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Effect of the availability of various nutrients in maize-groundnut cropping sequence after application of various P sources in an *Alfisols*

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Abstract
Low grade Rock phosphate (RP) was supplied by FCI Aravali Gypsum and Minerals India ltd. A field experiment was conducted with maize-groundnut cropping sequence. Rock phosphate and its combination with 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 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 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 MOP. The results of present investigation were obtained that the harvest of the crop the soil exhibited a marginal increase or decrease in the available N level. 100% P (SSP) + Lime @ 0.2 LR exhibited the maximum available N throughout the growth period of groundnut. The treatment 100% P (SSP) + Lime@ 0.2 L.R produced maximum soil available P during flowering and harvesting stages (33.7 and 27.7 kg P_2O_5 ha^{-1}). This level of potassium slightly decreased towards the harvest of the crop. The maximum available S was obtained with 100% P (SSP) + Lime@ 0.2 LR followed by 100% P (SSP) at all stages of growth. Control had the lowest available S during the period of all growth stages. The treatment received 75% P (RP) +25% P (SSP) produced maximum and the minimum available Ca in control plot at all growth stages.

Keywords: Rock phosphate (RP), Single super phosphate (SSP), Lime requirement (LR)

1. 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 (Mengel and Kirkby, 1987) [7]. It also plays any important role in photosynthesis, nitrogen fixation and other vital processes (Uchida, 2000) [17]. 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) [11]. The work on phosphorus nutrition of plant carried out in India suggest that about 15-25 percent applied P is only utilized by the crop, the fertilizer use efficiency being on the lower side when the soil is acidic (Tandon, 1987) [15].

In India, about 49 million hectors of cultivated area are considered acidic, out of which 26 million hectors have pH below 5.6 and 2.3 million hectors between 5.5 and 6.5 (Bhumbla and Mandal, 1972) [1]. A large part of Odisha is also covered with acidic red and laterite soil (Mitra *et al.*, 1993) [8]. 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).

The high content of exchangeable Al limits root growth and decrease crop production due to Al toxicity (Watanabe *et al.*, 2006) [19]. In addition to Al toxicity, deficiency of P is one of the important obstacles to farming acid dry land (Vitousek *et al.*, 2010) [18]. In acid soils, the majority of P added to the soil will be transformed into forms of Al - P and Fe – P (Trevisan *et al.*, 2010) [16].

The forms are relatively insoluble in the soil, thus the availability of P in acid soils is relatively low (Setiawati *et al.*, 2016) [13]. The acidic soils develop physical, chemical, nutritional and biological constraints for crop 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 1:1type of clay), low base saturation (16-67%), high Al, Fe and Mn saturation percentage, high P fixing capacity (92%) (Pattanayak and Misra, 1989) [10], 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 etc. Thus, it is a need of hour to improve nutrient availability and food production, especially in the maize-groundnut yield.

2. 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 2015-16 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 22.6 °C and 32.6 °C respectively. Temperatures drop December and January in approximately 15° C during these months.

2.1 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.

2.2 Crop Information and Inputs Used

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

2.3 Collection and processing of soil sample

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.

2.4 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) [12]. 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) [9].

Available nitrogen in soil was determined by alkaline $KMnO_4$ method by Subbiah and Asija, (1956) [14]. Available phosphorous in the soil was determined by Bray's 1 method (Bray and Kurtz, 1945) [2] as out lined by page *et al.*, (1982) [9]. 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 $BaCl_2$ (Chesnin and Yien, 1951) [3]. The NH_4OAc 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) [5].

2.5 Statistical Analysis

The data recorded for different parameters were analyzed with the help of analysis of variance (ANOVA) technique (Gomez and Gomez, 1984) [4] for randomized block design. ANOVA was found significant and accordingly results are presented at 5% level of significance (P=0.05).

3. Results and Discussion

The physico-chemical properties of the soil of experimental site are given in Table-1. It had 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.

Table 1: Physico-chemical properties of the experimental soil

Physical Parameters	
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
pH_w (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
Exchangeable Mg^{2+}[cmol(p^+) kg^{-1}]	0.13
Lime requirement [t $CaCO_3$ ha^{-1}]	1.75

3.1 Effect on soil properties

3.1.1 Soil Reaction

The change in soil reaction during the growth of Groundnut crop has been shown in Table 2. At the time of harvest of maize crop the soil was acidic. The pH of the soil varied between 5.03 to 5.69. At flowering it ranged from 4.95 to 5.80 and harvest 4.80 to 5.70. The pH of the soil was higher in flowering than at Pod formation4.80 to 5.70. Soils treated with Rock Phosphate and various combination products maintained higher pH than the soil treated with 100% P (SSP).

3.1.2 Available Nitrogen
Available nitrogen level of soil at different growth stages of groundnut crop has been shown in Table 2. All the treatments exhibited a decreasing trend throughout the growing period. The nitrogen level in soil after the harvest of maize varied between 167 to 212 kg ha^{-1}. It increased in the flowering stage of the plant to a level ranging from 218 to 265 kg ha^{-1} after which there was a considerable decline in its concentration at pod formation stage. Towards the harvest of the crop the soil exhibited a marginal increase or decrease in the available N level. 100% P (SSP) + Lime @ 0.2 LR exhibited the maximum available N throughout the growth period of groundnut.

3.1.3 Available Phosphorus
Addition of another dose of P resulted in higher status of available P for Groundnut crop (Table 2). At flowering stage it ranged from 10.2 kg ha^{-1} in control to 33.7 kg ha^{-1} in 100%P(SSP)+ Lime @ 0.2 LR treated soil. The available P status of soil suffered a drop during Pod formation and showed a marginal change in all the treatments towards the harvest stage. The available P from the lone SSP sources (T3) was the lowest among P sources. It might be caused due to less release and fixation of this source. Out of the restsources100% P(SSP)+Lime@ 0.2L.R maintained the available P higher than all other source followed by 75% P(RP) +25% P(SSP). In all the days studied. The treatment 100%P(SSP)+Lime@ 0.2L.R produced maximum soil available P during flowering and harvesting stages(33.7 and 27.7 kg P_2O_5 ha^{-1}).

3.1.4 Available Potassium
Soils at flowering stage of groundnut crop contained 158 to 202 kg K ha^{-1} (Table 3) which further decreased to a level ranging from 149 to 195 kg ha^{-1} at pod formation stage. This level of potassium slightly decreased towards the harvest of the crop. The study the K content of the soil increased in the following order control,100%P(RP), 100% P(SSP), 50% P(RP)+50%P(SSP), 25% P(RP)+75% P(SSP), 100% P(SSP)+Lime@0.2LR, 75%P(RP)+25% P(SSP).

3.1.5 Available Sulphur
Information's relating to available sulphur in soil is given in Table 3. After harvest of maize available sulphur in soil varied between 28.33 to 55.62 kg ha^{-1}. At flowering stage of groundnut it increased and varied between 30.67 to 60.05 kg ha^{-1}. It was decreased later in soil during crop growth. The maximum available S was obtained with 100% P(SSP)+ Lime@ 0.2 LR followed by 100% P(SSP) at all stages of growth. Control had the lowest available S during the period of all growth stages. 100% P(RP) and 75% P(RP)+25%P(SSP) were less than 50% P(RP)+50% P(SSP) which was in turn lesser than 25%P(RP)+75% P(SSP). However as compared to initial status of 27 kg S ha^{-1} it had increased in all the treatments after harvest of maize crops and decreased after harvest of groundnut might be much more uptake by groundnut as it was oil seed crops.

3.1.6 Exchangeable Calcium
Soil exchangeable calcium status has been given in Table 3. At the time of maize harvest it varied from 0.69 to 0.74 [cmol (P^+) kg^{-1}soil] in various treatments. The results revealed that exchangeable calcium decreased in all the treatments throughout the period but showed a marginal increase after harvest of groundnut crop. The treatment received 75% P (RP) +25% P (SSP) produced maximum and the minimum available Ca in control plot at all growth stages of study. Exchangeable Ca levels among the P sources can be arranged in ascending order as 100% P(RP), 100% P (SSP),50% P(RP)+50% P(SSP) in all the growth stages. However there was considerable decreased in its status in all the treatments except RP: SSP (3:1) as compared to initial status of 0.89 [cmol (P^+) kg^{-1} soil] after harvest of maize crops.

Table 2: Soil Reaction (pH), Available Nitrogen (N), and Phosphorus (P) status of soil at Harvest stage of Maize and different growth stages of Groundnut crop treated with various Phosphorus sources.

	Treatment	Soil reaction (pH)				Available N in soil (kg ha^{-1})				Available P in soil (kg ha^{-1})			
		Harvest of Maize crop	Growth stage of Groundnut crop			Harvest of Maize crop	Growth stage of Groundnut crop			Harvest of Maize crop	Growth stage of Groundnut crop		
			Flowering	Pod formation	Harvest		Flowering	Pod formation	Harvest		Flowering	Pod formation	Harvest
T1	Control	5.03	4.95	4.80	4.95	167	218	187	187	11.7	10.2	10.0	8.5
T2	100% P(RP)	5.39	5.50	5.30	5.45	172	223	223	218	17.2	24.3	20.3	22.7
T3	100% P(SSP)	5.18	5.19	5.10	5.15	180	228	227	234	21.1	20.0	18.0	16.7
T4	75%P(RP)+25% P(SSP)	5.70	5.60	5.30	5.54	191	223	208	202	25.2	34.0	24.7	23.3
T5	50%P(RP)+50% P(SSP)	5.69	5.73	5.55	5.65	199	249	238	239	26.3	30.3	26.0	24.0
T6	25%P(RP)+75%P (SSP)	5.60	5.70	5.50	5.55	191	253	249	239	20.5	21.3	19.3	18.0
T7	100%P(SSP)+ Lime @0.2 L.R	5.69	5.80	5.70	5.75	212	265	249	253	31.7	33.7	24.3	27.7
	S.E.M(±)	-	-	-	-	3.95	13.40	12.81	14.37	0.83	1.59	1.59	2.06
	CD(0.05)	-	-	-	-	11.83	40.16	38.39	43.05	2.49	4.76	4.77	6.18

Table 3: Available Potassium (K), Sulphur (S) and Exchangeable Calcium (Ca) status of soil at Harvest stage of Maize and different growth stages of Groundnut crop treated with various Phosphorus sources

	Treatment	Available K in soil (kg ha^{-1})				Available S in soil (kg ha^{-1})				Exchangeable Ca [cmol (P^+) kg^{-1} soil]			
		Harvest of Maize crop	Growth stage of Groundnut crop			Harvest of Maize crop	Growth stage of Groundnut crop			Harvest of Maize crop	Growth stage of Groundnut crop		
			Flowering	Pod formation	Harvest		Flowering	Pod formation	Harvest		Flowering	Pod formation	Harvest
T_1	Control	134	158	149	131	28.33	30.67	23.99	16.67	0.69	0.46	0.35	0.47
T_2	100% P(RP)	138	165	153	132	46.22	50.42	25.32	20.33	0.72	0.59	0.49	0.52
T_3	100% P(SSP)	139	168	159	138	47.32	54.12	31.49	25.00	0.74	0.63	0.51	0.56
T_4	75%P(RP)+25% P(SSP)	136	172	159	156	39.44	44.14	25.49	22.67	0.96	0.97	0.59	0.71
T_5	50%P(RP)+50% P(SSP)	142	174	171	168	42.92	52.46	25.97	23.67	0.82	0.85	0.53	0.63
T_6	25%P(RP)+75%P (SSP)	144	178	177	175	50.27	54.03	26.04	24.33	0.87	0.88	0.57	0.67

T_7	100%P(SSP)+ Lime @0.2 L.R	155	202	195	190	55.62	60.05	36.9	28.00	0.74	0.65	0.53	0.61
	S.E.M(±)	3.58	5.00	7.68	6.23	3.41	2.75	2.06	2.27	0.06	0.05	0.05	0.03
	CD(0.05)	10.74	14.98	23.01	18.68	10.21	8.24	6.17	6.79	0.18	0.16	0.16	0.09

4. Conclusion

The harvest of the crop the soil exhibited a marginal increase or decrease in the available N level. 100% P (SSP) + Lime @ 0.2 LR exhibited the maximum available N throughout the growth period of groundnut. The treatment 100% P (SSP) + Lime@ 0.2 L.R produced maximum soil available P during flowering and harvesting stages (33.7 and 27.7 kg P_2O_5 ha^{-1}). This level of potassium slightly decreased towards the harvest of the crop. The maximum available S was obtained with 100% P (SSP) + Lime@ 0.2 LR followed by 100% P (SSP) at all stages of growth. Control had the lowest available S during the period of all growth stages. The treatment received 75% P (RP) +25% P (SSP) produced maximum and the minimum available Ca in control plot at all growth stages.

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