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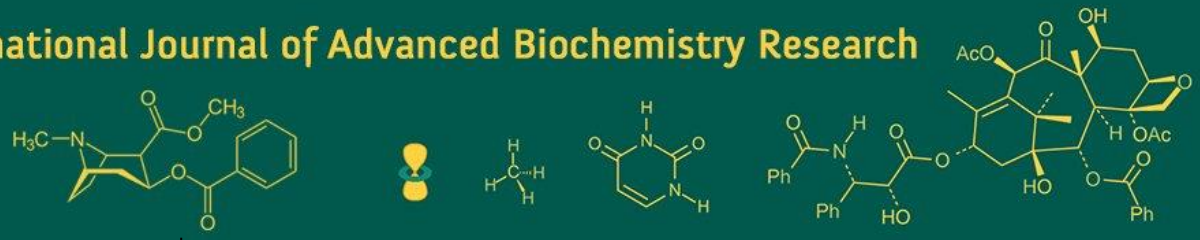

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Effect of phosphorus and sulphur on nutrient content and uptake of summer groundnut

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Abstract
A field experiment was conducted at Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during summer 2019 in loamy sand soil. The experiment consisted of two levels of phosphorus (25 and 50 kg/ha), sulphur (20 and 40 kg/ha) and three bio-fertilizers (Phosphorus solubilizing bacteria, Sulphur oxidizing bacteria, Phosphorus solubilizing bacteria + Sulphur oxidizing bacteria) with four replications in randomized block design with factorial concept. Nutrient content and uptake of nitrogen, phosphorus and sulphur found significantly superior with application of 50 kg P_2O_5/ha and 40 kg S/ha than lower levels of 25 kg P_2O_5/ha and 20 kg S/ha. Inoculation of kernels with PSB + SOB significantly improved nutrient content and uptake than inoculation with SOB only and was at par with treatment PSB.

Keywords: Groundnut, Phosphorus, sulphur, content, uptake, biofertilizers

Introduction
Oil seed crops occupy a unique role in Indian agriculture. On the oil seed map of the world, India occupies a prominent position, both in regard to acreage and production. Oilseeds constitute the second major agricultural crop in the country next to food grains in terms of tonnage and value. For increasing their production, improvement in quality, better processing techniques, efficient distribution and marketing facilities are absolutely necessary in order to provide the basic requirements of fats, oils and proteins for mankind. Groundnut (*Arachis hypogaea* L.), king of oilseeds, belongs to the family Leguminoceae and commonly called as poor man's almond. It is the world's fourth most important source of edible oil and third most important source of vegetable protein. The groundnut is used for different purposes *viz.*, food, animal feed and industrial raw materials. Seed is valued both for its oil and protein content as the seeds contain about 40-45 percent oil, 25 percent protein and 18 percent carbohydrates in addition to minerals and vitamins. Groundnut oil contains a higher proportion of unsaturated fatty acids, including essential fatty acids like linolenic and linoleic acids (Desai *et al*., 1999) [6]. It is also fairly rich in calcium, iron and vitamin B complex like thiamine, riboflavin, niacin and vitamin A. It has multifarious usages; it is not only used as a major cooking medium for various food items but also utilized for manufacturing of soap, cosmetics, shaving creams, lubricants, etc. It plays a pivotal role in oilseed economy of India. Groundnut is leguminous crop and grown for oil purpose requires huge amount of phosphorus and sulphur. Phosphorus encourages the formation of new cells involved in conversion of solar energy into plant food, root growth, enhances plant maturity and also reduces harmful effect of excess nitrogen. Sulphur plays a vital role in metabolism of plant, helps in biological oxidation – reduction process and involves directly in biosynthesis of oil and protein (Hawkesford, 2006) [9]. The application of sulphur resulted into increase of sulphur bearing amino acid as methionine and cysteine (Singh and Chaudhary, 1996) [3]. Fertilizers are scare and costly inputs and has high gap between demand and supply. To reduce the margin between demand and supply use of non-convectional sources of plant nutrients *viz.*, crop residues, FYM, cakes, bio-fertilizers *etc*. with inorganic sources of nutrients. Combine use of organic and inorganic sources not only save the fertilizer requirement but increase the net profit and sustain the soil health also. Thus, it is known as an eco-friendly approach.

Materials and Methods

A field experiment was conducted during summer season of 2019 to study effect of phosphorus and sulphur on nutrient content and uptake of summer groundnut. The experiment was laid out at Agronomy Instructional Farm, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Dist: Banaskantha, Gujarat. Geographically, Sardarkrushinagar, where the experiment was laid out is situated geographically 24° 19' North latitude and 72° 19' East longitude with an altitude of 154.52 meter above the mean sea level. It represents the North Gujarat Agro-Climatic Zone. The climate of this region is sub-tropical monsoon type and falls under semi-arid region, in general, the monsoon is warm and humid, winter is fairly cold and dry, while summer is largely hot and dry. The soil of the experimental area was loamy sand in texture having pH value 7.5, which was low organic carbon (0.15%) and nitrogen (162.3 kg/ha), while it is medium in available phosphorus (46.5 kg/ha) and sulphur (17.2 kg/ha). Elemental sulphur was applied before 21 days of sowing while, DAP applied as basal doses and kernels are treated with PSB and SOB bio-fertilizers as per the treatment. The experiment consisted of two levels of phosphorus (25 and 50 kg/ha), sulphur (20 and 40 kg/ha) and three bio-fertilizers (Phosphorus solubilizing bacteria, Sulphur oxidizing bacteria, Phosphorus solubilizing bacteria + Sulphur oxidizing bacteria) with four replications in randomized block design with factorial concept. Groundnut variety TG 37 A was sown on 6th march, 2019 using seed rate of 120 kg/ha and keeping 45 cm distance between two rows and seeds were sown manually at the depth of about 5-7 cm.

Results and Discussion

Effect of phosphorus: Application of 50 kg P_2O_5/ha increased the nitrogen, phosphorus and sulphur concentrations as well as their uptake by various plant parts (kernel and haulm) significantly. Higher nitrogen (3.90%), phosphorus (0.493%) and sulphur (0.333%) content in kernels and in halum it was (1.48%), phosphorus (0.204%) and sulphur (0.544%) (Table.1). The higher nutrients content may be due to accumulation and its translocation from vegetative parts to reproductive parts at the letter stages of crop growth. Increase in nutrients concentration with phosphorus application was due to enhanced absorption of nitrogen due to increased root proliferation, enhanced N-fixation and greater assimilation of nutrients in the presence of phosphorus. These results were closely agreement with Deka *et al.* (2001) [5], Kumar *et al*. (2014) [11], Yadav *et al*. (2015) [22] and Kamal *et al*., (2023) [10].

Increase in uptake of N, P and S by kernel and haulm with 50 kg P_2O_5/ha might be attributed to cumulative effect of increased yield and comparatively higher content of N, P and S in kernel and haulm than 25 kg P_2O_5/ha (Table. 1). Musa *et al.* (2017) [13] reported that that under field conditions in early growth stages, groundnut was not limited by low phosphorus soil. Increased root production is a well-known acclimation of phosphorus deficient plants to improve phosphorus uptake. At early growth stages groundnut was very phosphorus efficient mainly because of a high phosphorus uptake rate which declines later in the growing period with a concomitant decrease in Phosphorus efficiency. This therefore suggests that phosphorus influx differed greatly between species as well as with the stage of growth of particular species. Similar the results were obtained by Deka *et al*. (2001) [5], Kumar *et al*. (2014) [11] Kumar and Kamal *et al*., (2023) [10].

Table 1: Nitrogen, phosphorus and Sulphur contents (%) in kernel and haulm of summer groundnut as influenced by various levels phosphorus, Sulphur and bio-fertilizers

Treatments	Nutrient content in kernel (%)			Nutrient content in haulm (%)		
	Nitrogen	Phosphorus	Sulphur	Nitrogen	Phosphorus	Sulphur
Levels of phosphorus						
P_1 (25 kg/ha)	3.62	0.465	0.305	1.41	0.168	0.508
P_2 (50 kg/ha)	3.90	0.493	0.333	1.48	0.204	0.544
S.Em. ±	0.04	0.004	0.004	0.01	0.002	0.002
CD at 5%	0.13	0.011	0.011	0.03	0.007	0.007
Levels of Sulphur						
S_1 (20 kg/ha)	3.65	0.461	0.301	1.42	0.176	0.516
S_2 (40 kg/ha)	3.88	0.497	0.337	1.47	0.195	0.535
S.Em. ±	0.04	0.004	0.004	0.01	0.002	0.002
CD at 5%	0.13	0.011	0.011	0.03	0.007	0.007
Bio-fertilizers						
B_1 (PSB)	3.81	0.488	0.328	1.45	0.188	0.528
B_2 (SOB)	3.61	0.451	0.291	1.42	0.160	0.500
B_3 (PSB + SOB)	3.87	0.497	0.337	1.47	0.210	0.550
S.Em. ±	0.05	0.005	0.005	0.01	0.003	0.003
CD at 5%	0.16	0.013	0.013	0.04	0.008	0.008
Interaction						
P×S	NS	NS	NS	NS	NS	NS
P×B	NS	NS	NS	NS	NS	NS
S×B	NS	NS	NS	NS	NS	NS
P×S×B	NS	NS	NS	NS	NS	NS
C.V. %	5.74	3.85	5.80	3.40	5.99	2.12

Table 2: Nitrogen, phosphorus and Sulphur uptake (kg/ha) by kernel and haulm of summer groundnut as influenced by various levels phosphorus, Sulphur and bio-fertilizers

Treatments	Nutrients uptake by kernel (kg/ha)			Nutrients uptake by haulm (kg/ha)		
	Nitrogen	Phosphorus	Sulphur	Nitrogen	Phosphorus	Sulphur
Levels of phosphorus						
P_1 (25 kg/ha)	68.35	8.79	5.78	69.56	8.37	25.13
P_2 (50 kg/ha)	80.88	10.25	6.95	78.93	10.95	29.04
S.Em. ±	2.06	0.28	0.21	1.63	0.29	0.66
CD at 5%	5.92	0.80	0.60	4.70	0.84	1.90
Levels of Sulphur						
S_1 (20 kg/ha)	69.22	8.75	5.73	70.14	8.78	25.56
S_2 (40 kg/ha)	80.00	10.29	7.00	78.36	10.54	28.61
S.Em. ±	2.06	0.28	0.21	1.63	0.29	0.66
CD at 5%	5.92	0.80	0.60	4.70	0.84	1.90
Bio-fertilizers						
B_1 (PSB)	76.59	9.82	6.62	75.84	9.89	27.68
B_2 (SOB)	66.27	8.30	5.37	67.71	7.72	23.98
B_3 (PSB + SOB)	80.98	10.43	7.10	79.19	11.36	29.59
S.Em. ±	2.52	0.34	0.26	2.00	0.36	0.81
CD at 5%	7.25	0.98	0.73	5.76	1.03	2.32
Interaction						
P×S	NS	NS	NS	NS	NS	NS
P×B	NS	NS	NS	NS	NS	NS
S×B	NS	NS	NS	NS	NS	NS
P×S×B	NS	NS	NS	NS	NS	NS
C.V. %	13.50	14.34	16.02	10.79	14.82	11.93

Effect of Sulphur

Each successive increase in sulphur levels had significantly increased nitrogen, phosphorus and sulphur contents (Table. 1) as well as their uptake (Table. 2) by kernel and haulm. Significantly higher nutrient content and their uptake by crop with application of 20 kg S/ha. Sulphur contribute in synthesis of essential sulphur containing amino acid like cysteine, cystine, and methionine this may be the reason for enhancing protein content in groundnut. Also might be due to fact that as protein content and pod yield increased remarkably with increase in sulphur levels. The results are in accordance with findings of Vagharsia *et al*. (2007) and Nayak *et al.* (2009) [14]. Adequate application of sulphur regulates the metabolic and enzymatic processes including photosynthesis, respiration and in legume symbiotic nitrogen fixation which reflected in more nutrients content in haulm. Similar trend was also reported by Ranparia *et al.* (2006) in groundnut.

Application of higher level of sulphur (40 kg/ha) increased nutrient content and pod yield remarkably than lower dose (20 kg/ha) which resulted in higher nutrients uptake by crop (pod and haulm) (Table. 2). The added nutrients and synergistic effect N and S might have enhanced the microbial activities resulting in higher nitrogen fixation, profuse plant and root growth which ultimately increased total uptake of nutrients. Higher uptake of sulphur might have their higher concentration in soil solution which increased availability and uptake of Sulphur. The findings are in accordance with findings of Giri *et al.* (2014) [8], Dutta *et al*. (2015) [7], Patel *et al.* (2019) [17] and Nayee *et al.* (2022) [15].

Effect of biofertilizers

Significantly the maximum content and uptake of nutrients (N, P and S) by groundnut (pod and haulm) was recorded under the treatment B_3 (PSB + SOB) and was at par with treatment B_1 (PSB) but significantly higher than treatment B_2 (SOB). The kernels of groundnut inoculated with PSB helped in releasing phosphorus from native as well as protecting fixation of added phosphate and rendered more available phosphorus for the plant leading to increased nutrients content of the plant (Ola *et al.* 2014) [16]. According to Mostafavian *et al.* (2008) [12] in case of soybean, SOB bio-fertilizer mobilize the native sulphur as well as oxidized the added sulphur in available form leading to greater nutrients content in kernel of groundnut. These results are in close proximity with the findings of Basu *et al.* (2011) [2], Bhutadiya *et al*. (2019) [3] and Dabhi *et al*. (2022) [4].

Inoculation of kernels with bio-fertilizers (PSB + SOB) and PSB were at par and recorded significantly higher uptake of nitrogen, phosphorus and sulphur by kernel and haulm than that of with SOB. The maximum and significantly lowest uptake was recorded with PSB + SOB and SOB, respectively. Bio-fertilizer convert the unavailable nutrients into available from which might be increase the absorption of nutrients. Moreover, bio-fertilizer has pronounced effect on nutrients content in and pod yield which increased uptake of nutrients by kernels and haulm. Similar results were also reported by Basu *et al*. (2006) [1], Ola *et al.* (2014) [16] in groundnut and Singh and Singh (2017) [13] in cowpea.

Conclusion

Based on investigation, it can be concluded that application of phosphorus @ 50 kg/ha and Sulphur @ 40 kg/ha with inoculation of kernels with PSB (*Bacillus coagulans*) + SOB (*Acidithiobacillus ferrooxidans*) or PSB (*Bacillus coagulans*) gave higher content and uptake of nutrients by groundnut crop under North Gujrat Agro Climatic conditions.

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