¹) and 100% P (SSP) (15.3 q ha⁻¹) were in that order but at par. It follows the same trend as the grain yield [4, 5].

Application of P increased the stover yield to a maximum of 20.8 q ha⁻¹. It was achieved with addition of lime @ 0.2 LR to soluble source (SSP) of P which yielded 15.3 q ha⁻¹. Liming improved the productivity to the tune of 35% it corroborates earlier findings [4, 5].

RAE of different P sources varied from 68 to 144%. Combination of rock phosphate with water soluble SSP improved their efficiency. The treatment 100% P (SSP) + Lime @ 0.2 LR showed the highest RAE of 144%. The agronomic use efficiency of P of different sources varied from 26.1 to 55.4. Application of P as 100% SSP and Lime @ 0.2 LR resulted in maxi-

mum agronomic use efficiency of P (55.4) followed by 1:1 mixture of RP and SSP (47.2). It corroborates the findings [4, 5].

Conclusion

SSP + Lime@0.2 LR was found to be superior to SSP. Compaction of the rock phosphate with water soluble source improved their efficacy over the lone RP source. Liming @ 0.21 LR along with water soluble source was the best treatment followed by equal proportion mixture of soluble (SSP) and insoluble (RP) source of P. Among the combination products 50% P(RP) + 50%P (SSP) proved to be better.

References

1. Basak BB, Biswas DR (2016) Potentiality of Indian rock phosphate as liming material in acid soil. *Geoderma* 263 : 104—109.
2. Jackson ML (1973) Soil chemical analysis. Prentice Hall of India, Pvt Ltd, New Delhi.
3. Gomez KA, Gomez AA (1976) In statistical procedure for agricultural research. IRRI, Philippines.
4. Behera RD (2014) Comparative performance of different types of liming materials for maize crop grown in acid soil. Thesis. OUAT, Bhubaneswar.
5. Hayagreeva NR (2015) Evaluation of low grade rock phosphate and its combination with SSP as a source of phosphorus in groundnut in *Alfisols* of Odisha. Thesis. OUAT, Bhubaneswar.