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Influence of low grade rock phosphate alone and in combination with SSP on yield and nutrient uptake of maize-groundnut cropping sequence in Alfisols

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Abstract
A field experiment was conducted with maize-groundnut cropping sequence. Rock phosphate and its combination with Single super phosphate (SSP) were used as nutrient sources during Rabi 2016-17 (maize taken up in Kharif 2016). The study was carried out in the Central Farm, OUAT with the help of a field experiment laid out in Randomized Block Design with seven treatment 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) and T_7 100% P(SSP) + Lime @ 0.2 Lime requirement (LR) and replicated in thrice. The soil of the experimental field was loamy acidic (pH 5.2) having Bray's P of 15.68 kg ha^{-1}. The different combinations with single super phosphate (SSP) were evaluated for their effectiveness in the cropping system. In addition to P applied @50kg P_2O_5 ha^{-1} and 40 kg P_2O_5 ha^{-1} to maize and groundnut crops respectively from various sources, N was added @ 150kg ha^{-1} to maize and 20 kg ha^{-1} to groundnut crop in the form of urea and K @50 and 40 kg K_2O ha^{-1} was added to maize and groundnut crop in the form of murate of potash (MOP). Highest maize grain yield (5.03 t ha^{-1}) was produced due to addition of 100%P (SSP) +Lime @0.2LR and highest pod yield (2.77 t ha^{-1}) of groundnut was also due to 100%P (SSP)+Lime@0.2LR. Yield due to single super phosphate (SSP) and lime applied in combination was more than lone application of single super phosphate (SSP). Lone sources of rock phosphate (RP) was better in respect of pod yield of groundnut than lone sources of single super phosphate (SSP). All the combination of Rock phosphate and soluble source single super phosphate was produced better yield than lone source of single super phosphate except treatment received 25%P (RP) +75%P (SSP). The treatment 100%P (SSP) +Lime @0.2LR also recorded the highest uptake of nutrients like P, S, Ca and K.

Keywords: low grade rock phosphate (rp), single super phosphate (ssp), lime@0.2lr, loamy acidic soil, maize-groundnut crop, urea, murate of potash (mop), lime requirement (LR)

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 harvesting of the crop maturity besides being an essential constituent of nucleic acids (Mangel and Kirkby, 1987) [1]. It also plays any important role in photosynthesis, nitrogen fixation and other vital processes (Uchida, 2000) [2]. In the soil, P is present in the soil solution, soil organic matter or occurs as in organic 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 Malawain soils (Phiri *et al*, 2010) [3].

Rock phosphate is out of the basic raw material for the manufacture of commercial phosphatic fertilizers. Its usefulness for phosphatic fertilizer production depend on its chemical and mineralogical composition. Phosphatic rock and apatite are referred to micro-crystalline calcium fluroapatite of sedimentary origin and microcrystalline fluroapatite of igneous origin respectively. Rock phosphate of sedimentary origin is generally reactive and very much suitable for low pH, low calcium saturation and low available Phosphorus. Besides phosphate rock, sulphur is the other raw material required for the manufacture of H_2SO_4 which is imported and used for production of phosphatic fertilizer resulting in a marked increase in the cost of nutrient phosphorus is processed phosphatic fertilizer. After decontrol of phosphatic fertilizer and consequent increase in its price reduce phosphatic fertilizer use in India as a result fertilizer consumption has become more imbalanced.

A large part of Odisha is also covered with acidic red and laterite soil (Mitra *et al*., 1993) [4]. Entire upland (46%) and major part of medium land (30%) are acidic. About 21.2% of the acid soil (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, Jajpur, Koraput, Khurda, Navrangpur, Malkangiri, Dhenkanal, Puri, Raygada).

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. Liming of acid soil is the way to raise pH, base status, cation exchange capacity, inactive Al, Fe and Mn in soil solution and reduce P fixation. To create a favourable environment for uptake of other essential nutrients and higher crop yields, liming is an important management option in acid soils.

Materials and Methods

The efficiency of Rock Phosphate namely sourced from FCI Aravali Gypsum & Minerals India Ltd., Jodhpur alone and its different combination with Single Super Phosphate (SSP) in Maize - Groundnut cropping sequence during Kharif - Rabi session 2016-17 was studied with the help of a field experiment.

The experimental site is located in the Central Farm, OUAT, and Bhubaneswar which lies at 850 47' 18" E latitude 200 16' 51" N longitudes with an elevation of 25.9 meter above mean sea level. The summer months from March to May / June are hot and humid. The mean minimum and maximum temperature were 22.6ºC and 32.6ºC respectively. Temperatures drop December and January in approximately 15° C during these months.

The physico-chemical properties of the soil of experimental site was loamy texture with pH 5.2 and Exchangeable Ca^{2+} 0.89 [cmol (p^+) kg^{-1}]. The soil had the available Bray's P 15.68 kg ha^{-1} (medium), Available Nitrogen 239 kg ha^{-1}(low), Available Potassium 150 kg ha^{-1} (medium) and Organic carbon 3.4 g kg^{-1} Soil.

Experimental Design and Treatments

field experimental design laid out in Randomized Block Design with seven treatment 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) and T_7 100% P(SSP) + Lime @ 0.2 LR and replicated in thrice times.

Crop Information and Inputs

Test Crop	Maize	Groundnut
Variety	PAC-752	TAG-24
Duration	120 days	120 days
Season	Kharif	Rabi
Fertilizer dose	150-50-50	20-40-40
(N-P_2O_5-K_2O) kg ha^{-1}		
Lime	@ 0.2 L.R	@ 0.2 L.R

Collection and Processing of Soil and Plant samples

The samples were dried under shade, grinded with wooden hammer and sieved through 2 mm sieve. The samples were preserved in polythene bags with proper labels for analysis. Five plants from each treatment were selected randomly (avoiding boundary line). After washing with deionised water and sun drying the samples were kept inside the oven at 75^0C temperature till constant weight was attained. The plant samples were grinded in a wiley mill to pass through 20 mesh sieve and were preserved in paper envelopes for analysis.

Method of analysis

The soil samples were analyzed for different physico-chemical parameters by adopting following standard methods. The sand, silt and clay content of the soil samples were determined by Bouyoucos Hydrometer method as described by Piper (1950) [5]. Soil pH was determined in 1:2.5 soils: water ratio by pH meter as described by Jackson (1973) [6]. The Organic carbon content of soil was determined by wet digestion procedure of Walkley and Black as outlined by Page *et. al.*, (1982) [7].

Available nitrogen in soil was determined by alkaline $KMnO_4$ method (Subbiah and Asija, 1956) [8]. Available phosphorous in the soil was determined by Bray's 1 method (Bray and Kurtz, 1945) as out lined by page *et al.*, (1982). Available potassium was determined by extracting the soil with neutral normal ammonium acetate solution and estimated by flame photometer. Available sulphur was determined by extracting the soil with 0.15 per cent $CaCl_2$ solution and determined colorimetrically by turbidimetric method using $BaCl_2$ (Chesin and Yien, 1951) [9]. The NH4OAc extract was evaporated to dryness, treated with aquarejia (HCl: HNO_3=3:1) again evaporated to dryness and diluted with distilled water to suitable volume. The Calcium were determined by using EDTA (Versenate) complexometric titration by using Calcon indicators as outline by Hesse (1971) [10].

The plant and grain samples were analyzed for determination of N, P, K, Ca and S concentration. Nitrogen in the processed sample was determined by Kjeldahl digestion method as described in AOAC (1960). The P, K, Ca, and S were determined by pre-digested in diacidmixure [HNO_3: $HClO_4$ (3:2)]. Aliquot was collected, dilution was made. The P and S were estimated by help of spectrophotometer, K by flame photometer, Calcium by EDTA titration method (Jackson, 1973) [6].

Statistical Analysis

The experimental data pertaining to biometric observations, nutrient uptake, yield were recorded, compiled in appropriate tables and analyzed statistically as per the procedure appropriate to the design (Panse and Sukhatme, 1978) [11].

Empericalformulae

$$\text{Nutrient uptake (Kg ha}^{-1}\text{)} : \frac{\text{Nutrient conc. (\%) X Dry matter (Kg ha}^{-1}\text{)}}{100}$$

Results and Discussion

The soil was loamy in texture with acidic pH 5.2 (acidic) and exchangeable Ca 0.89 [cmol (P^+) kg^{-1} soil], organic carbon 3.4 g kg^{-1}, low available P, available N and medium available K, qualifying for Alfisols i.e. ustichaplustalf with hyperthermic temperature regime.

Table 1: Physico-chemical properties of the experimental soils

Physical Parameters	
Sand (%)	64.6
Silt (%)	14.8
Clay (%)	20.6
Texture	Loam
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 Sulphur (kg ha^{-1})	27
Exchangeable Ca^{2+} [cmol(p^+) kg^{-1}]	0.89

Total biomass production (t ha^{-1}) in the cropping sequence as affected by different P-sources

The total biomass production in maize which ranged from 5.59-11.15 t ha^{-1} with the treatment control and 100% P (SSP) + Lime @ 0.2 LR respectively. The highest biomass yield was produced by the treatment received 100% P (SSP) +Lime@ 0.2 LR (11.15 t ha^{-1}).

The same trend was observed in total biomass production in groundnut which ranged from 4.07 – 7.67 t ha^{-1} the total biomass produced by cropping system ranged from 9.66-18.82 (t ha^{-1}) with control and 100% P (SSP) +Lime@ 0.2 LR. The treatment received 50% (RP) +50%SSP followed the 2nd highest.

Uptake of Nutrients

Uptake of Phosphorus, Sulphur, Calcium and Potassium in the cropping sequence

The uptake of phosphorus was more than groundnut might be caused due to more yield in case of maize. The uptake (X) was significantly related to total biomass production (Y) as $Y = 0.140x^2 - 1.525x + 9.921$ with $R^2=0.971$.

The total S uptake of the sequence ranged from 14.29- 62.97 kg ha^{-1}, with the maximum being with 100% P (SSP)+Lime@0.2LR (62.97 kg ha^{-1}) followed by 50%P(RP)+50% P(SSP) (49.83 kg ha^{-1}). The uptake (X) was significantly related to total biomass production (Y) as $Y = 0.285x^2 - 3.456x + 21.68$ with $R^2=0.932$.

The total Ca uptake of the sequence ranged from 14.40-51.40 kg ha^{-1}.100% P(SSP)+Lime@0.2LR (51.40 kg ha^{-1}) recorded the maximum uptake followed by 50%P(RP)+50% P(SSP) (48.40 kg ha^{-1}). The uptake (X) was significantly related to total biomass production (Y) as $Y = 0.481x^2 - 9.745x + 64.03$ with $R^2=0.941$.

The total K uptake of the sequence ranged from 28.44-88.76 kg ha^{-1}.The maximum uptake was observed with 100% P(SSP)+Lime@0.2 LR (88.76 kg ha^{-1}) followed by 50%P(RP)+50% P(SSP) (75.88 kg ha^{-1}). The uptake (X) was significantly related to total biomass production (Y) as $Y = 0.335x^2 - 3.585x + 32.65$ with $R^2=0.922$.

Table 2: Total biomass production (t ha^{-1}) in the cropping sequence as affected by different P-sources

Treatment		**Biomass production (t ha^{-1})**						
		Maize			**Groundnut**			**Maize+ Groundnut**
		Grain	**Stover**	**Total**	**Pod**	**Haulm**	**Total**	**Total biomass (t ha^{-1})**
T1	Control	2.44	3.15	5.59	1.67	2.40	4.07	9.66
T2	100% P(RP)	4.13	5.21	9.34	2.47	3.37	5.83	15.17
T3	100% P(SSP)	4.35	5.80	10.15	2.23	3.80	6.03	16.18
T4	75%P (RP)+25% P(SSP)	4.90	5.97	10.87	2.50	3.87	6.37	17.24
T5	50%P (RP)+50% P(SSP)	4.94	5.83	10.77	2.60	4.73	7.33	18.10
T6	25%P (RP)+75%P (SSP)	4.30	4.90	9.20	2.10	3.50	5.60	14.80
T7	100%P (SSP)+ Lime@ 0.2LR	5.03	6.12	11.15	2.77	4.90	7.67	18.82
	S.E.M(±)	0.12	0.15	0.16	0.21	0.34	0.05	-
	CD(0.05)	0.35	0.44	0.49	0.62	1.02	0.14	-

Table 3: Uptake of Phosphorus, Sulphur, Calcium and Potassium (Uptake of Nutrients (kg ha^{-1}) as affected by addition of various P- sources in the cropping sequence.

Treatment		**Phosphorus**			**Sulphur**			**Calcium**			**Potassium**		
		Maize	**G. Nut**	**Total**	**Maize**	**G. Nut**	**Total**	**Maize**	**G. Nut**	**Total**	**Maize**	**G. Nut**	**Total**
T_1	Control	4.1	4.04	8.14	10.12	4.17	14.29	5.12	9.28	14.40	10.8	17.64	28.44
T_2	100% P(RP)	9.4	9.41	18.81	28.69	8.06	36.75	12.5	13.28	25.78	21.7	30.12	51.82
T_3	100% P(SSP)	13.2	8.41	21.61	31.11	8.95	40.06	18.01	10.95	28.96	29	30.84	59.84
T_4	75%P (RP)+25%P(SSP)	14.8	10.62	25.42	32.01	8.60	40.61	22.4	13.43	35.83	33.7	31.01	64.71
T_5	50%P (RP)+50%P(SSP)	15.6	10.45	26.05	40.7	9.13	49.83	33.41	14.99	48.40	39.4	36.48	75.88
T_6	25%P (RP)+75%P(SSP)	11.9	7.40	19.30	28.6	7.46	36.06	19.22	11.07	30.29	31.6	30.71	62.31
T_7	100%P(SSP)+ Lime@0.2 LR	21.3	11.41	32.71	52.52	10.45	62.97	35.52	15.88	51.40	51.8	36.96	88.76
	S.E.M(±)	0.262	0.88	-	0.33	0.81	-	0.147	0.94	-	0.242	1.43	-
	CD(0.05)	0.807	2.57	-	1.03	2.44	-	0.452	2.81	-	0.745	4.27	-

Conclusion

The treatment 100%P (SSP) + Lime @ 0.2LR also recorded the highest yield and uptake of nutrients like P, S, Ca and K as compared to other treatments.

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