

Original Research Article

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## Effect of Phosphorus and Sulphur using PSB on Groundnut (*Arachis hypogaea* L.) in Calcareous Soils

R. Dileepkumar and Vikram Singh\*

Department Of Agricultural Chemistry And Soil Science, Junagadh Agricultural University,  
Junagadh-362001(Gujarat), India

\*Corresponding author

### ABSTRACT

#### Keywords

Groundnut, Cystine, cysteine, Methionine, Proteolytic enzymes, Ferredoxins

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A field experiment on groundnut (*Arachis hypogaea* L.) under calcareous soil was conducted during summer 2016 at Instructional Farm, Department of Agronomy, College of Agriculture, JAU, Junagadh. Results of the experiment revealed that significantly higher growth and yield attributes and yield were recorded with RDP @ 50 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> + 30 kg S ha<sup>-1</sup> + PSB. Plant height was at par with RDP + PSB, 30 kg S ha<sup>-1</sup> + PSB, RDP + 30 kg S ha<sup>-1</sup> and RDP at 60 DAS, RDP + PSB and RDP at 90 DAS, and RDP + PSB and RDP at harvest. Dry matter accumulation of plant was at par with all other treatments except control at both 60 and 90 DAS but significant with RDP + 30 kg S ha<sup>-1</sup> at harvest. Pod yield was at par with RDP + 30 kg S ha<sup>-1</sup>. Significantly higher nutrient content and their uptake, and available nutrients (N, P, K and S) in soil were observed with RDP @ 50 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> + 30 kg S ha<sup>-1</sup> + PSB. P content in plant was at par with RDP + 30 kg S/ha, RDP + PSB and RDP. Significantly higher S content was recorded in 30 kg S ha<sup>-1</sup> + PSB, which was at par with RDP + 30 kg S ha<sup>-1</sup> + PSB. Uptake of P and S was at par with RDP + 30 kg S ha<sup>-1</sup>. The available P in soil was at par with RDP + 30 kg S ha<sup>-1</sup> at both 60 and 90 DAS and available S in soil was at par with RDP + 30 kg S ha<sup>-1</sup>.

### Introduction

India is being the leading groundnut producing country since it accounts for about 21 % of world's groundnut area and about 17 % production (Anon, 2014). Groundnut being a leguminous crop and rich in oil requires higher amounts of phosphorus (P) as compared to other nutrients. Phosphorus is an

important nutrient in crop production. It promotes plant root growth and help in energy transformations as well as photosynthesis of plant. The major problem of phosphorus is its availability. Only 1 to 3 % of phosphorus in any soil is in plant available form. Similarly, sulphur (S) is increasingly being recognized as the fourth major plant nutrient. It is known for its role in synthesis of sulphur containing

amino acids viz., cystine, cysteine and methionine. It is required for the formation of chlorophyll, vitamins, glucosides, ferredoxins and certain disulphide linkages besides activation of proteolytic enzymes and ATP-sulphurylase. It is well evidenced that uses of organics and microorganisms play an important role for improving the phosphorus availability in agricultural soils. Phosphate solubilizing bacteria (PSB) are the microbes involved in a range of processes that affect the transformation of soil phosphorus and are thus an integral component of the soil P cycle. Particularly these are effective in releasing P from inorganic and organic pools of soil phosphorus through solubilization and mineralization.

### Materials and Methods

A field experiment entitled “Mobilization of soil phosphorus for groundnut (*Arachis hypogaea* L.) nutrition using sulphur and PSB in calcareous soils” was conducted during summer 2016 at Instructional Farm, Department of Agronomy, College of Agriculture, JAU, Junagadh. The experiment comprising of eight treatments (T<sub>1</sub>-Control, T<sub>2</sub>-RDP @ 50 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>, T<sub>3</sub>-30 kg S ha<sup>-1</sup>, T<sub>4</sub>-RDP @ 50 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> + 30 kg S ha<sup>-1</sup>, T<sub>5</sub>-PSB @ 40 ml/kg seeds, T<sub>6</sub>-RDP @ 50 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup> + PSB, T<sub>7</sub>-30 kg S ha<sup>-1</sup> + PSB and T<sub>8</sub>-RDP @ 50 kg ha<sup>-1</sup> + 30 kg S ha<sup>-1</sup> + PSB) with four replications was carried out in randomized block design. N and K was applied in all the treatments as per recommendation (N -K<sub>2</sub>O; 25 - 50 kg ha<sup>-1</sup>). A composite soil sample (Vertic Haplustepts) was collected from the experimental field before commencement of the experiment from 0-20 cm depth to record the physico-chemical properties of the soil. The soil of the experimental plot was clayey in texture and alkaline in reaction with pH<sub>2.5</sub> 8.0, EC<sub>2.5</sub> 0.56 dS m<sup>-1</sup>, CaCO<sub>3</sub> 315 g kg<sup>-1</sup> and OC 4.5 g kg<sup>-1</sup>. The soil was low in available nitrogen (182.34

kg ha<sup>-1</sup>), medium in available phosphorus (11.73 kg ha<sup>-1</sup>), available potassium (217.49 kg ha<sup>-1</sup>), sulphur (8.75 kg ha<sup>-1</sup>), iron (5.26 ppm), zinc (0.5 ppm), and high in manganese (16.77 ppm) and copper (2.07 ppm). The groundnut variety TG-37A was selected for this study. This variety was developed and released by BARC, Mumbai. The weather condition during *summer* of 2016 was favorable for normal growth and development of groundnut. No severe incidence of insect-pest was observed.

### Results and Discussion

The data pertaining to effect of treatments on various aspects of biometric observations, yield parameters, nutrient content and their uptake by pod and haulm, nutrient status of soil after harvest of groundnut were statistically computed to test significance of results.

### Growth parameters

Marked differences among the treatments were noticed at different stages of crop with regard to plant height and dry matter production. Application RDP + 30 kg S ha<sup>-1</sup> + PSB (T<sub>8</sub>) recorded the higher plant height, which was at par with RDP + PSB, 30 kg S ha<sup>-1</sup> + PSB, RDP + 30 kg S ha<sup>-1</sup> and RDP at 60 DAS and RDP + PSB and RDP at 90 DAS and RDP + PSB and RDP at harvest. This might be attributed to enhance release of nutrients in the soil and applied fertilizers by the action of S and PSB during different growth stages of plants provides better plant nutrition for proper root growth and establishment. Similar results were reported by Zelate and Padmani (2009) in groundnut and Sharma *et al.*, (2002) in green gram at different plant stages. Higher dry matter accumulation was also noticed in RDP + 30 kg S ha<sup>-1</sup> + PSB (T<sub>8</sub>) and was at par with all other treatments except control at both 60 and 90 DAS but significantly at par with

RDP + 30 kg S ha<sup>-1</sup> at harvest (Table 1). However, these treatments were significantly superior over rest of the treatments. While, control plot (T<sub>1</sub>) recorded the lowest plant height and dry matter accumulation. This might be attributed to the cumulative effect of S and PSB on P solubilization and mobilization for better nutrition of the plants. Similar results were reported by Singh *et al.*, (2002) in groundnut and Khamparia (1994) in soybean and groundnut at different plant growth stages

### Yield parameters

Significant differences among the treatments were noticed with respect to number of pods per plant, 100 pod weight (g), 100 kernel weight (g), pod and haulm yield (Table 2).

The higher number of pods per plant (29.25), 100 pod weight (43.17g), 100 kernel weight (26.81), pod yield (1316.66 kg ha<sup>-1</sup>) and haulm yield (2566.66 kg ha<sup>-1</sup>) were recorded in the treatment comprising RDP + 30 kg S ha<sup>-1</sup> + PSB (T<sub>8</sub>) and at par with RDP + 30 kg S ha<sup>-1</sup> (T<sub>4</sub>) with respect to pod yield only. However, the treatment native soil-P (T<sub>1</sub>) registered the lowest number of pods per plant (19.00), pod yield (908.33 kg ha<sup>-1</sup>) and haulm yield (2158.33 kg ha<sup>-1</sup>). Similar results were reported by More *et al.*, (2002), Rao and Shektawat (2002), Srilatha (2002), Detroja *et al.*, (1997), Panwar and Singh (2003) in groundnut, Reddy *et al.*, (2016) in sunflower. Solanki *et al.*, (2015) in mustard, Mir *et al.*, (2013) in *Vigna mungo* and Aulakh *et al.*, (1990) in soybean.

### Content and Uptake of Nutrients

N and K content in groundnut pod and haulm did not differ significantly, but significantly, higher P content in pod was recorded in RDP + 30 kg S ha<sup>-1</sup> + PSB (0.56%), which was at par with RDP + 30 kg S ha<sup>-1</sup>, RDP + PSB and

RDP. The effect of sulphur and PSB as solubilization and mobilization of unavailable soil phosphorus might be possible cause for better P nutrition of the plants. This may enhance the availability of the soil phosphorus for plant nutrition. Similar results were reported by Singh *et al.*, (2002) in groundnut and Dwivedi *et al.*, (1999) in faba bean. Whereas, minimum phosphorus content in pod was recorded with native soil-P (0.47%). With respect to S, significantly higher S content was recorded in 30 kg S ha<sup>-1</sup> + PSB (0.32%) which was at par with RDP + 30 kg S ha<sup>-1</sup> + PSB (0.30%). With respect to haulm, higher P content was recorded in RDP + 30 kg S ha<sup>-1</sup> + PSB (0.41%), which was at par with RDP + 30 kg S ha<sup>-1</sup> (0.38%) and higher S content was recorded in RDP + 30 kg S ha<sup>-1</sup> + PSB (0.27%), which was at par with 30 kg S ha<sup>-1</sup> (0.24%), RDP + 30 kg S ha<sup>-1</sup> (0.26%), 30 kg S ha<sup>-1</sup> + PSB (0.26%). Whereas lowest P and S content in pod was recorded in T<sub>1</sub> (native soil-P). This might be due to quick supply of available plant nutrients to plants through fertilizers. Similar results were reported in faba bean by Dwivedi *et al.*, (1999).

The uptake of N, P, S and K as impelled by various treatments differed markedly. The higher uptake of N, P, S and K in pod and haulm was registered in the plots applied RDP + 30 kg S ha<sup>-1</sup> + PSB (T<sub>8</sub>), with respect to nutrient uptake by pod it was at par with RDP + 30 kg S ha<sup>-1</sup> (T<sub>4</sub>) and with respect to nutrient uptake by haulm pod it was at par with RDP + 30 kg S ha<sup>-1</sup>. But all these treatments differed markedly over rest of the treatments. While, native soil-P (T<sub>1</sub>) recorded the lowest uptake of N, P, K and S by pod and haulm. This might be due to quick supply of available plant nutrients to plants due to cumulative effect of fertilizers and PSB. Similar results were reported by Singh *et al.*, (2002), Sakal *et al.*, (1993) in groundnut, Rajput *et al.*, (1991), Majumdar *et al.*, (2001) in soybean and Sinha *et al.*, (1995) in maize.

**Table.1** Effect of different treatments on dry matter accumulation at different growth stages of groundnut

Treatments	Dry matter accumulation (g plant <sup>-1</sup> )		
	60 DAS	90 DAS	At harvest
<b>T<sub>1</sub> - Native soil-P</b>	10.69	13.20	19.77
<b>T<sub>2</sub> - RDP</b>	12.76	17.90	26.13
<b>T<sub>3</sub> -30 kg S ha<sup>-1</sup></b>	12.58	16.88	25.64
<b>T<sub>4</sub> - RDP + 30 kg S ha<sup>-1</sup></b>	13.52	18.15	27.53
<b>T<sub>5</sub> - PSB</b>	11.80	15.77	23.46
<b>T<sub>6</sub> - RDP + PSB</b>	13.67	17.71	25.81
<b>T<sub>7</sub> - 30 kg S ha<sup>-1</sup> + PSB</b>	13.77	17.54	26.43
<b>T<sub>8</sub> - RDP + 30 kg S ha<sup>-1</sup> + PSB</b>	14.33	19.17	29.71
<b>S.Em.±</b>	0.18	0.23	0.32
<b>C.D. at 5 %</b>	0.54	0.67	0.94
<b>C.V. %</b>	8.83	6.68	9.51

**Table.2** Effect of different treatments on yield parameters

Treatments	No. of pods plant <sup>-1</sup>	Pod yield (kg ha <sup>-1</sup> )	Haulm yield (kg ha <sup>-1</sup> )	100 pod weight (g)	100 kernel weight (g)	Harvest index (%)
<b>T<sub>1</sub> - Native soil-P</b>	19.00	908.33	2158.33	32.21	23.00	31.93
<b>T<sub>2</sub> – RDP</b>	23.75	1091.66	2308.33	38.19	25.23	32.20
<b>T<sub>3</sub> - 30 kg S ha<sup>-1</sup></b>	21.25	1016.66	2191.66	37.90	25.02	32.10
<b>T<sub>4</sub> - RDP + 30 kg S ha<sup>-1</sup></b>	25.75	1300.00	2525.00	41.95	26.27	32.54
<b>T<sub>5</sub> – PSB</b>	19.75	966.66	2141.66	34.44	23.93	32.02
<b>T<sub>6</sub> - RDP + PSB</b>	24.00	1150.00	2500.00	40.44	25.51	32.49
<b>T<sub>7</sub> - 30 kg S ha<sup>-1</sup> + PSB</b>	22.00	1116.66	2425.00	39.11	25.10	32.46
<b>T<sub>8</sub> - RDP + 30 kg S ha<sup>-1</sup> + PSB</b>	29.25	1316.66	2566.66	43.17	26.81	32.80
<b>S.Em.±</b>	0.83	25.93	30.80	0.26	0.15	0.20
<b>C.D. at 5 %</b>	2.43	76.28	90.60	0.77	0.43	NS
<b>C.V. %</b>	7.16	11.76	14.12	6.36	7.16	4.25

**Table.3** Effect of different treatments on available nutrient status of soil after harvest of groundnut

Treatments	Nutrient status of soil (kg ha <sup>-1</sup> )			
	N	K <sub>2</sub> O	S	P
T1 - Native soil-P	216.38	258.71	9.69	7.45
T2 - RDP	214.03	257.4	10.35	18.65
T3 - 30 kg S ha <sup>-1</sup>	223.05	257.44	17.53	12.71
T4 - RDP + 30 kg S ha <sup>-1</sup>	217.95	259.30	17.84	25.26
T5 - PSB	219.95	256.56	10.13	13.72
T6 - RDP + PSB	215.21	260.48	10.48	25.31
T7 - 30 kg S ha <sup>-1</sup> + PSB	224.62	259.11	17.47	14.62
T8 - RDP + 30 kg S ha <sup>-1</sup> + PSB	223.83	261.20	17.94	27.27
S.Em.±	3.76	1.12	0.09	0.61
C.D. at 5 %	NS	NS	0.27	1.79
C.V. %	9.43	7.87	9.30	14.71
Initial status (kg ha <sup>-1</sup> )	182.34	217.49	8.75	11.73

### Available Soil Nutrient Status after Harvest

The higher available phosphorus in soil was found in treatment RDP + 30 kg S ha<sup>-1</sup> + PSB (T<sub>8</sub>) at different crop growth stages and it was at par with RDP + 30 kg S ha<sup>-1</sup> at both 60 and 90 DAS (Table 3). All these treatments differed significantly over other treatments.

While, the lowest available phosphorus was registered with native soil-P (T<sub>1</sub>). The higher available P status of soil was recorded in T<sub>8</sub> which might be due to combine application of RDF along with seed inoculation of PSB resulted in increase in available phosphorus due to more phosphate solubilization by P-solubilizers. The phosphate solubilization was attributed to the production of non-volatile organic acids (Arora and Gaur, 1979). These organic acids were effective chelating agents and form stable complexes with Ca, Mg, Fe and Al and thus render P available to the plants (Sperber, 1958).

With respect to sulphur, significantly higher available sulphur was noticed in RDP + 30 kg S ha<sup>-1</sup> + PSB, which was at par with RDP + 30 kg S ha<sup>-1</sup>. Thus, integrated resource management improved the soil fertility status. This might be due to the application of sulphur through fertilizer along with PSB. Similar results were reported by Sharma *et al.*, (2013) in wheat.

The combined application of PSB (*Bacillus polymixa* N5), sulphur (30 kg S ha<sup>-1</sup>) and phosphorus (50 kg P<sub>2</sub>O<sub>5</sub> ha<sup>-1</sup>) along with recommended dose of nitrogen and potash increased the nutrient availability, plant growth, yield & yield attributes of groundnut in *summer* season.

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