Int. J. Agriworld, Vol. 7[2] August 2026
©2020 SVPSS, India
Online ISSN: 2582-7537
Journal's URL:http://www.svpss.in/ijaw
DOI: https://doi.org/10.51470/IJAW.2026.07.02.61
Received 15.07.2026 Revised 05.08.2026 Accepted 16.08.2026
ORIGINAL ARTICLE OPEN ACCESS

Response of Sulphur Solubilizers on Sulphur Fractions at Various Growth Stages of Groundnut under Vertisol

Dalavi V.M.[1&2*], Singare P. B.[1] and Hanwate G.R.[1]
[1]Department of Soil Science and Agriculture Chemistry, College of Agriculture, Vasantrao Naik Marathwada Krushi Vidhayapeeth, Parbhani-431402 (India)
[2*]Division of Soil Science, College of Agriculture, Alani, Dharashiv, MH, India
***Corresponding E- mail:** vishaldalavi33@gmail.com

Abstract

The results emerged out in this experiment indicated that the was significant increase in available sulphur, in treatment T_7 (100% RDF + FYM @10 Mg ha^{-1} +10 kg E.S. ha^{-1}+S.S.B.). Significant highest values were recorded in treatment T_7 with liquid inoculants and found to be at par with T_6 and T_8 treatments. Further, content and uptake of secondary (S) nutrient improved with sulphur oxidizing bacteria showing better results in inoculation with 100% RDF+FYM @10 Mg ha^{-1} +10Kg ha^{-1} elemental sulphur. The experiment was conducted with eight treatments which include 100 % RDF, 75 % RDF, elemental sulphur @10 and 20Kg ha^{-1} FYM @5 and 10 Mg ha^{-1} and sulphur solubilizing bacteria. The experiment was laid out in complete randomized design and replicated thrice. Thiobacillus thiooxidants used as sulphur oxidizing bioinculates. Sulphur oxidizing bioinculates also applied at the same time and soil samples were collected at 40,80 DAS and at harvest stage of crop. Collected soil sample were dried, well ground and sieved through 2 mm sieves and stored in polyethylene bags. Soil samples were analyzed for sulphur fraction i.e. water-soluble sulphur, heat soluble sulphur, sulphate sulphur, and organic sulphur fraction. Plant samples were collected during 40, 80 DAS and at harvest stages of crop and analyzed for total S uptake.

Keywords: *Sulphur, Sulphur oxidizing bacteria (Thiobacillus thiooxidants), Sulphur fraction, Groundnut, etc.*

Introduction

Sulphur is one of the most important nutrients for all plants and animals. It is considered as the fourth major essential nutrient after nitrogen, phosphorus and potassium for agricultural crop production. Sulphur is a structural constituent of organic compounds, some of which are uniquely synthesized by plants, providing human and animals with essential amino acids (methionine and cysteine). It is involved in chlorophyll formation, activation of enzymes and is a part of vitamins biotin and thiamine (B_1) (Hedge, *et al.,* 2019). There are many other sulphur containing compounds in plants which are not essential, but may be involved in defense mechanisms against herbivores, pest and pathogens or contribute to the special taste and odour of food plants. Sulphur improves oil and protein content, flour quality for milling and baking, marketability of quality of tobacco and nutritive value of forages etc.

Sulphur is extremely important to plant growth and soil health. Most of agricultural soils contain some micro-organisms that are able to oxidize sulphur. The most important organism in this respect is a group of bacteria belonging to the genus Thiobacillus. Most of these bacteria determine the degree to which sulphur is converted to SO4- in soil. Thiobacillus are involved in oxidation of elemental sulphur to convert fixed and unavailable form of soil sulphur to available form of sulphur for plant. Availability of sulphur is influenced by various soil biological factors and hence the status of different forms of sulphur in soil varied widely with soil type. Distribution of sulphur forms and their interrelationship with some important soil characteristics decide the sulphur supplying power of the soil by influencing its rebase and dynamics in soil (Malewar, *et al.,* 2019).

Groundnut (*Arachis hypogaea* L.) is an important oilseed and leguminous crop, which has high

requirement of sulphur for oil synthesis, protein formation and biological nitrogen fixation. Sulphur is the fourth major nutrient after N, P, K and is an integral part of S-containing amino acids, coenzyme-A, vitamins and glucosides. In recent years, sulphur deficiency has emerged as a major constraint in Vertisols of Maharashtra and Central India due to intensive cropping, use of high analysis sulphur-free fertilizers and low organic matter addition. Vertisols, being clayey, calcareous and having swell-shrink behavior, fix applied sulphur in different forms and reduce its immediate availability to groundnut crop at critical stages. In soil, sulphur exists in various fractions such as Total S, Organic S, Inorganic S, Sulphate-S (SO_4-S), Water Soluble S and Heat Soluble S, and the transformation between these fractions is mediated by chemical and biological processes. The use of sulphur solubilizers *i.e.,* sulphur oxidizing bacteria like *Thiobacillus spp.* and other PSB accelerates the oxidation and solubilization of native and applied elemental sulphur, thereby increasing the availability of SO_4-S in the rhizosphere. The population and activity of these solubilizers and the distribution of sulphur fractions vary significantly at different growth stages of groundnut viz., flowering, pegging and pod filling, which ultimately decides the sulphur use efficiency and pod yield. Therefore, to understand the dynamics of sulphur fractions in relation to microbial solubilization, the present study entitled "Response of Sulphur Solubilizers on Sulphur Fractions at Various Growth Stages of Groundnut under Vertisol" has been planned (Arora, *et al.,* 2022 & Gajbhiye, *et al.,* 2020)

MATERIALS AND METHODS

A pot culture experiment was conducted in Kharif season. This pot culture experiment was laid out by using completely randomized design (CRD) with three replications with eight treatments. The Groundnut was sown by dibbling method with two or five seed per pots. Organic manures *i.e.* FYM was applied at the rate of FYM @ 10 Mg ha^{-1}. N, P, K @ 25:50:0 kg ha^{-1}. were applied through urea (46%), di-ammonium phosphate (18%) and murate of potash (60%) as per treatment. Soil samples were collected from each pot at the time of sowing after 40 days of at pod formation stage on at the time of harvesting. The collected soil samples were thoroughly mixed and brought to the laboratory, air dried, ground with wooden mortar and pestle and sieved through 2 mm sieve, for analyzing sulphur fractions (Total sulphur, Water soluble sulphur, Heat soluble sulphur, Sulphate sulphur and Organic sulphur).

RESULTS AND DISCUSSION

Effect of sulphur solubilizers on sulphur fractions at various growth stages of groundnut under Vertisol.

Total sulphur (ppm) in Soil

The data presented in Table 1 showed that the total sulphur content of soil ranged from 160.55-165.74, 151.68-158.80 and 149.94-155.84 kg ha^{-1} at 40,80DAS and at harvest stage of groundnut crop respectively which indicated that sulphur solubilizing bacteria and sulphur application with and without FYM had significant influence on total sulphur content of soil. Total sulphur content of soil at 40,80 DAS and at harvest of groundnut crop was noticed significantly highest *i.e.*165.74,158.80 and 155.84 ppm in treatment T_7 (100% RDF + FYM @10 Mg ha^{-1} +10 kg E.S. ha^{-1}+S.S.B) which was found at par with treatment T_8 (100% RDF + FYM @5 Mg ha^{-1} +10 kg E.S. ha^{-1} +S.S.B.) and T_6 (100% RDF + FYM @5 Mg ha^{-1} +S.S.B.) respectively, while lowest values were noticed in absolute control treatment T_1 (100% RDF).Total sulphur may be due to high clay content and lower values of total sulphur.

Water soluble sulphur fraction (ppm) in soil

The data presented in Table 1 revealed that the water-soluble sulphur content of soil ranged from 10.45 to 22.16, 10.20 to 18.63 and 10.35 to 16.23 ppm at 40,80 DAS and at harvest stage respectively in groundnut. The values indicated that sulphur solubilizing bacteria and elemental sulphur with and without FYM had significant influence on water soluble sulphur content of soil.

Water soluble sulphur content of soil at 40, 80 DAS and at harvest stage of groundnut crop was noticed significantly highest *i.e.* 22.16, 18.63 and 16.23 ppm respectively. In treatment T_7 (100% RDF + FYM @10 Mg ha^{-1}+10 kg E.S. ha^{-1} + S.S.B) while at par with treatment T_8 (100% RDF + FYM @5 Mg ha^{-1} +10 kg E.S. ha^{-1} +S.S.B.) and T_6 (100% RDF + FYM @5 Mg ha^{-1} +S.S.B.) respectively. Whereas lowest content was noticed in absolute control treatment T_1 (100% RDF). This is attributed to higher organic matter in calcium chloride with interference to barium sulphate.

Heat soluble sulphur fraction (ppm) in soil

The data presented in Table 1 indicated that the elemental sulphur, sulphur solubilizing bacteria with and without FYM had significant influence on heat soluble sulphur content of soil.

© Int. J. Agriworld, INDIA

Table No:1 Effect on Sulphur solubilizers on Sulphur fraction at various growth stages of groundnut under Vertisol

Tr. No.	Treatments	Total Sulphur (ppm)			Water Soluble Sulphur (ppm)			Heat Soluble Sulphur (ppm)			Sulphate Sulphur (ppm)			Organic Sulphur (ppm)		
		Sampling period (DAS)			Sampling period (DAS)			Sampling period (DAS)			Sampling period (DAS)			Sampling period (DAS)		
		40	80	At Harvest	40	80	At Harvest	40	80	At Harvest	40	80	At Harvest	40	80	At Harvest
T_1	100% RDF	160.5	151.6	149.9	10	10	10	30	28	28	10	10	10	40	31	30
T_2	100% RDF + S.S.B.	161	152.1	150	10	11	11	31	29	29	12	11	10	40	41	31
T_3	100 % RDF + 20 kg E.S. ha^{-1}+ S.S.B.	161.8	152.6	150.2	11	11	11	31	29	29	11	11	10	52	43	32
T_4	100 % RDF + 10 kg E.S. ha^{-1}+S.S.B.	162.1	153	151	13	11	12	32	30	30	12	12	11	54	45	32
T_5	75 % RDF + FYM @10 Mg ha^{-1} +S.S.B.	162.7	153.2	152.1	16	11	12	32	31	31	15	12	12	56	46	35
T_6	100 %RDF + FYM @10 Mg ha^{-1} +S.S.B.	163.4	155.4	153.6	20	15	12	33	32	31	19	13	13	56	46	36
T_7	100% RDF + FYM @10 Mg ha^{-1} +10 kg E.S. ha^{-1}+S.S.B.	165.7	158.8	155.8	22	18	16	35	33	32	20	15	14	58	48	38
T_8	100% RDF + FYM@5 Mg ha^{-1} +10 kg E.S. ha^{-1} +S.S.B.	164.6	157.4	154.5	21	16	15	34	33	32	18	14	13	57	47	37
	SE(m)	0.77	1.18	1.16	0.57	0.45	0.37	0.83	0.54	0.45	1.12	0.6	0.54	0.46	0.7	0.63
	CD @ 1%	2.33	3.45	3.46	1.7	1.25	1.1	2.5	1.6	1.3	3.3	1.8	1.6	1.4	2.1	1.9

Note: RDF-Recommended dose of fertilizer SSB: Sulphur Solubilizers Bacteria ES: Elemental Sulphur FYM: Farm Yard Manure DAS: Day after Sowing PPM: Parts per Million.

© Int. J. Agriworld, INDIA

The value ranged from 30.56-35.90, 28.27-33.87 and 28.09-32.83 ppm at 40, 80 DAS and at harvest stage of groundnut crop. Heat soluble sulphur content of soil at 40, 80 DAS and harvest stage of groundnut crop was noticed significantly highest in treatment T_7 (100% RDF + FYM @10 Mg ha-1 +10 kg E.S. ha^{-1} + S.S.B) and recorded as 35.90, 33.87 and 32.83 ppm respectively, was found at par with treatment T_8 (100% RDF + FYM @5 Mg ha^{-1} +10 kg E.S. ha^{-1} + S.S.B.) and T_6 (100% RDF + FYM @5 Mg ha^{-1} + S.S.B.), whereas values lowest were noticed in absolute control treatment T_1 (100% RDF). Higher amount of heat soluble sulphur is attributed to release of additional amount of sulphur from, organic pool on wet and dry heating of soil during extraction. The increased solubility by heating may be attributed to the liberation of SO_4^{2-} to sulphur covalently by organic matter.

Sulphate sulphur fraction (ppm) in soil

The data Table 1 showed that the sulphate sulphur fraction of soil was affected with administration of various treatments of elemental sulphur and sulphur solubilizers with and without FYM.

The values of sulphate sulphur content varied from 10.56-20.90, 10.27-15.10 and 10.09-14.83 ppm at 40, 80 DAS and at harvest stage of groundnut crop. Sulphate sulphur content of soil at 40,80 DAS and harvest of groundnut crop was noticed significantly highest and that values were 20.90, 15.10 and 14.83 ppm respectively in treatment T_7 (100% RDF + FYM @10 Mg ha^{-1} +10 kg E.S. ha^{-1} + S.S.B) was found at par with treatment T_8 (100% RDF + FYM @5 Mg ha^{-1} +10 kg E.S. ha^{-1} + S.S.B.) and T_6 (100% RDF + FYM @5 Mg ha^{-1} +S.S.B.) respectively. Whereas lowest value was noticed in absolute control treatment T_1 (100% RDF). No regular trend, soil may be of leaching upon rainfall/irrigation and 10 ppm critical limit in soil.

Organic sulphur (ppm) fraction in soil

The data presented in Table 1 revealed that elemental sulphur, sulphur solubilizing bacteria with and without FYM significantly influenced organic sulphur content in soil. The value was ranged from 40.17-58.92, 31.42-48.61 and 30.08-38.59 ppm at 40, 80 DAS at harvest stage respectively.

Organic sulphur content of soil at 40,80 DAS and harvest stage of groundnut crop was noticed significantly highest in treatment T_7 (100% RDF + FYM @10 Mg ha^{-1} + 10 kg E.S. ha^{-1} + S.S.B.) was found at par with treatment T8 (100% RDF + FYM@5 Mg ha^{-1} +10 kg E.S. ha^{-1} +S.S.B.) and T_6 (100% RDF + FYM @ 10 Mg ha^{-1} +S.S.B.) respectively, while lowest content was noticed in absolute control treatment T_1 (100% RDF). Decreasing trend with depth due to reduction in organic matter content.

Conclusion

Sulphur solubilizers improve the availability of sulphur by converting insoluble sulphur fractions into plant-available forms. Different sulphur fractions in Vertisol vary with the growth stages of groundnut. Sulphur-solubilizing microorganisms enhance sulphur transformation and nutrient availability in soil. The application of effective sulphur solubilizers can improve sulphur nutrition and soil fertility under groundnut cultivation in Vertisols.

REFERENCES

Arora, B.R., Hundal, H.S and Shekhon, G.S. (2022) Efficiency of different sulphur carries to peanut,maize and wheat on an alkaline soil. *J. of Indian soc. of soil sci.,* 39:591-593.

Borkotoki, T.K., Mohammad Sedghi, Raouf Seyed Sharifi, Ali Namvar and Peyman Molaei. (2021). Seed priming and sulfur effects on soybean cell membrane stability and yield in saline soil. *Pesq. agropec. Bras* 44(9):1114-1117.

Das, K.N., Anjali Basumatari, and Bikram Borkotoki., (2020) Forms of Sulphur in some Rapeseed growing Soils of Assam. *J. of the Indian soc. of soil Sci.* .60(1):13-19.

Gajbhiye, B.R. and Bhoye, R.C. (2020) Studies on sulphur fraction in soil of Lohara of Osmanabad district. *International J. of current Res.* 06(03):5381-5386.

Geetha, K.N., Shadashari, Y.G.Karuna, K., Jagdish, K.S., Puttarangaswamy, K.T., and Yogananada (2019) Effect of sulphur sources and levels on the productivity of sunflower. *J. oil seed Res.* 27(1):34-35.

Hedge, B.C. Sudhakara, S.K. Dutta, H.N. Thatoi (2019). Isolation and characterization of Sulphur oxidizing bacteria from Mangrove Soil of Mahanadi River Delta and their sulphur oxidizing ability. *J. of applied and Environment Microbiology*.02(1):1-5.

Lande, M.G., Varade, S.B. and badhe, N.N. (2019). Sulphur Status and its Relationships with physico-Chemicals Properties of Marathwada Soils. *J. of MAU.* 2 (3):195-201.

Malewar, G.U., Ismail, S., (2019) Sulphur Research in Marathwada Agriculture: A Review. *Marathwada Agricultural University, Parbhani, Dept. of Agril. Chem. Soil Sci.* 431402

 © Int. J. Agriworld, INDIA

Malewar, G.U., Ismail, S., (2019). Sulphur Research in Soils and Crops in Maharashtra: An Appraisal. *Marathwada Agricultural University, Parbhani, Dept. of Agril. Chem. Soil Sci.* 431402

Malewar, G.U., Ismail, S., (2019). Sulphur in Balanced Fertilizations in Western India. *Marathwada Agricultural University, Parbhani, Dept. of Agril. Chem. Soil Sci.* 431402

Patel, J.M., Patel, M.V., Jadhav, N.J. and Patel, V.R. (2018) Sulphur fraction and their relationship with properties in Banaskantha district Gujarat. *Agro-pedology*. 21(2):35-41.

Singh, S.P., Ram, J. and Singh, N. (2017). Forms of Sulphur in relation to soils Characteristics in Some Soils Series of Nagaland. *J. of Maharashtra Agric. Univ.* 25(1):3-8.

Vidyalakshmi, R. Paranthaman, R. and Bhakyaraj, R. (2016) Sulphur oxidizing bacteria and pulse Nutrition – A review. *World J. of Agril. Sci.* 5(3):270-278.

CITATION OF THIS ARTICLE

Dalavi V.M., Singare P. B. and Hanwate G.R. (2026). Response of Sulphur Solubilizers on Sulphur Fractions at Various Growth Stages of Groundnut under Vertisol, *Int. J. Agriworld*, 7 [2]: 61-65.

IJAW