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Change in available sulphur, sulphur build up as influenced by the application of low grade rock phosphate, single super phosphate and their mixtures in a groundnut-maize cropping system on the acid Alfisols of Odisha State, India

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Abstract
To find out the effect of low grade Udaipur rock phosphate (URP), single super phosphate and their mixtures on soil available sulphur at different growth stages of a groundnut- maize cropping system, a field experiment was conducted in a randomized block design with three replications and eight treatments from 2013-14 to 2015. The soil has a loam texture, a pH of 5.18, low available nitrogen and medium phosphorus and potassium. In control, soil available sulphur decreased gradually from the initial value of 27.45 to 12.35 kg ha^{-1} after four seasons. In sole URP treatments (T_2 and T_7) the soil available sulphur in T_2 and T_7 after four seasons were 29.67 and 22.54 kg ha^{-1} respectively. The highest value of soil available sulphur 38.41 kg ha^{-1} was recorded in SSP+ lime treatment (T_8) followed by 35.71 in SSP (T_3) and 33.13 kg ha^{-1} in URP+SSP 1:1 (T_5) treatments respectively.

Keywords: URP; available sulphur; sulphur build up; groundnut-maize cropping system

Introduction

Experimental site

The effects of low grade Udaipur rock phosphate (URP), single super phosphate (SSP) and their combinations on changes in soil exchangeable calcium in different growth stages was studied in a groundnut-maize cropping system during two consecutive years (2013-2014 to 2015) through a field experiment. The experiment was conducted in the Central Farm, Odisha University of Agriculture and Technology. The site is at Bhubaneswar 85° 47' 18" E latitude 20° 16' 51" N longitudes with an elevation of 25.9 m above mean sea level. It is situated at about 64 km away from the Bay of Bengal within the East and South- Eastern Coastal Plain agro-climatic zone of Odisha and falls under the East Coastal Plains and Hills zone of the humid tropics of India. The climate is characterized as hot, moist and sub-humid with hot summers and mild winters. Broadly, 76% of the annual rainfall is received during June - September. The rainfall is monsoonal and unimodal. The south-west monsoon usually sets in around mid-June and recedes by mid-October.

Experimental design and treatments

The experiment was conducted in a randomized block design with 8 treatments and 3 replications. Treatments were : T_1-Control P; T_2-100%P (URP); T_3-100% P(SSP); T_4- 75% P (URP) + 25% P (SSP); T_5-50% P (URP) + 50% P (SSP); T_6-25% P (URP) + 75% P (SSP); T_7-200% P (URP) only on 1st crop; T_8- 100% P (SSP) + lime@0.2 LR. Each plot was 10 m x10 m. The groundnut crop cv. TAG 24 of 115 days duration was sown during rabi 2013-14 and rabi 2014-15 at a spacing of 30x10 cm. Except the control treatment (T_1), the crop received recommended doses of N, P_2O_5, K_2O @ 20:40:40 kg ha^{-1}. Control treatment (T_1) received only N and K_2O at 20 and 40 kg ha^{-1}respectively. All N, P, K were applied as basal dose. Phosphorus was applied in all the treatments from T_2 to T_8 with the sources as per treatments. The hybrid maize crop cv. P-3441 of 90 days duration was sown during kharif 2014 and kharif

2015 at a spacing of 60 x 30 cm. Except the control treatment (T_1), the crop received recommended doses of N, P_2O_5, K_2O @ 100:50:50 kg ha^{-1}. Control treatment (T_1) received only N and K_2O 100 and 50 kg ha^{-1}. The crop received one third dose of nitrogen, full dose of P and half dose of K as basal at the time of sowing. Rest one third dose of nitrogen and half dose of potash were applied at 25 DAS. Remaining one third dose of nitrogen was applied at 50 DAS. Phosphorus was applied in all the treatments from T_2 to T_8 as per treatments at sowing. A composite soil sample (0 -15 cm depth) was collected from the experimental site before sowing of seeds and fertilizers application.

Crop management

All the recommended agronomic practices i.e., irrigation, intercultural operations, pest control were uniformly kept in all the treatments as and when needed. The mean temperatures during groundnut crop growing seasons were 26.5°C and 28.0°C respectively while the relative humidity 67.6% and 67.0% respectively. The mean temperatures during hybrid maize crop growing seasons were 27.9°C and 28.8°C respectively while the relative humidity 83.7% and 82.3% respectively.

Soil sampling, processing and analysis

Soil samples (0-15 cm) were collected from each treatment replication wise at flowering (30 DAS), pod formation (60 DAS) and harvesting (115 DAS) stage of groundnut crop and knee-high (30 DAS), tasseling (60 DAS) and harvesting stage (90 DAS) stage of maize crop. The samples were air dried under shade, crushed with wooden hammer and passed through 2 mm sieve and preserved in polythene bags for analysis. Analyses were for: soil texture, bulk density, water holding capacity, pH, electrical conductivity, lime requirement value, organic carbon, exchange acidity, exchangeable acidity, exchangeable calcium, effective cation exchange capacity, available nitrogen, available phosphorus, available potassium, available sulfur. The texture of soil samples were determined with the help of Bouyoucous Hydrometer as given by Piper (1950) [11]. The bulk density of soil (undisturbed) was determined by Core method (Black, 1965) [1]. The water holding capacity of soil samples were determined by Keen Raczkowski Box method (Piper, 1950) [11]. The pH was determined in 1:2.5 soil-water ratio by pH meter (ELICO LI 613 pH meter) as described by Jackson (1973) [8]. As suggested by Jackson (1973) [8], the electrical conductivity of soil samples was determined in 1:2.5 soil-water suspension by conductivity meter (ELICO CM 180 Conductivity meter). Lime requirement value of soil was determined by Woodruff Buffer method (Woodruff, 1948). The organic carbon content of soil was determined by Wet digestion procedure of Walkley and Black (1934) [14] as outlined in soil chemical analysis (Page *et al.*, 1982) [10]. Exchange acidity, exchangeable acidity: Exchange acidity, exchangeable acidity were estimated by using the methods of Lin and Coleman (1960) [9] as described by Page *et al.*, (1982) [10]. Exchangeable Calcium was determined using EDTA (Versenate) complexometric titration by using Calcon indicator as outline by Hesse (1971) [7]. Effective Cation Exchange Capacity refers to the sum of the milli equivalents of Ca, Mg, K, Na plus H and Al. Exchangeable Ca, Mg, K and Na were extracted using neutral normal ammonium acetate and determined separately. Available nitrogen in soil was determined by alkaline KMnO4 method (Subbiah and Asija, 1956) [13] using Kelplus nitrogen auto analyzer (Kelplus: Model classic DX). 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) [10]. Available potassium was determined by extracting the soil with neutral normal ammonium acetate solution and estimated by flame photometer as described by Hanway and Heidal (1952) [6]. The available S content was determined turbidimetrically following the procedure of Chesnin and Yien (1952) [3] as described by Page *et al*., (1982) [10].

Statistical analysis of data

The data from the experiment were analysed statistically following the procedure given by Gomez and Gomez (1984) [5]. Whenever the treatmental differences were significant, critical difference were calculated at five per cent probability level and used for interpretations.

Results and discussion

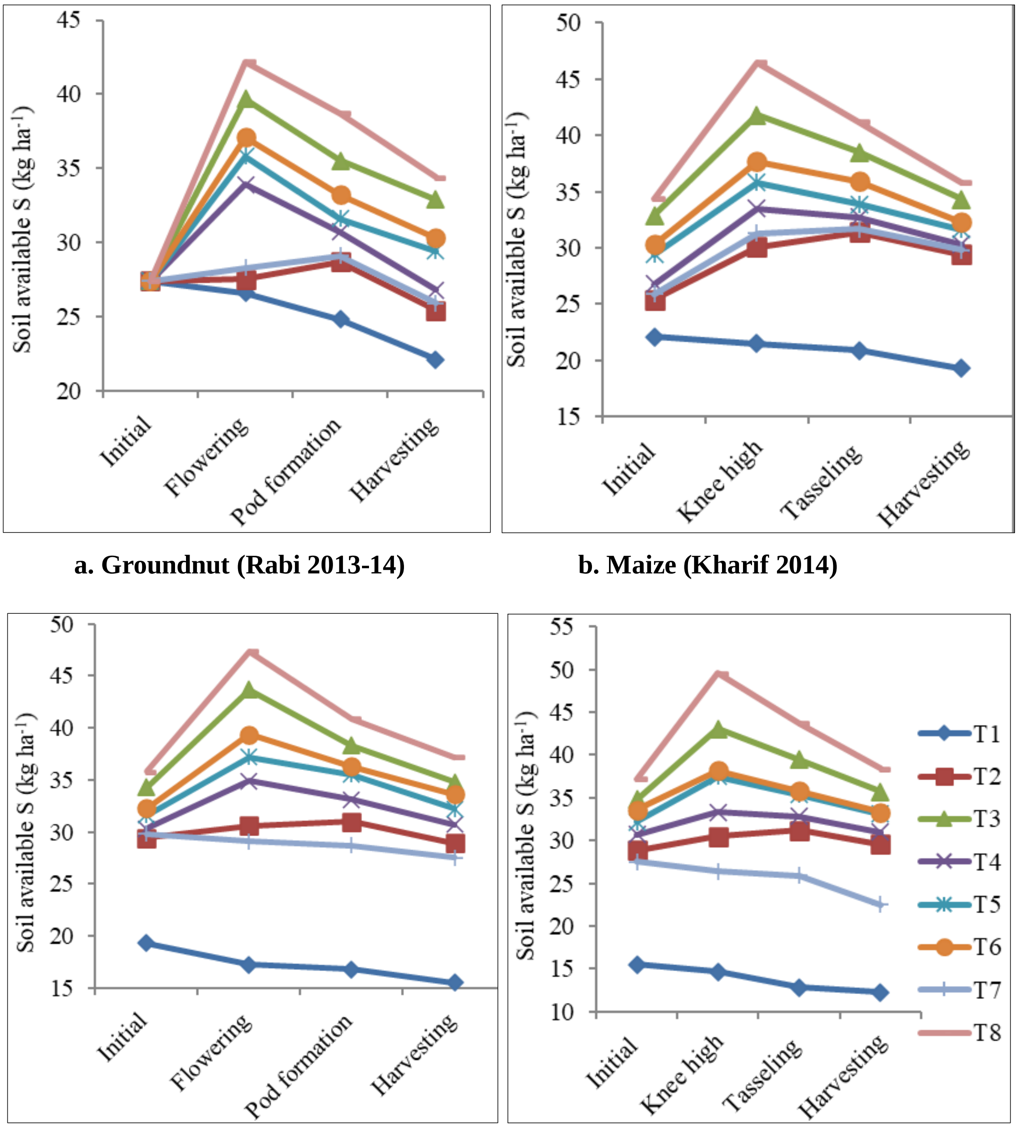
The soil of the experimental site is loam in texture with 64.6% sand, 14.8% silt and 20.6% of clay. The maximum water holding capacity is 31% with bulk density (BD) 1.59 Mg m^{-3}. The soil is acidic in reaction (pH-5.18), non saline (EC- 0.09 dS m^{-1}) with exchangeable Al^{3+} and exchangeable H^+ of 0.05 and 0.06 c mol (p+) kg^{-1} respectively. The soil is low in available N (239.0 kg ha^{-1}), medium in P (14.64 kg ha^{-1}) and K (150.0 kg ha^{-1}) and S (27.4 kg ha^{-1}) indicating low soil fertility. The CEC is 4.2 c mol (p^+) kg^{-1} soil and base saturation of 43%. The samples of URP used had 7.8% total P, 25.6% Ca, 0.26% Mg, 0.24% K and 1.2% S indicating a moderate reactivity of the material.

Available sulphur

Figure 1 presented the available sulphur content in soil at various stages of growth of groundnut- maize cropping system. In control treatment the available sulphur content decreased gradually from initial value of 27.45 kg ha^{-1} to 26.63, 24.83 and 22.18 kg ha^{-1} at flowering, pod formation and harvest stage of groundnut during rabi 2013-14.

On the other hand, when the crop received URP alone either at 100% (T_2) or 200% P(T_7), it increased from initial value, attained the peak (28.75-29.17 kg ha^{-1}) at pod formation stage and then declined at harvest. At harvest the values were lower than the initial value. But in other treatments, the peak was attained at flowering stage and thereafter decreased gradually at pod formation and harvest stage. Among the treatments, SSP+ lime treatment recorded significantly higher available sulphur followed by SSP at all growth stages indicating that lime application induces sulphur availability.

Further the data showed that similar trend of available sulphur was recorded at different growth stages of second (maize), third (groundnut) and fourth (maize) crop. The value of available sulphur was also increased over seasons in all treatments with few exceptions.



a. Groundnut (Rabi 2013-14) **b. Maize (Kharif 2014)**

c. Groundnut (Rabi 2014-15) **d. Maize (Kharif 2015)**

Fig 1: (a, b, c, d) Effects of treatments on soil available S (kg ha^{-1}) at different growth stages of groundnut and maize

Available sulphur build up in soil

Table 1 and figure 2 presented the value of available sulphur build up in soil after harvest of four crops. The available sulphur before start of the experiment was 27.5 kg ha^{-1} indicating a medium soil sulphur status. During four cropping seasons (the crop) received 180 kg P_2O_5 ha^{-1} through 1125 kg SSP in T_3 which add 135 kg S ha^{-1}. In other words, T_3 and T_8 treatment received 135 kg S ha^{-1} over four seasons. The data presented in Table 1 showed that after the harvest of four crops, the available sulphur in control decreased from 27.45 kg ha^{-1} to 12.3 kg ha^{-1} indicating a negative build up of 15.15 kg S ha^{-1} (-55.2%) was due to crop removal. Application of URP (T_2) alone recorded 7.8% available sulphur build up as compared to initial value. The build-up in available sulphur further increased by 13 to 21% when the crop received URP+SSP mixture in 3:1 or 1:1 or 1:3 ratio. Application of whole P through SSP (T_3) further increased the S build up to 30%. Application of SSP, URP+SSP resulted in significantly higher soil available sulphur over sole URP treatments was due to addition of S through SSP. Application of lime with SSP recorded the maximum build up which is about 40% higher over the initial value indicating a rise in pH through liming induces the sulphur availability in soil. Shinde *et al*. (1978b) [12], Das *et al*. (1982) [4] reported similar results.

Table 1: Available S build up (kg ha^{-1}) in soil after harvest of fourth crop in groundnut-maize cropping system

S. No.	Treatments	Initial soil available sulphur (kg ha^{-1})	Soil available sulphur after harvest of 4th crop (kg ha^{-1})	Available S build up (kg ha^{-1})
T1	Control	27.45	12.35	-15.1 (-55.01)
T2	100% P(URP)	27.45	29.67	2.22 (8.09)
T3	100% P(SSP)	27.45	35.71	8.26 (30.09)
T4	75% P(URP)+25% P(SSP)	27.45	31.18	3.73 (13.59)
T5	50% P(URP)+50% P(SSP)	27.45	33.13	5.68 (20.69)
T6	25%P(URP)+75%P (SSP)	27.45	33.36	5.91 (21.53)
T7	200% P(URP) only on 1st crop	27.45	22.54	-4.91 (-17.89)
T8	100%P(SSP)+Lime@0.2 LR	27.45	38.41	10.96 (39.93)

*Figures in parentheses indicate percentage of S build up

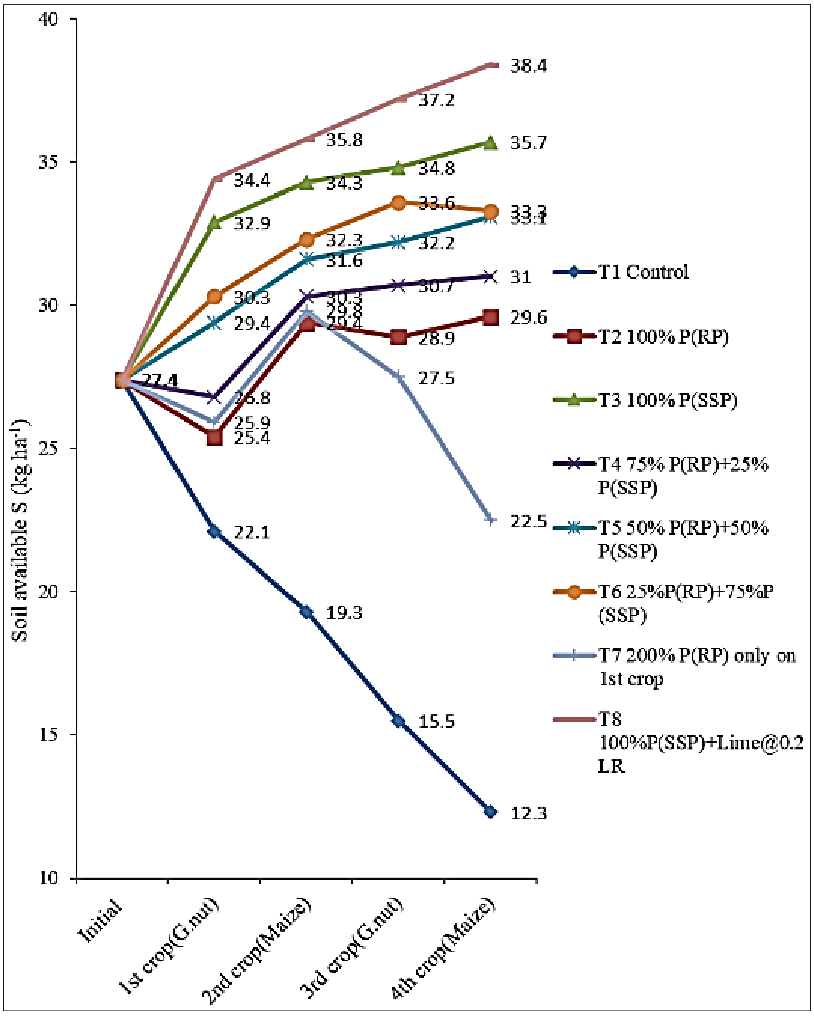


Fig 2: Effects of treatments on soil available S (kg ha^{-1}) at harvest of crops over four seasons

Conclusion

The build-up in available sulphur increased by 21% over the initial value when the crop received URP and SSP in 1:1 ratio. Application of P through SSP (T_3) increased the sulphur build up by 30%. Application of lime with SSP resulted highest value of available sulphur build up which is about 40% higher over the initial value.

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